UNIVERSITY OF SOUTHAMPTON
FACULTY OF MEDICINE, HEALTH AND LIFE SCIENCES
School of Medicine

Preventing childhood obesity; a school-based intervention trial

CHOPPS

The Christchurch Obesity Prevention Programme in Schools

by

Janet James

Thesis for the degree of Doctor of Philosophy

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<u>ABSTRACT</u>

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CHOPPS:

THE CHRISTCHURCH OBESITY PREVENTION PROGRAMME IN SCHOOLS

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The prevention of childhood obesity has become a national priority and previous school-based obesity prevention interventions have shown limited success. The consumption of sugar-sweetened drinks is a known causative factor of childhood obesity. The aim of this study was to determine if a school based education programme, specifically focused on discouraging the consumption of carbonated drinks could reduce the prevalence of childhood obesity.

The study design was a cluster randomised controlled trial, including 644 children from 6 schools, in 29 classes. Anthropometric measures of height and weight and waist circumference were obtained. Body Mass Index (weight (kg)/(height (m) ^{2})) was converted to standard deviation scores (or z-scores) and to centile values using the 1990 UK growth reference curves. Measurements were taken at baseline, 12 months after completion of the intervention and further longitudinal measurements were taken 3 years post baseline. 3-day drinks diaries were completed at baseline and at 12 months. The intervention was conducted over one school year, including 4 sessions of focused education promoting a healthy diet and discouraging the consumption of carbonated drinks.

At 12 months the consumption of carbonated drinks decreased in the intervention group by 0.6 glasses/3 days and increased in the control group by 0.2 glasses in the control group (mean difference 0.7, 95% CI 0.1 10 1.3). The percentage of overweight children increased in the control group by 7.5% but decreased in the intervention group by 0.2% (mean difference 7.7%, 95% CI 2.2%-13.1%). The prevalence of overweight increased in both the intervention and control group at 3 years and the significance difference seen at 12 months was no longer evident (risk difference 4.6%, 95% CI -4.3%, 13.5%).

The initial results at 12 months suggested that this specific intervention produced a modest reduction in the number of carbonated drinks consumed and there was a reduction in the number of overweight and obese children in the control group. The longitudinal results 2 years following the intervention suggest that the difference in prevalence of overweight seen at 12 months was not sustained at 3 years.

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DECLARATION OF AUTHORSHIP

I, Janet James declare that the thesis entitled

Preventing childhood obesity; a school-based interventional trial
CHOPPS: The Christchurch Obesity Prevention Programme in Schools

and the work presented in the thesis are both my own, and have been generated by me as the result of my own original research. I confirm that:

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James, J. Kerr, D. (2005) Prevention of Childhood Obesity by reducing Soft drinks. International Journal of Obesity 29, S54- S57.

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Date:……………………………………………………………………….

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Chapter 1. Introduction

The original motivation for this thesis developed from a desire to prevent further type 2 diabetes. During clinical practice as a Diabetes Nurse Specialist, the researcher noticed that her patients seemed to be younger and more overweight at diagnosis. On examination of the literature, it became apparent that obesity, one of the main causes of type 2 diabetes was not only increasing in adults but in children too. The background to this thesis will describe the increase in obesity in both adults and children, and the impact of the condition on peoples' lives. It will also discuss the possible causes, and past preventative strategies. Finally, the results from a simple school based education initiative focusing on preventing the consumption of a known causative factor of obesity; carbonated drinks, will be described.

This thesis describes a research journey, which has lasted over a decade. The initial pilot project was commenced in April 2001, and this was closely followed by a randomized controlled trial in September of that same year. The majority of the literature included in the background of this thesis therefore considers work before this time.

1.1 Adult Obesity

Overweight and obesity are recognised as major public health problems, with the prevalence increasing throughout both the developed and developing world.[3] The focus of health has changed dramatically over the last few decades. Historically infectious diseases and under nutrition were the main concern of global healthcare initiatives. Presently non-communicable diseases such as cardiovascular disease, diabetes, obesity and cancer are now responsible for 40% of all deaths in the developing world and 75% in industrial countries.[4] It has been predicted that chronic diseases will account for almost three quarters of deaths worldwide by 2020. The World Health Organisation has compared the mobilisation and modernisation of today's cultures and societies to an infectious disease, where modern dietary habits and changed physical lifestyles are risk behaviours that are travelling across the globe afflicting many populations. Many of these chronic diseases are preventable and primary intervention which is sustainable and affordable is necessary to combat the increasing epidemic.[5]

1.1.1 The History of Obesity

In today's society, it is easy to assume that the extreme obesity confronting health professionals and public policy makers is the by-product of the 20th century environment and way of life. George Bray reassures his readers in his chapter on the Historical Framework about Obesity, that this condition is as much part of our past as it seems to be in our future.[2] Paleolithic man immortalized obese women, with pendulous breasts and central adiposity, in stone sculptures. The most famous of these is the Venus of Willendorf.

These sculptures have been found all across Europe and date back to between 23, 000 to 25, 000 years ago. Similar shaped terracotta figures from the Neolithic period dating between 8000BC to 5500BC have been found in the area of modern day Turkey.[2] These statues suggest that a well-rounded figure was a desired and acceptable phenomenon. Throughout history perceptions have changed, and at times where food is scarce, being overweight was seen as a sign of prosperity and well-being. [6]

Egyptian art has provided historians with great insight into life in those times. Obese individuals are evident in many of the Egyptian stone reliefs from the time 2500BC to 1500BC. The skinfolds of some mummies have even been measured and have shown that particularly the higher classes were overweight. Obesity is mentioned in many historical medical writings, one example is the cuneiform writings from the Tigris and Euphrates river basins from 2000BC, which describes such cases. Through history many cultures have also tried different treatments. The early Chinese used herbal medicine and acupuncture and most notably in the 3rd century AD, Hua Toh, an ancient Chinese surgeon is said to have used acupuncture to reduce appetite, inserting needles into the pinna of the ear. [2]

It seems that the Romans also enjoyed the good life and obesity is regularly mentioned in the writing of Galen, a leading physician of the time. One of the complications of morbid obesity, sleep apnoea is recorded to have afflicted some of the great leaders of the time. Dionysius, the tyrant of Heracleia of Pontius (360BC) is said to have been woken by his servants using long needles, and another Magas, King of Cyrene (258BC), was said to have been weighed down by his own flesh and choked to death.

The " Father of Medicine", Hippocrates also wrote about the subject and noted the health risks associated with obesity stating; [2]

" Sudden death is more common in those who are naturally fat than in the lean."

Hippocrates also appeared to have an understanding of the causes of obesity and he accepted that diet and exercise were fundamental to resolving the problem, although some his suggestions could be considered controversial;

> "Obese people and those desiring to lose weight should perform hard work before meals. Meals should be taken after exertion and while still panting from fatigue and with no other refreshment before meals except wine, diluted and slightly cold. Their meals should be prepared with a sesame or seasoning and other similar substance and be of a fatty nature as people get thus, satiated with little food. They should, more over, eat only once a day and take no baths and sleep on a hard bed and walk naked as long as possible." [2;3]

Throughout history it seems that individuals of a larger size where recognised as having greater health concerns. This was further confirmed by the life insurance industry in the early 20th century. Data emerged that excessive weight and central adiposity were associated with a shortened life expectancy.[7] How obesity is defined has not always been clear, but as early as 1835 Adolphe Quetelet developed the concept of the average man, using a mathematical equation of weight divided by the square of the statue. This became known as the Quetelet index, which is now also commonly called the Body Mass Index (BMI). [8]

1.1.2 Defining Adult Obesity

The Oxford Dictionary describes obesity as;

> "a condition of being extremely fat or overweight; stoutness, corpulence". [9]

This definition is vague and gives no description of how an individual might be identified as obese. The definition of overweight provides slightly more clarity; as it is defined as;

> "something beyond a specified, allowed, or suitable weight; extra weight; excess of weight."[9]

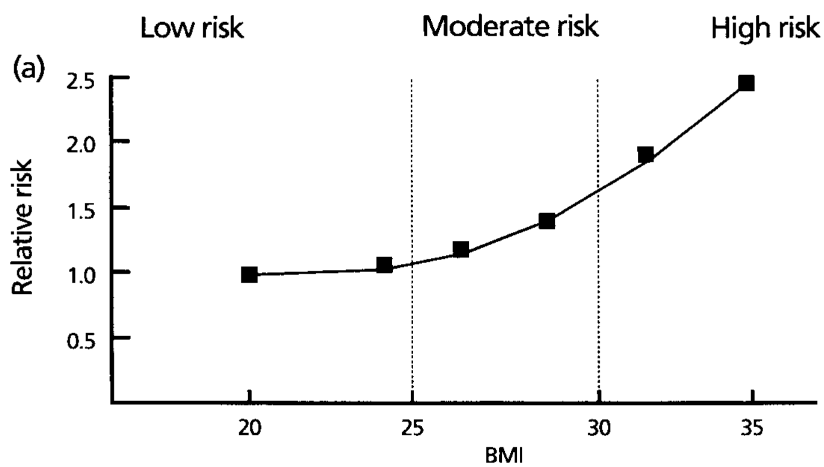
These definitions highlight the difficulties that exist in defining overweight and obesity in both adults and children. Obesity is a condition where excess weight gain endangers life;[10] and for this reason public health definitions are often defined in relation to morbidity and mortality. Overweight is often defined as weight that exceeds either, a criterion standard or reference value.[11] An example of one of the original standards is from the Metropolitan Life Insurance Company (MLIC) tables, which presented ideal weight-for-height standards. These tables were compiled from data obtained from 26 insurance companies from people applying for life insurance between 1935-1954. These standards were based on weight-for-height and were associated with the lowest mortality but not necessarily morbidity. [11]

Historically, overweight was measured using one of two approaches. The first considering weight standards that vary by height. Using this approach tables were developed which showed gender specific weight ranges for each inch of height. The second is the weight-for-height index. [11] The object of the weight-for-height indices is to obtain a measure of body weight that is independent of height. The best known weight-for-height index was first described by the Belgium statistician Adolphe Quetelet in the 19th century. This index was reinvented in the 1950's by Ancel Keys who called it the Body Mass Index (BMI) but it is still very occasionally referred to as the Quetelet index. [11] Body Mass Index (BMI), is calculated as weight in kilograms divided by the square of the height in meters (weight/height^2).

The World Health Organisation (WHO) describes obesity as a condition of excessive body fat which is adversely affecting the health and well being of the individual. The WHO recommended that a uniform definition to define overweight and obesity in adults be adopted internationally.[3] The cut-off points suggested for overweight and obesity are based on observational studies on the relationship between morbidity and mortality and

BMI. Figure 1 demonstrates the relationship between BMI and the risk of mortality, the relative risk is notably steeper from a BMI of 30. [12]

Figure 1. Relationship between BMI and the relative risk of mortality. [12]



The latest WHO recommendations for the classification of overweight and obesity in adults using BMI are show in Table 1.[12] The WHO acknowledges that these values represent a simplistic relationship between BMI and the risk of co-morbidities. The effects of race, diet and physical activity are not accounted for. These studies were mainly conducted with caucasians from Europe and the United States.[13]

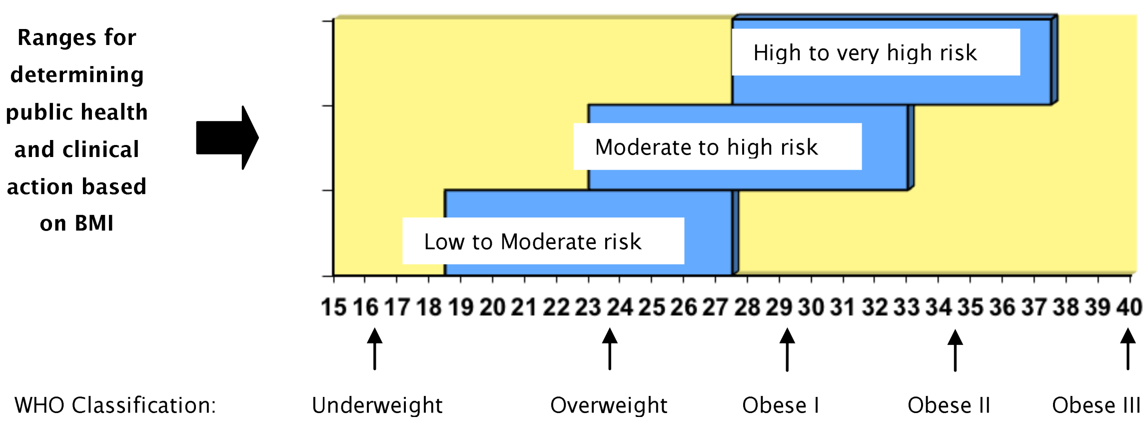
Table 1. WHO classification of adults according to BMI [12] *

Classification	BMI (kg/m^2)	Risk of co-morbidities
Underweight	< 18.50	Low (but increased risk of other clinical problems)
Normal weight	18.50 – 24.99	Average
Overweight	≥ 25.00	
Pre-obese (overweight)	25.00 – 29.99	Increased
Obese class I	30.00 – 34.99	Moderate
Obese class II	35.00 – 39.99	Severe
Obese class III	≥ 40.00	Very severe

* These BMI values are age-independent and the same for both sexes

In 2002, another expert panel from the World Health Organisation met to discuss the validity of the BMI cut-off points for determining overweight and obesity in Asian populations.[14] Body composition analysis confirmed that there are differences in the relationship between BMI and the percentage of body fat across ethnic groups and also within the different Asian populations. Assessment also showed that Asian people have higher risk of developing type 2 diabetes and cardiovascular disease at lower BMIs than the WHO cut-off point for overweight (25 kg/m^2). Unfortunately the panel could not confirm one clear BMI cut-off point for overweight and obesity in all Asians. The cut-off point for risk, varied in different Asian populations between 22kg/m^2 to 25kg/m^2 and for high risk between 26kg/m^2 to 31kg/m^2. The panel decided to highlight potential public health action points (23.0, 27.5, 32.5, and 37.5 kg/m^2) along the continuum of BMI, while maintaining the original BMI cut-off points for overweight and obesity.[14] (Figure 2)

Figure 2. Body-mass index (BMI) cut-off points for public health action in Asians[14]



1.1.3 Measuring Obesity

Obesity can be assessed in different ways. Anthropometry means, “measuring man” and includes basic measurements of the human body, including height, weight, body length, width, circumference and skin-fold thickness. [15] It represents a means of assessing individuals or groups, in a clinical environment or as part of larger epidemiological studies but is by no means a conclusive measurement of exact body composition. [16] Unfortunately there is lack of standardised methodology for some of the measures and well-trained anthropometrists are required to ensure accuracy.[17] Interestingly, observer reliability has been confirmed for large scale epidemiological studies.[18] Reliability is higher for measurements such as height and weight compared to measurements of circumference and skin folds. As expected, intra-observer variability is smaller than inter-observer variability.[18]

Individuals with obesity can have different potential co-morbidities related to the distribution of their body fat. This is commonly termed the “apple” or “pear” phenomenon[19] or android and gynoid fat disturbutions.[12] Those with subcutaneous fat in the gluteofemoral areas and lower abdomen are thought to be at less risk of metabolic complications than those with upper body fat (subcutaneous and visceral).[19] Data from Smith and colleagues show that total body fat is important when considering the metabolic consequence of obesity but that visceral adipose tissue (VAT) and deep subcutaneous abdominal adipose have greater associations with morbidity outcomes when compared to subcutaneous adipose tissue and subcutaneous abdominal adipose tissue.[20] It is important to recognise that there are many different methods of measuring and evaluating obesity, and some of these methods are better at discerning the various types of fat.[19] Visceral fat is best measured directly using dual-energy X-ray absorptiometry, sonography and magnetic resonance imaging although indirect measurements can be obtained through echocardiographic measurement of epicardial fat. Waist circumference is recognised as a crude but simple and effective way of measuring visceral fat, [21] and is highly correlated with VAT measurements in both genders. [20]

1.1.3.1 Traditional measurement methods

1.1.3.1.1 Body Mass Index

The most common anthropometric measurements taken are height and weight. These are used to calculate the aforementioned Body Mass Index (weight/height^2). There are an infinite number of weight-for-height indices and the correlation of each may be influenced by age, body proportion, and lean as well as fat mass. A disadvantage of this measure is that an athletic person may be described as overweight due to excess muscle. [11] Although to date, BMI still provides the most useful population measure of obesity and weight/height^2 has become the most internationally accepted index.[12]

Research suggests that BMI agrees closely with actuarial tables stipulating ideal body weight for height but it is accepted that BMI does not account for frame size, muscle mass or fat distribution, essentially providing a measure of fatness sufficient for epidemiological studies but not representing individuals distribution of obesity.[22] Researchers from Western Australia examined the effectiveness of weight/height, weight/height^2 (body mass index or BMI), and weight/height^3 as a direct measure of fat, in conjunction with associations of subsequent mortality. The study examined cross-sectional data from surveys of 6948 adults (3334 men) and found that weight/height^2 was effective in assessing leanness and obesity in males whereas weight/height was better for this in females. When considering mortality; weight/height^2 and weight/height were similar in males, but weight/height was better in females. The authors suggest an ideal weight/height^2 of 25 kg/m^2 with a range of 22.5-27.5 kg/m^2 as appropriate in men and women; and for women using weight/height, with a measure of 45 kg/m^2 and a range 40-50 kg/m^2.

