

Obesity and Underweight in Camden School Children: Fact or Fiction?

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ABSTRACT

Aim

To use existing height and weight data on 4-7 year old children, routinely recorded as part of the school entry medical, to determine prevalence and trends in overweight, obesity and underweight, over the last 10 years in the London Borough of Camden

Method

Body mass index (BMI) and percentage of children over the cut off points for overweight and obesity were determined by two methods, (the Standard Deviation Score BMI (SDSBMI) cut offs and the International Obesity Task Force (IOTF) cut offs) as well as the percentage of children under the cut offs for underweight, (determined by the 15th, 5th and 2nd centile for SDSBMI) in 5225 children with a valid BMI in each school year between 1994/5 and 2003/4 from data held on the Regional Interactive Child Health Computer System, held by the Child Health Department at the Royal Free NHS Trust.

Results

The coverage for valid BMI ranged between 19.8% and 52%, with a mean coverage of 34.4%. 21.3% of initial data was not useable because of inadequate or implausible data, not amenable to correction. Logistic regression showed a significant trend over time in boys for underweight only, (defined as <5th centile) and a borderline trend in boys for severe underweight (defined as < 2nd centile). Although there was no significant linear trend in overweight or obesity over time, the prevalence of obesity and overweight in girls and boys, was higher than expected from the UK 1990 national dataset.

Conclusion

Underweight boys have increased in prevalence in this population. The prevalence of overweight and obesity is higher than expected from the UK 1990 national dataset. These findings need to be viewed cautiously as the overall coverage of data was low. Further work needs to be done to optimise the quality and completeness of routine data collected in Camden, in order to maximise the accuracy of the dataset for determining local prevalence and trends in BMI.

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AIMS AND OBJECTIVES

Aims

To determine the prevalence of obesity, overweight and underweight in Camden primary school children over the last 10 years (1994 – 2004) from routine data and to determine whether there have been any significant trends over time.

Objectives

1. To review and critically appraise the current literature on prevalence and time trends in overweight, obesity and underweight in children in the UK.
2. To study a group of children, currently aged 5 – 16 years, whose dates of birth (DOB) run from 1.09.89 to 31.08.99 who attend mainstream Camden primary schools. Their routinely collected data from the school entry medical, at age 5, i.e. 1994 – 2004, includes height and weight, recorded on a computerised database, the Regional Interactive Child Health System (RICHS). Using this (anonymised) height and weight data, the corresponding Body Mass Index (BMI), as an indicator of overweight and obesity, will be calculated.
3. To apply appropriate cut offs to the calculated BMI, to determine the prevalence and trends over time of overweight, obesity and underweight in these children.
4. To make recommendations for future practice and research

INTRODUCTION

“Please, sir, I want some more.”¹

Obesity and underweight can cause health problems in both children and adults.²⁻⁸

Recent studies^{5;9-12} have documented rising obesity levels nationally across the UK in all age groups, including children. The Health survey for England 2002¹³, reported that between 1995 and 2002, the prevalence of obesity in boys doubled from 2.9 to 5.7% and in girls increased by more than half from 4.9% to 7.8%. Anecdotal evidence suggests that this finding is not reflected in Camden primary school children and this study will investigate whether or not this hypothesis is correct.

It is tempting to assume that these national trends are applicable in all localities. To date studies looking at trends in obesity have only been done in a few localities^{10;14-18}, but those published, do reflect the national findings.

Government has responded to these findings. The proposed Government interventions laid out in the White Paper "Choosing Health: making healthier choices easier"¹⁹ include both national and local initiatives, such as the 'Healthy Start' scheme, where from 2005, the government will be providing young children in low income families with vouchers for fresh fruit, vegetables and milk, to improve dietary intake.

The increasing levels of obesity reported in the medical literature, government reports and policy, have not escaped the attention of the media. Broadcast media have produced a wealth of new programming devoted to 'the obesity epidemic' including: the BBC's 'Fat Nation' campaign in 2004 and Channel 4's Gillian McKeith with 'You Are What You Eat'. In film, 'Supersize Me', highlighted the issues created by a diet of fast food. Children's nutrition has not escaped the media spotlight, Jamie Oliver's 'School Dinners' television programme highlighted the high fat, substandard food served out to many children in schools across the UK.

Whilst it has been overweight and obesity that have caught the headlines, underweight, remains an important cause of health problems in children, with an impact not only on growth, but with possible implications for cognitive development too^{2,20}.

To implement the proposed initiatives from the White Paper¹⁹ locally, such as those on children's nutrition, it is important to know what the local prevalence of overweight, obesity and underweight is, so that local variations in prevalence are taken into account.

In common with many other individual localities, there has been no study of the prevalence of overweight, obesity and underweight in Camden primary school children.

Anecdotally, I had been told by those school nurses working in primary schools in Camden, that they did not feel there had been a recent rise in overweight and obese children. In fact, in primary schools they were concerned that there were a lot of underweight, rather than overweight children.

This study will use routine data, collected at the school entry examination i.e. at age 5 years, in mainstream primary schools in Camden, to determine the local prevalence of overweight, obesity and underweight and find out and whether there have been any significant trends in prevalence over time over the last 10 years.

BACKGROUND

Definitions

Dictionary Definitions

Overweight and Obesity

'Overweight' is defined in the Oxford English Dictionary as 'above a normal, desirable or permitted weight'. The adjective obese, is derived from the latin *obesus* meaning excessively fat. The noun, obesity is defined in Dorland's medical dictionary as, '*an increase in body weight beyond the limitation of skeletal and physical requirement, as the result of an excessive accumulation of fat in the body.*'

Underweight

'Underweight', is defined in the Oxford English Dictionary as '*below a weight considered normal or desirable*'

Practical Definitions for Children

Overweight and Obesity

Translating these dictionary definitions into practical definitions, when measuring children has proven difficult. In adults the Body Mass Index (BMI), defined as [weight (kg)/height (m²)], is a well established method of determining rates of obesity and overweight using specified cut off values, where overweight corresponds to a BMI $\geq 25\text{kg/m}^2$ and obesity to a BMI of $\geq 30\text{kg/m}^2$.

These BMI cut offs for determining overweight and obesity cannot be applied directly to children. This is because BMI in children is generally much lower than in adults and because BMI is not static, but increases throughout childhood at a variable velocity, creating a non-linear growth curve with two peaks, one in early childhood and one in puberty.

Practical Definitions for Children (continued ...)

Different BMI cut off methods for determining overweight and obesity in children have been devised for UK children. One or both of these two main methods are usually used in the UK literature. One is the method recommended by the International Obesity Task Force and is therefore referred to as the 'IOTF cut off'. This method is based on international growth data on children from six countries (Brazil, Britain, Hong Kong, Netherlands, Singapore and USA). The adult BMI cut offs for overweight of $\geq 25\text{kg/m}^2$ and for obesity of $\geq 30\text{kg/m}^2$ were back-extrapolated into childhood. A smoothed curve of the all six countries' data was produced, so that the cut-off points generated could be applicable internationally²¹.

The other method also used in the UK, takes cut offs from the 1990s UK BMI dataset and uses BMI standard deviation scores (SDS BMI) of $\geq 85^{\text{th}}$ centile as overweight and $\geq 95^{\text{th}}$ centile as obese^{22,23}. This second method generally increases the prevalence rates found, because the thresholds for overweight and obesity are lower. Both these methods are used to determine overweight and obesity in the current study.

Underweight

Definitions for underweight children also cause some debate. The clinical guidelines on the UK BMI reference charts, have led some authors to use $< 2^{\text{nd}}$ centile as a cut off for underweight¹⁴. However, this method incorporates only the most severely underweight children. One recent study^{14,17} using the UK 1990 growth reference data, took the 5th centile to define very underweight and the 15th centile to define underweight, in order to have a definition comparable to the 85th and 95th centile for overweight and obesity. Both these methods are used to determine underweight in the current study.

Impact on health

Impact of overweight and obesity on adult health

Obesity in adulthood is linked to an increased risk of several life limiting diseases, including cardiovascular disease and type 2 diabetes. Obesity also has psychological consequences, including low self esteem. Persistence of childhood overweight and obesity into adulthood accounts for some of the current rising levels of adult obesity.^{4;5;7;24 25}

Impact of overweight and obesity on child health

However, there are also health risks of obesity during childhood²⁶. A systematic review of the literature⁶ in 2003 concluded that childhood obesity had significant effects on health in childhood, particularly psychological morbidity and on increasing cardiovascular risk factors such as hypertension. A subsequent study²⁷ has shown an association between childhood fatness and Type 1 diabetes presenting in childhood.

Impact of underweight on child health

Underweight is largely a consequence of malnutrition.²⁸ Research has shown that underweight in childhood has an impact not only on growth², but also on cognitive development²⁰, although a more recent systematic review found only small cognitive differences of 1-3 IQ points²⁹. Certainly underweight children tend to come from more deprived backgrounds and identifying them, can act as a trigger for positive multidisciplinary support to the whole family²³.

As has been illustrated above, childhood overweight, obesity and underweight all have a considerable impact on health. Determining which children fall into these categories is the next step. Parents have been shown to be unreliable at determining overweight in themselves and their children^{30;31}; accurate methods of measurement are needed.

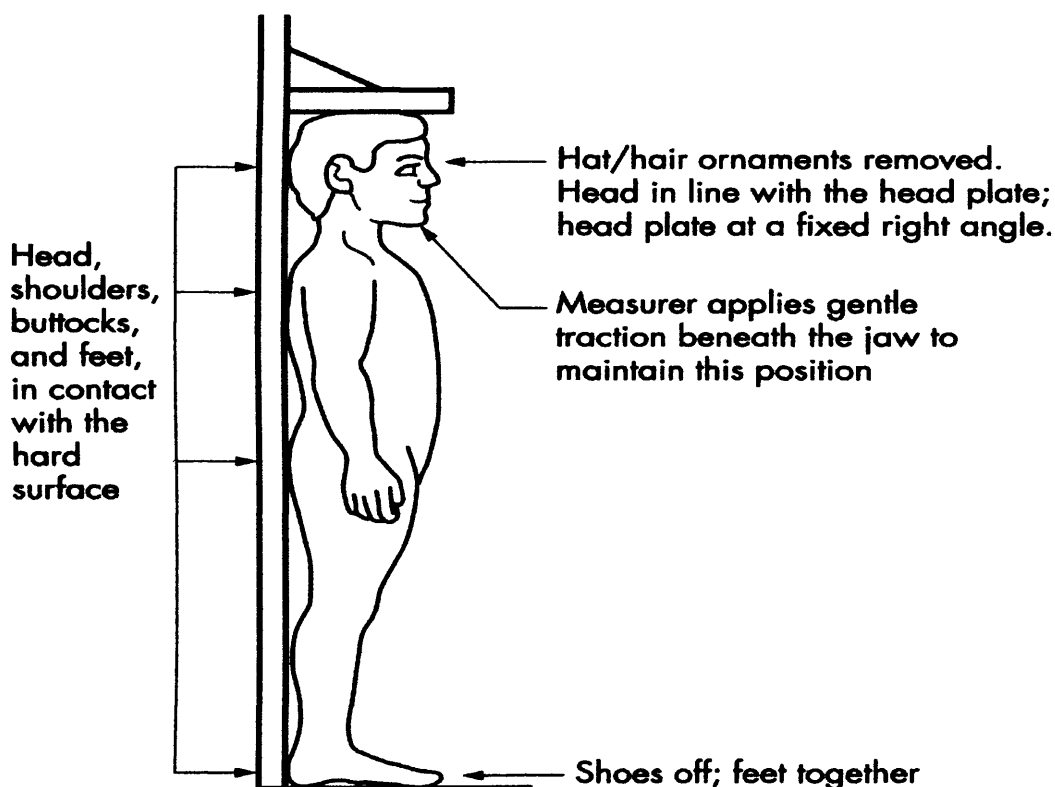
Methods available for determining overweight, obesity and underweight

It is important that the methods used for determining overweight, obesity and underweight produce repeatable results, minimising inter and intra observer variability, to maximise validity. There are a variety of anthropometric methods that may be used for this. These are detailed below, alongside their advantages and disadvantages.

Height

Height needs to be measured accurately, as detailed in the diagram below. Different standardised height 'measures' are available in the UK such as the 'Minimeter' (*Raven, Essex*) and Leicester height measure (*Invicta, Leicester*). Inter-observer variability can be minimised with standardised training³² and correct installation of the height measures.

Illustration of Correct Measuring Technique



From: Lipman, T H et al. Arch Dis Child 2004;89:342-346

Weight

Measurement of weight is the most reliably reproducible anthropometric method, particularly if done with digital scales.³³ Mechanical scales, such as beam balance introduce more inter observer variability. Scales need to be calibrated regularly to ensure accuracy of measurement.

BMI

From height and weight, BMI can be calculated [weight (kg)/height (m²)]. BMI is used as a proxy method of determining overweight, obesity and underweight in children, from the cut offs described above. The main advantages of using BMI, calculated from measurements of height and weight, are two-fold. Firstly, measuring height and weight accurately, requires relatively inexpensive equipment and basic training. Secondly, from the epidemiological point of view, height and weight measurements are standard measurements, done on children throughout life. This means that large scale data sets, of routinely collected height and weight measurements ('routine data'), are potentially available for analysis to determine prevalence and trends in BMI in children.

The sensitivity and specificity of using BMI to determine overweight and obesity has been examined^{34,35}. A study by Reilly et al³⁵ found BMI to be highly specific (ie. few false positives) but relatively insensitive (ie. some false negatives) using the 85th and 95th centile cut offs for SDS BMI. In another study, examining the adequacy of the body mass index for clinical practice and epidemiology, Reilly et al concluded, the SDS cut offs were more sensitive than the IOTF cut offs³⁶. The debate rages on about which cut offs should be used^{37,38,38-40} with a mixture used in the current literature and in this study.

Waist circumference

Waist circumference measurements can be used as an indicator of overweight and obesity. The waist measurement is taken at a fixed distance above the umbilicus. Centile charts for child waist circumference have been developed in the UK.⁴¹ There is a link between adult waist circumference measurements and cardiovascular morbidity; findings of large waist circumferences in children may have similar importance. In a cohort

study of secondary school children in Leeds, Rudolf et al¹⁸ found waist circumference measurements rose with increases in BMI.

Triceps Measurements

Triceps Measurements can be used to determine skin fold thickness and provide an indication of fatness. Few studies rely on triceps measurement alone, as it can be inconsistent with other measures of overweight and obesity,¹⁸ and has a high level of inter-observer variability.³³

Bioimpedance

Bioimpedance techniques use electrical equipment to determine the bioelectrical impedance of an individual's adipose tissue.³³ Mast et al⁴² compared BMI with bioelectrical impedance analysis (BIA) measurements in a study of over 2000 German school children. They concluded that BMI was more sensitive for determining obese children, but BIA was much more sensitive than BMI for determining overweight children.

Two and four component models

The gold standard methods for measuring percentage body fat include the more complex two and four component (2C and 4C) models. The 2C model divides body weight into fat mass and fat free mass. The 4C model divides body weight into four compartments; fat, water, mineral and protein⁴³. These are determined using a combination of DEXA scanning, underwater weight, bioelectrical impedance analysis and anthropometry, each of which may also be used individually to estimate body fat. These methods require highly specialised, expensive, non-portable equipment unsuitable for epidemiological studies.

BMI remains a valid measurement for overweight, obesity and underweight as an epidemiological tool, despite the limitations outlined above and in practice⁴⁴. For this study, height and weight measurements were the only anthropometric measurements available from the routine dataset. They were therefore used to calculate BMI, as a proxy indicator for obesity, overweight and underweight in Camden school children.

Literature Review

What is known about the current prevalence of overweight, obesity and underweight in UK Children?

The medical literature, like the media, nationally and internationally has been full of reports about the rising prevalence of obesity, in both adults and children^{11;45}. There have been several studies in the UK to support this conclusion, nationally, regionally and in cities. These are discussed below.

There are far fewer recent studies of underweight in children in the UK. In the current literature, most studies of underweight are from developing countries, where underweight and malnutrition are much more common or in particular sub-groups of children such as cancer patients⁴⁶. Two of the studies included in the following section^{14;17} determined at underweight (as well as overweight and obesity) in an unselected population and their findings are discussed.

National Studies

National Study of Health and Growth

Chinn and Rona reviewed height and weight data from the National Studies of Health and Growth (NSHG) from 1974, 1984 and 1994 and examined the trends in overweight and obesity, in the children measured⁴⁷. They converted the height/weight data to BMI and used the IOTF cut-offs²¹ to determine the prevalence of obesity and overweight amongst the study children. The main findings were that BMI had been stable between 1974 and 1984 but then started to show a rise among boys and girls, particularly in Scotland. Between 1984 and 1994 the number of overweight children increased nationally, with a mean prevalence of overweight of 9.0% in English boys, 13.5% in English girls, 10% in Scottish boys and 15.5% in Scottish girls. The prevalence of overweight was higher in older children and the increase in prevalence was higher in older children too. Obesity rose in all groups between 1984 and 1994, with a maximum

prevalence in Scottish girls of 3.2%.

The main strength of this study was that its sample size was very large, over 30,000, who were selected from a random sample of UK schools. However, these schools did include a weighting towards poorer areas, which may skew the findings, if as some studies have demonstrated,^{14,15} obesity is related to socio-economic status. This study does not include children from ethnic minorities as there were '*too few non-white children for useful analysis*', which may also limit the generalisability of its findings, to more ethnically diverse areas, as ethnicity can influence prevalence of obesity⁹. The measuring tools used for weight changed in 1994 from a mechanical balance to digital scales and therefore comparisons with weights from previous years may not be totally robust.

Health Survey for England

Stamatakis et al analysed data from the national survey that replaced the NSHG, the Health Survey for England (HSE)¹². The authors used only the English data from the previous NHSG studies, as Scotland is not included in the HSE. The HSE has been carried out annually since 1991 and included children from 1995. This study included HSE data on children age 5-10 years from 1996 to 2003. The heights and weights recorded were converted to BMI. The social economic status of the household the child came from was also determined, from 1997 onwards and analysed alongside BMI to see if there was any relationship. IOTF cut offs²¹ and the UK 1990 BMI reference data classification standards^{20,48} were used to calculate the prevalence of overweight and obesity.

Using the BMI cut offs, their study found that from 1994 to 2003, the prevalence of overweight in girls rose from 14.4% to 23.7% and in boys from 12.7% to 22.6% . Over the same time period the prevalence of obesity rose in girls from 2.7% to 6.6% and in boys from 2.4% to 6.0%. Using the IOTF cut offs, over the same time period, the prevalence of overweight in girls rose from 13.8% to 23.3% and in boys from 8.6% to

16.4%. The prevalence of obesity in girls rose from 1.6% to 4.6% and in boys from 2.9% to 6.8%. These increases were found to be statistically significant. The association between parental social class and obesity was of borderline significance.

Again the main strength of this study is the relatively large sample size (approx. 4000 children per year) which examined trends over a long time period. The study utilised the additional information on household income to try to draw out any associations between income and obesity. The HSE uses standardised equipment (digital weighing scales and Chasmors stadiometers) for all measurements across the country, which increases the robustness of any trends detected. Interestingly, children are weighed with more clothing in the HSE study than the NHSG studies; they are asked only to remove shoes, accessories and heavy clothing whereas in the NHSG study they were measured in underpants only; this could lead to some increase into recorded weight and reduce comparability with the earlier NHSG studies. The equipment used is also different from the NHSG, which may also account for some of the findings of increased prevalence between the NHSG studies and the HSE.

What is not clear from the data is how many of the HSE sample are from London, nor how many from the borough of Camden. So on a local level, we still require more information.

National Diet and Nutrition Survey

Jebb et al describe a cross-sectional analysis of data from the National Diet and Nutrition Survey. This included anthropometric data on 1836 young people aged 4-18 years. The sample was nationally representative, from a wide demographic. Trained investigators measured the participants' height and weight and collected demographic data (occupation of the head of household) and self-rated ethnicity data.

They used the IOTF cut-offs and found that in 4-6 year olds, the prevalence of overweight was 17.4% in girls and 13.5% in boys, the prevalence of obesity was 6% in girls and 4%

in boys. They found significantly higher levels of obesity in social classes IV and V. They also found higher levels of overweight and obesity in Scotland and Wales than in England. Children in social classes IV and V were three times as likely to be obese as other children. The strengths of this study were that it contained a large sample, from across the UK, including different ethnic groups and social classes. The characteristics of the non-responders (20%) and those with out sufficient data (291) , if they differ significantly from the responders, could have skewed the results.

Their findings of regional variations in the UK, with higher levels in Scotland and Wales borne out by other studies^{10,14}. This is one of the few studies in the UK to identify a high level of obesity in Asian children. This may be particularly significant in view of the risks for cardiovascular disease in Asian adults⁴⁹.

Scotland

Another national study has been done in Scotland retrospectively, using routine data, by Armstong et al¹⁴, looking at prevalence of obesity and underweight, which they refer to as 'undernutrition'. The investigators carried out a study of routine data and examined the health records of 74,500 children who had a routine 39-42 month health review in 1998/99. Height, weight, deprivation category and birth weight were extracted. They used Carstair's Deprivation which is based on postcode sector, recorded at the time of review. Relevant health data was accessible for 80% of Scottish pre-school children. The BMI for these children was calculated and compared their findings to the UK 1990 Reference data. Obesity was defined as > 95th centile and severe obesity > 98th centile and undernutrition defined as < 2nd centile. In Scotland, 3.2% of boys and 3.3.% of girls were found to be underweight and 9.0% of boys and 8.0% of girls were found to be obese. Severe obesity was present in 4.1% of girls and 4.4% of boys. Both undernutrition and severe obesity had a significantly higher prevalence in the more deprived children. This study indicated a worrying 'u' shaped association of both under and over nutrition with social deprivation. These findings on obesity corresponded with the previous NHSG study⁴⁷ that the prevalence of obesity in Children is higher in Scotland that the national average.

Regional Studies

ALSPAC

The Avon longitudinal study of pregnancy and childhood (ALSPAC) is a prospective population cohort study based in the Bristol-Avon area, of children born between 1991-1992. Reilly et al ¹⁶ describe a random sample from this population cohort which was selected for a study on obesity. 1031 children were included in this study at the start (age 24 months), 1013 remained at 49 months and 972 (94% of original study population) by 61 months. The cohort was measured at 24, 49 and 61 months of age with standardised equipment. The SDS BMIs of this cohort were calculated and this study used the 1990s UK reference data to define their cut-offs for overweight > 85th centile and obesity as > 95th centile, giving expected prevalence for overweight of 10% and for obesity of 5%, to determine the prevalence of overweight and obesity in this cohort.

This study found that over the time period measured (24 – 61 months), the prevalence of overweight in children increased from 15.8% to 18.7% and obesity increased from 6.0% to 7.2%. The prevalence of obesity significantly exceeded the expected frequencies at 49 and 61 months. They did not find a statistically significant difference between girls and boys.

This main strength of this study was that a cohort was followed over time, with standardised instruments used to measure all the participants. The numbers recruited were relatively small, but were a randomised selection of the whole cohort and providing the randomisation was reliable, should be representative of the cohort at a whole.

The characteristics of the non-responders i.e. those who dropped out of the study (59 children) were not described. Although only 6% of the original cohort, if they differed significantly in BMI and other relevant characteristics, from the responders, their omission may have led to some sample bias. The main analysis of this study concentrated on these results relative to the expected frequent from 1990 BMI dataset; 15% for

overweight and 5% obese⁵⁰. Compared to these figures, the ALSPAC prevalence of obesity was higher, 7.1%, significant by Chi squared, ($p=0.001$), though no confidence intervals were given. The study did not use the IOTF cut-offs²¹ which would have reduced the prevalence rates found.

This ALSPAC study was one of the earliest recent studies describing a rise in obesity UK children. It studied children prospectively and used standardised techniques. The follow-up rate of 94% is fairly complete. Therefore although smaller than the national studies, its findings were significant and were followed by publication of other studies.

The Wirral

In the Wirral, Bundred et al⁵¹ BMJ 2001: 322;326]analysed routine data collected from 1989 to 1997, from the 6 week assessment and pre-school check, this data was analysed retrospectively to look for trend in weight and BMI. Data for weight at the 6 week check and height and weight at pre-school checks was available for 32655 children; 88% of all live births over that period. 25% of the measurements were removed because of missing or inaccurate data. The weights at 6 weeks were compared to the reference centiles for weight. With the 85th centile defined as overweight and the 95th centile defined as obese. The BMI for pre-school children was calculated using data from the 1990 dataset and standard deviation scores were calculated. The 85th centile (1.04 SD) was used as the cut off for overweight and the 95th centile (1.64 SD) was used as the cut-off for obese.

There was very little increase in weight at the 6 week check. However, the SD score for pre-school children did change significantly over the 10 year study period. The percentage of overweight children rose from 14.7% in 1989 to 23.6% and the proportion of obese children rose from 5.4 to 9.2%.

The strengths of this study lie in the large numbers of children measured and the coverage; 88% is very good. However, the large number of measurements that had to be discounted (25%) is concerning, particularly as no information is given about these ‘non-

responders' and whether they differ from the non-responders. These findings indicate that it is between 6 weeks and the pre-school check (Age 2yrs 11mths – 4yrs) that weight gain has increased over and above expected gains. The main weakness of this study is that it relies on routine data and therefore the accuracy of the measurements may be questioned. It is not clear from the study whether the same types of instruments (weighing scales and height measures) were used throughout, or how regularly training updates for staff measuring children were provided.

South Wales

In South Wales, another study by Jones et al ¹⁰ was carried out using school entry routine data from the local child health database. This study looked at routine data from the school entry medical, at age 5 years. The height and weight data was converted to BMI and outliers were scrutinised and obvious recording errors (e.g. decimal point in incorrect place) corrected. The IOTF cut-offs for overweight and obesity were used. Time trends were analysed using year as the covariate and logistic regression to analyse the proportion of children in different weight categories. In this study Jones et al reported a rising prevalence in overweight and obesity in the South Wales primary school population between 1986 and 2002. The prevalence of overweight in girls rose from 13.5% to 19.5% and the prevalence of obesity in girls rose from 3.6% to 6.9%. The prevalence of both categories in boys were lower, the prevalence of overweight boys rose from 11.3% to 13.7% and the prevalence of obese boys rose from 2.5% to 4.6%.

The strength of the study is that it included large numbers of children, with good coverage; it states that it included data on between 86.6% and 98.5% of eligible children. There were no demographic data included in the study, which makes it difficult to determine the characteristics of the 'non-responders'. It may be that the children excluded from the study were overweight, normal weight or underweight, any of which would have changed the prevalence rates for obesity and overweight.

The coverage is stated to be very good 86.8% - 98.5%. However, the denominator used is

the number of children on the computerised database. Apart from one year (1994/5) when few children were entered on the system because of transition from one system to another, there is no indication that this figure may be incomplete. However, even excluding this year, the denominator varies between 1131 (1991/2) and 1958 (2001/2) in girls and 1197 (1992/3) to 2062 (2001/2) in boys, an almost 100% rise in the school entry population for that area. This variability is unaccounted for and seems unlikely to be genuine, indicating underreporting for some children, particularly in the early years of the system. This may have created sample bias, if the non-responders differed from the responders in characteristics relevant to overweight and obesity. This in turn may have affected the prevalence rates for obesity and overweight.

The geographical area of the study is defined as one of 'high social deprivation', however it is unclear whether this is an ethnically homogenous population, which may limit the generalisability of its findings, if ethnicity is related to overweight and obesity. In this study they looked closely at children with two or more measurements (duplicate entries) and used the term 'shrinking children' to determine children whose height measurement decreased over time, as an indicator of the reliability of measurements. The number of these children with duplicate entries is not stated, but 20% of them had 'shrunk', which calls into question the reliability of the other measurements used. It is unclear whether either or both measurements for these shrinking children were excluded from the study. Other criticisms of this study include the variation in tools used to measure children, which changed in 1990, possibly reducing robustness of comparisons with measurements from later years.

Overall the findings appear to be valid, indicating an increasing prevalence of both obesity and overweight, particularly in girls, in South Wales, in line with national data.

Cities

Plymouth

In Plymouth a cross-sectional growth study was carried out from 1994-1996 to measure all primary school age children. These investigators¹⁵ then calculated the BMI for all these children and correlated the BMI with the Townsend score (a deprivation score which can be calculated from census data using the home address). The BMI measurements were compared to the 1990 British reference population using BMI z scores and centiles⁵⁰ 5 % of children overall were obese. The prevalence of obesity increased with increasing age, in boys from 3.9% in the youngest age group (5.1-7.1 years) to 5.7 % (in the 9.0 – 11.7 yr age group). In girls obesity rose from 3.3% in the youngest group to 5.0% (in the 9.0 – 11.7 yr age group). (p<0.001)The prevalence of obesity also increased with increasing Townsend scores, ie. increasing deprivation. For boys from 4.3% in the least deprived group to 5.6% in the most deprived group and in girls from 4.2% in the least deprived group to 5.7 % in the most deprived group.

This study is useful for several reasons. They measured children prospectively, with well trained staff, standardised techniques and equipment. The population in Portsmouth is described as ethnically quite homogenous, '*with an almost entirely white population 98.8%*', which reduces ethnicity as a potential confounder, though may limit generalisability to more ethnically diverse communities. The dataset was very large, with more than 20,000 records, giving added strength to the findings. Plymouth has large variation in deprivation and therefore the opportunity to ascertain trends in obesity with socio-economic status were perhaps greater than in some areas. Information on the underweight children was not included. It would have been interesting to see if the BMIs of the underweight children, tallied with the 'u' shaped association demonstrated in the Scottish study¹⁴; that an association with deprivation is seen for underweight children as well as for those with obesity.

Leeds

A further study comes from Rudolf et al in Leeds¹⁸. The study excluded schools from inner city Leeds, leading to a slight tendency towards more affluent areas. This study involved follow-up of a cohort of children in Leeds who had 6 years previously been recruited into a trial of APPLES, a primary school health promotion programme designed to improve children's diets and lifestyle. They followed those children into secondary school, measured their heights and weights to determine their current BMI and also measured their waist circumference and triceps measurements to gain more information about obesity.

The original study had had 694 participants. Only 608 could be tracked by school leaving lists (87.6%) and those where 5 pupils or less were attending a school were also excluded (108/694=15.6%) This left 500 pupils of whom , 348 consented to be followed-up. The follow up was complete for 315 children ie. $315/694 = 45.4\%$.

The results showed that there had been a substantial increase in mean SD BMI and waist circumference score over the time period studied 1996-2001. Waist circumference size is important because of implications for future cardiovascular disease.

The triceps measures did not change significantly. Using the IOTF criteria of for overweight and obese, the percentage of obese and overweight boys and girls increased over time, with 10% of boys being obese in 1996 and 14% in 2001. The number of boys who were obese was 0% in 1996 and 3% in 2001, 3% of girls were obese in 1996 and 4% in 2001. The trends in obesity over time were not significant.

The main strengths of this study were that it was a cohort study and used standardised equipment to measure all the children, lending robustness to their data. In terms of analysing trends over time, the main weakness of their study is loss to follow up. Of the original 698 children they only achieved complete information for 315, $315/694=45.4\%$. However the investigators have attempted to compensate for this by comparing the

original growth characteristics of the non-responders with the responders and found no significant difference, indicating that the responders are representative of the group as a whole.

A possible confounder in this study is that some of the participants (the cases) had been enrolled in a diet and lifestyle programme, APPLES, whilst the others had been enrolled as controls. It is possible that participation in this programme had impacted on some or all of the participants, modified their diet and lifestyle over time and limited disproportionate weight gain. If so this would have led to a lower weight gain, leading this study to underestimate the increase in overweight and obesity in a similar, non-APPLES community.