BMI (weight/height$^{2)}$ still provides the best population measure of obesity and the risks associated with it. While BMI cannot not establish individual body fat distribution, in conjunction with other measures such as waist circumference or skinfold thickness measurements (both discussed further below) more detailed information can be obtained.[12]

1.1.3.1.2 Skinfolds

Skinfolds measure the “folds” of skin; a double thickness of fascia and subcutaneous adipose tissue; using callipers at anatomical sites on the body. Approximately 70-90% of adipose tissue is subcutaneous, and skin fold thickness is a useful predictor of total body fat and body density. [23] Body density, Total Free Fat Mass (FFM) or percent body fat can be calculated from prediction equations using these measurements, the most widely used were developed by Dumin and Womersley.[24] This method is limited as it does not assess intra-abdominal adipose tissue, and the accuracy of the measurements are dependent on strict adherence to the standardised methods.[16] Skinfold thickness can be measured anywhere on the body where a double fold of skin and subcutaneous tissue can be pinched. Triceps and subscapular sites are most commonly used, but the supra-iliac and subscapular sites are also periodically used. Unfortunately the reliability of skinfolds is thought to lessen with increasing thickness and obesity.[15;16]

1.1.3.1.3 Circumferences

Circumferences are useful as they can be measured on any size individual and also give an indication of subcutaneous as well as internal adipose tissue. The most commonly used circumferences include upper arm, chest, waist, hip, mid-thigh and calf.[16] Waist, hip and thigh circumferences are commonly used to predict fat distribution. As previously described many of the co-morbidities associated with obesity are related to the excessive distribution of fat around the abdomen and there is a strong correlation between central adiposity and cardiovascular disease.[25;26] Waist circumference is used in the clinical environment as a predictor of risk factors. Currently there are no accepted cut-off values for the classification of overweight and obesity using waist circumference, although the World Health Organisation suggests that increased risk is present when the waist circumference exceeds 94cm for men and 80cm for women.[12] The waist: hip ratio is also used as an indicator of body fat distribution and is calculated by dividing the waist circumference at its narrowest point, by the widest point of the hip circumference. Values above 0.8 in women and 0.9 in men are thought to be indicative of increased health risk. [15] The advantage of measuring circumferences over other anthropometric measures such as skinfold thickness relates to confirmed reliably, and that these measures can always be obtained regardless of body size or fatness. [17]

1.1.3.1.4 Demispan

This measurement is useful when height is difficult to accurately measure, and can be done when the individual is seated. It is measured as the distance between the sternal notch and the roots of the middle and third fingers with the arm stretched out at shoulder height to the side of the body. The demispan shows good agreement with BMI, and is calculated by dividing the weight by the square of the demispan.[15]

1.1.3.2 Advanced Measurement Methods

1.1.3.2.1 Hydro-densitometry

Hydrodenitometry is one of the oldest methods for estimating density and body composition. The theory is based on the Archimedean principle that any solid object submerged in water is subject to a buoyant force that is equal to the weight of the water displaced by the object. [16] This assumes there are just two body compartments; fat (density of 0.70g/ml) and free-fat mass (density of 1.0g/ml). If two individuals of the same weight are measured using this method, the person with more body fat will weigh less under water. Using total body density, and the specific densities of fat and fat-free mass, the percentage of body fat can be calculated.[27] This test requires the subject to exhale maximally and be submerged in a large tank of water; it is therefore not suitable for young children or older subjects who lack water confidence.[27]

1.1.3.2.2 Air-displacement plethysmography

Air-displacement plethysmography uses the same theory as hydro-densitometry but air is used rather than water. The body volume is calculated by measuring the air displaced by a body's introduction to a controlled environment.[16] The device used is called a BOD-POD and the subject sits comfortably within the pod while computerised pressure sensors determine the amount of air displaced by the person's body, the process takes less than five seconds. It is more practical for large studies and use with young subjects. Studies suggest that there is good agreement between percent fat estimates achieved with the BOD POD and Dual- Energy X-ray Absorptiometry (DEXA). [15] The device is said to be transportable but weighs over 130kg.[16]

1.1.3.2.3 Magnetic Resonance Imaging (MRI)

Magnetic resonance imaging uses interaction between the hydrogen nuclei found in all biological tissue, and magnetic fields generated by the MRI system to produce images. These images provide views of adipose tissue and non-fat tissue. With this technology total body fat volume, total fat mass and percentage of body fat can be estimated. This technology is expensive and requires subject co-operation as it takes more than 20 minutes to complete.[16;27]

1.1.3.2.4 Computerized Tomography (CT)

CT scan produces high-resolution images using X-Ray. Small deposits of adipose tissue can be identified; and total, regional and percentage of body fat can be calculated. The limitations of CT are that it is expensive, and require subject cooperation. The radiation exposure makes this form of technology less suitable for research participants.[27]

1.1.3.2.5 Dual- Energy X-ray Absorptiometry (DEXA)

Dual- Energy X-ray Absorptiometry (DEXA) is based on the attenuation of two x-ray beams as the various tissues of the body absorb them.[16] Unfortunately DEXA cannot distinguish between intra-abdominal and subcutaneous fat but has a high correlation with CT in determining total fat mass. The DEXA emits lower levels of radiation than CT but requires subject co-operation and can take up to 20 minutes to complete. It is also expensive and is usually housed in a major medical facility, although it can be portable but requires skilled technicians. [27] In addition, this form of technology has practical limitations in its use with obese patients, as many obese individuals are just too wide for the scan field, and the manufacturers do not recommend its use in people who weigh more than 100kg

1.1.3.2.6 Bioelectrical Impedance Analysis (BIA)

Bioimpedance analysis is based on the concept that tissue rich in water and electrolytes is more resistant to the passage of electrical current than adipose tissue. Equations measure the free fat from the measured impedance by subtraction of the fat mass. This method is inexpensive, non invasive and has a high reliability rate, although measurements may vary with hydration status and ethnic origin. [27]

1.1.4 Prevalence of Adult Obesity

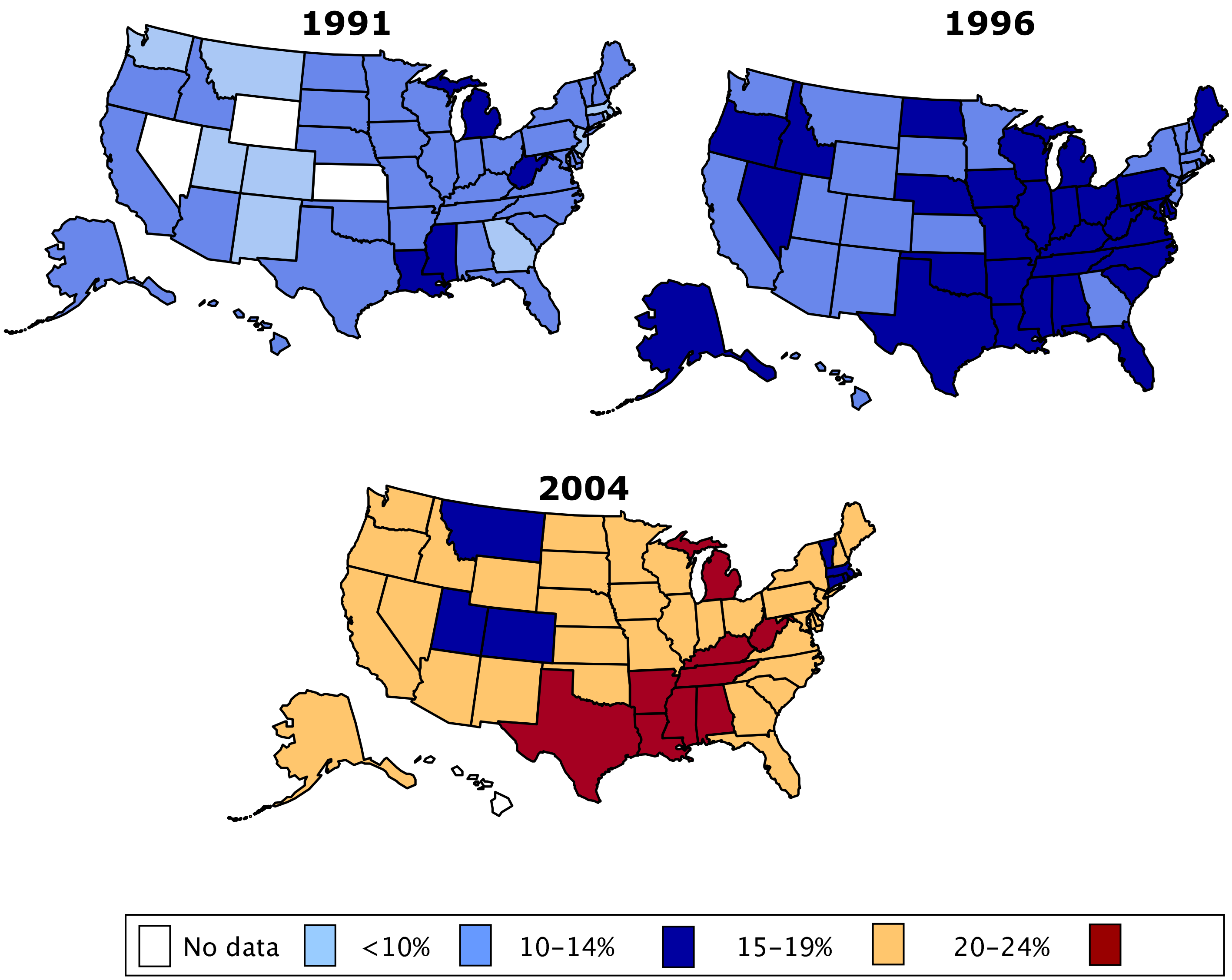
1.1.4.1 Worldwide

The global picture of obesity shows a dramatic increase in prevalence of the problem over the last few decades, with obesity reaching epidemic proportions internationally, in both industrialised and developing countries.[4] In 1999 the global prevalence of obesity exceeded 250 million, accounting for 7% of the worlds' adult population. The International Obesity Task Force (IOTF) has predicted that if the rate of increase of obesity continues at its current level, the prevalence will have doubled by 2025, although this is thought to be a very conservative estimate. [4]

In the United States, obesity has increased in every state, across all genders, racial groups and educational levels. Between 1991 and 1998 the prevalence (defined as BMI$\geq$30kg/m^2) increased from 12% to 17.9%.[28] At the end of the 1990's more than 56% of the population was overweight (defined as BMI$\geq$25kg/m^2)' with almost 1 in 5 obese.[29] Figure 3 demonstrates the increasing prevalence of obesity across the United States of America.[30] The data is collected yearly by each State through monthly telephone interviews. Each person is asked a variety of questions; including two about their weight in light clothes and height without shoes. This data may underestimate the actual prevalence of the problem, as previous research suggests that many participants under report weight and some may even over report height. [31;32]

Most large reference studies use BMI to indicate overweight and obesity, but recently different methods, in particular waist circumference have also been used. Ford and colleagues used data from the NHANES III (1988 to 1994) and NHANES (1999 to 2000) to assess changes in waist circumference in the American population. These authors felt that waist circumference provided a better indicator of potential risks such as cardiovascular disease, the metabolic syndrome, type 2 diabetes and all cause mortality. Over the period between these two surveys, age-adjusted mean waist circumference increased by 3cm in men and 3.2cm in women. Large increases were seen in white men and African-American women, with the greatest increase in high-risk waist circumference in men and women aged between 20 to 39 years old.[33] These trends in younger adults have been replicated in other surveys and cause concern for the future well-being of these generations of obese young adults.[34]

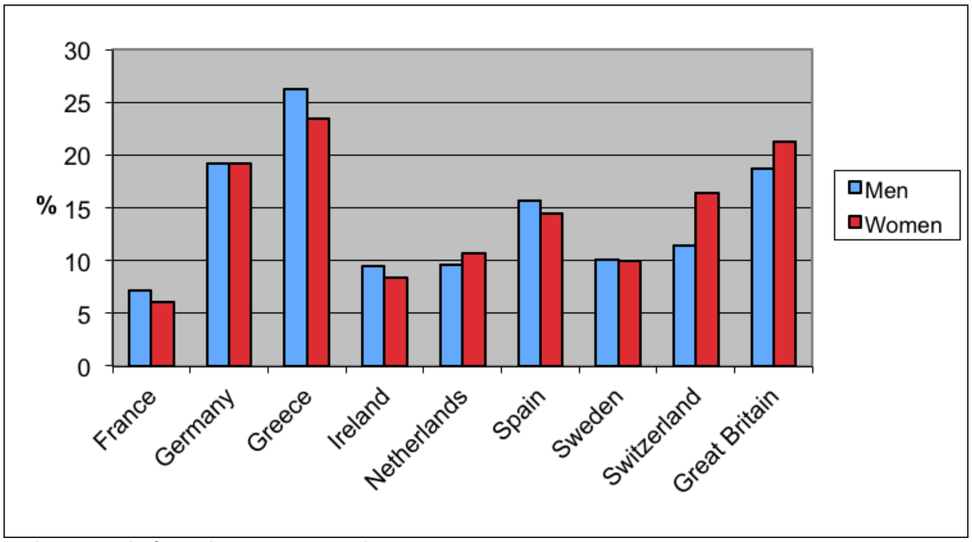
Figure 3. Trends of Adult obesity* across the United States of America [30]



*obesity defined as BMI$\geq$30kg/m^2

The EURALIM project was established as a European collaboration to collate data across Europe for international comparison of risk factors. Not surprisingly marked variations were found across the continent and represented the different social and cultural environments, which have an impact on overweight and obesity. In general, the European prevalence of overweight for women was found to be 43% and 57% for men, with a consistent trend of increasing overweight and obesity.[35] The World Health Report for 2002 states that Europe, compared with all other WHO regions, has the highest average BMI of nearly 26.5kg/m^2, with 400 million adults estimated as overweight and 130 million thought to be obese. Figure 4 represents data taken for the WHO global InfoBase from 2002 representing the prevalence of overweight and obesity in adults for rural and urban populations across a number of European countries.[36] This graph demonstrates the variations of obesity across the continent, showing that countries in close geographical proximity to each other may have considerable differences in the proportions of their populations that are obese.

Figure 4. Prevalence of obesity* across 9 different European Countries.[36]



*obesity defined as BMI≥30kg/m^2

The problem of obesity is also very noticeable in Latin America, where 68% of the population of Peru are overweight. There are also large variations within this continent, with 35% of the Brazilian population overweight compared to 60% of the Argentinean population. Overall the trends all demonstrate an increase in BMI. [37]

Until recently the problem of overweight and obesity was relatively uncommon in South East Asia. Recent data from China suggests that 14.7% of the population are overweight and 2.6% are obese. Considering the size of China's population this accounts for one fifth of the world's overweight population.[38] This problem may be compounded further in the future, as China still has one million more births than deaths every five weeks, even with the implementation of the one child policy.[39] Of further concern is the cut-off points for overweight, which are derived from white populations and research has shown that Chinese adults are more susceptible to risk factors at lower weights and that the optimal BMI for Chinese adults is between 18.5- 23.9kg/m^2. Using these cut-off point 17.6% of Chinese adult are overweight and 5.6% are obese. [38]

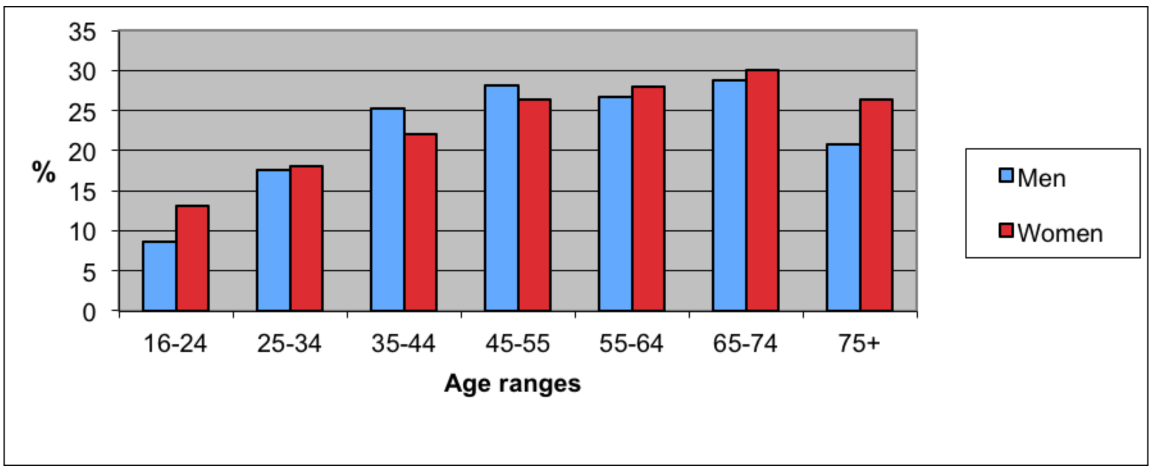
The prevalence of obesity worldwide is changing and historically it was a condition that mainly affected developed countries, with an inverse association between level of education and BMI. [4] In some parts of the developing world, an improvement in the economic status has caused a resultant shift in BMI, towards overweight. In countries with diverse communities, underweight and overweight can coexist, resulting in a double burden of disease and a rural/urban divide is also common with obesity evident in urban communities. Worldwide there are higher percentages of female obesity, but higher proportions of male overweight.[39] Before 1989 the evidence suggested that obesity in the developing world would be confined to the social elite. [39] More recent evidence suggests that this is not the case and that the prevalence of the problem is increasing in the middle and low socioeconomic groups too. The increases seem to be apparent in countries where the shift in the country's gross national product is increasing, and the effects of this shift are tending to impact more on women than man regarding the development of overweight and obesity. This research has highlighted that obesity is not solely a problem confined to the industrialised or Western world and that effective preventive measures are required for all communities. [39]

1.1.4.2 United Kingdom

Currently one in five adults in the United Kingdom are obese. In 1980, eight percent of women and six percent of men were obese (obesity defined as $BMI \geq 30kg/m^2$) but by 1998, 21% of women and 17% of men were obese.[10] The Health survey for England has been conducted annually from 1991 using interviews and nurse visits to assess the health and health-related behaviours of the general population.[40] This survey has shown that the average weight of adults in the United Kingdom has increased. In 1993, the average man weighed 78.9kg and this increased to 83.2kg in 2004, for women the increase was from 66.6kg to 70.0kg. Over the same time period the proportion of the population that fell within the ideal or desirable BMI range of 20-25 kg/m^2 dropped in men from 37.8% to 27.2% and 44.3% to 35.8% in women. Overall the survey did not demonstrate a significant increase in the prevalence of overweight but showed very significant changes in the numbers of obese individuals. Obesity increased over the 11-year period in men from 13.2% to 23.6% and from 16.4% to 23.8% in women.[40] These results confirm a 3-fold increase in the problem since the 1980's. In the late 1980's the prevalence of overweight in the United Kingdom was considered to be one of the lowest in Europe but by the late 1990's, the United Kingdom had one of the highest rates. [10]

As with most countries, gender, ethnicity and social class influence the risk of overweight and obesity in the United Kingdom. Women particularly, in the lower social classes are more at risk of becoming obese. There is also a higher prevalence amongst certain ethnic groups, in particular amongst the Black Caribbean and Pakistani women. Notably the problem of obesity increases with age. Variations between areas also exist, although all regions demonstrate a trend of increasing BMI.[41] Figure 5 demonstrates the prevalence of obesity in men and women in 2004 in the United Kingdom according to various age ranges.[36;40]

Figure 5. Prevalence of obesity* in 2004 in the United Kingdom according to age group.[36;40]



*obesity defined as BMI≥30kg/m^2

1.1.5 Health Risks

1.5.1.1 Health Cost implications

Currently in the United Kingdom 1 in 5 adults are obese with nearly two thirds of men and more than half of all women overweight. This has enormous human and financial costs. [10]

The human cost of obesity is well documented with research describing a variety of health complications. In an effort to establish the individual effect of obesity, researchers from the United States quantified the effect in years of life lost (YLL); this is the difference between the numbers of years a person would be expected to live if he/she were not obese versus the number of years if the person is obese.[42] This study found marked differences in the effect of obesity on both race and gender. Amongst whites there is a J-shaped association between increasing obesity and YLL. For a white young male, aged twenty to thirty with a BMI >45 kg/m^2 the maximum YLL is thirteen, representing a seventeen percent reduction in total life expectancy, white young women in the same age group and BMI range had eight YLL. Amongst blacks, obesity does not decrease life expectancy until a BMI of 32 kg/m^2 for men and 37 kg/m^2 for women, with twenty YLL's for young black males. The authors cite variations in socioeconomic status amongst other variables that may affect the mortality of different races. Interestingly, this study found that the optimal BMI, associated with the least YLL for whites was between 23 kg/m^2 - 25 kg/m^2, and blacks 23 - 30kg/m^2.[42] This study has great clinical value, as health care workers can now really convey the magnitude of the effect of the patient's obesity.