London

London Borough of Hackney

Taylor et al carried out a school-based survey of 11-14 year olds in the borough of Hackney, in East London, measuring the height and weight of 2482 young people. They used both the IOTF and UK 1990 cut offs to determine rates of overweight and obesity. They also looked at underweight, using the 5th and 15th centile of the UK 1990 dataset as their cut-off. 73% of the participants were from non-white ethnic groups. Their study found high levels of overweight across all ethnic groups. More than 1/3 of the study group was overweight and 1/5 obese using the UK 1990 cut offs. More than ¼ were overweight and 1/10 obese using the IOTF cut offs.

Indian males were much more likely to be overweight than their white peers. Underweight was more common in Bangladeshi, Indian and Pakistanis children. They did not find a correlation between over or underweight and socio-economic status. The strengths of this study were that they collected their rigorous methodology, the high response rate, the representativeness of the sample and the inclusion of clear socio-economic indices and ethnic data. The difficulty presented in measuring growth and BMI in this multiethnic population, is that the growth references used do not adequately

reflect the variation in growth in different ethnic groups, but such references do not yet exist.

London Borough of Islington

Islington, the neighbouring borough to Camden, have collected routine data from the school entry medical, age 4-7, that showed 14% girls and 10% boys were overweight or obese at school entry, in 2003/4 ⁵². The study data were thought to be fairly complete, including 1257 children.

London Borough of Camden

Camden is an ethnically diverse inner London borough. Black and other non-white ethnic minority groups constitute 27% of Camden's population. Under 25 years, 41% of the population is from a black or ethnic minority group. The largest ethnic minority groups are Bangladeshi and Black African, this is reflected in the primary school population ⁵³. In the school year 2004/2005 out of 11,489 children in Camden primary schools, the ethnic breakdown included White British comprised 26.3%, Bangladeshi 17.5% and African 14.4% ⁵⁴.

In 2004, Camden was the 18th most deprived borough in England⁵⁵, although there were wide disparities within the Borough. 22% of Camden households receive housing benefit with either income support or job-seekers allowance, compared with 19% for inner London and 11% for England⁵³. This is reflected in schools by the number of children having free school meals. Entitlement is dependent on low parental income^{*56}, in the school year 2004/5 37.2% of children in Camden schools were on free school meals.

* *'Children whose parents receive Income Support; Income-based Job Seekers Allowance; support under Part VI of the Immigration and Asylum Act 1999; or Child Tax Credit, but who are not entitled to Working Tax Credit and whose annual income (as assessed by the Inland Revenue does not exceed £13,910 are entitled to free school meals.'*

Knowledge of the local population and local prevalence of overweight, obesity and underweight, is important when it comes to implementing related policies^{4,7}. Indeed, an Department of Health expert advisory group, is currently meeting to discuss how to implement the recommendation of the House of Commons Select Committee Report⁴, on monitoring changing prevalence in obesity in each PCT⁴⁴. Local policy makers will particularly need to be aware of underweight children; where policies to reduce BMI alone would be counter productive¹⁴.

This present study aims to determine prevalence of overweight, obesity and underweight in the London Borough of Camden, using routine data gathered at the school entry medical, i.e. age 4-7 years. It will also examine what trends there have been in BMI in these children, over the last 10 years.

METHODS

Study Population

The group used in this study were children with DOB 1.9.89 to 31.08.99 to cover 5 year olds in mainstream Camden primary schools from 01.09.94 – 31.08.04. We used routinely collected data from the 5 year school entry assessment ('5 year exam') across all Camden mainstream state primary schools. The denominator, i.e. number of children in school entry year, in mainstream state primary school, for each school year from September 1994 to August 2004, was obtained from Camden Education Department.

The database, (Regional Interactive Child Health Systems) RICHS, based in the Child Health Department at the Royal Free Hospital, held information on every child either born in Camden, or who had had contact with the child immunisation, surveillance or school health programme. This included who had moved out of the area before the 5 year exam, moved into the area after the 5 year exam or who did not attend a mainstream state primary school. The total number on the RICHS database who fitted the DOB criteria above were 24019, the number of children in the school entry year group for mainstream primary school over the 10 year period studied was 15171, hence the need to take the denominator from the Education department and not from the RICHS database itself.

Measurements

In Camden all primary school children are supposed to be measured in the year of school entry ie the year that they turn 5 years old. The height and weight measurements are done by school nurses and trained auxiliary nurses using a variety of measuring equipment, mainly 'Minimeters' for height, though some wooden height measures are still used in some schools and either balance beam or Seca mechanical (ie non-digital) floor scales for weight. The weighing scales are calibrated annually. The staff weighing and measuring children have training when first using the equipment. The height and weight measurements, along with other information such as ethnicity and DOB, are recorded manually on a separate datasheet for each child, which is returned to Child Health and then entered onto the RICHS system by administrative staff.

Child Health Databases

History of child health databases

Databases in the UK were first developed in the 1960s for childhood immunisation and surveillance programmes. The national system was developed from the Welsh Health Services Consortium in the 1970s and 1980s. Several local systems were developed, the RICHS system for North East Thames was the one used for Camden data. In addition to routine child health promotion functions, the RICHS database had modules for special needs, community activity eg school health and a dentistry. These computerised systems, including RICHS have underpinned the excellent UK COVER programme (Cover of Vaccination Evaluated Rapidly) for immunisation, run by the Health Protection Agency⁵⁷ and have provided information to identify disabilities and support vaccine safety studies.

Recent national developments in information technology including ‘NHS Connecting For Health’ which incorporates the NHS Programme for IT (NpfiT), a national programme for information technology, and newer computing technology have led to many of the current local systems being superseded, and therefore closed, including RICHS.

An interim solution; CHIA (Child Health Interim Applications), commenced in the summer of 2005 and it is hoped that it will provide equivalent functionality until the national programme delivers.

RICHS - information and limitations

The data available from RICHS was reasonably complete for the years 1989 – 2005. Therefore the children in this study had a DOB range between 1.9.89 to 31.08.99, ie to be age 5 at school entry between 1.9.94 and 31.08.04.

Unfortunately the changeover from RICHS to CHIA coincided with this study and RICHS was closed before CHIA was able to access previous data reliably, (still not

perfected at the time of writing) leading to limitations for this study. For example we were unable to access data on primary school attended or gestational age and therefore unable to link the 5 year examination data to the primary school attended, or birth weight to gestational age.

Data Collected

Data for all children in the study group was downloaded from RICHS onto a spreadsheet in Access along with other variables. The remainder of the variables in the dataset were:

- *Unique anonymised identifier for the child*
- *Date of 5 year examination (DOE),*
- *Age of child at 5 year examination (calculated in Access by subtracting DOB from DOE),*
- *Height at 5 year examination*
- *Weight at 5 year examination*
- *Residential postcode*
- *School code – only most recent school attended available, not necessarily school at 5 year exam*
- *Birthweight*
- *Weight and height/length at other health assessments (6-8wk check, pre-school checks, 7 and 11 year checks – all except birthweight were insufficiently frequently recorded for further analysis.)*

Data Cleaning, Manipulation and Creation of a Working File

The data was then transferred into SPSS via Excel for data cleaning. (SPSS for Windows version 12).

Special Schools

Data on children attending the 3 main special schools in Camden were excluded from our analysis as they are not included in our denominator; number of children in mainstream primary school for each reception year group. There are few small behavioural units, also deemed 'special schools' in Camden, but these tend to take older children who have been excluded from mainstream school. Less than 20 children fell into this category and were left in the working file, as there was a very high likelihood they were in mainstream school at the time of the 5 year exam and therefore included in the denominator.

Duplicates

There were 602 cases with duplicate, triplicate or quadruple entries. These occur when a child is weighed and measured more than once, for example when being recalled for a repeat hearing test. For those children with more than one height and weight entry, the measurement closest to age 5 was kept in and other measurements deleted. For those children without a height and weight entry, the first entry was kept in, for simplicity, as all cases without a height and weight entry would later be deleted.

Record of 5 year exam and age at exam

Only those entries with a record of a 5 year exam were kept in for further analysis. The other cases, ie. those in the appropriate date of birth range but without a record of a 5 year exam were deleted. It became apparent that most, but not all children were measured in the school year that they turned 5, ie between age 4 and 6. A sizeable minority were measured between 6 and 7 years. Therefore all children aged less than 4 years or more than or equal to 7 years at the time of the '5 year exam' were excluded. So only children with a measurement done between 4 and 7 years of age remained in the dataset.

Height and weight information available?

The dataset was filtered further by deleting those cases without any height and weight information, ie without data available to calculate BMI. Height was converted from centimetres to metres and the BMI was then calculated [BMI=weight (kg)/height² (m²)] in SPSS for each case.

Outliers and Corrections

The dataset was analysed for outliers, by examining the extreme ends of the distributions for height, weight and BMI. Two clear types of data entry errors were noted and corrected. The first was where a negative value for weight had been entered (impossible) instead of a positive value and this was corrected for all 60 cases where this error had occurred. The second error type was a transposition error, where height had been entered in the weight category and weight had been entered in the height category. These were apparent at extreme end of the weight distribution, as weight was entered as 100 (the average height in cm for a 5 year old) and height was entered as 20 (the average weight for a 5 year old) and these transposition errors were corrected for the 3 cases where this error had occurred.

Valid BMI

The dataset was then filtered so that all remaining cases had a plausible BMI. We used the BMI range 10 to 33. This is not dissimilar from the range used in other studies, Jones et al who also examined routine data from school entry, used a range of 10 to 27¹⁰. Examining the extremes of BMI, there was one case with a BMI of 33, which was confirmed as genuine, from previous surveillance data which was available for that case (at the 6 week and 3 year checks and a second '5 year exam'). Beyond that, there were no plausible higher BMI measurements, therefore 33 was used as the upper cut off.

Thus a 'clean' dataset was produced for further descriptive analysis.

Descriptive Analysis

Splitting the dataset by sex and year group

The dataset was split into male and female, as BMI is related to sex and divided into 10 'year groups' by DOB as follows to allow determination of any trends over time.

A table to show how year group corresponds to DOB range and school year

Year Group	DOB Range	School Year ¹	Year Group	DOB Range	School Year
1	01.09.89 – 31.08.90	1994/5	6	01.09.94 – 31.08.95	1999/2000
2	01.09.90 – 31.08.91	1995/6	7	01.09.95 – 31.08.96	2000/01
3	01.09.91 – 31.08.92	1996/7	8	01.09.96 – 31.08.97	2001/02
4	01.09.92 – 31.08.93	1997/8	9	01.09.97 – 31.08.98	2002/03
5	01.09.93 – 31.08.94	1998/9	10	01.09.98 – 31.08.99	2003/04

SDS BMI and IOTF Grading

In order to determine whether a given BMI was within the normal range, the dataset was then transferred back into Excel for further analysis. The ImmsGrowth program, version 2.08 [developed by Tim Cole and Huiqi Pan, ICH] was used to

- (i) Calculate the BMI Standard Deviation score (SDS BMI)⁴⁸, appropriate for age and sex, using UK 1990 data as a reference
- (ii) Calculate the Overweight and Obesity status based on the IOTF data²¹.

The dataset was then reimported into SPSS.

¹ Where 'School Year' is defined as the year of school entry, ie. the year the child turned 5. This does not always correspond exactly to the year of '5 year exam', as some were 6-7 years old at their 5 year exam

Assignment of overweight and obesity status

Overweight/obesity status was then assigned based on the SDS BMI score (ie using the UK 1990 data as a reference) where $SDS > 1.04$ corresponds to overweight and $SDS > 1.64$ corresponds to obese¹⁶.

Overweight and obesity status was also assigned using the IOTF criteria, calculated from the ImmsGrowth programme, which has BMI cut off points as illustrated in the table.

International cut off points for body mass index for overweight and obesity by sex between 2 and 18 years, defined to pass through body mass index of 25 and 30kg/m² at age 18 as recommended by the IOTF. [From: Cole TJ et al ²¹]

Age (years)	BMI corresponding to 25kg/m ² - overweight		BMI corresponding to 30kg/m ² - obese	
	Males	Females	Males	Females
4	17.6	17.3	19.3	19.1
4.5	17.5	17.2	19.3	19.1
5	17.4	17.1	19.3	19.2
5.5	17.5	17.2	19.5	19.3
6	17.6	17.3	19.8	19.7
6.5	17.7	17.5	20.2	20.1
7	17.9	17.8	20.6	20.5

The frequencies in each IOTF category, designated as: 0 = not overweight or obese, 1 = overweight and 2 = obese, were determined in SPSS and illustrated in tables.

Assignment of underweight, very underweight and severely underweight status

Underweight/severely underweight status was assigned in two ways. First, severely underweight was defined using 2nd centile (SD scores <-2.06); as this is the cut off clinical guideline on the UK BMI reference chart [Harlow Printing South Shields, England; Child Growth Foundation London, England] as used by Armstrong J and ReillyJJ¹⁴.

However in order to provide a comparison with the SDS BMI cut off points for overweight and obesity (85th and 95th centile), we also used a second method, described by Taylor et al¹⁷ using the 15th Centile for underweight and the 5th Centile, for very underweight, from the UK 1990 data. Underweight/very underweight status was then determined based on the SDS BMI where SDS < -1.04 corresponds to underweight and SDS < -1.64 corresponds to very underweight. The frequencies for both methods were illustrated in tables.

Further descriptive analysis

The mean age, height, weight, BMI and SDS BMI at examination was determined for each year group. The BMI results in this dataset, in common with other datasets for BMI are not normally distributed, so paired t-tests etc cannot be used to look for trends. Using SDS BMI allowed further analysis for trends by variance and logistic regression.

Further BMI descriptives were also obtained; mean, mode, median, maximum and minimum. Boxplot diagrams were generated to demonstrate variation in BMI. Mean birthweight, with median and mode was also determined for each year group.

Birthweight

The data on birthweight were not suitable for further analysis, as lack of gestational age meant it was impossible to separate the children with genuinely low birth weight, from those that were simply premature but of appropriate weight for their gestation.

Data Protection and Research and Development (R&D) Approval

Data Protection and Patient Confidentiality

Before undertaking research, careful consideration needs to be given as to whether the proposed use of the data, will comply with legal and ethical requirements. This has been emphasised even more following the Caldicott Report in 1997⁵⁸, which identified weaknesses in the ways in which the NHS handled confidential patient data, and the Data Protection Act in 1998, which set out the law for all processing of data from which individuals can be identified, including special provisions relating to the processing of medical data.

Anonymised data was used for this study to ensure compliance with all these requirements, which are detailed further in the discussion section.

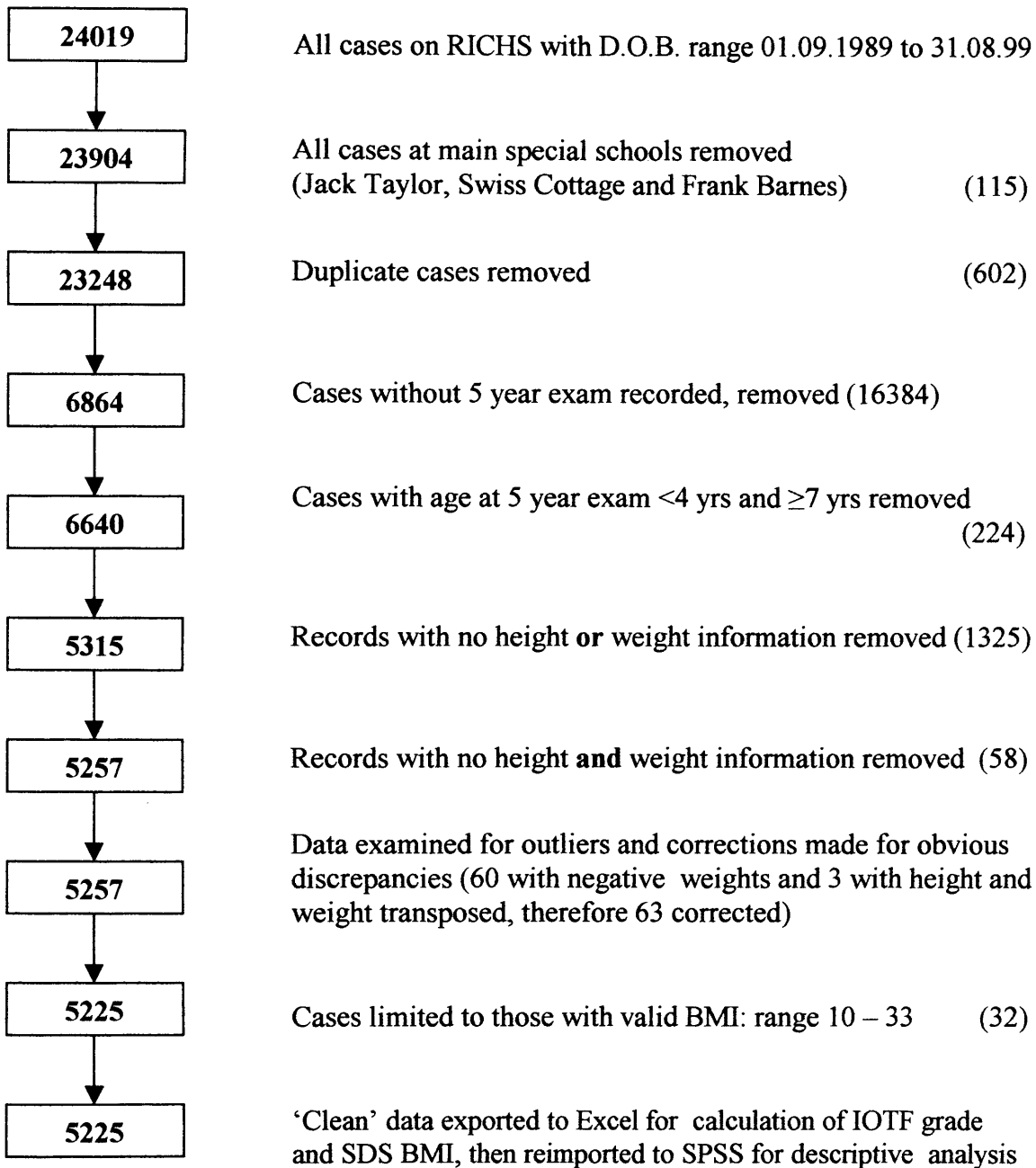
Research and Development (R&D) Approval

As this study used only anonymised data from a computerised database, only R&D approval was required, which was granted by the Royal Free Hospital R& D department.

RESULTS

Figure 1

Flowchart of Data Cleaning



Tables of Descriptives

Table 1a: GIRLS with height and weight records by school year and those within specified ranges of BMI

Year Group	1	2	3	4	5	6	7	8	9	10
Year of School Entry ¹	1994/95	1995/6	1996/7	1997/8	1998/9	1999/00	2000/01	2001/02	2002/03	2003/04
No. on school roll for Y.S.E. ²	751	705	722	739	738	725	760	738	757	712
No. and (%) with valid data ³	300 (39.9)	339 (48.0)	376 (52.0)	314 (42.0)	247 (33.5)	282 (38.9)	247 (32.5)	158 (21.4)	150 (19.8)	176 (24.7)
Mean age	5.53	5.48	5.44	5.41	5.40	5.75	5.64	5.72	5.58	5.35
Mean height (m)	1.12	1.11	1.11	1.11	1.11	1.13	1.13	1.14	1.13	1.12
Mean weight (kg)	20.0	20.32	19.94	20.41	20.38	21.07	20.65	21.11	20.84	20.61
Mean BMI (kg/m ²)	15.95	16.30	16.03	16.39	16.5	16.25	16.12	16.12	16.28	16.37
Mean SDS BMI	0.17	0.35	0.22	0.43	0.46	0.30	0.22	0.21	0.31	0.42

¹ Year of School Entry, ie. the year the child turned 5. This does not always correspond exactly to the year of '5 year exam', as some children were 6-7 years old at their 5 year exam.

² Number of children on school roll for year of school entry (Y.S.E.) provided by the London Borough of Camden Education Department

³ Valid data for sex, height and weight

Table 1b: BOYS with height and weight records by school year and those within specified ranges of BMI

Year Group	1	2	3	4	5	6	7	8	9	10
Year of School Entry ¹	1994/95	1995/6	1996/7	1997/8	1998/9	1999/00	2000/01	2001/02	2002/03	2003/04
No on school roll for Y.S.E. ²	774	797	787	783	793	790	755	799	758	788
No. and (%) with valid data ³	276 (35.7)	372 (46.6)	370 (47.0)	315 (40.2)	263 (33.2)	282 (35.7)	220 (39.1)	168 (21.0)	167 (22.0)	203 (25.8)
Mean age	5.53	5.50	5.40	5.39	5.43	5.70	5.64	5.62	5.63	5.28
Mean height (m)	1.13	1.12	1.12	1.12	1.12	1.14	1.14	1.14	1.15	1.12
Mean weight (kg)	20.48	20.61	20.71	20.50	20.79	21.43	21.20	21.34	21.30	20.63
Mean BMI (kg/m ²)	16.09	16.28	16.31	16.19	16.45	16.36	16.26	16.34	16.16	16.36
Mean SDS BMI	0.24	0.38	0.42	0.34	0.50	0.39	0.32	0.36	0.26	0.37

¹ Year of School Entry, ie. the year the child turned 5. This does not always correspond exactly to the year of '5 year exam', as some children were 6-7 years old at their 5 year exam.

² Number of children on school roll for year of school entry (Y.S.E.) provided by the London Borough of Camden Education Department

³ Valid data for sex, height and weight

Tables 1a & 1b above, show the percentage of valid data available for each year group, using for the denominator in each year group from the figures provided by Education. The highest coverage for girls and boys, was for year group 3, YSE 1996/7, 52% and 47% respectively. The lowest coverage was for year group 9, YSE 2003/3 in girls at 19.8% and in year group 8, 2001/2 in boys, at 21%. The mean age, height and weight, mean BMI and SDS BMI are also shown for each year group.

There was considerable variation in BMI within the dataset. This was analysed further by determining the mean, median, mode, standard deviation and maximum and minimum for each year group. This variation is illustrated by these results in Tables 2a & 2b below.

BMI Descriptives

Table 2a **Girls**

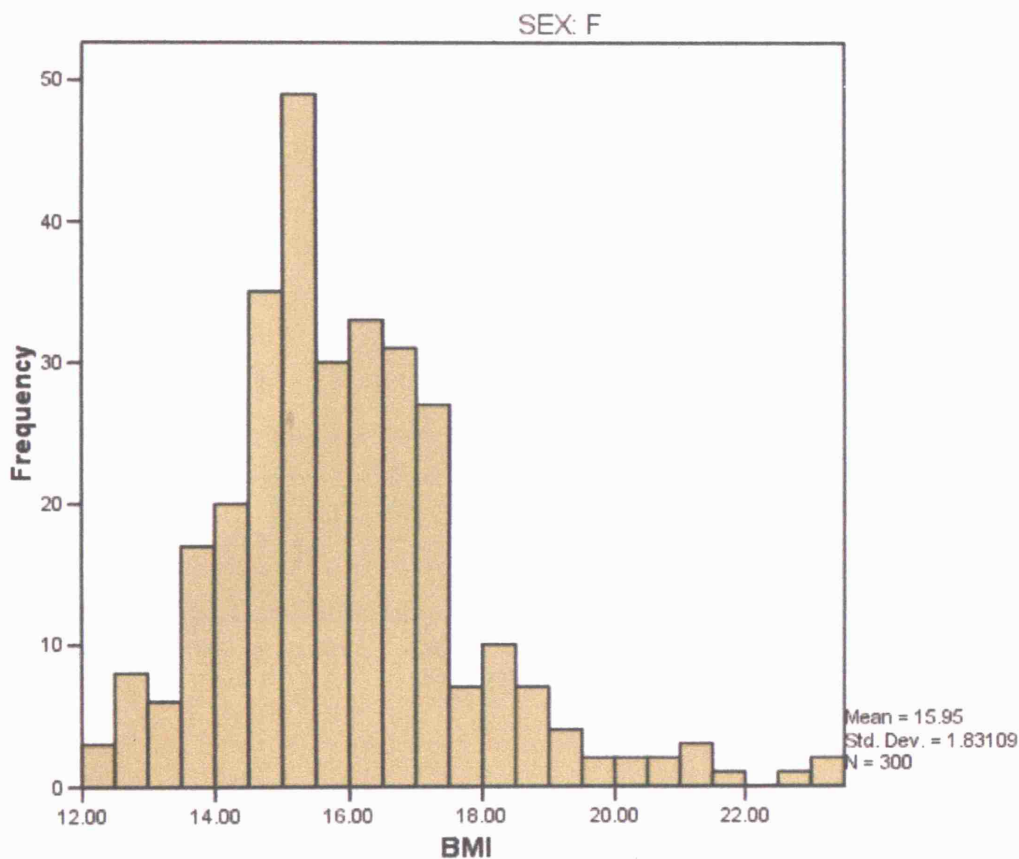
Year Group & Date of Birth		Mean	Median	Mode	Standard Deviation	Valid <i>n</i>	Maximum	Minimum
1	01.09.89 – 31.08.90	15.95	16.16	15.73	1.83	300	23.24	12.25
2	01.09.90 – 31.08.91	16.30	15.13	15.98	2.10	339	26.16	11.14
3	01.09.91 – 31.08.92	16.03	16.60	15.86	1.88	376	23.96	11.30
4	01.09.92 – 31.08.93	16.39	14.24	16.07	1.98	314	27.40	11.82
5	01.09.93 – 31.08.94	16.50	16.45	16.12	2.34	247	28.24	11.83
6	01.09.94 – 31.08.95	16.25	16.31	15.97	2.16	282	30.32	12.23
7	01.09.95 – 31.08.96	16.12	14.88	15.88	2.15	247	26.08	11.32
8	01.09.96 – 31.08.97	16.12	13.92	15.66	2.16	158	24.29	11.40
9	01.09.97 – 31.08.98	16.28	14.35	15.92	2.33	150	27.77	11.40
10	01.09.98 – 31.08.99	16.37	16.23	16.18	1.95	176	26.51	12.09

Table 2b **Boys**

Year Group & Date of Birth		Mean	Median	Mode	Standard Deviation	Valid <i>n</i>	Maximum	Minimum
1	01.09.89 – 31.08.90	16.09	15.87	15.39	1.95	276	24.31	11.47
2	01.09.90 – 31.08.91	16.28	15.99	15.94	2.01	372	26.22	11.69
3	01.09.91 – 31.08.92	16.31	16.06	16.23	1.85	370	28.27	10.20
4	01.09.92 – 31.08.93	16.19	15.91	15.29	1.79	315	23.97	11.06
5	01.09.93 – 31.08.94	16.45	16.07	16.23	2.06	263	28.93	13.08
6	01.09.94 – 31.08.95	16.36	16.01	16.23	2.22	282	26.35	11.96
7	01.09.95 – 31.08.96	16.26	15.94	16.16	2.14	220	25.74	10.68
8	01.09.96 – 31.08.97	16.34	15.79	14.25	2.37	168	28.73	12.51
9	01.09.97 – 31.08.98	16.16	15.93	14.12	2.06	167	25.27	12.40
10	01.09.98 – 31.08.99	16.36	15.99	14.85	2.34	203	32.96	12.02

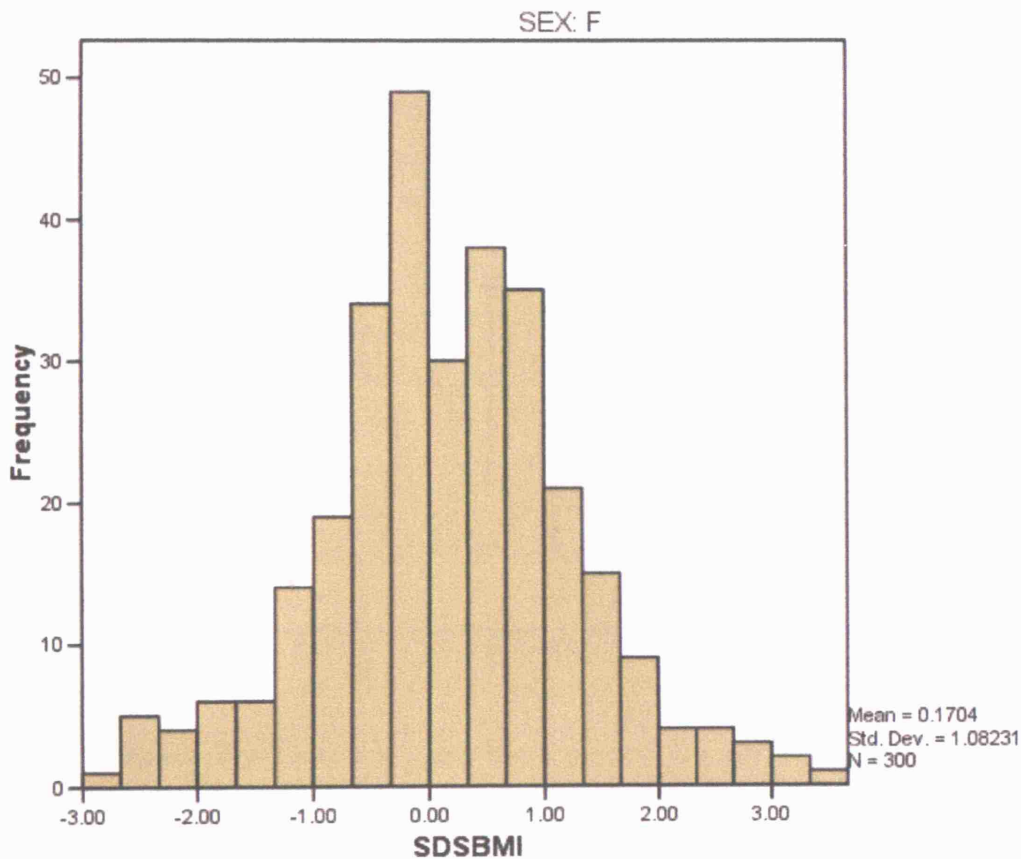
The BMI for the dataset was not normally distributed. There was a skewed distribution. An example to demonstrate this is shown in Figure 2 below, with a longer tail for high BMI results than would be found if BMI was normally distributed.

Figure 2 A Histogram to show spread of BMI results in females, from Year Group 1 (DOB 01.09.89-31.08.90)



In order to analyse the BMI results further, they were converted to standard deviation scores (SDS BMI), creating a more normal distribution, on which further analysis could be performed, for each year group. This transformed data is shown in Figure 3 below.

Figure 3 A Histogram to show spread of SDS BMI results in females, from Year Group 1 (DOB 01.09.89-31.08.90)



To determine trends over time, the SDS BMI scores for boys and girls from each year group were plotted, as shown in the error bar graphs below, Figure 4 and 5. As can be seen, there was considerable variation in the spread of the SDS BMI, particularly amongst girls, where the trend is up and down and then up and down again.

Analysis of variance between the year groups for girls showed no evidence for a linear trend and for boys showed no significant trend. A quadratic test was then applied to the girls' SDS BMI and no significant trend was found. A cubic test was then applied and evidence for a cubic pattern in BMI in girls was found to be significant, $p=0.012$.