Another study has examined the data from the Framingham Heart Study from 1948 to 1990, analysing the reduction in life expectancy associated with overweight and obesity at 40 years of age. This study does not describe the effect of race on obesity and mortality but does look at the effect of smoking. Adults found to be obese at age 40 lived 6-7 years less than a normal weight person. Overweight, non-smoking adults lived 3 years less. The most profound loss of years of life was found amongst obese smoking individuals who lived 13 -14 years less than non-smoking, normal weight people.[43]

The financial costs of obesity, estimated in the year 2000 in the United Kingdom were summarised in a National Audit Office report and are listed in Table 2.[10] In the United States, for all deaths during 1991, 280 000 were attributed to obesity, making obesity a major cause of mortality.[44] Another American study found that the financial cost estimates associated with increasing obesity are very similar to those attributed to smoking levels, which historically has always been seen as the primary modifiable risk factor for morbidity and mortality.[45] This study which used data from the Third National Health and Nutrition Examination Survey, the Framingham Heart Study and other secondary sources found that the additional cost of obesity and its associated complications amounted to an estimated difference of $10 000 (medical costs from the late 1990's) for a moderately obese middle aged man.[45]

Table 2. Cost of Obesity in the United Kingdom[10]

Estimated Human cost	Estimated Financial cost
18 million sick days a year	£ ½ billion a year in treatment cost to the NHS
30 000 deaths a year	Possibly £2 billion a year impact on the economy
Deaths linked to obesity shorten lives on average by 9 years	40 000 lost years of working life

Obesity is associated with a number of co-morbidities. [46] Historically, the four most common problems included heart disease, type 2 diabetes, hypertension and osteoarthritis. Further research has worryingly confirmed the association between obesity and cancer, with 14 percent of all deaths from cancer in men and 20 percent in women related to obesity.[47] Obesity leads not only to single conditions but may also lead to a clustering of complications, resulting in conditions such as the metabolic syndrome. [48]

1.1.5.2 Hypertension

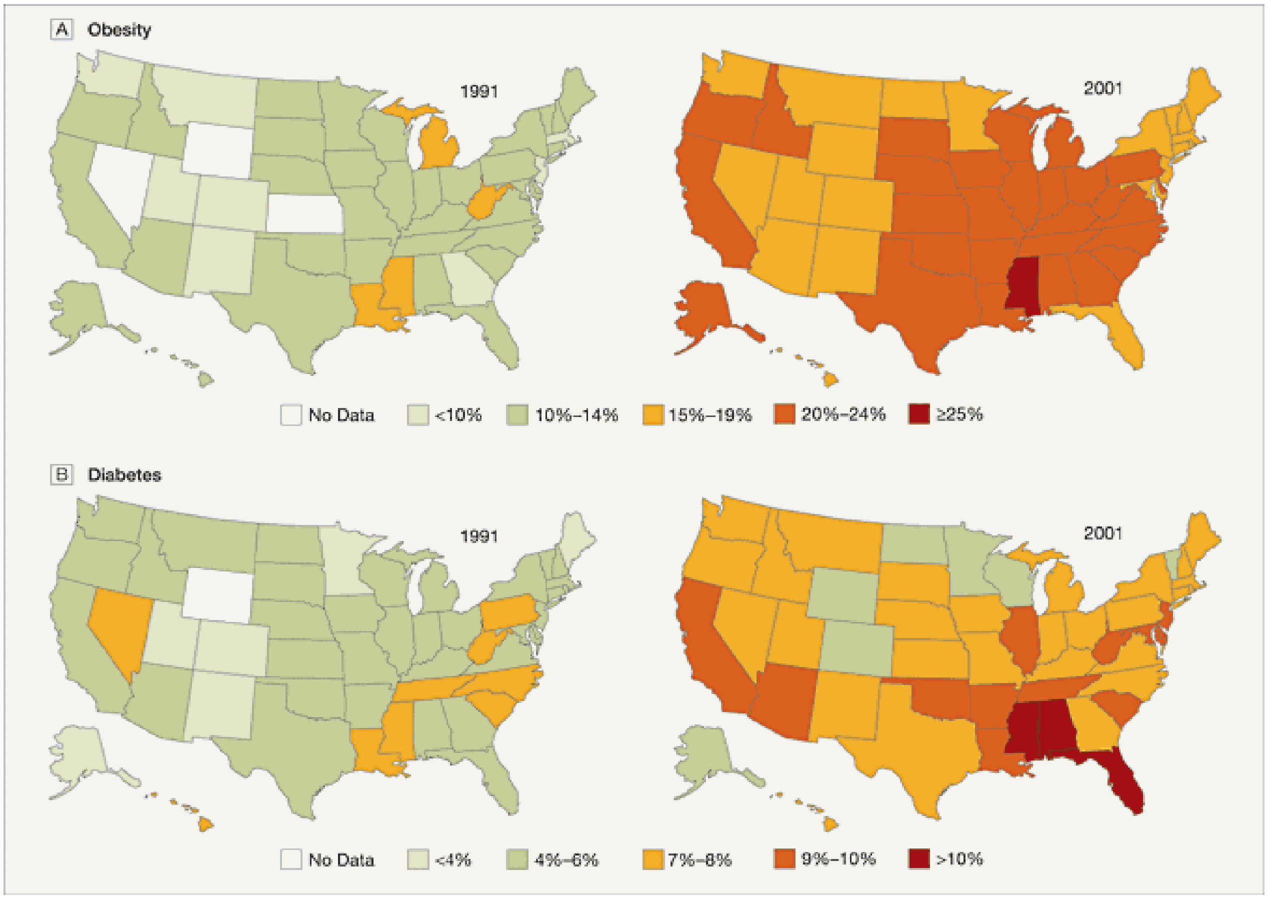
There is a strong association between hypertension and increasing overweight.[46] Two large American studies have shown that with increasing obesity, the risk of hypertension increases. The first study incorporated a dynamic model, which assesses the relationship between obesity and its risk factors. The data used was from; the Third National Health and Nutrition Examination survey, the Framingham heart study and other secondary sources. The study concluded that the risk of hypertension is 40-60% higher in an overweight person compared to a non-obese person. This increases even further with increasing obesity, with a 2-fold risk for a person with a BMI≥32, and a 3-fold risk for a person with a BMI≥37.5. [45] Mokdad and colleagues[49] conducted a random-digit telephone survey of nearly 200 000 adults, using self reported data of weight, height, diabetes and hypertension. This survey found that obese individuals with a BMI of greater than 40kg/m^2 had a 6-fold increased risk of developing hypertension. These researchers felt that their results represented an under-reporting of the exact potential, as it is well documented that many individuals over report actual height and under report weight.

1.1.5.3 Diabetes

The prevalence of obesity is increasing at an alarming rate and is associated with a concurrent increase in diabetes. Figure 6, demonstrates the increasing prevalence of obesity and diabetes over the 10 year period from 1991 to 2001 across the Unites States of Amercia.[50] Recent data from 2002 suggests that 6.3% of the American population, accounting for 18.2 million people, have diabetes. Of the 18.2 million people, 5.2 million are unaware of this condition.[50] According to Diabetes UK two million people in the United Kingdom have diabetes and an estimated further one million have the condition but are unaware of their diagnosis. [51]

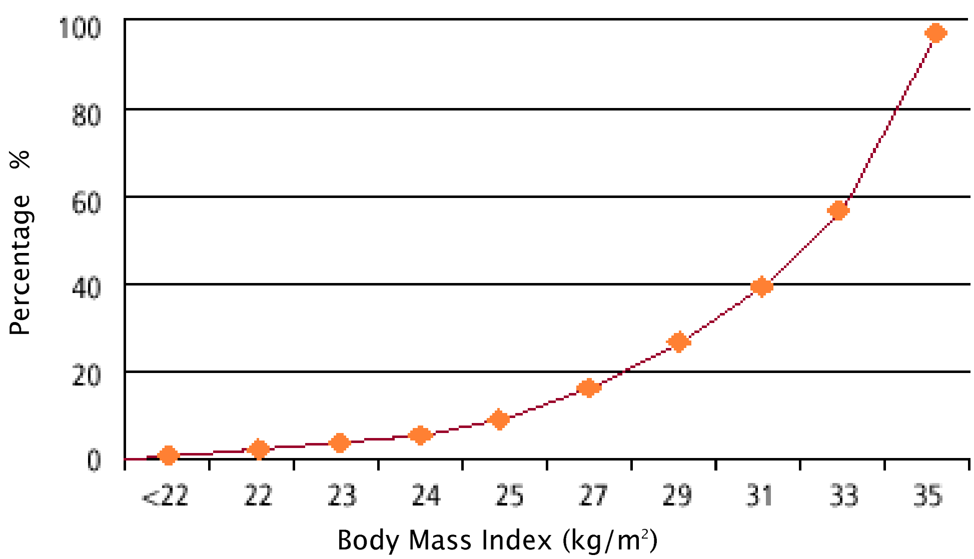
A number of researchers have assessed the link between obesity and diabetes. The same random-digit telephone survey that established an association between obesity and hypertension also looked at obesity and diabetes. Mokdad and colleagues found that severely obese individuals, with a BMI greater than 40 kg/m^2, were 7-fold more likely to develop diabetes.[49] Data taken from the Third National Health and Nutrition Examination Survey (NHANES III) suggests that the risk of developing diabetes is significantly higher in the younger age groups, with a risk ratio of 18.1 (95%CI, 6.7- 46.8) in very obese young men, compared to 3.4 (95% CI 1.1-8.3) in older obese men.[46] Another study also using data from the NHANES survey has found that for every kilogram of increase in weight, the risk for diabetes increases by 4.5%. These researchers found no difference in risk associated with age, gender or race, but that the population relative risk was 27% for increases in weight of 5kg or more.[52] Colditz and colleagues confirmed the association of increasing risk of diabetes with increasing BMI following a large prospective cohort study of female nurses aged between 30 and 55 years (Figure 7).[53] The results of the above studies may vary in the effects of race, gender and age but all find a very strong association between obesity and diabetes, both preventable conditions.

Figure 6. Prevalence of obesity and diabetes amongst United States adults, 1991-2001.[49]



Modest weight loss (5% of original body weight) can also prevent the development of new diabetes in high-risk overweight or obese individuals. A number of studies have achieved results using lifestyle dietary and activity modifications.[54;55] The Finnish Diabetes Prevention study had very modest weight losses of 5% of original body weight and subsequently prevented diabetes by 58%. This study included high-risk overweight individuals with impaired glucose tolerance. Subjects in the intervention group received individualised additional support regarding weight loss, focusing on reduced fat intake, increased fiber and increased physical activity.[54;55] The Swedish SOS study, which had more significant weight losses (16% of original body weight) due to gastric surgery, demonstrated a 5-fold decrease in the cumulative risk of developing diabetes for 8 years.[56]

Figure 7. Relative risk of diabetes by Body Mass Index.[53]



1.1.5.4 Cardiovascular Disease

Obesity is an important risk factor for coronary heart disease, ventricular dysfunction, congestive heart failure, stroke and cardiac arrhythmias.[46;57] Weight loss has been shown to reduce many of the associated risk factors; such as diabetes, hypertension, dyslipidaemia and insulin resistance.[58] Left ventricular mass is another known risk factors. As part of the Framingham heart study, 3922 healthy subjects underwent echocardiograms. Measurements from these tests found that Body Mass Index was associated with left ventricular mass, especially in subjects with a BMI > 30kg/m^2, even after controlling for age and blood pressure.[59] In another branch of the Framingham Heart study the association between heart failure and BMI was examined. A cohort of 5881 subjects was followed for 15 years. When compared with normal subjects, obese individuals had a doubling of risk for heart failure. There was an increase in risk for heart failure of 5% for men and 7% for women for each incremental increase in BMI of 1kg/m^2.[60] Added to this, further research suggests that the prevalence of high cholesterol and raised triglycerides increases with BMI.[61] A large number of women aged 30 to 55, took part in the Nurses' Health Study. One of the findings from this cohort after 16 years follow-up was the association of stroke, in particular ischemic stroke, with BMI. This study found that women with a BMI > 32 kg/m^2 had a 137% increased risk of an ischemic stroke, compared to women with a BMI < 21kg/m^2.[62] Interestingly, there was no association between BMI and hemorrhagic stroke.

1.1.5.5 Cancer

Obesity is also associated with an increased risk of cancer.[63, 64, 65] A number of large studies have examined the association between BMI and a variety of different cancers. In Canada, Sai Pan and colleagues conducted a population-based study of 21022 incident cases and 19 types of cancer. This study was completed over 5 years and included individuals aged between 20 and 76 years. Men and women with a BMI greater than 30kg/m^2 had a significantly increased risk of developing cancer. Overweight and obesity accounted for 7.7% of all cancers. For some specific cancers the risk of being overweight and obese was an even greater risk; with an 11% increase of non-Hodgkin's lymphoma, 18% increased risk of leukaemia, 41% increased risk of cancers of the kidney, 24% increased risk of colon cancer and for post-menopausal women an increased risk of 13% of breast cancer. No relationship was found between overweight or obesity and the risk of cancers of the brain, liver, bone/cartilage, testicular cancer in men or pre-menopausal breast cancer, bladder, stomach and salivary glands in women.[66] A similar study was completed in an American cohort of more than 900 000 adults who were free from cancer at the beginning of the study and were followed for 16 years. This study found congruous results to the Canadian study; showing overweight and obesity were associated with an increased risk of developing particular cancers, including those affecting the oesophagus, colon, rectum, liver, gallbladder, pancreas, kidney and for deaths due to non-Hodgkin's lymphoma and multiple myeloma. In men, more deaths were seen from cancers of the stomach and prostate and in women, from the breast, ovary, uterus and cervix. The authors of this research showed that overweight and obesity accounted for 14% of all deaths from cancer in men and 20% of those in women.[47] Both of these studies have confirmed the very serious risk of obesity on cancer risk.

1.1.5.6 Respiratory difficulties

Obesity is insidious, and its effects are widespread even affecting the respiratory system. Obstructive Sleep Apnoea Syndrome (OSAS) is characterised by episodes of pharyngeal closure during sleep, and is most common in middle-aged obese men. Obesity can influence the structure and function of skeletal muscles and some research suggests that sleep apnoea may be caused by differences in the genioglossus, an important pharyngeal muscle.[67] Other researchers feel that clear-cut anatomical differences are not the only cause of sleep apnoea. Vgontzas and colleagues debate that sleep apnoea is a manifestation of the metabolic syndrome and have conducted research showing elevated leptin and insulin plasma levels independent of BMI in sleep apnoeic patients.[68] The debate continues but there is a clear association between obesity and OSAS, a syndrome with a high morbidity and mortality.

A large Norwegian study examined the association between obesity and asthma. The research included over 135 000 men and women who were followed-up for an average of 21 years. The researchers concluded that the risk of asthma increases steadily from a BMI of 20kg/m^2 in men and 22 kg/m^2 in women. The risk of asthma in men increased by 10% for each unit of increased BMI between 25 kg/m^2 and 30 kg/m^2. Even when adjustments were made for smoking, education and physical activity; overweight and obese individuals reported asthma significantly more than thinner individuals.[69]

1.1.5.7 Digestive Complications

The relationship between obesity and hiatus hernia was confirmed after a retrospective case control study of 1389 adults. Overweight patients had an increased risk of developing a hiatus hernia, with the significant increase in risk with each increasing level of BMI. There was also a significant association between BMI and oesophagitis. This problem was found to be more common in the overweight white population than amongst overweight blacks.[70] Obesity has also been found to be an independent risk factor for the development of Gastro-oesophageal reflux disease (GERD).[71] This condition is associated with increased morbidity and mortality due to an association with oesophageal carcinoma.[71]

1.1.5.8 Osteoarthritis and Fracture Risk

Osteoarthritis or degenerative joint disease is the most common form of arthritis in the elderly and results in reduced mobility and pain. A number of studies have confirmed the relationship between increasing BMI and the risk of developing osteoarthritis.[72; 73]
This association is not only limited to osteoarthritis in the knee but there is a definite although less strong correlation between overweight and osteoarthritis affecting the carpometacarpel; distal interphalangeal and proximal interphalangeal.[72] Being overweight is also thought to accelerate the progression of the disease in the knee. Felson and colleagues suggest that although there is limited evidence, early data suggests that weight loss, even in small amounts can have favourable effects of osteoarthritis especially where it is evident in the knee.

In contrast to the effect of BMI on osteoarthritis, there is an increased risk of fracture with weight loss. A study of 2413 men aged 67 or older who were followed for eight years, found that a weight gain of 10% or more after the age of 50 was protective against hip fractures, whereas a weight loss or 10% or more suggested a significant increased risk.[74] Similar findings where confirmed in women, following a study of 9516 women aged 65 years or older. Weight gain after the age of 25 and especially maintaining body weight amongst other things was found to be protective.[75] Rarely does weight gain have any benefits, but it does seem to be beneficial in preventing fractures.

1.1.5.9 Skin complications

Individuals with obesity may also suffer with dermatological complications. One such complication, acanthosis nigricans, is characterised by hyperpigmented skin with velvety plaques of body folds; most commonly seen in the neck area but also found in the folds of the knuckles; on elbows; knees; armpits; the soles of the feet; inner thighs (groin area) and in skin folds of the abdomen.[76] Researchers have found that 74% of obese adults have this condition, although the prevalence is higher amongst black obese patients. The researchers also confirmed that acanthosis nigricans is a reliable cutaneous marker for hyperinsulinemia, and may be used as a screening tool for high insulin levels.[77] Other endocrine conditions with resultant dermatological complications, include; diabetes (skin tags), hyperandrogenism (acne and hirsutism), hypothyroidism (dry skin, brittle nails and myxedema) and Prader Willi syndrome (lymphedema and cellulitis).[78]

Obese individuals also often develop striae, related to skin stretching. These occur perpendicular to the direction of tension, often on the breasts, buttocks, lateral abdomen and thighs. Worryingly, 50% of obese people are estimated to have cutaneous infections. The most serious of these being necrotizing fasciitis and gas gangrene. Less serious conditions mainly found in the skin folds include candidiasis, candida folliculitis, furunculosis, erythrasma, tinea cruris and folliculitis. [78]

1.1.5.10 Fertility

Pre-menopausal women, with excessive weight are at an increased risk of amenorrhoea, and menstrual irregularity, with resultant fertility problems.[63] Polycystic ovarian (PCO) syndrome is closely associated with abdominal obesity, although some research suggests that there is no significant difference in the clinical and hormonal characteristics of obese and non-obese women with PCO syndrome.[79] Mitchell and colleagues describe how the physiological mechanisms that control energy balance, regulate appetite and metabolism are related to those which govern fertility, in particular leptin which is produced by the adipose tissue.[80] Leptin regulates the gonadotrophine surge which initiates the onset of puberty, and evidence has shown that the age of menarche is younger in obese girls and also that menopause occurs at a younger age in obese women. Obese girls are more likely to have menstrual irregularities. [81]

A simple weight loss programme was conducted amongst a group of obese women who were having difficulty conceiving. Women completing the programme were compared against those who did not. Amongst the completers, 60 of the 67 anovulatory subjects resumed ovulation, with 45 live births. The miscarriage rate was also lower amongst this group of women.[82] The effect of BMI and infertility is not only restricted to women. A Danish study including 1558 men confirmed that men with an ideal BMI of between 20-25 kg/m^2 had better sperm concentrations and sperm counts than man that were considered to be underweight or overweight.[83] These studies suggest that there is an association between obesity and fertility and highlight that a percentage of sub-fertility problems may be preventable or reversible.

1.1.5.11 Psychosocial effects

The psychosocial effects of obesity are often forgotten but can have an enormous impact on the individual's life including social stigmatisation, binge eating, psychopathology and body image problems.[63] Some studies even suggest that being obese can affect a person's progression through life, resulting in discrimination in employment opportunities and even reduced earnings.[84] Women appear to be more sensitive than men regarding their weight and health, and one study has found that overweight and obese women rate their overall health more negatively than do non-overweight women.[85] The relationship between obesity and depression has also been examined using data from the Third National Health and Nutrition Examination survey. This data included 8773 people between the ages of 15 and 39 years who had randomly been selected for structured psychiatric interviews. The results showed that obese individuals had a higher prevalence of depression than their normal weight counterparts, with the prevalence of depression highest amongst the most severely obese individuals (BMI > 40 kg/m^2). [86]

1.1.5.12 Dementia

The western population is living longer and it has been suggested that the incidence of dementia will increase by 400% in the next 20 years. Any relationship between dementia and obesity has been difficult to study, as there is a normal reduction in appetite and subsequent weight loss prior to the onset of this condition in elderly patients. One study has examined this association using longitudinal data from a group of 10 276 men and women between 1964 and 2003. Individuals with a BMI greater than 30 kg/m^2 were found to have a 74% increased risk of dementia while those with a BMI greater than 25 kg/m^2 had a 35% increase risk of the condition. The authors cannot fully explain the mechanism of this relationship but cite other studies that describe possible links between obesity and neural degradation following studies with obese rats. They also call for further research examining cytokines produced in adipose cells and any effects on neural functioning.[85]

Obesity is a chronic disease, which can lead to many associated conditions and cause an untimely death. This condition is not selective and is insidious in its ability to affect so many organs. In most cases obesity is preventable, if not reversible and research is essential to find ways of halting the continuing epidemic.

1.1.6 Aetiology of obesity

"genetics load the gun, but the environment pulls the trigger"

George Bray, 1996 [87]

1.1.6.1 Energy balance and the environment

Obesity is a chronic disease with a number of interlinking and complex causes.[63] Three main factors are known to contribute to its cause, including; metabolic factors, dietary intake and physical activity. Genetic traits are also known to influence each of these factors.[88] Humans, just like other mammals obey the physical laws of thermodynamics thereby ensuring energy balance. Obesity should only develop when the intake of food exceeds the energy expenditure or metabolic rate.[89]

Energy expenditure is divided into three components, including energy that is expended:

: during rest – Resting Energy Expenditure (REE)

: due to the thermal effect of food

: or through any physical activity.[88]

Resting Energy Expenditure (REE) is described as the energy expended during a period of rest 8 to 12 hours after a meal in a thermoneutral environment, and this constitutes 60% of all energy expenditure and is dependent on body mass, therefore an obese person will have a higher REE due to their body size.[88] A number of studies conducted on adults[88], children[90] and Pima Indians[91] have failed to show that variations in REE can have a significant impact on weight gain. Conversely, activity related energy expenditure, which accounts for 30% of all daily energy expenditure has been shown to have an effect, with reduced amounts resulting in a predisposition for obesity. [92;93]

The human body is programmed to conserve energy, seeking foods in times of need and storing energy at times of plenty. Throughout evolution the homeostatic system controlling energy balance has been programmed towards weight gain and storage of food.[94] Lean individuals are able to store 2-3 months of their energy needs in adipose tissue, while some obese individuals carry over a years worth of their actual energy needs.[89] Animal studies have demonstrated the ability of rats to internally regulate their food intake. Following periods of being force-fed these animals will reduce their own intake to bring their body weight back to normal levels. The same is true following periods of starvation, once food is freely available again, the rats will consume more to increase their body weight back to normal levels.[95] In nature the ability to internally regulate is regularly seen in birds and mammals. Migrating birds gain weight prior to migration, and animals that hibernate gain weight over spring and summer, losing this additional weight in the winter.