Figure 4 Error Bar Graph to show the Year to Year variation in SDS BMI distribution in Girls, with Year Group (x Axis) plotted against SDS BMI (y axis)

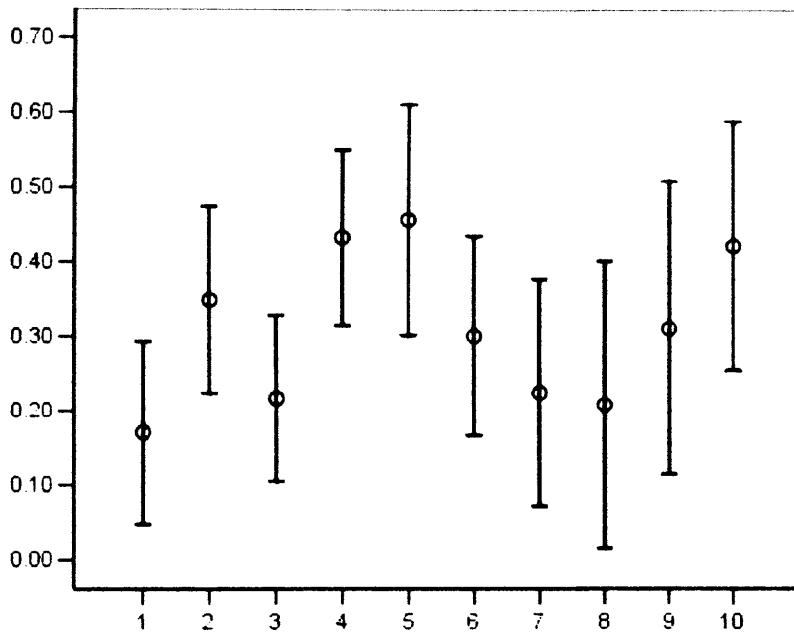
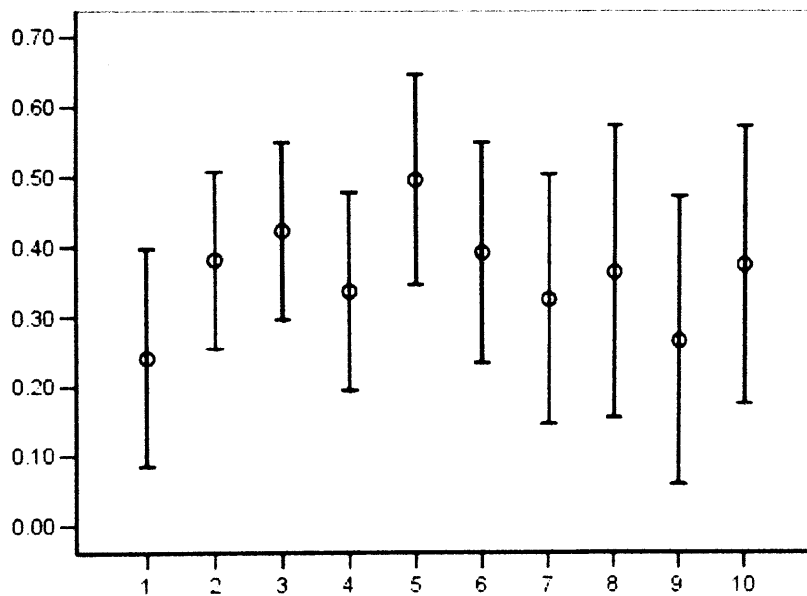


Figure 5 Error Bar Graph to show the Year to Year variation in SDS BMI distribution in Boys, with Year Group (x Axis) plotted against SDS BMI (y axis)



The SDS BMI were categorised, with a score between 1.04 and 1.64 SDS (>85th centile and < 95th centile) being categorised as overweight and a SDS BMI of >1.64 being categorised as obese, as compared with the UK 1990 reference dataset. If data from the current study, are in accordance with the UK 1990 dataset, no more than 10% of children should be categorised as overweight in this way, and no more than 5% as obese.

The results for SDS BMI for girls are set out in Table 3a.

What is actually seen in the Camden dataset is that in girls, the overweight prevalence meets this expected prevalence in two year groups, year 3 and year 8, with year 8 having the lowest prevalence for overweight of 7.6% and year 10 having the highest prevalence of overweight in girls at 15.9%.

For obesity, the prevalence is always above the expected 5%, in girls the prevalence is lowest in year 1 at 7.7% and highest in year 5 at 15.8%.

The results of SDS BMI grading for boys are set out in Table 3b. Again the expected prevalence for overweight from the UK 1990 dataset is 10% and for obesity is 5%.

What is actually seen in the Camden dataset is that in boys, the overweight prevalence is always above this threshold, with a lowest prevalence of 10.7% in year 8 and a highest prevalence for overweight of 16% in year 5.

For obesity, in boys the prevalence is always more than double the expected prevalence of 5%, with the lowest prevalence found being in year 1 at 10.9% and the highest in year 5 of 15.6%.

Tables of SDS BMI Grading in Year Groupings

Table 3a Results SDS BMI Grading Girls

Year Group & Date of Birth		Overweight		Obese		Overweight & Obese Combined		Total Number
		Number	%	Number	%	Number	%	
1	01.09.89 - 31.08.90	30	10	23	7.7	53	17.7	300
2	01.09.90 - 31.08.91	45	13.3	39	11.5	84	24.8	339
3	01.09.91 - 31.08.92	38	10.1	34	9.0	72	19.1	376
4	01.09.92 - 31.08.93	37	11.8	41	13.1	78	24.9	314
5	01.09.93 - 31.08.94	31	12.6	39	15.8	70	28.4	247
6	01.09.94 - 31.08.95	38	13.5	34	12.1	72	25.6	282
7	01.09.95 - 31.08.96	34	13.8	25	10.1	59	23.9	247
8	01.09.96 - 31.08.97	12	7.6	19	12.0	31	19.6	158
9	01.09.97 - 31.08.98	21	14	19	12.7	40	26.7	150
10	01.09.98 - 31.08.99	28	15.9	20	11.4	48	27.3	176

Table 3b Results SDS BMI Grading Boys

Year Group & Date of Birth		Overweight		Obese		Overweight & Obese Combined		Total Number
		Number	%	Number	%	Number	%	
1	01.09.89 - 31.08.90	35	12.7	30	10.9	65	23.6	276
2	01.09.90 - 31.08.91	45	12.1	42	11.3	87	23.4	372
3	01.09.91 - 31.08.92	50	13.5	52	14.1	102	27.6	370
4	01.09.92 - 31.08.93	45	14.3	40	12.7	85	27.0	315
5	01.09.93 - 31.08.94	42	16	41	15.6	83	31.4	263
6	01.09.94 - 31.08.95	36	12.8	43	15.2	79	28.0	282
7	01.09.95 - 31.08.96	24	10.9	34	15.5	58	26.4	220
8	01.09.96 - 31.08.97	18	10.7	26	15.5	44	26.2	168
9	01.09.97 - 31.08.98	25	15.0	21	12.6	46	27.6	167
10	01.09.98 - 31.08.99	27	13.3	30	14.8	57	28.1	203

When the IOTF thresholds are applied to the dataset, slightly different results are found.

The IOTF gradings can be related to the UK 1990 growth charts, but differ slightly between boys and girls.¹⁸ For girls the equivalent UK 1990 centile for overweight is 88.3-98.8 and for obesity is >98.8. Therefore, using the IOTF thresholds, there would be an expected prevalence of 10.5% for overweight and 1.2% for obese. For boys the equivalent centile for overweight is 90.4-99.1 and for obesity is >99.1. Therefore, using the IOTF thresholds, there would be an expected prevalence of 8.7% for overweight and 0.9% for obesity.

Details of prevalence for IOTF grading within each year group, is set out in the tables below (Tables 4a and 4b and Figures 6a and 6b). In girls the prevalence of overweight is close to the expected prevalence of 10.5%, just once at 10.1% in year 8. Otherwise the prevalence of overweight is always higher than expected, with a maximum prevalence of 22% in year 9. Obesity is always above the expected prevalence of 1.2%, with the lowest prevalence being 4.7% in Years 1 and 9 and the highest prevalence being 9.7% in year 5.

In boys, the prevalence of overweight is always above the expected IOTF prevalence of 8.7%, with the lowest prevalence being 11.2% in Year 1 and the highest prevalence being 17.0% in year 3. Obesity too is always above the expected prevalence of 0.9%, with the lowest prevalence being 5.1% in year 1 and the highest prevalence being 8.9% in year 8.

It is interesting to note that in this present study, the IOTF method groups less children as obese, but more as overweight, and the SDS BMI cut offs, group more children as obese and less as overweight. This finding is related to the position of the different cut offs relative to the spread of SDS BMI in the dataset.

Tables and Histograms of IOTF Grading in Year Groupings

Table 4a Results by IOTF Grading - Girls

Year Group & Date of Birth		Overweight (1)		Obese (2)		Overweight & Obese Combined		Total Number
		Number	%	Number	%	Number	%	
1	01.09.89 – 31.08.90	41	13.7	14	4.7	55	18.4	300
2	01.09.90 – 31.08.91	56	16.5	28	8.3	84	24.8	339
3	01.09.91 – 31.08.92	51	13.6	21	5.6	72	19.2	376
4	01.09.92 – 31.08.93	59	18.8	21	6.7	80	25.5	314
5	01.09.93 – 31.08.94	48	19.4	24	9.7	72	29.1	247
6	01.09.94 – 31.08.95	59	20.9	14	5.0	73	25.9	282
7	01.09.95 – 31.08.96	45	18.2	14	5.7	59	23.9	247
8	01.09.96 – 31.08.97	16	10.1	15	9.5	31	19.6	158
9	01.09.97 – 31.08.98	33	22.0	7	4.7	40	26.7	150
10	01.09.98 – 31.08.99	37	21.0	12	6.8	49	27.8	176

Figure 6 A Histogram to Illustrate the Percentage of Obese and Overweight Girls at 5 year Exam by IOTF cut off points

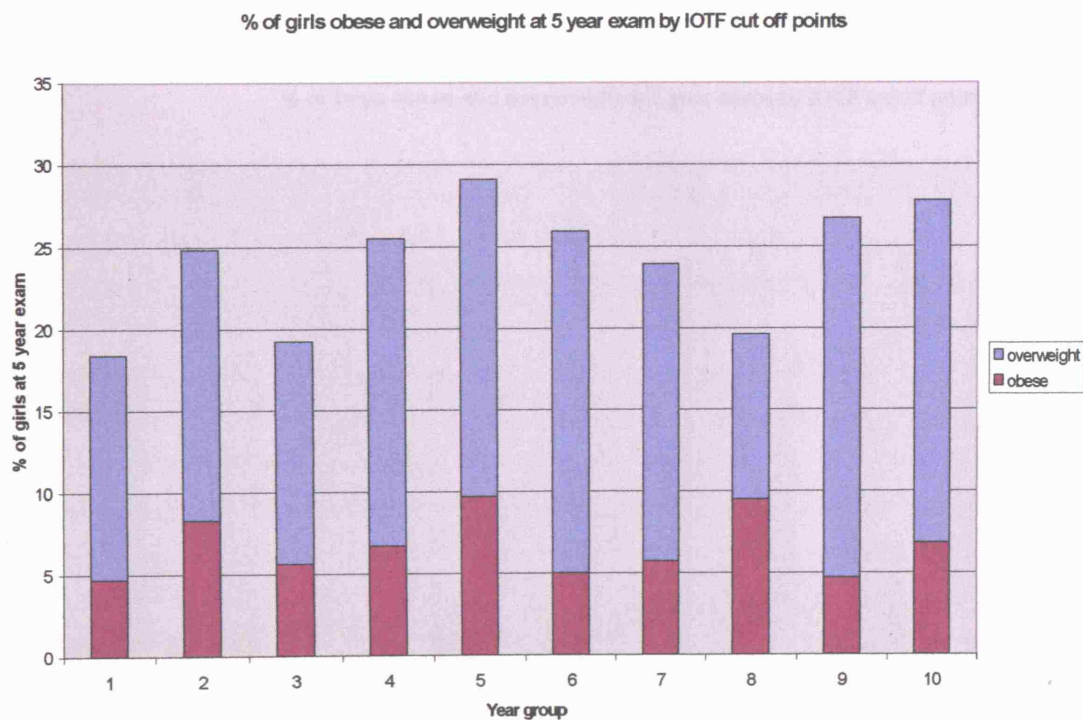
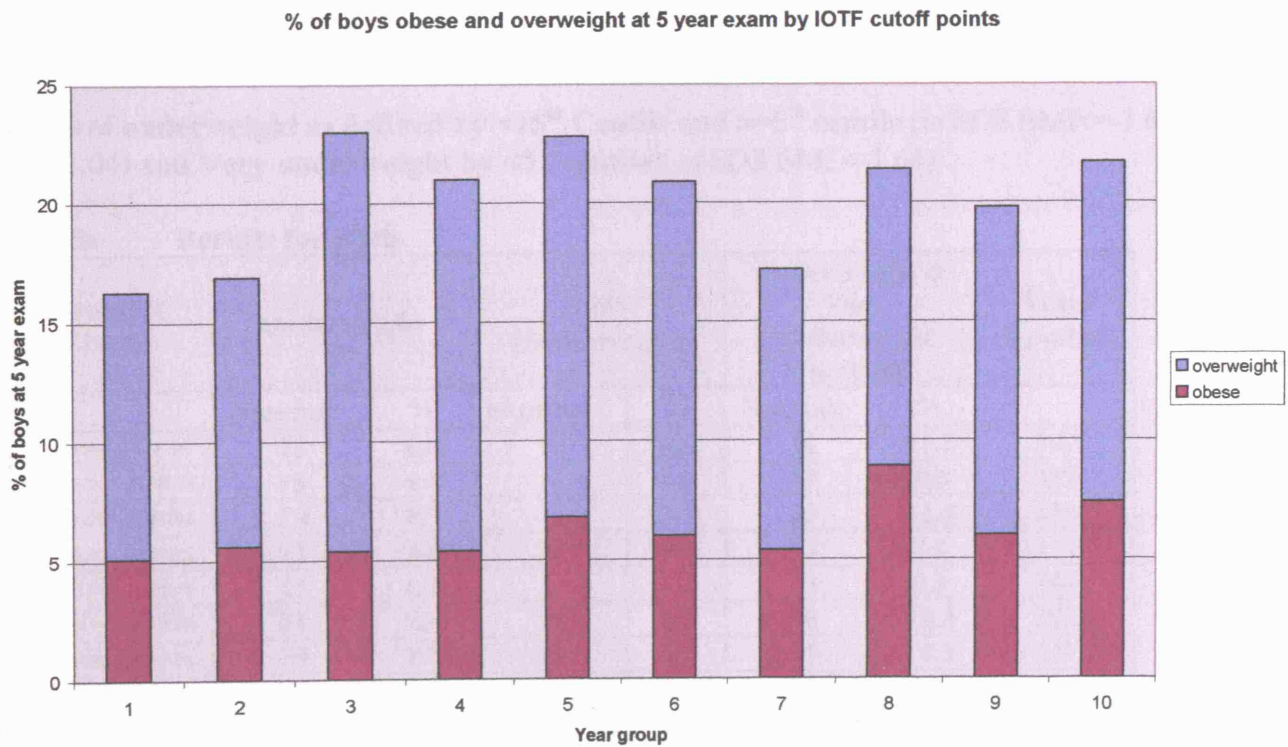


Table 4b Results by IOTF Grading –Boys

Year Group & Date of Birth		Overweight		Obese		Overweight & Obese Combined		Total Number
		Number	%	Number	%	Number	%	
1	01.09.89 – 31.08.90	31	11.2	14	5.1	45	16.3	276
2	01.09.90 – 31.08.91	42	11.3	21	5.6	63	16.9	372
3	01.09.91 - 31.08.92	65	17.6	20	5.4	85	23.0	370
4	01.09.92 - 31.08.93	49	15.6	17	5.4	66	21.0	315
5	01.09.93 - 31.08.94	42	16.0	18	6.8	60	22.8	263
6	01.09.94 - 31.08.95	42	14.9	17	6.0	59	20.9	282
7	01.09.95 - 31.08.96	26	11.8	14	6.4	40	18.2	220
8	01.09.96 - 31.08.97	21	12.5	15	8.9	36	21.4	168
9	01.09.97 - 31.08.98	23	13.8	10	6.0	33	19.8	167
10	01.09.98 - 31.08.99	29	14.3	15	7.4	44	21.7	203

Figure 7 A Histogram to Illustrate the Percentage of Obese and Overweight Boys at 5 year Exam by IOTF cut off points



Underweight

For underweight, the SDS BMI were categorised with an SDS BMI of ≤ -1.64 ($\leq 5^{\text{th}}$ centile) being very underweight and a SDS BMI of ≤ -1.04 and > -1.64 ($> 5^{\text{th}}$ centile but $\leq 15^{\text{th}}$ centile) being underweight, as compared with the UK 1990 reference dataset. Therefore the expected prevalence of underweight is 10% and the expected prevalence of very underweight is 5%.

The results for underweight SDS BMI for girls are set out in Table 5a and Figure 5a.