Animals in their natural environment are able to regulate their body weight, why then are humans not able to do the same? Blundell and Gillett [95] feel that the regulation of weight gain in humans is asymmetrical and allows for a positive energy balance resulting in weight gain. They feel there is a strong resistance to a negative energy balance, which could result in weight loss. In their opinion the body lacks a robust negative feedback system to respond to a positive energy balance and the internal signals from the post-ingestive process and energy stores are not strong enough.[95]

1.1.6.1.1 Environmental Influences

The modern day environment and lifestyle have been termed obesigenic (obesity promoting).[96] Swinburn and Egger describe how the modern environment of easy living, with high-energy dense fast foods and inactivity, make unhealthy choices easy.[96] The recent rapid increase in obesity has occurred in too short a time period to be related to genetic changes and the most likely causes relate to environmental and lifestyle influences brought about through changes in the industrialised world.[10] These main changes have affected accessibility to food, transport and have made peoples' lives more sedentary. Some studies focusing on migration have shown an increase in average body weight in individuals who have moved from a traditional to a westernised environment.[63] Increasing portion sizes and aggressive marketing have resulted in an environment, which promotes obesity.[96] The social environment is in conflict with the food marketing industry, as it is socially unacceptable to be obese. Woman's magazines and the press portray images of the ideal body shape, with celebrities striving to be a desirable "size 0".[97] This social environment creates additional stresses, and being obese often results in low self-esteem and guilt and for some individuals this exacerbates the cycle and results in binge or comfort eating.[95]

1.1.6.1.2 Dietary influences

The current western environment includes an abundance of palatable, relatively inexpensive, energy dense foods, juxtaposed against an environment with excessive exposure to multimedia and persuasive advertising.[63] One of the most notable environmental changes over the last few decades has been food availability and portion size. There is a trend for increased consumption of food outside the home environment; and these foods tend to be highly calorific.[63] The Unites States is renowned for fast food restaurants offering larger than normal portions, and "super sizing " has become commonplace, with the larger meals advertised as being better value for money. [98]The fast food industry has become an international success with one fast food chain claiming to have 30 000 restaurants in 119 countries, serving an average of 47 million customers each day. [99]

The advent of the increasing obesity epidemic has lead to copious best seller diet books all promising rapid weight loss and any would-be dieter is confronted with a vast array of choice.[100] Some of the diet literature calls for drastic changes resulting in the exclusion of one food group from the diet, for example; *Sugar Buster*[101] or the *Atkins Diet*[102]. There are a multitude of different diets and ideas; one even encourages dieters to eat according to their blood group; *Eat Right 4 Your Type*.[103] The medical world entered into the debate with the British Medical Journal publishing results from four commercially recognised diets. Interesting, this randomised controlled trial showed that all the diets resulted in significant weight loss, although the Atkins diet had a greater initial loss, but after six months there was no difference between the diets.[104]

There is also debate in the literature concerning the effect of dietary fat on obesity. Numerous studies have shown that energy intake is higher in subjects who consume high fat diets and therefore subsequently gain more weight. Body fat storage occurs at a greater rate when the excessive energy comes from fat rather than carbohydrate or protein. There is controversy over whether it is the effect of the fat on energy intake or the actual energy density, which is higher in high fat foods than low fat foods. Although the argument is confounded by results showing that the mean dietary intake of fat has decreased since the 1960's from 42% to 34% of total dietary energy, whereas the prevalence of obesity has increased. [105]

The Glycaemic index (GI) has gained credence over the last few decades, and some food companies now even label foods as low, medium or high GI. The GI is defined as the rate of absorption of carbohydrate after a meal, and is affected by the carbohydrate type, fibre content, protein, fat and method of preparation.[106] It has been reported that low GI diets lower post-prandial glucose and insulin responses whereas high GI diets stimulate lipogenesis and cause increased adipocyte size.[107] It is thought that reductions in dietary fat tend to cause a compensatory rise in carbohydrate consumption, and consumption of high GI carbohydrate has increased since the 1970's.[105] It has been suggested that the GI of the American diet has increased in recent years and this may be contributing to the rising obesity epidemic.[106] The effect of GI on energy metabolism and voluntary food intake has been studied with a small sample of obese boys. On different days the boys were given meals with varying GI's and their ad libitum food intake for a 5-hour period was monitored. It was found that various meals that contained the same amount of energy but had varying GI's had very different effects on metabolism, perceived hunger and additional food intake. The voluntary food intake after the high GI meal was 53% more than after the medium GI meal, and 81% more than after the low-GI meal. This suggests that the rapid absorption of glucose after a high GI meal, can promote excessive food intake.[108]

The effect of portion sizing and influence on consumption was examined during a study in an American University. The participants were recruited to a study involving soup and they were unaware that half of the soup bowls were self-filling. The participants who unknowingly consumed soup from the self-filling bowls ate on average 73% more soup and yet they did not feel more satiated. Amongst the American population, 54% of people admit to eating everything on their plates. This study highlights how people generally are not able to estimate their energy intake accurately, and portion sizing is essential in obesity prevention. [109]

1.1.6.1.3 Psychosocial Influences

Governments regularly publish recommendations regarding healthy lifestyles, focusing on the balance of good health and moderation.[110;111] Most individuals have an awareness of what constitutes a healthy diet and yet obesity levels are still increasing. Food intake is a conscious act but is influenced by a variety of factors. Firstly the urge to eat is driven by a complex system of biological processes. Environmental factors including timing and availability of food also play a major role. Finally many people try to impose self control over their consumption but this is heavily influenced by both the biological and environmental influences.[95]

In the late 1960's, Schachter developed the externality theory of obesity stating that obese individuals are more responsive to external food cues (time, taste, smell, environment, presence and quality of food,) than normal weight individuals. A number of research studies have been conducted with some confirming this theory,[112] while others failed to find the link between externality and overweight. [113;114] In general the theory is considered robust but does require further analysis.[115]

Restrained eating is also thought to play a role in the aetiology of obesity. This behaviour tends to be associated with dis-inhibited overeating.[115] Individuals with this tendency may be influenced by social environment, type of food or the presence of other people eating. In experiments where restrained eaters have been led to believe that they would later receive high calorie foods, many have eaten more initially.[116] The dis-inhibition is thought to occur when a situation arises that causes a normally restrained eater to suspend his or her own self-control. It may occur as a result of increased externality, for example after a period of dieting, there may be heightened responsiveness to a situation and this may result in overeating.[116]

One of the most notable psychological problems that results in obesity is binge eating and this problem has only recently been classified as a disorder. The characteristics include; binge eating two days out of seven over a period of six months, eating alone and in an uncontrolled manner; following which the individual feels very distressed.[115] In a study examining binge eating and depression, researchers found that of all the factors related to binge eating, the strongest associations were found with, body image, concern with public appearance and a strong sense of shame.[117] Another study examined differences in obese bingers and non-bingers. Obese bingers were more influenced by behavioural eating including social eating, negative emotional eating and had difficulty in resisting temptation. There was also evidence of a higher proportion of psychopathology, such as depression and borderline characteristics.[118] There is debate in the literature concerning whether obesity is an eating disorder. Jebb and Prentice argue that considering the proportion of obese individuals who are binge eaters and the propensity for under reporting of food intake, along with the psychological profile of obese binge eaters, there are certain cases where obesity is certainly an eating disorder.[119]

The criteria for classifying binge eating is strict and many obese individuals may not meet the standards but do admit to overeating during times of stress. Stress and associated comfort eating are thought to play a role in obesity.[115] High fat and carbohydrate foods have been shown to improve people's mood and when feeling better these individuals are able to function normally.[120] Unfortunately habitual use of "comfort food" can ultimately result in obesity.

A review of 34 articles has assessed the association between obesity and lower status occupations in developed countries.[121] This review found some association, although this was not consistent particularly when socioeconomic status (SES) was assessed using income or education level. In studies of black population samples there was no relationship between SES and weight gain. The authors speculate that peoples' occupations have a huge impact on day-to-day living and this is perhaps more influential than education, which may have been attained years ago; or income, when numerous exercises are free. This review suggests that prevention efforts should be targeted at individuals in lower status occupations but clearly there is a need for further research to evaluate the mechanisms underlying SES and obesity.

The causes of obesity are multi-facetted, and the idea that obesity is essentially an imbalance between energy input and output, undermines some of the very complex issues discussed above. Anyone working with obese individuals or developing public health initiatives to prevent obesity needs an understanding of the additional social and psychological factors that make obesity an interesting, but chronically difficult condition to treat.

1.1.6.1.4 Physical inactivity

The current western environment tends to discourage physical activity. Due to advances in technology and transportation, the natural physical activities of daily living have been substantially reduced.[98] One review suggests that the extra physical activity involved in normal living in the 1940's, compared to this decade would be the equivalent of running a marathon once a week.[10] Physical activity has decreased while sedentary behaviours are increasing. The average person in England is thought to spend 26 hours per week watching television, whereas in the 1960's, half of this time would be normal.[10] The association between overweight and physical activity is well documented. One example from Finland showed that overweight was significantly higher in sedentary people, with 21% of women and 14% of sedate men overweight compared with the physically active population of which only 8% of women and 7% of men were overweight.[122]

Research has shown that increased physical activity can protect against health risks. If physical inactivity is combined with obesity and smoking, a woman will have a 10-fold increased risk of a poor health status compared with a non-smoking physically active normal weight woman.[123] One of the greatest difficulties is motivating people to remain physically active. One report has shown that two thirds of overweight people participating in a weight loss programme reported using physical activity as part of their plan. But only one fifth were found to achieve the recommended amount of 30 minutes of physical activity most days of the week. The report was unsure as to the reason for the lack of physical activity and commented that either time constraints or poor motivation may be part of the problem.[124]

A survey conducted on health care plan members in the United States aged 40 years and older with 2 or more chronic health problems; found that individuals who reported less than 30 minutes of activity over a 7 day period had a significantly increased risk of mortality over the following 3 years (mortality risk ratio of 2.82; $p<0.001$).[125] This same survey found that 25% of the respondents were completely inactive. The authors suggest that policy initiatives to encourage people to do low levels of physical activity may have substantial public health benefits and suggest that just walking the dog or walking in the shopping mall may be beneficial. Essentially these authors are suggesting that something is better than nothing. Research has shown that exercise training can lead to a decrease in body fat, but only 0.1kg per week at a moderate level of exercise.[88] Moderate activity is described as 30minutes of moderately intensive exercise that causes an increased pulse rate on five days in of a week.[41] Worryingly in the United Kingdom a recent survey has found that only a quarter of women and just over a third of men regularly engage in moderate physical activity.[41]

As described above energy expenditure and exercise have an important influence on obesity. American researchers have studied the causes of inactivity in children using a sample of twins to examine if genetic or environmental influences were more powerful in effecting the activity levels of children. These researchers concluded that the heritability of physical activity is influenced more by environmental factors than by genetic variability. This study suggests that improving the environment should promote activity and may encourage increased energy expenditure. [126]

1.1.6.2 Genetic influences.

The recent increase in obesity worldwide has occurred too rapidly to solely be attributed to genetic influences. The modern influences in our environment combined with genetic factors, may be accelerating the problem. To date, over 400 genes have been identified as key in weight regulation but very few humans have been found to have true genetic obesity, although it is essential for health professionals to recognise that severe obesity may have other causes apart from environmental factors.[127] Importantly, genetic factors are key to how the individuals respond to the environment. [128]

1.1.6.2.1 Heritability

Any genetic associations are influenced by the environment and also by the individual's developmental stage or gender.[129] In assessing family resemblance and BMI, there has been debate in the literature as to whether it is the genetic effect or the common familial environment, which has the greatest impact. One study compared identical twins raised together or apart, and confirmed that the genetic influences on body mass index were far greater than any shared childhood environment.[130] In a study involving Hispanic families the heritability of traits associated with obesity was confirmed.[131] Another very interesting study, which included male adult monozygotic twins, showed that following a 100-day period of overfeeding; there was significantly greater variance of changes in body weight, percentage of fat and fat mass between the pairs of twins than within the pairs. There were six times more variance between, than among the pairs, when changes to abdominal visceral fat and regional fat distribution were assessed. The authors concluded that the tendency to store energy as fat or lean tissue must therefore be influenced by genetic factors.[132] Studies comparing correlations in BMI of adult adoptees against both their biological and adoptive families have further confirmed the genetic relationship of familial resemblance of body size. [133;134]

There is research that correlates a child's risk of obesity with parental obesity. In a very large European study, including 3306 children aged 5 to 7 years; children were 20% more likely to become overweight if their parents, especially their mother, was overweight.[135] In a cohort of American families, the risk of obesity in adulthood was found to be double for children under the age of 10 with obese parents. The authors concluded that the association is most likely due to shared genetic and environmental factors.[136]

1.1.6.2.2 Monogenic Obesity

Animal studies using rodents and recent advances in molecular biology have contributed phenomenally to improving our understanding of the genetics of obesity. In 1994 the *ob* (obese) gene was identified along with leptin, which is a hormone secreted by adipocytes. This caused widespread optimism as it was felt that the cause of obesity had been found and successful treatments could now be developed.[137] The *ob* gene defect was found to be responsible for the failure to produce the hormone leptin, and when recombinant leptin was injected, body weight, fat mass, serum glucose and insulin decreased. [138] During animals studies ob/ob mice with the *ob* gene defect were found to be hyperphagic and constantly searched for food and also had very low levels of spontaneous physical activity. [115] In humans, leptin deficiency is very rare and results in early onset obesity with deceased secretions of growth hormone and thyrotropin and no pubertal development, indicating that leptin plays a key role in many endocrine functions. [139] Leptin therapy in children with this deficit has resulted in reduced body weight and in some cases improved insulinemia and pubertal development. To date monogenic obesity has only been seen in 200 cases in human obesity. Currently treatments are not available for the other single gene mutations of *POMC-*, *PC1-*, *SIM1-*, *TRKB-* and *MC4R-*.[140]

1.1.6.2.3 Polygenic Obesity

Polygenic or common obesity occurs when the individual's genetic make-up is affected by environmental influences, which also promote inactivity, and over consumption. Polygenic obesity represents complex interactions between genetic, social, behavioural and environmental factors all of which have an impact on the obese phenotype

1.1.6.2.4 Syndromic Obesity

A very small proportion of cases of obesity are the result of endocrine disorders. The most common condition in this group is hypothyroidism, which results in reduced energy expenditure. [115] Another condition is Cushing Syndrome, which develops after prolonged exposure to glucocorticoids, either from external pharmacologic doses or as a result of endogenous glucocorticoid excesses from an adrenocorticotropic hormone (ACTH)-secreting pituitary tumour, ectopic (non-pituitary) ACTH production, or adrenal tumour. Amongst a variety of other symptoms, obesity is common in these patients with fat deposition in the abdomen, mediastinum, face, and neck, presenting with the recognisable buffalo hump, moon face, and centripetal obesity. [141] Polycystic ovary syndrome (PCOS) is another such endocrine condition and approximately 50% of women with PCOS are overweight or obese, the majority of which have abdominal obesity.[142] Other endocrine disorders, which may result in obesity, include insulinoma, growth hormone deficiency; and sex hormone disorders including hypogonadism in men and ovariectomy in women. [115]

A small number of congenital abnormalities result in obesity. The most common of these, Prader-Willi Syndrome (1 in 25 000 births) is characterised by obesity, hyperphagia, mental retardation, hypogonadism and diminished foetal activity. It is thought that the gastric hormone Ghrelin may be responsible for some of the molecular components of this condition. Bardet-Biedl Syndrome and Alstrom Syndrome are also conditions that result from genetic defects and produce obesity. [140]

Hypothalamic tumours can also result in obesity. [115] Doctors from a childrens hospital in America completed a retrospective evaluation of children treated for hypothalamic tumours over a 30-year period. Their finding confirmed that damage to the hypothalamus either from the tumour, surgery or radiation could result in intractable obesity.[143]

As described above very few cases of obesity have a pure genetic cause but the combination of genetic influences within a susceptible population living in an obesogenic society make prevention and treatment of this condition very difficult.

1.1.6.3 Metabolism and appetite control

The internal mechanisms that control energy balance are complicated. Obesity could be considered a failure of the biological regulatory system. Although the reality may be that it is the inability of this system to evolve fast enough to compensate for the new obesogenic environment.[87]

In mammals, the brain is central to maintaining the body's energy requirements in relation to the environment, and adjusts eating behaviour to maintain the correct balance between intake of food and the usage of energy.[144] The hypothalamus receives and interprets a variety of messages regarding energy balance and appetite control. These signals may be humoral or neural, and may be influenced by the sight, smell, texture and memory of foods or even social situations. [94;145] Although the majority of signals are received by the hypothalamus, other parts of the brain such as the nucleus tractus solitarius, parts of the brainstem, the amygdala and the cerebral cortex also play significant roles. [94]

One of the main roles of the hypothalamus is to synthesize neuropeptides, which in turn control secretions from the pituitary thereby controlling hormone synthesis at organ level. [144] Figure 8 portrays a simplified diagram of some of the factors, which contribute to maintaining energy balance.

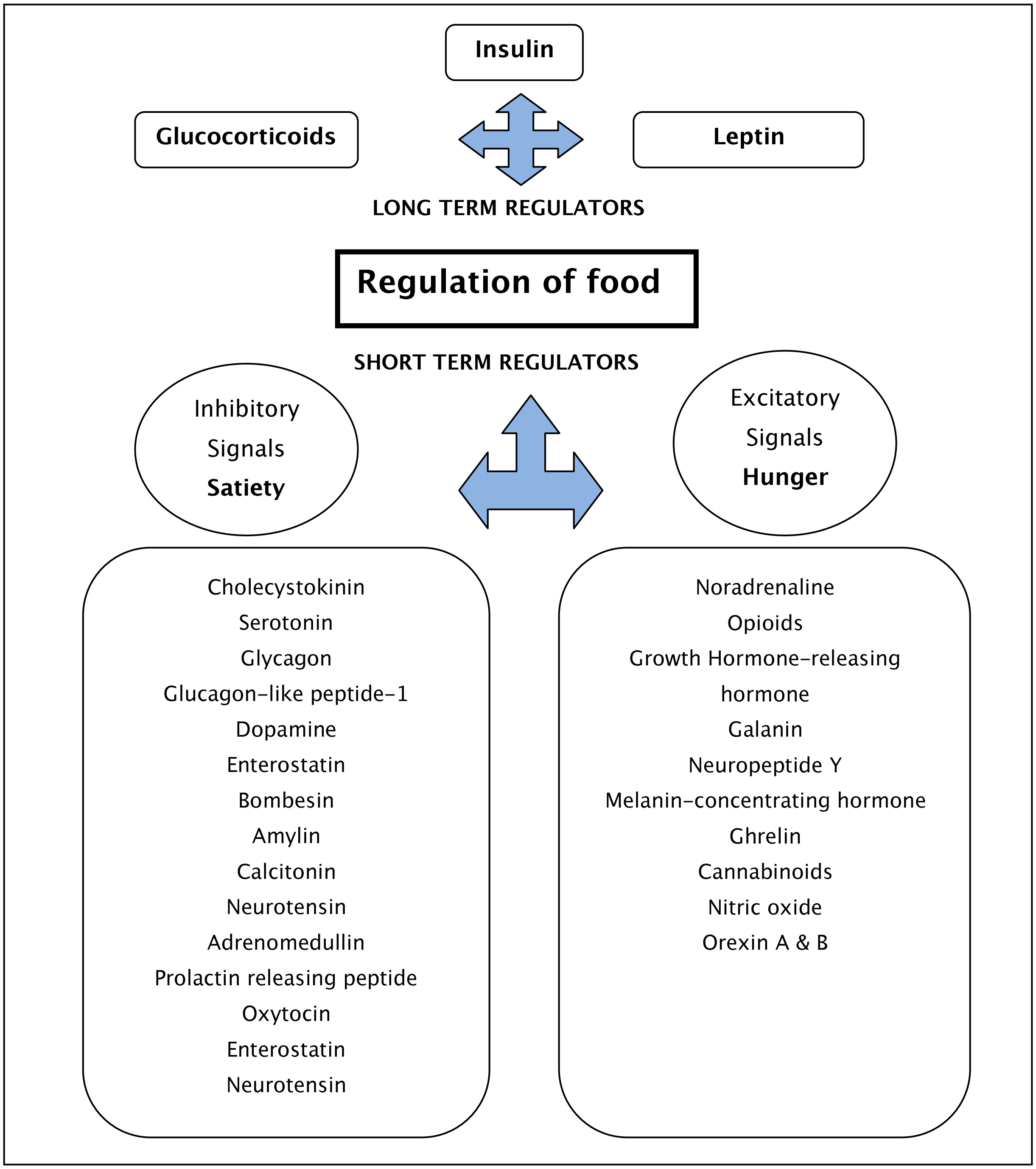
1.1.6.3.1 Short-term regulators

Inhibitory signals are triggered in response to eating food and inhibit further eating. There are a number of hormones and peptides, which play a role in supporting appetite and satiety.[95] One of the main hormones that induce satiety is Cholecystokinin (CCK). CCK is released from the duodenum in response to digested food in the form of fatty acids and amino acids.[94] This hormone works locally to stimulate pancreatic secretions and gall bladder contractions, as well as stimulating the vagus nerve sending signals via the nucleus tractus solitarius to the hypothalamus.[144] Glucagon is also responsible for satiety signals. It is released from the pancreas during meals, and evidence suggests that it involves signals within the liver and it may input signals via the hepatic branch of the abdominal vagus. Glucagon-like peptide 1 (GLP-1) is secreted into the circulation following ingestion of meals, and is thought to be a natural mediator of satiety in response to the post meal rise in glucose. [144] Serotonin, is another neurotransmitter that favours a negative energy balance. [94] Other hormones and peptides such as bombesin; neuromedin U; amylin; calcitonin; prolactin-releasing peptide; oxytocin, enterostatin; neurotensin also play a role in inducing the sensation of satiety.

Excitatory signals represent the drive to eat, or the sensation of hunger. This occurs due to energy expenditure and thermogenesis.[95] Changes in the availability of glucose in the blood, and other neurotransmitters such as neuropeptide -Y (NPY) are thought to play a role in increasing food intake. NPY is synthesised in the neurones in the arcuate nucleus. The NPY neurons have been shown to be active during periods of starvation and conditions of negative energy balance.[146] Other neurotransmitters that favour a positive energy balance are Melanin-concentrating hormone (MCH), orexin A and B, galanin, opioid peptides, cannabinoids, and nitric oxide. [94] Ghrelin is the only peripherally active appetite stimulating hormone, and plasma levels of this hormone are known to rise during periods of weight loss.[145]

Figure 8: Regulation of Food intake.

Food intake regulation is the balance of inhibitory signals (sensations of fullness and suppression of hunger) and excitatory signals (driven by the bodies energy needs and is influenced by hunger) this in turn is influenced by long term signals controlling body weight. [94;95;146]



1.1.6.3.2 Long-term regulators

A number of factors contribute to long-term weight regulation. Both Leptin and Insulin are thought to act in a similar way and represent a body weight signal, which is able to control food intake. Insulin, which is produced by the β cells of the pancreatic islets of Langerhams, stimulates glucose and amino acid uptake by cells and also fat, protein and glucose synthesis. [147] Insulin is also thought to play a role as an adiposity signal, and basal levels of insulin correlate with body adiposity levels. [145] Leptin is produced by the adipocytes and acts on the hypothalamus to suppress appetite. Leptin is also responsible for gluconeogenesis, glucose metabolism and lipolysis.[144;148] When leptin levels are low an increased food intake occurs. This is also evidence suggesting that the absence of the MC4-R receptor results in hyperphagia. [145] Extremes in glucocorticoids levels are also known to affect body weight, with excesses resulting in truncal obesity (Cushing syndrome) and deficiencies resulting in weight loss (Addison's disease).

Recently our understanding of the fundamental systems, which control and regulate body weight has led to interest from the pharmaceutical world. The ability to chemically reduce appetite and food intake, or to potentially increase energy expenditure through thermogenesis could have a significant impact on reducing obesity. [146] A number of anti-obesity agents have been developed and a recent Cochrane review examined results from a few randomised controlled trails. Of the eight agents reviewed only Orlistat and Sibutramine met the inclusion criteria. Orlistat is an inhibitor of intestinal fat absorption and acts by inhibiting pancreatic and other lipases. Sibutramine inhibits the re-uptake of serotonin and norepinephrine. The authors found that both drugs have a very modest weight loss, which may be accompanied by some unpleasant side-effects.[149] Although our understanding of the genetics and biology of obesity is increasing, we cannot at present successfully alter either of these and therefore obesity prevention is essential.

Our ancestors aspired to have a constant supply of food, and most individuals living in westernised societies today have food security and use many labour saving devices. It is important that we learn to adapt to our new environment to prevent further obesity.[87] This is a condition that is not just affecting adults; and its causes, effects and even possible prevention may begin early on in life.

1.2 Childhood Obesity

Childhood obesity is an international problem and currently 10% of the world's school aged population, and 22 million children under the age of five are estimated to be overweight.[27] Evidence suggests that the potential to develop childhood obesity may be apparent even before a child is born.[150]

1.2.1 Childhood growth and adult obesity

There is extensive research that suggests that obese children are very likely to become obese adults; [151-154] although other research suggests that just under a quarter of obese adults were obese as children.[155] The mechanisms by which childhood obesity continues into adulthood are not fully understood. Historically it was suggested that the number of fat cells were determined before the first year of life and that after this time, changes in adipose mass occurred due to an increase in size rather than number of cells.[156] It is now accepted that the size and number of fat cells change throughout childhood and adolescence, dependent on developmental stage and gender.[150] Interestingly overweight children, who lose weight, reduce adipocyte size but the numbers of adipocytes do not decrease. [157]

In obese and non obese children under the age of ten the presence of one or both obese parents more than doubles the risk of adult obesity, this is most likely due to influences from shared genes and the environment.[158] Remaining obese from childhood through to adulthood increases the all-cause mortality and morbidity for both genders from cardiovascular disease and diabetes.[159] In addition to the physical effects, a large longitudinal survey found that women who remained obese from adolescence were affected by psychosocial consequences. These women were less likely to be married, had completed fewer years of education, and had higher levels of poverty. [160] Other research has shown that childhood obesity increases the risk of developing the metabolic syndrome in adulthood. The risk of this syndrome was lower in obese adults who had been normal weight during childhood, suggesting that progressive obesity from childhood to adulthood is considerably more harmful than obesity established in adulthood. This study also showed that obese children, who lost weight and subsequently fell within the normal weight range as adults, had a reduced risk of developing the metabolic syndrome. [161]

Researchers from the Harvard growth study followed 508 adolescents through to late adulthood.[162] Those individuals who as adolescents had a BMI above the 75th centile, according to age and gender specific data were found to have an increased risk of all cause mortality. In men the morbidity was disease specific including increased risk from coronary heart disease, atherosclerosis and colorectal cancer while women were found to be more at risk of arthrosclerosis. These risks were independent of adult weight at age 55. [162] This research highlights the importance of preventing obesity in childhood as a means to preventing further disease in later life.

1.2.1.1 Critical periods for the development of overweight

There is a plethora of research describing different periods in development and potential causal factors for childhood obesity. William Dietz has consolidated many of these ideas in his description of the three critical periods of the development of obesity.[163] These included;

- The prenatal period (including gestation and early infancy)
- Period of adiposity rebound (between the ages of 5 and 7years)
- Adolescence

1.2.1.1.1 Prenatal Period and early infancy

The growth and development of the foetus is very dependent on the intrauterine environment. Foetal nutrition is not only affected by maternal nutrition but is also influenced by metabolic and endocrine factors, in combination with placental and uterine blood flow. [164]

Birth weight is often used as a crude indicator of the maternal environment.[165] The association between high birth weight and BMI later in life is well documented. [166;167] A large longitudinal cohort study which followed babies born in March 1958 has assessed the effect of birth weight on BMI at a number of different ages. This study found that at age thirty-three, maternal weight had the strongest association with adult BMI, and may be a more important risk factor than birth weight. [168]

The effects of prenatal and early postnatal nutrition were examined during a historical cohort study of 300 000 Dutch men exposed to famine in 1944-1945. Interestingly, babies exposed to the famine in the first half of pregnancy were twice as likely to be obese at age nineteen as those not exposed to the famine. Babies exposed in the last trimester and early infancy were subsequently less likely to be obese at nineteen years of age.[169] Fifty years after the famine further longitudinal measurements were taken on both men and women. At this time it was found that women exposed to famine in early gestation were heavier, had a higher BMI and waist circumference than unexposed women.

There was no significant difference between exposed and unexposed men at fifty years of age. There was also no notable effect on the birth weight of those babies exposed to the famine. [170] These results confirm the theory that early exposure to under or over nutrition may affect the ability of the hypothalamus to regulate food intake. In addition under nutrition in late pregnancy or early life may influence adipose tissue cellularity.[163] Obesity in later life may be due to nutritional programming that occurred very early in life.[171]

A prospective study that followed 139 children of diabetic mothers from birth to seventeen years of age, found that by late adolescence the subjects were significantly more overweight when compared to the standard United States growth curves. When these same children had been compared to the growth curves at one year there was very little difference, even though at birth the majority were heavy and macrosomic.[172] These findings suggest that endocrine change in utero, affecting early activation of the pancreatic beta cells may be linked to obesity in later life. [164] Furthermore, babies of diabetic mothers have an increased risk of not only developing obesity but also type 2 diabetes in later life.[173]

A recent large prospective cohort study; the Avon longitudinal study, has confirmed that factors in the early life environment are significantly related to obesity in later life.[174] As seen in previous studies parental obesity was a strong predictor. In addition children who slept for longer were found to have a reduced risk of obesity. This may simply be because more physically active children need to sleep longer at night, or those awake for more time may have increased exposure to environmental factors which promote obesity i.e. eating and television watching. As with other studies, children under 3 years of age who watched more than 8 hours of television per week were more likely to be obese. The children born with the highest birth weights and those with early adiposity rebound were also more likely to be obese at age 7. The study further confirmed the association between maternal smoking and increased risk of obesity in later life as seen in previous research.[175-177] Breastfeeding has previously been shown to be protective against later obesity. [178-180] It has been hypothesised that breastfeeding allows the infant to self-regulate feeding, ultimately affecting this regulation in later life. This protective effect was not seen in the Avon cohort, although there were strong univariate associations. [174] Other research has also failed to show conclusively that breast-feeding, apart from many other definite benefits, may prevent further obesity. [181;182]

The association between low birth weight, and the development of chronic diseases; such as diabetes and cardiovascular disease is well documented.[183;184] Many low birth weight babies show significant growth during the first 1 to 2 years of life and this is known as the “postnatal” catch-up period. Often these babies are more overweight and have more central adiposity at five years of age than other children, suggesting that low birth weight and “postnatal” catch-up may indicate increased risks of disease in adulthood.[185] The increasing prevalence of obesity in developing countries may in part be due to the phenomena of postnatal catch-up, as babies born in these areas tend to have low birth weights and some gain substantial weight in their first two years of life.[4]

Plagemann cites the case for very early primary prevention of obesity, and explains that obesity is certainly not only determined by our genes but that the environmental conditions experienced in early life also most certainly have a role to play.[186] During animal studies with rats, those reared in small litters have been observed to develop obesity and retain this condition into adulthood. These rats were found to have hyperinsulinemia and increased intrahypothalamic insulin concentrations in early life. The results from this study suggest that early overfeeding may result in permanent malprogramming of the neuro-endocrine system, which may ultimately predispose the individual to obesity.[186]

1.2.1.1.2 Period of adiposity rebound

Most children have a rapid increase in BMI during the first year of life, after which BMI declines and reaches a minimum; this is usually around five to six years of age. After this time there is a gradual increase in BMI through adolescence to adulthood. The term adiposity rebound refers to the point of minimum BMI just before the BMI begins to increase again,[187] and occurs as a product of the differences in the rate of height gain relative to the rate of weight gain. It has been suggested that children with an early adiposity rebound have an increased risk of becoming obese as adults.[188] Whitaker and colleagues found that an early age of adiposity rebound is independently associated with the increased risk of adult obesity, irrespective of parental obesity and the BMI at the time of the adiposity rebound. [189] The causes of adiposity rebound require further research and clinically this cannot be used as a practical predictor of future problems in individual children as this period of rebound can only be identified retrospectively. [163]

1.2.1.1.3 Adolescence

Puberty is a time of rapid change in size and body shape, and adolescence is thought to be the final critical period for the development of obesity in later life, with some research suggesting that this period may affect girls more than boys.[190] William Dietz describes that changes in amount and position of body fat are responsible for influencing the morbidity and mortality of persistent obesity from adolescence.[190] Girls experience an increase in total body fat through adolescence from approximately 17 to 24%, while boys reduce total body fat. In contrast, the central distribution of body fat increases five-fold in boys compared to only three fold in girls. Hormonal changes in puberty may have an influencing role. There is also natural physiological increase in insulin resistance during puberty. [191] A large historical cohort study from Aberdeen has confirmed that an earlier age of menarche is also associated with increased BMI later in life. These researchers discuss the implications of improved nutrition and generally healthier young children, with a resultant early puberty and that ultimately the consequence could be higher BMI's later in life.[192]

A longitudinal British study, which followed over 5000 babies from their birth in March 1946, showed that only 21% of the obese subjects aged 36 were obese as children.[155] Of the subjects with persistent obesity, significantly higher proportions were women. This same study found that the prevalence of obesity in this cohort peaked at around age 11 before falling and then subsequently rising again after age 20. A recent cohort study which aimed to assess the trajectory of obesity through adolescence, found that if persistent obesity was established before the age of 11 and children entered secondary school as obese they were likely to remain obese until adulthood. [193] The researchers concluded that the high-risk period for the onset of persistent obesity was the pre-adolescent years. Although the current evidence is not conclusive, there are definitive indications that changes either just before or during adolescence impact on future morbidity.

The three critical periods of development confirm that foetal growth and birth weight are important in predicting long-term health outcomes. The most unfavourable outcomes are seen in children who are thin at birth, and have a rapid increase in body weight.[194] A study of elderly men, predisposed to diabetes due to low birth weight found that those who exercised regularly had a reduced risk of developing the condition, suggesting that early risk factors are modifiable. [194] [195] The evidence has also highlighted that children are obese before puberty are most at risk of remaining so. Therefore this may be an ideal target population for obesity prevention.

1.2.2 Defining Childhood Obesity

Although childhood obesity and overweight has become an international problem, there is no universally accepted classification system for obesity in children. The World Health Organisation defines obesity as a condition where accumulated fat adversely affects health.[12] With the increasing prevalence of adult obesity, and its' associated complications and demand on health resources, it is imperative that individuals who are at risk of developing adult obesity are identified early.[196] In addition, the lack of a universal classification system means that there is no global picture of the extent of the problem and as different countries use their own classification systems, it is not possible to compare prevalences.[197]

<u>1.2.2.1 Measuring Children</u>

In the first part of chapter one, a number of different methods were described that can be used to measure obesity and overweight in adults. As with adults, a variety of different methods can be used to measure body composition in children but as yet none are universally recognised as the best method.[23] Laboratory methods including; dual-energy X-ray absorptiometry (DXA), computerised axial tomography (CT) and magnetic Resonance (MRI) are expensive and have limited usage with children. CT is not suitable for children due to the high radiation. DXA is effective and provides data on fat distribution, with little radiation exposure. MRI, though very expensive, provides excellent information on measures of visceral and subcutaneous fat.[198] These methods are normally exclusively used in small research studies due to cost, time and location of the machines. Hydro-densitometry and air-displacement plethysmography are both unsuitable for use with children.[27] Other direct methods, which are more transportable, include the bioelectrical impedance analyses (BIA) and triceps skinfold thickness. Skinfold thickness measurements are obtained using callipers. Unfortunately due to lack of ease of reproducibility, with high between observer variations and reduced reliability with increasing body fatness, this method is less viable. [150] Bioelectrical impedance analysis is gaining popularity, especially body fat reference curves for children.[199] This method is inexpensive, quick, and portable with high reliability. [27]

Anthropometric measurements are commonly used as indirect measures of adiposity. Historically, the weight-for height index has been used to screen for overweight. In 1995 the World Health Organisation recommended that overweight and obesity be classified according to the weight-for-height reference data. This system used the Z-score or standard deviation scores where the anthropometric value was expressed as a number above or below the reference mean. Overweight was defined as >1 standard deviation (SD) above the reference mean weight-for height and obesity as >2 SD above this mean. [200] This method is of great use in environments where the child's age may not be known, and has value in assessing children under the age of ten.[27] For children under the age of two this method is still the screening tool of choice.[150]

Waist circumference is another indirect measure of central adiposity. Researchers from the Bogalusa Heart study have shown a correlation between central adiposity and adverse lipid profiles and hyperinsulinaemia in children.[201] Previously waist circumference was not thought to be a good indicator of central fat distribution in children due to growth and puberty.[202] Recently, researchers have pooled data from studies to assess the relationship between waist circumference and visceral adipose tissue using MRI and concluded that waist circumference in children is a good predictor of abdominal adiposity.[203] Waist circumference percentile charts have been developed in the United Kingdom but as yet no definite cut-off points have been described for defining overweight or obesity.[204]

1.2.2.2 Body Mass Index

As previously described, adult overweight and obesity are uniformly defined in the western world using Body Mass Index, overweight is defined as a BMI>25kg/m^2 and obesity as a BMI>30 kg/m^2. Use of this method is controversial in children and adolescence, although studies have confirmed that BMI does correlate closely with body fat.[205;206] Some of the concerns centre on the variation in BMI with age and gender, and that changes during childhood may be attributed to increases in lean body mass, which is especially common in boys. Also the relationship between BMI, fatness risk and ethnicity has not been established.[196] Studies assessing the validity of BMI have found that this measure has a high specificity but low sensitivity.[207;208] The ideal classification system would measure body fat directly, be accessible, inexpensive andprecise.[196] BIA may in the future fit these criteria but to date BMI is easy, reproducible and relatively valid. [1]

The slope of the age and gender specific BMI charts for children differ from the adult chart, with a resultant V-shaped curve. This is representative of the pattern of BMI which generally decreases after age two until around five to six years of age when it increases again. This decrease reflects the normal changes of childhood growth with decreasing subcutaneous and percentage of total body fat.[212] This V-shaped pattern is often referred to as the adiposity rebound. As discussed earlier in this chapter, it is thought that children with an early adiposity rebound may be more at risk of obesity.[188] Assessment of this can only be done retrospectively, so is of little clinical value for obesity prevention. [163] A limiting factor of the BMI curve is that it does not portray the growth velocity seen during adolescence; this is better represented on both the height and weight growth charts. This is due to the nature of the BMI ratio and that height and weight spurts often happen at different times.[212]

A number of different classification systems have been developed for both national and international use. The greatest difficulty is in assessing the valid cut off points to classify children as overweight or obese. In theory these cut-off points should be established on future morbidity or mortality. As it is difficult to assess these long-term effects from

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[1] During the VIVA examination the lack of clarification of the absolute association between increasing BMI and health risks in children prior to the publication of the CHOPPS project was discussed. Whitaker and colleagues demonstrated that obesity in older children was a predictor of obesity in adulthood, and also that parental obesity doubled the risk of obesity in adulthood in all children under the age of ten[209] More recent work from Baker and colleagues has confirmed the association between increasing BMI in childhood and risk of cardio vascular disease risk later life. These researchers conducted a large population based cohort study of cardio vascular events in over 250 000 Danish schoolchildren born between 1930 and 1976. They found that a higher BMI in childhood increased the risk of a CHD event in adulthood, and that the association was greater with obesity in later childhood.[210] In addition this study showed that small increases in weight can increase the risk of CHD in later life and that this affects all children above the average weight, not only those typically classified as being at risk because they fall above overweight central ranges. Weiss and collagues[211] examined the association between varying degrees of obesity, using BMI z scores and the metabolic syndrome. Their results conclude that the prevalence of the metabolic syndrome increases with each degree of obesity and that it is more common in children than previously reported. These studies clarify the association between BMI and future health risks.