What is actually seen in the Camden dataset is that in girls, the underweight prevalence is always below the expected prevalence of 10%, with a maximum of 8.5% in year 6 and a minimum prevalence of 4.4% in year 2. For very underweight, the girls are more than the expected prevalence in three year groups, with a maximum prevalence of 6.5% in year group 7 and less than the expected prevalence in all the other year groups, with a minimum prevalence of 1.9% in year group 4.

Tables and Histograms of Underweight

Results of underweight as defined by $< 15^{\text{th}}$ Centile and $\geq 5^{\text{th}}$ centile (ie SDS BMI ≤ -1.64 and > -1.04) and Very underweight by $< 5^{\text{th}}$ centile (ie SDS BMI < -1.64)

Table 5a Results for Girls

Year Group & Date of Birth	Underweight		Very Underweight		Underweight & Very Underweight Combined		Total Number
	Number	%	Number	%	Number	%	
1 01.09.89 – 31.08.90	18	6.0	16	5.3	34	11.3	300
2 01.09.90 – 31.08.91	15	4.4	14	4.1	29	8.5	339
3 01.09.91 – 31.08.92	29	7.7	14	3.7	43	11.4	376
4 01.09.92 – 31.08.93	17	5.4	6	1.9	23	7.3	314
5 01.09.93 – 31.08.94	15	6.1	8	3.2	23	9.3	247
6 01.09.94 – 31.08.95	24	8.5	12	4.3	36	12.8	282
7 01.09.95 – 31.08.96	19	7.7	16	6.5	35	14.2	247
8 01.09.96 – 31.08.97	13	8.2	9	5.7	22	13.9	158
9 01.09.97 – 31.08.98	7	4.7	6	4.0	13	8.7	150
10 01.09.98 – 31.08.99	10	5.7	7	4.0	17	9.7	176

The results for underweight SDS BMI for boys are set out in Table 5b and Figure 5b.

What is actually seen in the Camden dataset is that in boys, the underweight prevalence is always below the expected prevalence of 10%, with a maximum of 9.1% in year 7 and a minimum prevalence of 5.1 % in year 7. For very underweight, the boys are more than the expected prevalence in 6 of the 10 year groups, with a maximum prevalence of 9.0% in year 9 group and a minimum prevalence of 3.8% in years 2 and 5.

Results of ‘underweight’ as defined by <15th Centile and >5th centile and ‘severely underweight’ by <5th centile

Table 5b Results for Boys

Year Group & Date of Birth		Underweight		Very Underweight		Underweight & Very Underweight Combined		Total Number
		Number	%	Number	%	Number	%	
1	01.09.89 - 31.08.90	21	7.6	17	6.2	48	13.8	276
2	01.09.90 - 31.08.91	20	5.4	14	3.8	34	9.2	372
3	01.09.91 - 31.08.92	24	6.5	16	4.3	40	10.8	370
4	01.09.92 - 31.08.93	16	5.1	15	4.8	31	9.9	315
5	01.09.93 - 31.08.94	17	6.5	10	3.8	27	10.3	263
6	01.09.94 - 31.08.95	15	5.3	16	5.7	31	11.0	282
7	01.09.95 - 31.08.96	20	9.1	11	5.0	31	13.1	220
8	01.09.96 - 31.08.97	9	5.4	11	6.5	20	11.9	168
9	01.09.97 - 31.08.98	10	6.0	15	9.0	25	15.0	167
10	01.09.98 - 31.08.99	11	5.4	14	6.9	25	13.3	203

Severe Underweight

Severe underweight was categorised as an SDS BMI < -2.06, ie. <2nd centile, therefore the expected number of children in this category is 2%. In girls the prevalence of severe underweight is more than 2% in 7 of the 10 year groups, with a minimum prevalence of 1.0% in year group 4 and a maximum prevalence of 3.3% in year 1. In boys the prevalence of severe underweight is more than 2% in 8 of the 10 year groups, with a minimum prevalence of 1.1% in year group 5 and a maximum prevalence of 5.4% in year 10. These results are set out in Tables 6a and 6b and Figures 7a and 7b below.

Table 6a - Results of Severely Underweight for Girls, determined by <2nd Centile

	Year Group & Date of Birth	Not Severely Underweight		Severely Underweight		Total Number
		Number	%	Number	%	
1	01.09.89 – 31.08.90	290	96.7	10	3.3	300
2	01.09.90 – 31.08.91	330	97.3	9	2.7	339
3	01.09.91 – 31.08.92	369	98.1	7	1.9	376
4	01.09.92 – 31.08.93	311	99.0	3	1.0	314
5	01.09.93 – 31.08.94	243	98.4	4	1.6	247
6	01.09.94 – 31.08.95	276	97.9	6	2.1	282
7	01.09.95 – 31.08.96	240	97.2	7	2.8	247
8	01.09.96 – 31.08.97	154	97.5	4	2.5	158
9	01.09.97 – 31.08.98	146	97.3	4	2.7	150
10	01.09.98 – 31.08.99	172	97.7	4	2.3	176

Figure 8 A Histogram to Illustrate the Percentage of Underweight, Very Underweight and Severely Underweight Girls at 5 year Exam

% of girls underweight, very underweight and severely underweight at 5 year exam

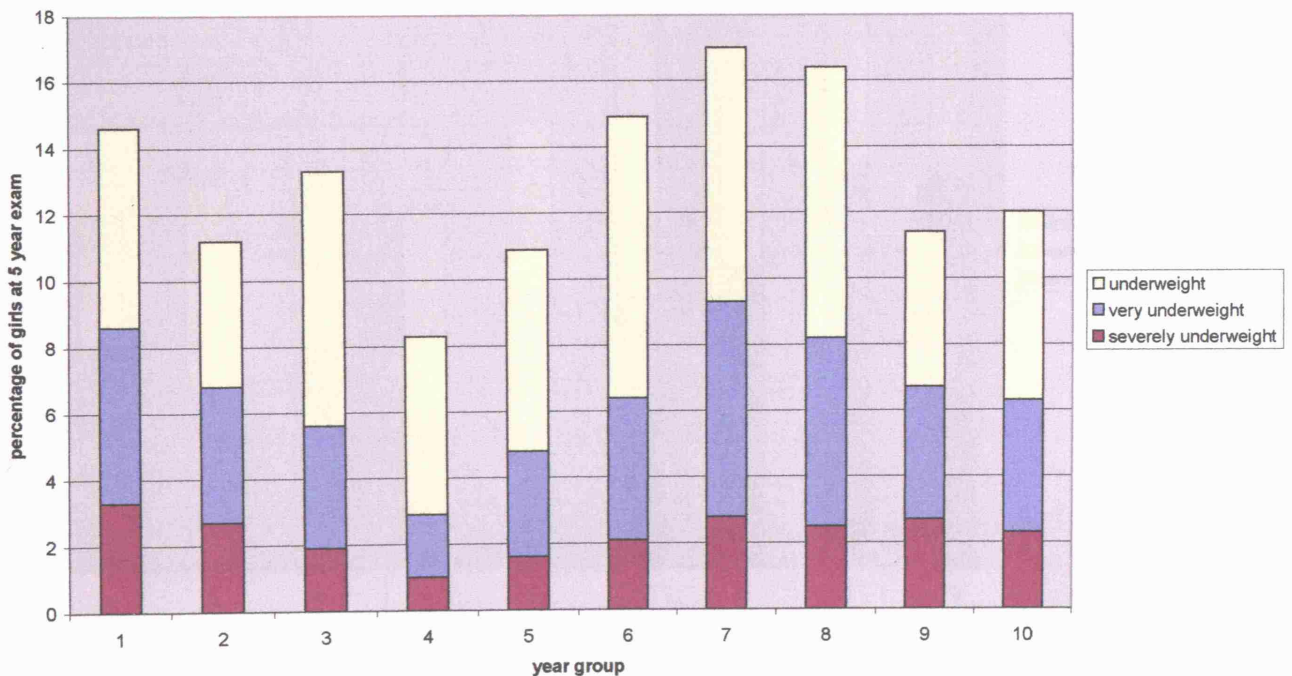
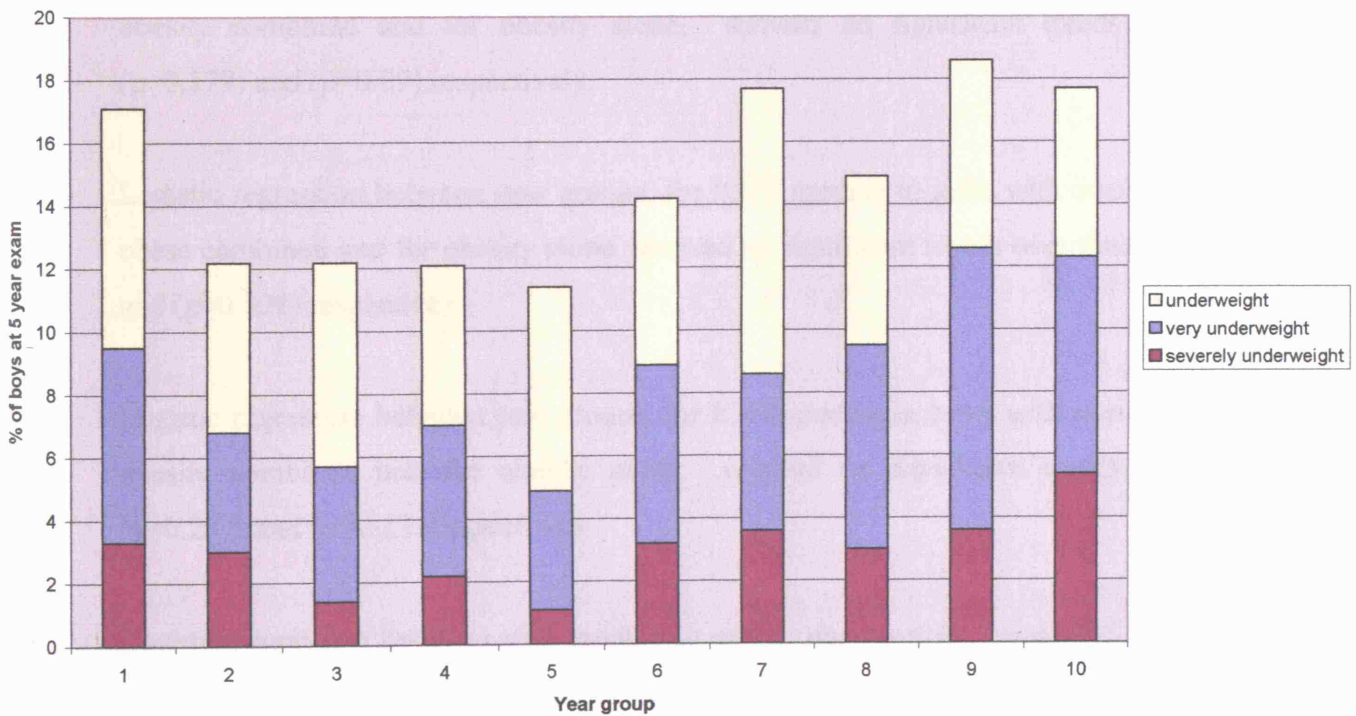


Table 6b - Results of Severely Underweight for Boys, determined by <2nd Centile

Year Group & Date of Birth		Not Severely Underweight		Severely Underweight		Total Number
		Number	%	Number	%	
1	01.09.89 – 31.08.90	267	96.7	9	3.3	276
2	01.09.90 – 31.08.91	361	97.0	11	3.0	372
3	01.09.91 - 31.08.92	365	98.6	5	1.4	370
4	01.09.92 - 31.08.93	308	97.8	7	2.2	315
5	01.09.93 - 31.08.94	260	98.9	3	1.1	263
6	01.09.94 - 31.08.95	273	96.8	9	3.2	282
7	01.09.95 - 31.08.96	212	96.4	8	3.6	220
8	01.09.96 - 31.08.97	163	97.0	5	3.0	168
9	01.09.97 - 31.08.98	161	96.4	6	3.6	167
10	01.09.98 - 31.08.99	192	94.6	11	5.4	203

Figure 9 A Histogram to Illustrate the Percentage of Underweight, Very Underweight and Severely Underweight Boys at 5 year Exam

% of boys underweight, very underweight and severely underweight at 5 year exam



Tests for Trend

Weighted analysis of variance for SDS BMI in girls between year groups was not significant for the linear term ($p=0.301$) or the quadratic term ($p=0.315$), but was significant for the cubic term ($p=0.012$).

Weighted analysis of variance for SDS BMI in boys between year groups was not significant for the linear term ($p=0.931$) or the quadratic term ($p=0.144$) or the cubic term ($p=0.17$).

Logistic regression between year groups, for SDS BMI in girls, with overweight or obesity combined and for obesity alone, showed no significant trends over time ($p=0.03$) and ($p=0.16$) respectively.

Logistic regression between year groups, for SDS BMI in boys, with overweight or obesity combined and for obesity alone, showed no significant trends over time ($p=0.179$) and ($p=0.09$) respectively.

Logistic regression between year groups, for IOTF grading in girls, with overweight and obese combined and for obesity alone, showed no significant trends over time ($p=0.034$) and ($p=0.808$) respectively.

Logistic regression between year groups, for IOTF grading in boys, with overweight and obesity combined and for obesity alone, showed no significant trends over time ($p=0.232$) and ($p=0.13$) respectively.

Logistic regression between year groups for severe underweight, using SDS BMI < 2nd Centile showed no significant trend over time in girls ($p= 0.86$) and a **borderline significant trend over time in boys ($p=0.065$)**.

Logistic regression between year groups for underweight and very underweight, using SDS BMI $>5^{\text{th}}$ centile and $\leq 15^{\text{th}}$ centile for underweight and $\leq 5^{\text{th}}$ centile for very underweight showed no significant trend over time for underweight and very underweight combined in girls ($p=0.4$) or in boys ($p=0.22$).

However logistic regression between year groups for very underweight alone (BMI $\leq 5^{\text{th}}$ centile) did show a significant trend over time i.e. increasing prevalence, ($p=0.045$) in boys, though was not significant in girls ($p=0.64$).

Two year groupings

Due to the variation in coverage, grouping the dataset into 2 year groupings 1994-6, 1996-8...etc was done to increase statistical significance, but no significant difference in trends were found by this method.

DISCUSSION

Summary of results

Overweight and Obesity

On statistical analysis there was no significant trend in the prevalence of overweight or obesity in Camden children at the 5 year examination. There was considerable variation between year groups in the BMI for girls and boys, even when adjusted for age and standard deviation. The SDS BMI (Standard Deviation Score BMI) showed variation up and down between year groups, more marked in the girls, than in boys, as illustrated in the Results Section by Figures 4 and 5, the box plots of SDS BMI. This variation reached significance in girls for the cubic term, $p=0.01$.

However, the actual prevalence of obesity and overweight in boys and girls is still higher than expected from the national dataset UK 1990. Using SDS BMI, with the 85th centile as the cut off for overweight and the 95th centile as the cut off for obesity, the prevalence of obesity should be no more than 10% and the prevalence of overweight, no more than 5%.

In this study, in girls the prevalence of overweight varied from 7.6% to 13.8%, with the prevalence being greater than the expected 10% prevalence, in all except two year groups (Year 1 and Year 8). The prevalence of obesity varied from 7.7% to 15.8%, with the prevalence being more than the expected 5% in all years. In boys the prevalence of overweight varied from 10.7% to 15.0%, above the expected prevalence of 10% in all years. For obesity, the prevalence varied from 10.9% to 15.6%, double or triple the expected prevalence for obesity of 5%.

Using the alternative, IOTF method, the prevalence of overweight and obesity remains high compared to the expected prevalence. Relating the IOTF cut offs to the UK 1990 dataset, the cut off in girls for overweight is 88.3rd centile and for obesity is 98.8th

centile, thus the expected prevalence of overweight is 10.5% and the expected prevalence of obesity is 1.2%. In boys the equivalent cut off for overweight is 90.4th centile and for obesity is the 98.8th centile, thus the expected prevalence of overweight is 8.7% and for obesity is 1.2% in boys.