childhood, distribution approaches have been used.[196] A number of different classification systems have been developed and are described below:

- 1990 Body mass index reference curves for the United Kingdom:
  Tim Cole and his colleagues felt that weight, used on its own, is a poor indicator of overweight, and they developed the first Body Mass Index reference curves for UK children. As weight and height are highly correlated in childhood, and a child's weight centile tends to be strongly influenced by their height centile, age and gender specific BMI centile charts seemed appropriate. These charts were based on a large representative sample of 15 000 UK children measured from 1980 to 1990, and were derived using Cole's LMS method, which adjusts the BMI for skewness. The individuals BMI can be expressed as an exact centile score. The chart has nine centiles, which are very useful in clinical practice, and the two extremes identify the heaviest and lightest 4% of the population. Using this method children falling above the 91st centile are considered overweight and those above the 98th are obese. [213]
- BMI centile reference curves from other countries.
  Various countries have developed their own national BMI reference curves which are based on a subset of children from a specific period in time. Both America and France have their own BMI centile reference curves; these are particular to each country as they have been developed from representative samples within the country.[213] In the USA these charts have been recently revised and are sex and age specific. The cut-offs for overweight differ from the UK, and those children above the 85th centile are considered at risk of overweight and those above the 95th are classified as obese. The latest Centre for Disease Control and Prevention (CDC) 2000 growth charts from the USA are based on national surveys of children from 1963 to 1995, so these charts are not statistically representative of the population of USA children today but they do in theory provide the best reference data for the growth of the USA children.[214]
- International Obesity Task Forces (IOTF) cut-off points for BMI
  The lack of a standardised international definition was recognised, and the International obesity task force developed cut-off points based on pooled data from several countries, including Brazil, Great Britain, Hong Kong, Netherlands, Singapore and the United States. The cut-off points for overweight and obesity were aligned to associate with the adult BMI cut off points of greater than 25kg/m^2 for overweight and greater than 30kg/m^2 for obesity (Table 3). The resulting curves are age and gender specific and representative of an international population.[197] When these cut off points are used overweight is defined as any BMI exceeding the cut-off, so an obese child is also considered to be overweight. [215]

The recent guidelines from the Scottish Intercollegiate guideline network suggest that for clinical practice, the UK 1990 reference charts for age and sex, where those children with a BMI≥98th centile are obese and those with a BMI≥91st centile are overweight be used.[216] This definition has a high specificity, and will rarely diagnose a lean individual as obese but may miss a few of the very obese as it only has moderate sensitivity. These guidelines also suggest that for epidemiological purposes the same UK 1990 reference charts should be used but the cut-off points are changed and overweight should be defined as a BMI≥ 85th centile and obesity as a BMI≥95th centile. This will enable for more consistency in the literature as most of the epidemiological data is currently reported using these cut off points. [216] Guidelines on weight management published by the Royal Collage of Paediatricians, describe the 91st and 98th centile cut off points for overweight and obesity, these guidelines also mention the addition of the IOTF cut off points on the more recently published centile charts since 2002. Experts on child health from Great Ormond Street Hospital in London, explain in their article on managing obesity in secondary care, that they use the International Obesity Taskforce (IOTF) cut-offs to identify obesity, which is approximately on the 99th BMI centile and for those with extreme obesity, a BMI≥3SD above the mean or ≥99.86th centile. [217]

There remains confusion in the literature as to which classification or cut-off point should be used. For the purpose of this thesis, the UK BMI 1990 reference charts for age and sex, where those with a BMI≥98th centile are obese and those with a BMI≥91st centile are overweight, have been used.[213] The original study commenced in 2001, prior to the publication of the recommendations from the Scottish Intercollegiate Guidelines Network, and also before the IOFT cut-off points became more widely used and appeared on the new BMI centile chart. For consistency this definition is used in all analysis, including baseline and longitudinal measurements.

Table 3: International cut off points for Body Mass Index[197]

	Body Mass Index 25kg/m^2		Body Mass Index 30kg/m^2	
Age	**Males**	**Females**	**Males**	**Females**
2	18.4	18.0	20.1	20.1
2.5	18.1	17.8	19.8	19.5
3	17.9	17.6	19.6	19.4
3.5	17.7	17.4	19.4	19.2
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
7.5	18.2	18.0	21.1	21.0
8	18.4	18.3	21.6	21.6
8.5	18.8	18.7	22.2	22.2
9	19.1	19.1	22.8	22.8
9.5	19.5	19.5	23.4	23.5
10	19.8	19.9	24.0	24.1
10.5	20.2	20.3	24.6	24.8
11	20.6	20.7	25.1	25.4
11.5	20.9	21.2	25.6	26.1
12	21.2	21.7	26.0	26.7
12.5	21.6	22.1	26.4	27.2
13	21.9	22.6	26.8	27.8
13.5	22.3	23.0	27.2	28.2
14	22.6	23.3	27.6	28.6
14.5	23.0	23.7	28.0	28.9
15	23.3	23.9	28.3	29.1
15.5	23.6	24.2	28.6	29.3
16	23.9	24.4	28.9	29.4
16.5	24.2	24.5	29.1	29.6
17	24.5	24.7	29.4	29.7
17.5	24.7	24.8	29.7	29.8
18	25	25	30	30

1.2.3 Prevalence of Childhood Obesity

Establishing the true prevalence of childhood obesity is complicated by the lack of a standard worldwide definition. A number of issues need to be considered when evaluating any survey or prevalence data, these include; assessing the age and representativeness of the sample, timing and whether the measurements were self reported or actually measured. Even with these difficulties the majority of countries to date report an increasing trend in overweight. [218]

1.2.3.1 Worldwide

Data collated by the International Obesity Task Force, using published and unpublished surveys, taken from 1990 to 2002, suggests that the global prevalence of overweight (including obesity) in young people aged 5-17 years, is approximately 10% and the prevalence of obesity is 2-3%. [27] There are marked differences in the prevalence of the problem between varying regions and countries. In African and Asia the prevalence is well below 10% and in American and Europe well above 20%. The prevalence is increasing globally, but is happening at different rates. North American and European countries are experiencing the highest year-on year increases, with approximately a 0.5% increase per annum in the USA and Brazil and a 1% increase in Canada, Australia and the United Kingdom. Figures 9 and 10 show the marked variations between the different regions according to gender.[27]

There is also a very interesting social divide, which is different between the industrialised and developing countries. Children in the lower socio-economic group in industrialised countries are more at risk of overweight, while it is the more affluent urban based children who are more at risk in the developing countries.[27] The correlation between obesity and socioeconomic (SES) factors in the United States, Russia and China has been examined. In the United States, the low SES groups have an increased risk of obesity, while in China the high SES group are at risk. In Russia both the low and high SES are at risk, compared to those in the medium income groups.[219] In China; meat and energy dense food are expensive and therefore only accessible to those in the high SES group, while in the United States, the “healthy options” of fruit and vegetables are perceived to be more expensive. Russia is a country in transition, with varied economic difficulties, and this is impacting on the prevalence of overweight. [219]

While obesity is an enormous global problem, 25% of the world’s children under the age of two have malnutrition.[220] A number of developing countries are experiencing a double burden of disease with both overweight and under-nutrition. Incredibly, researchers have found that in countries such as Brazil, China and Russia, it is possible for overweight and underweight to coexist within the same household. The cause of this phenomenon is not fully understood, and the researchers hypothesise that, the resultant changes in technologies and advances may impact more on certain members of the families, as with the adoption of the western diet, with differences in the quality and quantity of food eaten by members within the same household. [221]

The United States has very comprehensive nationally representative data from the 1960's. Over the last four decades the prevalence of overweight and obesity amongst children and adolescents has doubled and the prevalence of obesity alone has increased four-fold.[222-224] Although the prevalence has increased in all spheres of the population, recent data has shown that black and Hispanic children are twice as likely to be obese, with a 10% increase in prevalence amongst these sectors of the population between 1988-1994 and 1999-2000.[224] Amongst children aged 4-5 years old, the prevalence has doubled too, and the trends in this age group demonstrate a higher prevalence amongst young girls than boys but there has been no change in prevalence amongst the younger children aged 1 to 3 years.[223] The above surveys have used the 85th and 95th cut-off points for overweight and obesity. A study using the IOTF cut-off points shows the same increasing trend, and demonstrated that between 1988-1994; 25.6% of children in the United States were overweight. The prevalence of overweight amongst American adolescents was significantly higher at 27.3% compared to 22.0% amongst the younger children aged 6 to 9 years old.[225]

Figure 9. Prevalence of overweight and obesity among school-age boys by global region. (Overweight and obesity defined by IOTF criteria.)[27]

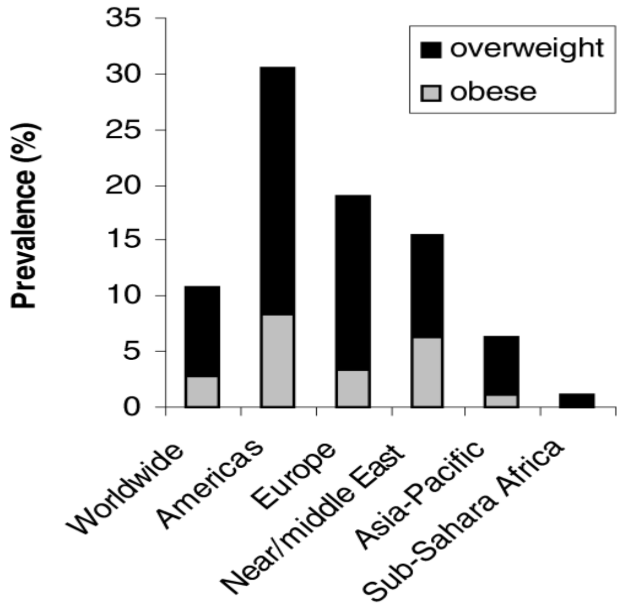
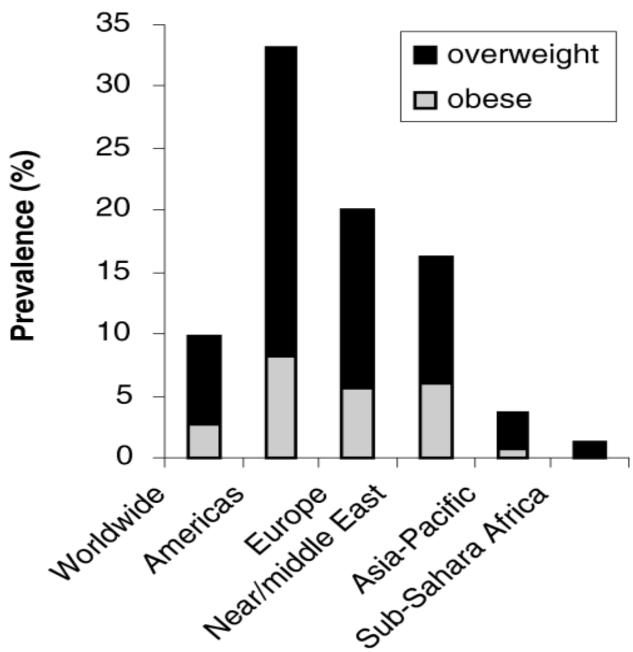


Figure 10. Prevalence of overweight and obesity among school-age girls by global region. (Overweight and obesity defined by IOTF criteria.)[27]

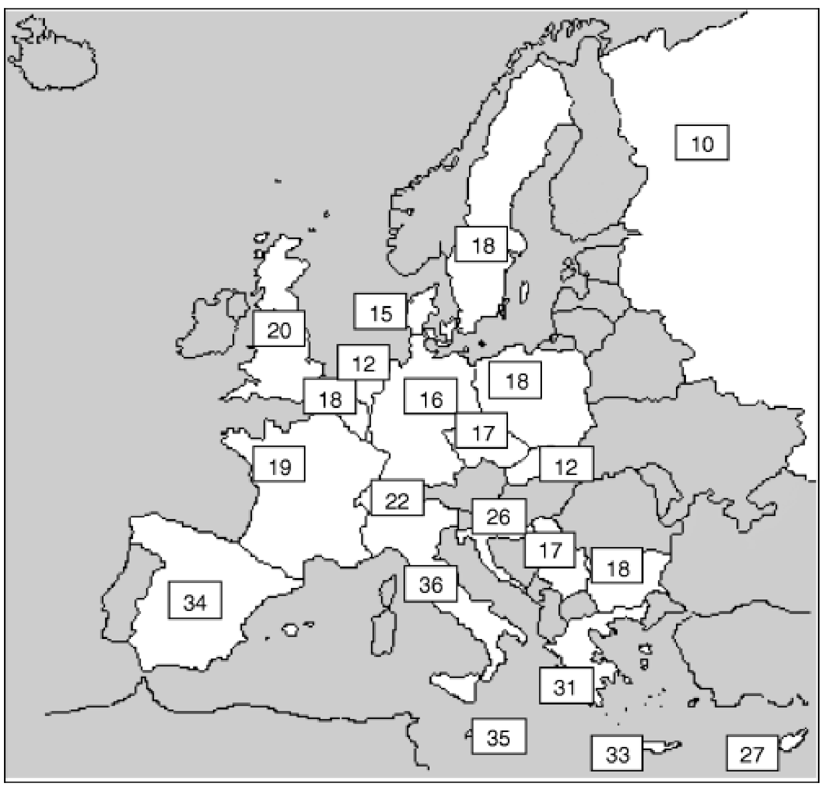


Data from South America suggests large variations of overweight across the continent. In assessing the prevalence differences in children aged between 1 and 5 years, the prevalence was 12.2% in Colombia compared to 23.9% in Peru, although historically under nourishment was a major problem in these countries and is still a concern in certain areas.[37] These results seem particularly high but overweight and obesity was classified according to height and weight, as per the previous recommendations from the World Health Organisation. Data, using the new IOTF cut-off points showed that overweight has increased in Brazil from 4.1% in 1974 to 13.9% in 1997, while underweight decreased from 14.8% to 8.6% over the same time frame.

Very little data is available on school children from some countries in Africa, south and central America and the Asia Pacific region, while limited data on pre-school children is more readily available. China, whose population accounts for one fifth of the global population, has shown a moderate increase in prevalence of overweight from 6.4% in 1991 to 7.7% in 1997.[225] Most importantly is the difference in change between the urban and rural population, in the rural areas of China the prevalence increased from 5.9% to 6.4% compared to an increase from 7.7% to 12.4% in the urban population. Researchers focusing on preschool children from developing countries have shown that overweight and obesity is less common in Asia and Sub-Saharan Africa; with the prevalence of obesity below 2.3% in 32 of the 50 countries examined. The limited cases of overweight were more apparent in urban areas; amongst children whose mothers had a higher education and amongst girls.[226] In contrast to the majority of other countries, the prevalence of overweight in Russia is decreasing. A comprehensive national representative longitudinal survey has shown that the prevalence of overweight amongst Russian children has decreased from 15.6% in 1992 to 9.0% in 1998, and underweight has increased from 6.9% to 8.1% over the same period. The authors cite tremendous economic stress and the reduction in energy density of typical meals as a cause.

According to the World Health Organisation, 14 million children living in the European Union are overweight, and this figure increases yearly by 400 000 children.[227] Recently data from 21 surveys in European countries have been evaluated using the IOFT cut off points to define overweight and obesity. This survey found that countries that had experienced economic and political instability during the 1990s were more likely to have lower rates of overweight. This was most noticeable in countries in Central and Eastern Europe. As already described, rates of overweight and obesity have reduced in Russia, and in Poland only 8% of children were found to be overweight. In Croatia levels remained stable and in the Czech Republic, which experienced less economic problems, there was a modest increase in overweight by 2.5%.[228] The prevalence of overweight appears to be much higher in Southern Europe, 36% of 9 year olds in Italy and Sicily were reported to be overweight, as have 26% of boys and 19% of girls in Greece. Crete has one of the highest levels, with 39% of children aged 12 shown to be overweight, and in Spain 27% of children and adolescents are overweight. Amongst the more northern countries the prevalence is lower, in Sweden 18% of 10 year olds are overweight and in Finland only 13% of adolescents are overweight. In northern Europe the prevalence of overweight affects approximately 10-20% of children, while in southern Europe 20-40% of children are overweight. Figure 11 shows the percentage of overweight children in different European Countries.

Figure 11. Percentage of overweight children in European countries. Children aged 7-10 years, IOTF definition, surveys taken after 1990.[228]



1.2.3.2. United Kingdom

From a European perspective, the United Kingdom falls within the Northern European region, having one of the higher prevalence of overweight within this region although significantly lower than its more southern counterparts. [228] Using the new IOTF cut-off points for overweight and obesity, Chinn and Rona described the trends of overweight and obesity from 1974 to 1994 in children aged 4-11 years old. Their results show that between 1974 and 1984 there was little overall change in the prevalence but in the following decade the trends changed, with the most noticeable difference occurring in the older age groups. Amongst English boys the prevalence increased from 5.4% to 9.0% and 9.3% to 13.5% amongst the girls. Demonstrating regional variation, the prevalence in Scotland was even greater, with an increase amongst the boys from 6.4% to 10% and 10.4% to 15.8% amongst the girls.[229] For preschool children under the age of 4, there was also a significant increase in overweight from 14.7% to 23.6% between 1989 and 1998, with obesity increasing from 5.4% to 9.2% over this same period. Overweight and obesity amongst this cohort has been described using the 85th and 95th centiles for overweight and obesity, and therefore appears significantly higher than the previously described data. [230] The International Obesity Task Force, using the IOTF cut-off points found that in 2002, 22% of boys and 27.5% of girls aged 2-15 were overweight and 5.5% of boys and 7.3% of girls were obese.[231] Figure 12 and 13 show the increasing trend on overweight and obesity over the last 4 decades in the United Kingdom, using the IOFT points for overweight and obesity. [231]

Figure 12. Increasing prevalence of childhood obesity in the United Kingdom.[231]

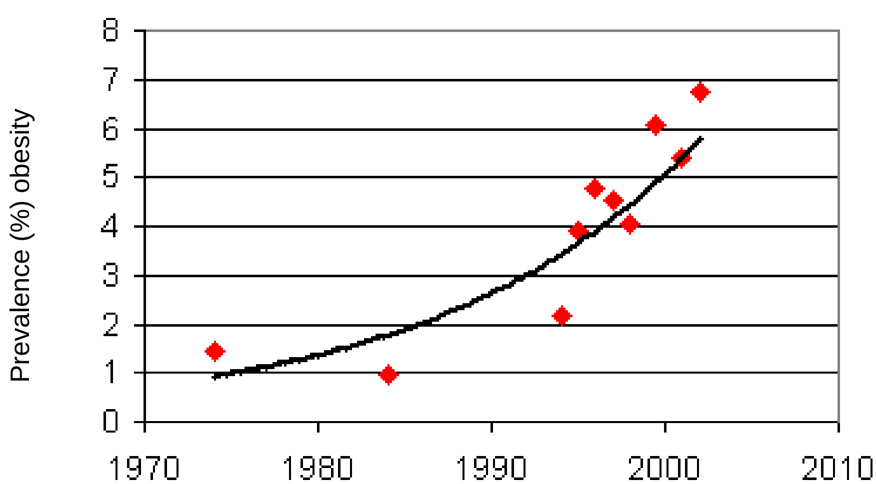
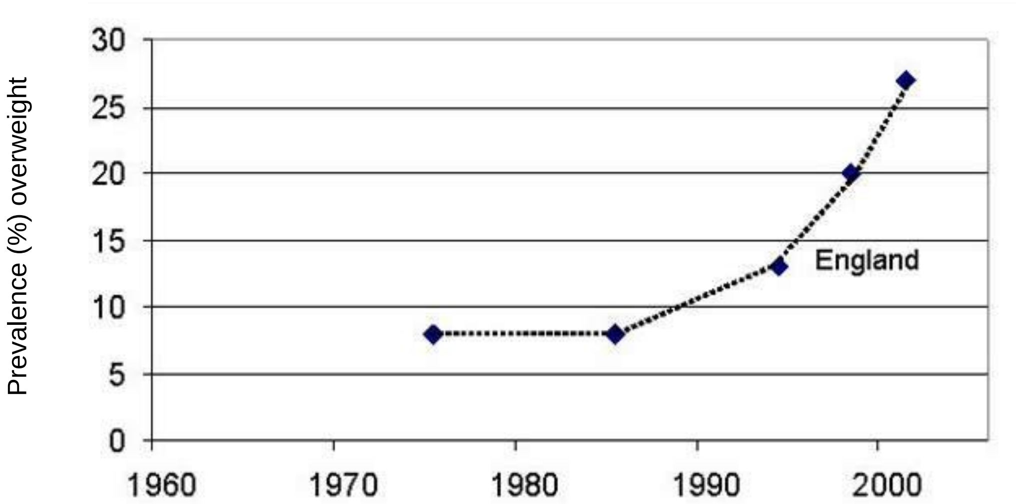


Figure 13. Increasing prevalence of childhood overweight in the United Kingdom.[231]



The current UK population comprises of many different races and people from varied ethic origins. Researchers have examined the potential that some of the minority groups may be more at risk from developing overweight and obesity. Data was analysed from the Health survey for England in 1999. Compared to the general population; Indian and Pakistani boys were found to have the highest prevalence of overweight, while Bangladeshi and Chinese boys had the lowest rates. Amongst girls, the Afro-Caribbean girls were most likely to be overweight and the Chinese girls were least likely to be overweight compared to the general population.[232]

In 2004 the United Kingdom government published the Public Health White paper, called Choosing Health; Making Healthier Choices easier. In this report the government announced an ambitious target of halting the year on year increase in childhood overweight and obesity by 2010. [233] A recent report prepared for the Department of Health, suggests that if the year on year increase in childhood overweight and obesity continues; 19% of boys and 24% of girls under the age 10 could be obese by 2010. The prediction is even worse for adolescents, with 31% of boys and 27% of girls expected to be obese by the end of this decade. [234] The most recent results are discussed later in Chapter 7.