In this study, using the IOTF method, the prevalence of overweight in girls ranged from 10.1% to 21.0%, higher than the expected 10.5% prevalence in 9 out of the 10 years. The prevalence of obesity in girls varied from 4.7% to 9.7%, well above the expected prevalence of 1.2% in all years. In boys the prevalence of overweight varied from 11.2% to 17.6%, well above the expected prevalence of 8.7% in all years. For obesity, the prevalence varied from 5.1% to 8.9%, well above the expected prevalence of 1.2%.

Underweight and Severely Underweight

The tests for trend showed a significant trend in the 'very underweight' category, (SDS BMI <5th centile) $p=0.045$, in boys but no significant trend in girls. The test for trend showed a borderline significant trend in 'severely underweight' (SDS BMI <2nd centile) for boys $p=0.07$, but was not significant in girls. The tests for trend in 'underweight' (<15th centile) did not show a significant trend in boys or girls. This indicates a worrying rise in prevalence of underweight in boys.

The expected prevalence of 'severe underweight' is 2% (<2nd centile) and the actual prevalence in the data collected varies from 1.0% to 3.3% in girls, above the 2% expected in 7 of the 10 year groups. In boys the prevalence varies from 1.1% to 5.4%, above the expected 2% in 8 out of the 10 years.

The expected prevalence of 'very underweight' is 5% (<5th centile) and the actual prevalence in the data collected varies in girls from 1.9 to 6.5%, above the expected prevalence in 3 out of the 10 year groups and varies from 3.8 to 9.0% in boys, above the expected prevalence in 6 out of the 10 Year groups, including the last 5 years of the dataset.

The expected prevalence of 'underweight' is 10% (between 5th and 15th centile) and the prevalence of 'underweight' is in fact less than this in the data collected, for boys and girls.

Thus our figures show that there is a higher than expected prevalence of obesity and overweight, although there is no evidence for a significant linear trend ie. an 'epidemic' of obesity. These results also indicate a peak at the extremes of underweight, <5th and <2nd centile, particularly in boys, with a significant rising trend for <5th centile in boys.

How these results compare with other results

Time trend studies

Three other UK studies have looked at time trends in BMI, in a similar age group, as set out in the table below:

Table comparing Time Trends Studies for cut off, age group and years measured

Study	BMI cut off used	Age group	Years measured
Katz (Camden)	IOTF & SDS BMI	4-7 yrs	1994/5-2003/4
Jones (South Wales)	IOTF	4-6 yrs	1986/7-2001/2
Stamatakis (UK)	IOTF & SDS BMI	5-7 yrs	1974, 1984, 1994, 1996 – 2003
Bundred (The Wirral)	SDS BMI	2.9-4 yrs	1989-1998

The three other studies above, unlike the Camden study, found a significant trend of increasing obesity and overweight. They too found a higher than expected prevalence of obesity and overweight, when compared with the UK reference data.

Cross-sectional Studies

There have been three cross sectional studies that have examined prevalence of obesity in a similar age group, in the UK, as set out in the table below. For the sake of comparability, year group 4 from the Camden study, 1997/8, has been chosen.

Table comparing Cross Sectional Studies for cut off, age group, years measured and prevalence

Study	BMI cut off used	Age Group	Years Measured	Prevalence overweight in Girls ,%	Prevalence overweight Boys (%)	Prevalence obesity Girls (%)	Prevalence obesity Boys (%)
Katz (Camden)	IOTF	4-7 yrs	1997/8	18.8	15.6	6.7	5.4
	SDS BMI			11.8	14.3	13.1	12.7
Jebb (UK)	IOTF	4-6 yrs	1997	17.4	13.5	3.3	2.0
Reilly (Alspac)	SDS BMI	5 yrs	1996/7	19.3	18.2	6.1	8.1
Armstrong (Scotland)	SDS BMI (obesity only)	3-4 yrs	1998/9	-----	-----	12.1	13.4

From the table above, the prevalence of overweight and obesity can be compared with the prevalence found in other studies using similar criteria, on similar age children at a similar time. Compared to Jebb et al (IOTF criteria), the prevalence of overweight and obesity is twice as high in the Camden girls and boys. Compared to Reilly et al, (SDS BMI criteria) the prevalence of overweight is considerably lower in Camden but the prevalence of obesity is considerably higher. Compared to Armstrong et al (SDS BMI criteria, obesity only), the prevalence of obesity in girls is slightly higher in Camden and for boys is slightly lower, than in their study.

Comparing our results on underweight to other studies is more difficult, as only one other recent UK study has looked at prevalence of underweight in a similar age group (Armstrong). Armstrong found the prevalence of severe underweight [defined as <2nd centile] to be 3.3% in girls and 3.2% in boys in 1998/9 .

In the Camden study for girls, except for 1994/5, when the prevalence of underweight was 3.3%, it has been slightly lower than that found by Armstrong. In boys, in 5 years out of 10, the prevalence of underweight has been equal to or higher than that found by Armstrong, with higher prevalence in the latter years of the Camden dataset, reaching a maximum prevalence of 5.4% in 2003/4.

Figures from Islington⁵², the neighbouring borough to Camden, show that in the 4-7 age group for 2002/03, 5% of girls and 3% of boys were obese and that 9% of girls and 6% of boys were overweight (by IOTF criteria). This compares, for the same year group 2002/3 to a prevalence in the Camden data, of obesity of 4.7% in girls and 6.0% in boys and of overweight to 22% in girls and 13.8% in boys in the Camden dataset. It must be noted that the Islington sample size was much bigger and more complete, it included 1257 children, versus a sample size of 317 for that year for Camden. (See further discussion on sample bias below).

Reasons for differences

Coverage

Coverage of data in this study was disappointingly low. Of the 15171 eligible children, there was a 5 year examination recorded on 6864 (45.2%) and useable height and weight information on just 5225 (34.4%). The problem of inadequate data collection has been reported elsewhere⁵⁹. However the coverage found in this study is far less than in other studies of routine data collected at the school entry medical¹⁰. It also falls far short of the recommendations in Health For All Children, 4th edition⁶⁰, which sets the standards for child health surveillance in the UK:

“Measurement of height and weight should be made at or around the time of school entry, preferably at about five years of age. These measurements should be stored so that BMI can be calculated and used as a public health indicator.”

Why the coverage was so low is an important question to answer for maximising utility of routine data in the future.

It is not clear whether the missing 5 year examinations were not actually done, were not attended, were refused, or were done but not recorded on the data entry sheets, were done and data entry sheets were returned but did not reach Child Health or were not then entered onto the database.

Certainly school nurses in Camden, as elsewhere, have been overstretched, with some long-term vacancies and use of agency staff. As well as this school nurses have been diverted to carry out catch-up immunisation campaigns in schools such as that for Meningococcal C in 2000 and MMR in 2004. Children are not always measured in the year they turn 5 for logistical reasons, hence our inclusion of BMI for children up to 7. The children in our last 2 data groups born in 1998 and 1999 will not turn 7 until 2005 and beyond. All these reasons may account for some of the poor coverage in our dataset.

The exact reasons need to be determined and addressed if the school entry medical is to provide potentially crucial information on the health status of children in Camden. Not collecting this information adequately is a waste of opportunity not to mention resources.

Sample Bias

It is possible that the poor data coverage in this study, just 34.4%, introduced sample bias. This bias may be systematic or random or a combination. If the bias is random, rather than systematic, it will simply increase the variation in our results and not impact on the findings. In order to determine this, information is needed to compare characteristics of the 65.6% of those excluded from the analysis, the 'non-responders' who number 9946, with the 'responders', to see if they differ with respect to obesity or some factor that is related to obesity, such as socio-economic deprivation.

This presupposes that we can determine which children out of our original dataset of 24019 are the 9946 non-responders and that we have further information characteristics on them.

To determine which of the children in the original dataset were the non-responders, we would need to be able to link our dataset to the Education database, preferably with a common identifier for each child; this is beyond the capability of the current system. Other characteristic information such as ethnicity and postcode (which can be used as a socio-economic indicator) were incomplete in the dataset.

It would also be helpful to be able to determine which primary school each child in the dataset attended, to try to determine whether particular schools have more missing data than others. With primary school information, we could then have determined whether schools with a higher prevalence of overweight, obesity or underweight, differed from those with a lower prevalence, for example; by the number of children on free school meals or school travel policy.

This is limited by RICHES only being able to give ‘current school’ information and not ‘school attended at 5 year exam’ information. As illustrated by the fact that many of the children in the dataset, have their current secondary school recorded under ‘school’.

This analysis looked only at BMI in the 4-7 year age group. There was insufficient routine data for older children for analysis. It may be that the prevalence of overweight and obesity in Camden is even higher in older children, as found in other parts of London¹⁷. Indeed anecdotal evidence from discussion with school nurses in Camden, suggests that the prevalence of obesity and overweight rises steeply in secondary school. Our results cannot give any information about prevalence in older children

Ethnicity

Camden primary schools have a large proportion of ethnic diversity. This may account for the differences in trends of overweight and obesity, found in our study compared with those done in less ethnically diverse communities. Ethnicity is known to influence body mass index, at both ends of the spectrum^{9;17;61;62}.

Environment

It is possible that in Camden obesity is rising less than in other areas in this age group for environmental reasons. The borough is geographically small, so many primary school children can walk to school. The education department runs a healthy schools campaign, providing information and free fruit for children.

Methodological Limitations

Sample Bias - Coverage

The low coverage may have significantly altered our results, if the non-responders differed significantly from the responders in prevalence of overweight, obese or underweight.

Measurement bias

This study used routine rather than prospectively collected data. This raises the concern of measurement bias, with different nurses using a variety of measuring instruments and measurers collected the height and weight data, with no regular training updates

Data Error

Data entry error is another potential source of measurement bias³⁹. We were able to determine and correct some obvious data errors including transposition and insertion a negative number for weight. The children with implausible BMI (n=32) may have had either their data recorded incorrectly or entered incorrectly. A computerised system that alerted the data entry clerk to all implausible values could address these types of errors.

BMI as a proxy measure for obesity, overweight and underweight

Using BMI as the measure of obesity, overweight and underweight, has presupposed that it can reliably pick them up. Certainly BMI is the widely used epidemiological tool. However, other measures, particularly waist circumference are more sensitive in assessing obesity and often used in prospective studies. McCarthy et al measured both and found that using BMI alone significantly underestimated levels of overweight and obesity³⁴. This present study may therefore have underestimated the prevalence of overweight and obesity.

Socio – Economic Characteristics

Other studies have shown a correlation between deprivation and overweight, obesity and underweight^{14;15;17}. Camden is the 18th poorest borough in the UK. The percentage of children on free-school meals (37.2 %) also indicates a high level of deprivation. This in turn may be having a significant impact on children's BMI. It would therefore have been useful (but beyond the scope of this study, due to time limitation) to evaluate the impact of deprivation on BMI, for example by using postcode as an indicator of socio-economic status.

Closure and Limitations of RICHs

The untimely (for this study!) closure of RICHs limited what information we could use, for example gestational age was requested but did not download correctly and the following day RICHs was closed and all its information inaccessible. As mentioned previously, the RICHs system did not have an interface with the Education database, to allow us to determine which of the children in our initial database were eligible for the numerator, and thus did not allow any determination of information about the non-responders.

Patient Confidentiality and Data Protection

The legal and ethical requirements relating to the protection of patient identifiable information, i.e. information from which a patient may be identified directly or indirectly^{58,63}, present a significant challenge for studies wanting to use patient data. Compliance with these requirements, needs to be met before research can commence.

These requirements have been closely heeded in the planning of the NHS Programme for IT (NPfIT), which aims to implement a national electronic patient records system with a unified NHS Care Record for every patient by 2010. The new system is hoped to allow researchers greater access to medical data. The system will be structured to anonymise this data, to ensure maximum legal and ethical compliance and correct practice for data collection and processing.

The key legal requirements are maintenance of the doctor-patient duty of confidentiality and the Data Protection Act 1998. In addition, attention must be paid to relevant ethical guidance. This is to be found in the Department of Health “NHS Confidentiality Code of Practice”⁶³, the Information Commissioner's guidance on “The Use and Disclosure of Health Data”⁶⁴, relevant Research Ethics Committee requirements and guidance given by the GMC⁶⁵.

Duty of Confidentiality

The common law of confidentiality stems from rulings of the Courts rather than Acts of Parliament. The Courts have readily found that information received by a doctor in a doctor-patient relationship is protected by an obligation of confidentiality (see *Hunter v Mann* [1974] 2 All ER 414; *W v Egdell and others* [1990] 1 All ER 835). Under this obligation, a doctor must keep patient information confidential and not use or disclose it to others, without the consent of the patient unless exceptional circumstances exist.

Therefore, when patient information is collected on a database, it is protected by a duty of confidentiality, requiring it to be used only to treat the patient unless patient consent is obtained for a wider use, or an exception to the right to confidentiality exists. The two main exceptions recognised by the Courts are where disclosure is required by law and where it is in the public interest to do so. However, in the context of carrying out research, these exceptions are unlikely to apply and if patient identifiable information is to be used, consent will generally be needed.

A further recent, and controversial, exception to the duty of confidentiality has been introduced by Section 60 of the Health and Social Care Act 2001. This gives the Secretary of State the power to make orders requiring the disclosure of patient data without patient consent, where it would otherwise have not been disclosable due to confidentiality obligations. Additional safeguards and restrictions must be put in place to protect the disclosed data if these powers are used. The powers will not in practice be used against the advice of the Patient Information Advisory Group, set up under the Act. To date, these powers have only been used once and they may not be used for much longer, as it is intended that section 60 will only apply as a transitional measure, until procedures for obtaining patient consent or data anonymisation are settled under the NPfIT.

The position is more straight forward where the patient data is "anonymised" (see the section on Anonymised data below) following the case of *R v Department of Health, Ex Parte Source Informatics CA (Civ Div) 21/12/99*. In this case, the Court decided that the anonymisation of patient data and its subsequent use by third parties, did not amount to a breach of patients' right to confidentiality.

Anonymised data was therefore used for this study to ensure that patient confidentiality was respected

Data Protection Act 1998

Patient identifiable information is regulated by the Data Protection Act 1998 (DPA) which was passed to implement the European Union Data Protection Directive (95/46/EC). The DPA applies generally to all 'personal data' (information from which an individual can be directly or indirectly identified) and sets out eight data protection principles.

Under the data protection principles data must be: obtained and processed fairly and lawfully; obtained and processed only for specific purposes; adequate, relevant and not excessive; accurate and up-to-date; not kept longer than necessary; processed in accordance with individuals rights under the DPA; subject to appropriate security, confidentiality and back-up procedures; not transferred outside of the European Economic Area unless adequate safeguards are in place.

These principles aim to give individuals control over what information is held on them ('personal data') and how that personal data is processed. In particular, special standards apply to 'sensitive personal data'. This includes any information about an individual's physical and mental health or sexual life and these standards would therefore apply to most patient identifiable information.

As with the duty of patient confidentiality, the DPA does not apply to anonymised data. Patient data is anonymised when all personal identifiers are removed from it, so that it is not possible to identify a patient from it. This approach is also consistent ethical guidance, including the 2nd Caldicott Principle, which requires that patient identifiable information should not be used unless absolutely necessary⁵⁸ and the Department of Health 'NHS code of practice'⁶³.

Patient identifiable information containing height and weight data is a clear example of sensitive personal data and to ensure legal compliance the Camden dataset was anonymised before any data processing took place.

Lessons to be learnt

Poor coverage of routine data

The poor coverage limits the strength of our findings. We need to address the question of why coverage was so poor, as detailed in the Coverage section above.

Analyse routinely collected data more regularly

The routine data being collected at school entry needs to be analysed regularly. The computerised child health databases including RICHs have been very successful in maximising immunisation coverage; they are overseen by the COVER and previously Korner system of returns, currently quarterly, administered centrally. If one area has a low immunisation uptake this information is fed back to a local level, in order to be addressed. Uptake is then reviewed again in the next quarter.

It would be very simple to produce a similar 'returns' system for school entry medicals, perhaps each term, to make it clear which schools or children are lacking in information on the computerised child health system. The details of children in denominator should be obtained from Education (preferably by a computer interface) or from school lists, which are currently used as the basis for catch-up immunisation campaigns.