1.2.4 Health risks associated with childhood obesity

As previously described, obese children are at risk of remaining overweight and becoming obese adults.[151-154] These children have an increased risk of premature death from a number of chronic conditions.[159;162] Individuals who were overweight as adolescents have an increased morbidity from coronary heart disease and atherosclerosis. Boys are more at risk of developing colorectal cancer and gout later in life and girls are more likely to develop arthritis and suffer psychosocial consequences.[159;162] Childhood obesity impacts on many of the physical systems of the body and may also have psychosocial ramifications.

The overwhelming health costs of obesity in adulthood were described earlier, but there is now evidence that childhood obesity is also attributing to increased costs. An American National Hospital Discharge Survey was conducted to assess for changes in obesity related admissions between 1979 and 1999. The survey included children between the ages 6 and 17 years and evaluated the increases in admissions where obesity was stated as either the primary or secondary cause of admission. Over this time period obesity related discharges increased, and in the majority of cases obesity (96%) was listed as a secondary diagnosis. The survey found that admissions due to diabetes doubled (from 1.4% to 3.36%), tripled from gallbladder disease (from 0.18% to 0.59%) and increased fivefold for sleep apnoea (from 0.14% to 0.75%). The associated financial implications found that cost attributed to obesity had increased three fold over the 20year period. [235]

<u>1.2.4.1 Psychosocial effects</u>

Being obese as a child can have long term psychological effects. Obesity may not only affect their happiness and self esteem in their youth but may also impact on their psychological health as an adult. [236] Obese children are often discriminated against and evidence suggest that it is more difficult for an obese child to make friends in their peer group and it is often easier for them be friendly with younger children who are eager to play with the obese child because he/she is older. Overweight younger children are unlikely to suffer with self-esteem problems until they become more aware of society and influences as adolescents, and then these problems can develop and persist into adulthood.[236] These findings were confirmed in an American study, which followed 1520 children for four years, aged from nine to ten. The initial scores showed little difference between the children aged 9-10 years but after the four-year period, the self-esteem of obese girls decreased significantly when compared to their non-obese counterparts. The differences between obese and non-obese boys were not as significant although notable differences did exist. The lower levels of self-esteem were also associated with increased levels of sadness, loneliness and nervousness. These children were also more likely to engage in high-risk behaviours such as smoking and drinking alcohol. [237]

The impact of being obese on children's quality of life was assessed through a cross sectional sample of 106 severely obese children aged between 5 and 18 years who attended a hospital clinic. These children were found to have markedly lower health-related quality of life (QOL) scores than children and adolescents who were healthy. Very worryingly the obese childrens' QOL score was similar to that of children diagnosed with cancer.[238]

The social effects of obesity continue into adulthood and may affect the individual's social environment and progress. A large American follow-up study of over 10 000 subjects followed young people who were aged 16-24 in 1981 for 7 years. The consequences for women who were obese as adolescents and young adults and remained so into adulthood were the most severe. These women were found to have higher rates of poverty, lower rates of marriage, completed fewer years at higher education and have lower household incomes in adulthood than women who were not overweight in adolescence. The effect on men was only limited to marriage in that overweight men were less likely to be married at follow up.[160] Another study confirmed that overweight women are more likely to experience social exclusion. This was found in an evaluation of college acceptance rates in the 1960's for an elite New England College, where obese women with the same credentials as their non-obese colleagues were less likely to be accepted. The same was not true for obese men. [239] More recently the results of the 1970 British birth cohort study have been published. These results are not dissimilar to the American findings. Women were more likely than men to suffer adversely from persistent obesity, the most notable risks being unemployment and lack of long-term partners. It is worth noting that obesity limited to childhood had negligible adverse social effects in adulthood.[240] All of these studies show that the effects of overweight in childhood and adolescence are far reaching, not only impacting physically but also psychologically and socially.

1.2.4.2 Physical effects

Childhood obesity is associated with several physical complications and very obese children are likely to develop a number of these problems, many of which may persist into adulthood.[236]

1.2.4.2.1 Respiratory Problems

One of the complications of obesity is obstructive sleep apnoea (OSA), this is a breathing disorder characterised by episodes of absent breathing caused by an upper airway obstruction during sleep. Essentially there is a significant decrease in air intake, in the presence of breathing effort. Signs and symptoms of this problem include loud snoring, mouth breathing, frequent waking and daytime sleepiness and even hyperactivity.[241] This condition occurs in approximately 17% of obese children.[242] Poor school performance and impaired intellectual functions have been observed in children with OSA. Psychometric test were conducted on a group of 14 morbidly obese children, five of whom suffered with sleep apnoea. These five children were found to have significantly poorer results on the standardised neurocognitive tests when compared to their peers. [243]

The prevalence of asthma is increasing in the developed world, with more than one in four children affected in many school-aged populations. In Southern California, 3792 children were followed for five years as part of the Children's Healthy Study. All children were free of asthma at the start of the study. After a five year period 288 cases of asthma were diagnosed, with a higher incidence amongst girls. It was found that the incidence varied according to gender, with little difference between normal and overweight girls but there was an increased risk for overweight boys (RR = 2.06, 95% 1.33, 3.18). Interestingly, the effect of being overweight was greater in non-allergic children.[244] Another study found that girls who became overweight or obese between the ages of 6 and 11 years were 7 times more likely to develop new asthma symptoms by the age of eleven.[245]

1.2.4.2.2 Cardiovascular Risk

In 1953, a landmark article was published describing the presence of arthrosclerosis in young American soldiers who had died during the Korean War.[246] These finding were confirmed in the Pathobiological Determinants of Atherosclerosis in Youth (PDAY), a large autopsy study with 2876 subjects. This study found fatty streaks in the aortas of adolescents and young adults, in a large diverse sample of the US population.[247] It highlighted the importance of primary prevention of cardiovascular disease in childhood, years before symptoms would ever appear. A further study assessing cardiovascular risk factors, in a sample of 24 adolescent girls (14 obese) found that the obese girls had significantly higher levels of; cholesterol, triacylglycerol, low-density lipoprotein (LDL) cholesterol, basal insulin and systolic and diastolic blood pressure. These factors were also closely correlated to the amount of intra-abdominal fat.[248]

Hypertension is a well documented complication of adult obesity. A study with rural school aged children in the United States confirmed an association between overweight and hypertension in childhood. In this study of 1173 children, aged between 5 to 18 years from different ethnic groups there was a stronger association between overweight and hypertension in Caucasian children. The African American children were more likely to have a raised blood pressure at normal weight.[249] Another large study which included 2460 children aged between 12 to 16 years found that obese children had a 3-fold higher risk of hypertension when compared with their non-obese peers[250] Historically, hypertension in childhood was rare and was most likely to be a complication of renal vascular disease (secondary hypertension). More recently paediatric hypertension practices are now treating primary hypertension in otherwise healthy adolescents who are obese.[251]

The Bolgalusa Heart Study is a study of cardiovascular risk factors and includes 9167 children aged between 5-17 years old.[252] The study has confirmed that overweight children have an increased risk from cardio vascular disease risk factors, namely; elevated lipids, diastolic and systolic blood pressure, triglycerides and fasting insulin. Worryingly, they found that 58% of overweight 5-10year olds, had one established risk factor and 25% had two or more risk factors. [252] There is agreement in the literature that childhood obesity has the similar effects as adult obesity on cardiovascular health and that lifestyle factors are essential to prevent further complications. [253]

1.2.4.2.3. Endocrine complications

A further complication seen in overweight and obese children is the development of insulin resistance, which is a precursor of type 2 diabetes and the metabolic syndrome.[254] The metabolic syndrome is a clustering of risk factors and there are a number of different definitions describing it. The National Cholesterol Education Program's Adults treatment Panel (ATP III) guidelines state that if an individual is found to have 3 or more risk factors they are thought to have the metabolic syndrome. The risk factors include; elevated blood pressure, a low high-density lipoprotein (HDL) cholesterol level, a high triglyceride level, a high fasting glucose level, and abdominal obesity. [255] Using the above definition researchers assessed the prevalence of the metabolic syndrome in a sample of 2430 overweight adolescents (aged 12 to 19years) in the United States. Worryingly, 4.2% of all these adolescents were found to have the metabolic syndrome. Of the obese adolescents; 29% had the syndrome, which is also an independent risk factor for developing premature cardiovascular disease.[255] Unsurprisingly, other research has also found that the prevalence of the metabolic syndrome increases with the severity of obesity. In a study of 490 children and adolescents (439 obese, 31 overweight) with a mean age of 11.9 years, it was found 50% of the most severely obese adolescents (BMI Z score>2.5) met the criteria for the metabolic syndrome. [256]

The prevalence of type 2 diabetes in children is increasing and there is evidence that type 2 diabetes will soon become the most common type of diabetes in school aged children.[257] In some parts of the USA, a third of all diabetic children have type 2 diabetes[258]. During the 1990's the incidence and prevalence of type 2 diabetes increased by 46% as opposed to 5% in type 1 diabetes.[259] Historically, type 2 diabetes was very rarely seen in younger people and was considered to be a disease related to age and obesity.[260] Impaired glucose tolerance (IGT) is the pre-cursor of type 2 diabetes. In an American cohort of 167 obese children (age 4-10 years) and adolescents (11 to 18 years), a quarter of the obese children and just over a fifth of the obese adolescents were found to have IGT. Four percent of the adolescents were also diagnosed with silent type 2 diabetes.[261] The increasing prevalence of type 2 diabetes in children is of enormous concern when considering the potential macro-vascular (heart disease, stroke, limb amputation) and micro-vascular complications (retinopathy and nephropathy) in the future. [262]

There is evidence that suggests that girls are entering puberty at a younger age than was previously seen. Researchers from America examined data considering body mass index in relation to age and signs of puberty. In Caucasian girls there was a direct association been the age of onset of puberty and a higher body mass index Z-score. There is also an association in black girls but to a lesser extent.[263] A cross sectional survey of 3021 children (1520 boys) was carried out to assess for differences between genders, and obesity and early sexual maturation. This study found that obese girls entered puberty at a younger age than their non-obese peers but with boys it was the thinner boys that matured earlier. [264]

1.2.4.2.4 Musculoskeletal

The long-term impact of prolonged obesity from childhood through to adulthood on the developing musculoskeletal system is cause for concern. The tensile strength of bone and cartilage is put under undue pressure in obese individuals, and can result in debilitating conditions. [236]

The prevalence of orthopaedic complications associated with obesity was assessed during a review of medical charts of otherwise healthy children and adolescents participating in paediatric studies. When compared with non-overweight participants the overweight participants had a higher proportion of fractures, musculoskeletal discomfort and reduced mobility. The authors of this study were concerned that these complications would serve to perpetuate the cycle of obesity, as the children were now less likely to participate in physical activity.[265]

Blounts disease is a rare orthopaedic condition, which results due to excessive pressure on the tibia and femur. The excessive pressure causes a resultant overgrowth on the proximal tibial metaphysis and this is referred to as Blounts disease or tibia vara. This condition is not exclusive to obese children but over two thirds of cases occur in overweight individuals.[266]

An Australian study of 124 children, with an average age of 8.5 years examined the effects of obesity on foot structure and development. This study found that obese children were more likely to have structural foot changes and develop pes plantus or flat feet, which is a painful condition and is associated with compromised foot function. Unfortunately, pes plantus is likely to be exacerbated with increasing age and weight. The discomfort may also reduce the child’s participation in physical activities. [267]

1.2.4.2.5 Renal and Liver Complications

In adults early renal damage has been associated with obesity and research has indicated that this is true for children too. A study of 165 (85 clinically obese) children aged between 12 and 13 years old, found that obese children had a significantly higher degree of albuminuria and beta-2-microglobulinuria than their normal weight counterparts. This indicates that early renal glomerular and tubular dysfunction can result from childhood obesity. [268] Importantly this study also found that those children with raised albumin/creatinine ratios were more likely to have other features of the metabolic syndrome.

Non-alcoholic fatty liver disease (NAFLD) refers to a number of conditions caused by a build-up of fat within the liver. The condition has various stages from simple fatty liver, to Non-alcoholic steatohepatitis, Fibrosis and Cirrhosis. The effects of NAFLD can be benign but it can also be aggressive and result in ultimate liver failure. A Chinese study aimed to assess the prevalence of non-alcoholic fatty liver disease (NAFLD) in their local population of obese children. Eighty four children (25 girls) with an average age of 12 years participated. Worryingly, 77% of children were diagnosed with fatty liver disease and 24% of these children had progressed to non-alcoholic steatohepatitis. [269]

The more obese the children were, the more likely they were to have a fatty liver.

The evidence above confirms the very worrying physical and psychosocial effects of childhood obesity, and highlights the importance of preventing this condition in the first place.

1.2.5 Causes of Childhood obesity

The prevalence of obesity is increasing both worldwide and in the United Kingdom, and the potential health and social implications for children are cause for concern. In section 1.1.6 factors attributing to the aetiology of obesity were described; including environmental factors (dietary and physical), genetic predisposition, along with psychosocial causes. This section will now focus specifically on some of the causes of childhood obesity, as a means to finding the focus for a prevention strategy.

1.2.5.1 Physical Activity

As previously described, the modern day environment promotes a more sedentary lifestyle. Concerned modern parents are also inadvertently reducing their child's activity levels for fear of strangers, and children are restricted to remain within the home environment. [270]

Physical activity as part of the normal school curriculum has also seen changes in recent times. A study commissioned by Sport England found that between 1994 and 1999 there had been a drop in the number of schools that devoted more than 2 hours per week to school sport activity, decreasing from 46% to 33% of schools.[271] Also in some areas in the United Kingdom school playing fields are being sold off for development.[272] A very interesting study looked at time allocated for physical activity and the activity levels of children in different schools. Three very different schools including; one private preparatory school, a village school and an inner city school participated in the study which used accelerometers to assess activity in children aged 9 years old. This study found that children who were more active at school, tended to be less active out of the school environment, and the inverse was also true. These results are encouraging as different schools place varying degrees of importance on physical activity and it is useful to know that children naturally compensate out of the school environment.[273] This same research team studied the impact of the "school run". According to reports the proportion of children who are driven to school doubled to 30% over a 10-year period from 1989 to 1999. The researchers focused on children in their first year of school and assessed their activity levels using accelerometers for a week. As with the previous study, those children who were driven to school had very similar total levels of activity to those who walked, and compensated for the "school run" at other times. [274]

In adolescence there may be a change particularly in girls where an American study has found that total energy expenditure decreases in girls as they approach puberty, without a compensatory reduction in energy intake.[275] Researchers from the Oslo Youth Study, tracked adolescents through to adulthood, starting with an average baseline age of 15 years and following subjects from 18 to 20 years. This study found that the BMI tracked significantly from adolescence through to adulthood and that leisure time physical activity (LTPA) was an important factor. Subjects who became more physically active, as they became adults had a lower risk of overweight. The authors of this study concluded that there can be stability of relative body weight through life and that encouraging more physical activity from adolescence may help to reduce overweight in later life. [276]

1.2.5.2 Television watching

According to reports children are increasing their sedentary behaviours, but not simultaneously reducing their energy intake. Worryingly there is also the potential for increased calorie intake from additional snacking during television viewing or as a result of food advertising on television.[277]

A national survey in the USA found that 26% of American children watch four or more hours of television per day, with 67% watching at least 2 hours every day. This survey also found that children who watched more than four hours each day had more body fat and a higher BMI than children who watched less than 2 hour each day.[278] This was confirmed in another US survey, which found that television watching was positively associated with obesity in girls, irrespective of age, ethnicity, social class or even physical activity. Children, who have a television in their own bedroom, are also likely to watch more television. Bedroom television viewing increases watching time by 38 minutes per day.[279] The effect of television watching on BMI has convincingly been established after a long-term birth cohort study which followed children from 3 to 15 years of age. Even following adjustments for parental BMI and socio-economic status, television watching was found to be a strong predictor of overweight, especially in girls. The relationship was also evident in boys but to a lesser extent especially at the older age groups.[280] The potential for increased calorie consumption while watching television has been assessed in a Belgian study of over 2546 secondary students.[281] On average the students watched 22.27 hours of television per week, with boys watching significantly more than girls. Only 3.5% of the students never ate snacks or drank soft drinks while watching television and the additional calories consumed increased the total daily intake by 20% in boys and 15% in girls. In this cohort of teenagers one hour of television viewing represented 653kJ or 156calories.[281] These studies show that television viewing is contributing to the increasing obesity epidemic in children.

1.2.5.3 Family and Social factors

In today's environment almost two third of adults are now overweight and this may be influencing what people view as normal. A very interesting study completed as part of the Earlybird project in southern England, assessed parental views of their child's size. Only a quarter of the parents of overweight children recognised the problem in their own child, and very worryingly 33% of mothers and 57% of fathers of obese children assessed their child to be "about right".[282] Parental lifestyles and activity levels have been found to correlate with their children, especially in overweight families. Using 3-day activity diaries researchers assessed activity levels amongst a cohort of 129 obese and 142 normal weight children with their parents. Parental inactivity was found to be a strong predictor of child inactivity. This study did also find that inactive parents could encourage their children to participate in sports activities, even if they were not role models themselves but through their encouragement and support.[283] These studies highlight the important role that parents could play in preventing obesity, but there is little hope for intervention, if the parents themselves do not recognise the problem.