Data should not be left dormant. The more it is used and analysed and this analysis fed back to those collecting it, the more the incentive for the data collection to be comprehensive and complete. The database should be made able to flag up implausible values. Annual prevalence rates for overweight, obesity and underweight could easily be generated annually from the school entry medical. If a similar system was run in all districts (just as the COVER system is national) suddenly a useful, consistent dataset of public health information on school entry children, would be available to inform national as well as local policy making and the effectiveness of interventions. A system of monitoring BMI may be required practice in the future and collecting anonymised BMI data in children, is currently being debated by an Expert Advisory Group to the Department of Health⁴⁴.

Engage with data Collectors

During this study I noted varying levels of enthusiasm for collecting routine data amongst school nurses. Some clearly understood why such information was useful but others saw it as detracting from their main job of caring for children and asked why, if public health wanted this information they could not collect it themselves. My adhoc one-to-one advocacy sessions for routine data collection, that stemmed from these conversations, are not the answer on a borough wide level.

A clear discussion on the benefit or otherwise of collecting routine data needs to be had with all the health professionals concerned. Health for All Children has a very clear policy on school entry medicals^{14;17;60}. A system is in place that is already much reduced from the doctor led service of a decade ago. If, on a local level we are to follow the Health for All Children policy, all involved need to be onboard and feel that their role is pivotal and valued. The feedback described above in my suggested 'returns' system would help with this too, to show that information gathered is not just an administrative tick box exercise but provides excellent child public health information and therefore can help shape health policy on children in Camden.

CONCLUSIONS

This study shows that in Camden primary school children, age 4-7, from measurements of BMI calculated from school entry examination data, from 1994 to 2004, the prevalence of overweight and obesity have not significantly changed over time. However, the baseline prevalence of overweight and obesity, in both boys and girls, is higher than expected from the UK reference data.

The prevalence of underweight (defined at <5th centile) in boys has increased significantly over time. The prevalence of the extremes of underweight (<5th centile) in boys are higher than that expected from the UK reference data.

These findings need to be viewed cautiously as the coverage of data was low, only 34.4% of all possible data was available and valid for analysis.

RECOMMENDATIONS FOR THE FUTURE PRACTICE

Use 'Returns' system to improve Coverage

Any utilisation of routine data has to stem from good coverage and good quality data. With good coverage – perhaps promoted by the 'returns' system outlined above – prevalence rates of overweight, obesity and underweight could be calculated on an annual basis and give a very reliable picture of their prevalence.

Engage with the data collectors - the school nurses

School nurses are the key to collecting good quality data, comprehensively. The equipment in schools should be further standardised and regular training updates arranged. The nurses need to be given feed back on what the data they have collected, has shown and be involved in the subsequent local policy decisions. In this way, their role in not only determining the health status of children, but improving it, will be shown to be valued.

Regular data analysis - implications for interventions and assessing trends

Once good coverage with good quality data, is achieved, the data collected can be used to inform interventions at a local level. Regular data analysis could provide reliable figures for overweight, obesity and underweight will indicate whether interventions are necessary and if so whether they should be targeted at an individual or community level. Annual data then be compared, to help assess trends in overweight, obesity and underweight in the school entry population.

RECOMMENDATIONS FOR FUTURE RESEARCH

Further routine data collection with full coverage

To determine the overall prevalence of obesity, overweight and underweight, routine data could be comprehensively collected, over the next school entry year, following a campaign to get school nurses on board.

Prospective Study in Secondary School

To maximise data quality, a prospective study, could be carried out. As other studies are pointing to an increase in obesity in adolescence, a secondary school study would be the ideal place to carry out this prospective study, which could include another measurement relevant for obesity such as waist circumference or bioimpedance, to maximise sensitivity.

Linkage: ethnicity, socio-economic indicators and schools

In the above studies, ideally an indicator of socio-economic status such as postcode as well as ethnicity should be determined. It would then be possible to establish if in our locality, there are particular ethnic or socio-economic groups with higher levels of overweight, obesity and underweight, who could then be targeted more effectively.

Appendix 1

Syntax File – final version Syntax for results data tables

/* This is working file for analysis */

GET
FILE='F:\13septworking2.sav'.

/*Sort cases by gender and display results. All data that follows will therefore be split into girls and boys */

SORT CASES BY SEX .
SPLIT FILE
SEPARATE BY SEX .

/*Frequency tables: to count total number (separately for girls and boys) in each year group */

* Basic Tables.

TABLES
/FORMAT BLANK MISSING('.')
/OBSERVATION age@5yexam
/TABLES dat_grp > age@5yexam
BY (STATISTICS)
/STATISTICS
mean()
stddev()
validn((NEQUAL5.0)) /TITLE 'mean age at 5y exam'.

/* To create data for Results table 1a & 1b in results, get mean age, hgt, wgt, BMI, SDS BMI, by year group*/

* Basic Tables.

```
TABLES
/FORMAT BLANK MISSING('.')
/OBSERVATION age@5yexam
/TABLES dat_grp > age@5yexam
BY (STATISTICS)
/STATISTICS
mean( ) /TITLE 'age by yr group'.
```

* Basic Tables.

```
TABLES
/FORMAT BLANK MISSING('.')
/OBSERVATION hgt@5yexam
/TABLES dat_grp > hgt@5yexam
BY (STATISTICS)
/STATISTICS
mean( ) /TITLE 'hgt (cm) by yr group'.
```

* Basic Tables.

```
TABLES
/FORMAT BLANK MISSING('.')
/OBSERVATION hgt5ym
/TABLES dat_grp > hgt5ym
BY (STATISTICS)
/STATISTICS
mean( ) /TITLE 'hgt (m) by yr group'.
```

* Basic Tables.

```
TABLES
/FORMAT BLANK MISSING('.')
/OBSERVATION wgt@5yexam
/TABLES dat_grp > wgt@5yexam
BY (STATISTICS)
/STATISTICS
mean( ) /TITLE 'wgt by yr group'.
```

* Basic Tables.

```
TABLES
/FORMAT BLANK MISSING('.')
/OBSERVATION BMI
/TABLES dat_grp > BMI
BY (STATISTICS)
/STATISTICS
mean( ) /TITLE 'BMI by yr group'.
```

* Basic Tables.

```
TABLES
/FORMAT BLANK MISSING('.')
/OBSERVATION SDSBMI
/TABLES dat_grp > SDSBMI
BY (STATISTICS)
/STATISTICS
mean( ) /TITLE 'SDSBMI by yr group'.
```

/* To generate information by year group on range of BMI, Results Table 2a & 2b */

TABLES

```
/FORMAT BLANK MISSING('.')
/OBSERVATION BMI
/TABLES dat_grp > BMI
BY (STATISTICS)
/STATISTICS
maximum( )
mean( )
median( )
minimum( )
mode( )
validn( ( NEQUAL5.0 ))
stddev( )/TITLE 'BMI descriptives at 5y exam'.
```

/Now do measures of OVERWEIGHT and OBESITY/

*/Separate data into SDS>1.04 and >1.64 ie overweight and obese according to Reilly et al */

```
COMPUTE SDSgroup = -1 .
IF (SDSBMI <= 1.04) SDSgroup = 0 .
IF (SDSBMI >1.04 & SDSBMI <=1.64) SDSgroup = 1 .
IF (SDSBMI >1.64) SDSgroup = 2 .
MISSING VALUES SDSgroup (-1) .
value labels SDSgroup 0 'not overweight or obese' 1 'overweight' 2 'obese'.
EXECUTE .
```

/Crosstabs SDS Group and each year group, to generate data for Results: error bar graph figures 4 & 5 and table 3a & 3b/

CROSSTABS

```
/TABLES=SDSgroup BY dat_grp
/FORMAT= AVALUE TABLES
/CELLS= COUNT COLUMN
/COUNT ROUND CELL .
```

*/Now do alternative measures of OBESITY and OVERWEIGHT, using IOTF grading */

/The grading uses discrete variables, determine IOTF grading for each year group, for Results table 4a & 4b/

CROSSTABS

```
/TABLES=IOTFgrade BY dat_grp
/FORMAT= AVALUE TABLES
/CELLS= COUNT COLUMN
/COUNT ROUND CELL .
```

```
/*Now do measures of UNDERWEIGHT*/
/* SEVERE UNDERWEIGHT ie identify those with SDS <2nd centile, ie SDS < -2.06 according to
Armstrong & Reilly et al */
```

```
COMPUTE underwgt = -1 .
IF (SDSBMI >= -2.06) underwgt = 0 .
IF (SDSBMI <-2.06) underwgt = 1 .
MISSING VALUES underwgt (-1) .
value labels underwgt 0 'not underweight' 1 'underweight'.
EXECUTE .
```

```
/* Crosstabs to determine frequency of <2nd centile underweight in each year group, for Results
Table 6a & 6b*/
```

```
CROSSTABS
/TABLES=underwgt BY dat_grp
/FORMAT= AVALUE TABLES
/CELLS= COUNT COLUMN
/COUNT ROUND CELL .
```

```
*/For alternative UNDERWGT information, ie UNDERWEIGHT AND VERY UNDERWEIGHT,
separate data into SDS>-1.04 and >-1.64 ie overweight and obese according to Taylor et al */
```

```
COMPUTE underwgt2 = -1 .
IF (SDSBMI >= -1.04) underwgt2 = 0 .
IF (SDSBMI <-1.04 & SDSBMI >=-1.64) underwgt2 = 1 .
IF (SDSBMI <-1.64) underwgt2 = 2 .
MISSING VALUES underwgt2 (-1) .
value labels underwgt2 0 'not underweight' 1 'underweight' 2 'very underwgt'.
EXECUTE .
```

```
/*to make the UNDERWEIGHT AND VERY UNDERWEIGHT tables of this for Results table 5a
& 5b*/
```

```
CROSSTABS
/TABLES=underwgt2 BY dat_grp
/FORMAT= AVALUE TABLES
/CELLS= COUNT COLUMN
/COUNT ROUND CELL .
```

Appendix 2

Syntax File – final version

Syntax for tests linearity and logistic regression

```
/* Get working analysis file */
```

```
GET  
FILE='F:\13septworking2.sav'.
```

```
/*sort cases by gender and display results */  
SORT CASES BY SEX .  
SPLIT FILE  
SEPARATE BY SEX .
```

```
/* First analyse SDS BMI, this Analysis of Variance (ANOVA ) tests linear term - ie is there a  
linear trend in SDSBMI over time? */
```

```
ONEWAY  
SDSBMI BY dat_grp  
/POLYNOMIAL= 1  
/MISSING ANALYSIS .
```

```
/* This ANOVA also tests the linear, quadratic & cubic terms – ie to check if there is a non-linear  
trend */
```

```
ONEWAY  
SDSBMI BY dat_grp  
/POLYNOMIAL= 3  
/MISSING ANALYSIS .
```

```
/*Tests of OVERWEIGHT and OBESE*/
```

```
/* To look at time trends for obese and overweight COMBINED using SDS-based grade of  
obesity. First need code */
```

```
/* Separate data into SDS>1.04 ie overweight according to Reilly et al
```

```
COMPUTE SDSgroup3 = -1 .  
IF (SDSBMI <= 1.04) SDSgroup3 = 0 .  
IF (SDSBMI >1.04) SDSgroup3 = 1 .  
MISSING VALUES SDSgroup3 (-1) .  
value labels SDSgroup3 0 'not overweight' 1 'owgt or obese'.  
EXECUTE .
```

```
/* Then run logistic regression model with SDSgroup3 as dependent binary variable */  
/* and year group as covariate */
```

```
LOGISTIC REGRESSION SDSgroup3  
/METHOD = ENTER dat_grp  
/CRITERIA = PIN(.05) POUT(.10) ITERATE(20) CUT(.5) .
```

/* To look at time trends for obese ONLY using SDS-based grade of obesity */
/* First need code */

/* Separate data into SDS>1.64 ie overweight according to Reilly et al

```
COMPUTE SDSgroup4 = -1 .  
IF (SDSBMI <= 1.64) SDSgroup4 = 0 .  
IF (SDSBMI >1.64) SDSgroup4 = 1 .  
MISSING VALUES SDSgroup4 (-1) .  
value labels SDSgroup4 0 'others' 1 'obese'.  
EXECUTE .
```

/* Then run logistic regression model with SDSgroup4 as dependent binary variable */
/* and year group as covariate */

```
LOGISTIC REGRESSION SDSgroup4  
/METHOD = ENTER dat_grp  
/CRITERIA = PIN(.05) POUT(.10) ITERATE(20) CUT(.5) .
```

/* To look at time trends for OBESE and OVERWEIGHT COMBINED using IOTF grade of obesity */

/* First need to combine overweight and obese, i.e. 1 and 2 */

```
COMPUTE IOTFgrade3 = -1 .  
IF (IOTFgrade=0) IOTFgrade3 = 0 .  
IF (IOTFgrade=1) IOTFgrade3 = 1 .  
IF (IOTFgrade=2) IOTFgrade3 = 1 .  
MISSING VALUES IOTFgrade3 (-1) .  
value labels IOTFgrade3 0 'healthy' 1 'owgt or obese'.  
EXECUTE .
```

/* Then run logistic regression model with IOTFgrade3 as dependent binary variable */
/* and year group as covariate */

```
LOGISTIC REGRESSION IOTFgrade3  
/METHOD = ENTER dat_grp  
/CRITERIA = PIN(.05) POUT(.10) ITERATE(20) CUT(.5) .
```

/* To look at time trends for obese ONLY using IOTF grade of obesity */
/* First need to code obese vs others */

```
COMPUTE IOTFgrade4 = -1 .  
IF (IOTFgrade=0) IOTFgrade4 = 0 .  
IF (IOTFgrade=1) IOTFgrade4 = 0 .  
IF (IOTFgrade=2) IOTFgrade4 = 1 .  
MISSING VALUES IOTFgrade4 (-1) .  
value labels IOTFgrade4 0 'others' 1 'obese'.  
EXECUTE .
```

/* Then run logistic regression model with IOTFgrade4 as dependent binary variable */
/* and year group as covariate */

LOGISTIC REGRESSION IOTFgrade4
/METHOD = ENTER dat_grp
/CRITERIA = PIN(.05) POUT(.10) ITERATE(20) CUT(.5) .

/*Tests of trend for UNDERWEIGHT*/

/* Then run logistic regression model with underwgt as dependent binary variable */
/* and year group as covariate, using underwgt as <2nd centile according to Reilly

LOGISTIC REGRESSION underwgt
/METHOD = ENTER dat_grp
/CRITERIA = PIN(.05) POUT(.10) ITERATE(20) CUT(.5) .

/* To look at time trends for underwgt and very underwgt COMBINED using Taylor SDS cut offs
for underwgt, ie <15th and <5th centile */

/* First need to combine underweight and very underweight, i.e. 1 and 2 */
/* Separate data into SDS<-1.04 ie underweight according to Taylor et al */

COMPUTE underwgt3 = -1 .
IF (SDSBMI >= -1.04) underwgt3 = 0 .
IF (SDSBMI <-1.04) underwgt3 = 1 .
MISSING VALUES underwgt3 (-1) .
value labels underwgt3 0 'not underweight' 1 'underweight or very underwgt'.
EXECUTE .

/* Then run logistic regression model with underwgt3 as dependent binary variable */
/* and year group as covariate */

LOGISTIC REGRESSION underwgt3
/METHOD = ENTER dat_grp
/CRITERIA = PIN(.05) POUT(.10) ITERATE(20) CUT(.5) .

/* To look at time trends for very underwgt ONLY using SDS-based grade of underwgt, Taylor cut
offs */

/* first need code */
/* Separate data into SDS<-1.64 ie very underweight according to Taylor et al

COMPUTE underwgt4 = -1 .
IF (SDSBMI >= -1.64) underwgt4 = 0 .
IF (SDSBMI <-1.64) underwgt4 = 1 .
MISSING VALUES underwgt4 (-1) .
value labels underwgt4 0 'others' 1 'very underwgt'.
EXECUTE .

/* Then run logistic regression model with underwgt4 as dependent binary variable */
/* and year group as covariate */

LOGISTIC REGRESSION underwgt4
/METHOD = ENTER dat_grp
/CRITERIA = PIN(.05) POUT(.10) ITERATE(20) CUT(.5) .

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