The home environment is also an important factor in the development of childhood obesity. Sørensen and Lissau conducted one of the first studies looking at this in Copenhagen. A sample of 881 children aged 9 to 10 years old were followed for ten years from 1974. This study showed a nine-fold increase in the risk of obesity for neglected children.[284] The authors also found that the area where the child is raised has a major impact on the potential for developing obesity, and living in a dilapidated area had far more influence, than the level of parental education or occupation. [285] These results were confirmed by later work looking at large prospective cohort study of around 3000 children aged under 8 years of age who were followed for a period of 6 years. The children from minority groups, most in the low socioeconomic group and often with single parents also lived in the most deprived areas. These researchers also found a strong association between cognitive stimulation, and obesity. [286] Cognitive stimulation is described as motivated involvement from parents to develop their child's cognitive and language development. For children with lower levels of cognitive stimulation they are at twice as much risk of becoming obese as children who have the highest levels of cognitive stimulation.[286] They hypothesised that children who were in a stimulating and interactive environment were more likely to be active and less inclined to engage in sedentary behaviours such as television watching. This study suggests that childhood obesity initiatives should target parents in depraved areas and possibly promote cognitive stimulation. [286]

1.2.5.4 Food Marketing

Both adults and children are spending more time watching television, which is the most commonly used advertising medium for food and drinks. In recent times, adults have been found to view on average 15 hours of television per week, and in the United States there are approximately 6 minutes of adverts per hour. Over a period of one week the average American adult is exposed to 90 minutes of television adverts. [287]

An American report[288] describes how the current food and beverage marketing patterns are threatening the health of the next generation. This report continues citing how children are intentionally targeted and are encouraged to consume highly calorific foods with little nutrition value. The effects are evident in the increased consumption of specific foods. Soft drink consumption has doubled since the 1980's and represents 10% of the daily calorie intake. Paediatricians treating obese children have found that these children regularly consume 1200 to 2000 calories in soft drinks alone each day, and the US Department of Agriculture has reported that even babies are given these drinks.[289]

Companies spend vast amounts of monies on promoting specific products; recently Kelloggs spent $22.2 million promoting *Cheeze-It Crackers*, while MacDonald's spent $528.8 million to promote $24.4 billion worth of sales.[289] Historically, television was the primary marketing tool, but newer more novel methods are now being used. These include; product placement with toys, celebrity endorsements and character licensing and even mobile phone text messaging. One of the best known marketing tools, is the MacDonalds *Happy meal*, which consists of a child's meal and drink in a box and this is accompanied by a toy which is often part of a marketing-tie-in with a popular film or toy. A prime example of an effective campaign was the MacDonald's "Teanie Beanie Baby" campaign in 1997. This targeted 3 to 8 year olds and miniature beanie baby stuffed toys were included in the *Happy meal.* Prior to this 10 million *Happy meals* were sold weekly in the United States, 10 days into the promotion 100 million were sold in one week.[290] Another very clever marketing tactic has been to create foods that are just for children and the campaigns focus on encouraging the children to eat these foods that are just for them. Children have become powerful consumers, and from the age of two are able to recognise products and ask for them by name.[288]

1.2.5.5 Dietary influences

Evidence suggests that lifelong patterns of eating and exercise behaviours are formulated in childhood.[291] The diets of children living in the United Kingdom were assessed in 1997 with a National Diet and Nutrition Survey for young people aged between 4 to 18 years.[292] This report highlighted a number of areas of concern regarding the normal weekly consumption in children at that time:

- 74% of children did not eat any citrus fruit
- 58% did not eat any green leafy vegetables
- The majority consumed carbonated soft drinks, with an average weekly consumption of 1500ml for boys and 750mls for girls

Over the last 30 years portion sizes have increased. Using data from various nationwide food consumption surveys between the 1970's and the late 1990's, researchers have assessed changes in average portion size. Worryingly, the results showed that portions have increased both within the home environment and outside the home particularly in fast food outlets.[293] A small study of preschool children assessed children's voluntary energy consumption. The children were given the same meal, on the same day of the week, but of varying portion sizes over a three week period. The younger children, with an average age of 3.4 years, were found to consume the same amount each week, but the older children, mean age of 5 years, increased their intake according to the increasing portion sizes. This suggests that as children get older they are more receptive to environmental cues and less to their own internal responses.[294]

Thirty percent of a nationally representative sample of over 6000 children in the United States were found to consume fast food on any typical day.[295] On days when children eat fast food, their diet as a whole suffers. Not only do they eat more calories, but their diet appears to be higher in fat, carbohydrate, added sugars and lower in fiber. In general these children consume more sugar sweetened beverages and less milk, fruit and vegetables.[295]

A number of reports have assessed how the diets of children today compare with previous generations. [292;296] In view of our current childhood obesity epidemic, it is very interesting that the average total daily calorie intake for children today is actually lower than previous generations. The estimated average requirements (EARS) are the estimated daily energy requirements needed to maintain weight, and are specific to gender and age. The UK national survey found that the mean daily energy intake in 1997 was below the EARS for every age group and gender.[292] When related to the size and growth, these current average energy intakes were adequate. This suggests that the lower levels maybe due to underreporting; or possibly the original EARS were based on population groups that sustained greater levels of physical activity.

Another area that has changed over the past three decades is beverage consumption. National Data from the United States shows that the intake of sweetened beverages has increased in children aged 2 to 18 years, while milk consumption has decreased, resulting in a daily increase of 278 calories.[297] There is evidence that milk consumption in addition to its important nutritional role may also have a favourable effect on weight. A review of 6 studies and 3 trials concluded that calcium intake may be beneficial in reducing overweight.[298] One theory for the effect relates to the ability of dietary calcium to suppress intracellular calcium and regulate energy metabolism, thus reducing the risk of obesity.[299]There is epidemiological and clinical evidence that calcium has a role to play in weight regulation, but further research in needed to confirm the exact mechanisms and how this could be implemented. [300]

1.2.5.6 Carbonated drinks

1.2.5.6.1 The evolution of carbonated drinks

> *"It began as a drink, as dark as night, and became an experience, flowing over time and place, linked by memory to the meal on the table and the company at hand. Over more than a hundred years it came to be seen as a constant amid changes, a rock standing against the tide."*
>
> *Constance L. Hays; 2004*[301]

Carbonated drinks or soft drinks as they are often referred to are non-alcoholic beverages. The basic ingredients are water, acid, flavourant, sugar or sweetener, preservative and carbon dioxide and some may contain fruit. The carbon dioxide provides the effervescence or characteristic "fizz" in soft drinks.[302]

The first marketed soft drinks were created in the 17th century, and were made from water and lemon juice sweetened with honey. Initially the drinks were non-carbonated and in 1867 the first carbonated man-made drinks were made. Drinking either natural or man-made mineral water was considered to be healthy and soda fountains became commonplace in American pharmacies from the mid 1830's. The pharmacists would occasionally flavour the mineral water using birch bark, dandelion, sarsaparilla, and fruit extracts. [303]

In 1886, a pharmacist, Dr John Pembleton in Atlanta Georgia developed a syrup using extracts of cocaine and the caffeine rich kola nut. He then mixed the syrup with carbonated water and sold the drink as a tonic in his pharmacy.[304] His bookmaker called it Coca-cola, and wrote out the name in a very distinct script which has become recognisable the world over. In the first year, nine servings of the coca-cola tonic were sold each day. Over a century later more than 10 billion gallons of the syrup have been distributed across the globe. Unfortunately Dr Pembleton died in 1888 never knowing the full success of his product. Asa Candler bought the secret formula for coca-cola in 1888, and this was the beginning of the Coca-Cola Company. This company has used innovative marketing to promote its product. In the beginning the drink was advertised as a "brain tonic" and "nerve tonic". As time went on, it was marketed as something simple that provided pleasure and a break from mundane routine. An advertising campaign in the 1920's focused on encouraging consumers to drink Coca-cola at any time of the year. This campaign used Santa Claus, a symbol of winter to promote its message that "thirst knows no season". The depiction of a jolly looking St Nicholas in a red suit, has become the modern symbol of Santa Claus and shows the power of successful marketing.[301;304] In the 1940's, the advertisements continued to target everyday life, and promoted Coca-cola as an ideal drink for a break in between doing housework. At this time they promoted the drink as "...pure wholesome refreshment." [304]

Promoting volume has been a key part of the clever marketing approach of soft drinks.[301] In 1915 Coca Cola was sold in 6.5oz bottles but by the 1950's 10oz and 12oz bottles were also available, although the 6.5oz bottles still remained the most popular. In recent times 20 and 32 oz. bottles are available on sale and in the United States the 20oz bottles are now the most commonly available as it has replaced the 12oz bottle in vending machines and convenience stores. [287] The original popular coca-cola in 6.5oz bottles contained just less than 80 calories while the more recent "super-sized" and commonly available 20oz bottles contain around 250 calories, tripling the original calorie intake at one sitting. Coca- cola represents only part of the market that produces soft drinks and the cola-cola company alone has over 400 different brands.[304]

In the United States soft drink consumption has increased by 500% over the last 50 years.[305] Although there is debate in the literature as to whether children's consumption of these drinks has changed. A study which was in part funded by the National Soft drink association, assessed changes in consumption of children between the ages of one and nineteen from 1987 to 1998. This study concluded that there was neither a significant decrease in milk consumption nor an increase in carbonated drink consumption in children over this period.[306] In this same journal another article by Wilkinson and colleagues (from the U.S. Department of Agricultural Research Service) found increases in soft drinks and decreases in milk consumption.[307] The first study used 2 weeks continuous recorded records to monitor beverage consumption and the second shorter dietary records for 2-3 days and one day. Harnack and colleagues[308] using 2-day recall of nationally representative sample found that soft drink consumption was displacing the consumption of more nutritious drinks such as milk and fruit juice. In addition, for those children who consumed these drinks they consumed on average 2010kcal/day compared to children who did not regularly consume these drinks of 1830kcal/day. The authors concluded that the high consumption of these drinks leads to excessive energy intake, with a mean adjusted energy intake that was 10% higher for children that regularly consumed carbonated drinks compared to non-consumers.[308]

Another America study reviewed the data collected by the department of Agriculture, using the continuing Food survey found that 16% of the total energy intake for Americans age 2 and above was derived from added sweeteners. They found that the largest source of sweeteners was soft drinks, which accounted for a third of the intake.[309] The current UK recommendations concerning the intake of non-milk extrinsic sugars, states that the intake of these sugars should not exceed 10% of the total dietary energy. The National Diet and Nutrition survey[292] found that both boys and girls of all ages exceeded this target with a mean intake of non-milk extrinsic sugars of 16.5%. The main sources of these sugars were drinks, sugar preserves and confectionary. The proportion of non-milk extrinsic sugars provided by drinks increased with age rising from 27% for 4-6 year olds to 42% for 15-18 year olds. Sugar sweetened carbonated soft drinks were the main type of drink in this group.

1.2.5.6.2 Obesity and Carbonated drinks

A number of studies have been conducted to assess the association between sugar-sweetened drinks and obesity. Ludwig and colleagues examined the relationship between the consumption of these drinks and childhood obesity in 548 ethnically diverse children, over a period of 19 months. [310] They reported that with each increased serving of sugar sweetened carbonated drink, body mass index and frequency of obesity increased. The odds ratio of becoming obese increases 1.6 times for each additional sugar sweetened drink consumed daily. Another small longitudinal study was conducted over a summer camp and assessed sweetened drink consumption in 30 children aged 6 to 13 years.[311] Although the results were not significant, the authors found that increased consumption of sweetened drinks was associated with a higher total daily energy intake. The children that consumed the most sweetened drinks had the highest energy intake and also gained the most weight over the summer camp. Welsh and colleagues conducted a large retrospective study in children aged 2 and 3, to assess for any association between obesity and consumption of sweet drinks in this younger age group.[312] This study found that daily consumption of one or more sugar-sweetened drinks increased the chance of becoming obese amongst children already at risk of overweight (those children above the 85th but below the 95th centile), and continued the likelihood of remaining obese. (BMI ≥ 95th centile).

The association between these drinks and obesity has also been assessed in adults. Schulze and colleagues used longitudinal data from the Nurses Health study II to examine the association between the consumption of sugar sweetened drinks; weight gain and the risk of type 2 diabetes in women.[313] This large study found that women, who increased their consumption of sugar sweetened soft drinks, also increased their total daily calorie intake, although most of the additional calories came from soft drinks. These women that consumed more than one soda a day and gained weight, had a significantly higher risk of developing diabetes than women that consumed less than one of these drinks a month. This research also highlighted that the women that consumed the most sugar containing drinks, also tended to smoke more, have a higher calorie intake and do less physical activity. The regular consumption of these drinks could also be marker of an unhealthy lifestyle.[314]

The above research suggests there is an association between obesity and the consumption of sugar-sweetened drinks at all ages. The exact mechanisms for this are not fully understood. The simplest explanation could be that an increase in calorific intake that is not compensated by additional energy expenditure or a reduction in calories from other sources may cause weight gain. This is pertinent when considering that that a single regular sugar sweetened drink (330mls) contains approximately 150kcals. Small changes in energy intake and output appear to have a impact on obesity risk.[262] For example the daily consumption of one can of a regular carbonated drink (120kcal) over a 10-year period in a constant environment theoretically will have the potential to result in a 50kg weight gain.[262] Reducing daily intake by a small amount of calories or by increasing energy output (the "energy gap") may help to prevent weight gain. Using data from national surveys, Hill and colleagues[315] have suggested that altering the energy gap by 100 kilocalories each day would prevent excessive weight gain in most adult Americans. For children the energy gap may have to be more than 200 kcal/day to have a similar preventative effect.[316]

The effect of sugar sweetened carbonated drinks on obesity has been attributed to the high glycaemic index (GI) and very low satiety value of these drinks. Research has shown that intake of a high glycaemic substance causes a rapid absorption of glucose and the resultant metabolic processes may cause excessive intake in individuals.[108] Following a high GI meal/drink the serum insulin levels are raised and this causes a rapid absorption of glucose. At the same time plasma glycogen levels are low, as a result of the natural inhibitory effects of high glucose and insulin levels. These high insulin levels and low glucagon concentrations result in uptake of glucose by the muscles and liver, which in return reduces hepatic glucose production and stops lipolysis. Following this; concentration of glucose and fatty acid levels in the plasma are reduced, which then results in increased levels of the counter- regulatory hormones, which ultimately leads to sensations of hunger and increase intake of food. [108]

Another theory, is that additional calories which are taken in the form of a liquid are less satisfying than food solids and people do not compensate for these additional calories by consuming less at subsequent meals.[317] Pre-load experiments have been conducted in both adults and children to assess the ability to compensate for additional calories. Birch and colleagues found that the food intake in children aged 2-5 years was reduced an hour after consuming a pre- load of a caloric sweetened drink and they were concerned that this could lead to reduced nutrition variety, with children eating less at meal times.[318] Conversely DiMeglio and Mattes[319] showed in their pre-load experiments in adults, that there was little compensatory reduction in calorie intake when additional carbohydrate was consumed in a liquid form. There is limited research on this issue, and the evidence is currently inconclusive although it is suggestive that age may influence the effect.

Recently there has also been controversy about the effect of high fructose corn syrup (HFCS) and obesity. HFCS is produced from corn syrup, which has U corn syrup (100% glucose). Different types of HFCS are used in different products. HFCS 90 is used mostly in baked goods and is approximately 90% fructose and 10% glucose whereas HFCS 55 and 42 are used mostly in soft drinks. HFCS has replaced sugar in many products, one of the primary reason for this is it sweetness. The sweetness taste from fructose reaches a peak, much earlier than sucrose and the taste diminishes sooner, this results in enhancement of other flavours which may have been overwhelmed by sucrose. Essentially the use of fructose improves the flavour profile of the product.[320] In addition, HFCS retains moisture for long periods of time and at low levels of humidity, this means that products containing HFCS will have longer shelf lives. HFCS are used by soft drink manufacturers, with 90% of soft drinks produced in the United States containing HFCS. [320]

Between 1970 and 1990 the consumption of HFCS increased by over 1000%, and in the United States this represented more than 40% of the caloric sweeteners added to foods, and the sole caloric agent used in soft drinks.[321] Some researchers feel that the increased consumption of HFCS mirrors that of the increasing obesity epidemic. These researchers state that the effect of fructose in the diet may contribute to increased calorie intake. Fructose does not stimulate insulin and leptin production which assist in the regulation of food intake.[321] These authors cite evidence that the effects of HFCS are more potent when it is in liquid form.[310;322;323] There is insufficient evidence to suggest that regulations for decreasing the use of HFCS in food production are necessary.[324] The exact association and mechanism of HFCS and obesity is inconclusive but there is a definite need for further research to establish if this sweetener has a role to play in the increasing obesity epidemic.

There is evidence that links obesity to the consumption of carbonated drinks, even if the exact mechanism is not fully understood. Currently there is no research focusing on interventions that focus specifically on these drinks as a means to preventing further obesity. This suggests that a specific intervention focusing on discouraging the consumption of these drinks may be effective in preventing further obesity.

1.2.6 The Prevention of Childhood Obesity.

The World Health Organisation's report on obesity in 1997 concluded that with the trends of increasing adult and childhood overweight and obesity, it was essential to not only focus on individuals with a high BMI and associated health problems but that preventative strategies that included populations as a whole were necessary to combat the problem.[3] Family based approaches are best suited in situations where the problem of overweight or obesity is already recognised,[325] but schools provide the ideal environment for prevention strategies.[3]

Whitaker describes four very simple behaviours that should improve overall health, and potentially reduce the chances of obesity.[326] He describes the sensitivities required by heath care professionals working with families in the community, and how some families react very negatively to the "o" word. His four key messages include, reducing television watching, limiting intake of sugar-sweetened soft drinks, encouraging physical activity and promoting breast-feeding. These messages sound incredibly simple, if not common sense. Whitaker describes normal communities; where every home has more than one television, there are soft drink vending machines in all schools and public venues, breastfeeding is not encouraged for mothers returning to work and parents are concerned for their children's safety when outdoors. These communities may not find it easy to adjust his suggestions, as this way of life has become commonplace.[326] Whitaker highlights how the social context of modern day society can make it difficult to implement successful initiatives.

The prevention of any illness and disease is complex especially if the causative factors are commonplace in everyday life. Preventatives strategies involving children tend to focus on either the family or the school environment.

1.2.6.1 Family based approaches

Family based interventions are centered on the idea that the family as a whole can change and support each other.[327] This can only be effective if the family recognise that there is a problem and as previously described, many parents of overweight children do not acknowledge the problem. [282]

Epstein and colleagues conducted a family-based intervention using behavioural strategies which focusing on deceasing intake of highly calorific foods and increasing exercise. After 10 years there was a decrease in overweight in the intervention group by

7.5%, while the proportion of overweight had increased by 14.3% in the control group.[328] these results are skewed as the families were selectively recruited for their motivation to change and the likelihood of success.[327]

Other family interventions have shown modest successes. In one study, children aged 10 to 11 years were screened for obesity, 50 were selected to the control group and of the remaining 44, two treatment groups were created.[329] The one treatment group participated in additional family therapy, while both groups received dietary counseling for a period of 14-18 months. The final assessment of the children was made when they were 14 years of age. Those children who received both family therapy and traditional counseling had significantly better outcome measures (reduction of triceps, subscapular, and suprailiac skinfold thicknesses, improved physical fitness) than both the control and other treatment group.[329] Another study unfortunately showed very poor long-term results.[330] In this programme, children and their parents participated in a behaviourally orientated programme. In one group parents had the primary responsibly for following the programme, while the other increased the child's involvement. At 6 months, both groups had a reduction in overweight but by 3 years, the levels of overweight were back to and above baseline measures for both groups.[330] To date most family based interventions have targeted children who are already overweight or obese.

According to the International Association for the Study of obesity, family based prevention programmes should be a primary public health goal but currently most of the prevention programmes for childhood obesity are school based.[27] One family based intervention has targeted families with obese parents, and non obese children.[331] These children are at risk of overweight and obesity as parental obesity is a major risk factor.[158] In this study 30 families participated in two separate intervention groups. The one group focused on decreasing intake of high fat and sugary foods, while the other group focused on increasing fruit and vegetable intake. The parents in the fruit and vegetable group had significantly greater decreases in percentage of overweight compared to the low fat and sugary food group. Interestingly, both groups of parents decreased their fat and sugary food intake. The children in both groups decreased their fat intake while those in the fruit and vegetable group, also increased their intake of fruit and vegetables. This study shows that by targeting at risk families, the nutritional intake of the family can be improved and hopefully this may prevent those children at risk of overweight from developing the problem.

1.1.6.2 School based interventions

Treatment of obesity generally takes place in a clinical environment or as described above as part of a family based intervention. Schools provide an ideal environment to prevent obesity and also potentially to treat the condition.[332] In addition they provide a link to the wider community and families.[27] The school environment offers continuous and intensive contact with children for the first two decades of their lives and programmes within schools are often more financially viable than those in the clinical environment and reach children from all socioeconomic groups. Children eat a minimum of one meal a day at school, and the cafeteria should provide an ideal environment for promoting healthy food.[332] Research has shown that the school environment and food policies can influence the nutritional intake of the students.[333] Schools with policies regarding the types of foods sold at school; and the number or restriction of access to vending machines at specific times can influence the snacking behaviours and soft drink intake of the students.[333]

A number of school based interventional studies have been completed, and a few reviews have compared the results and effectiveness of these studies. One review concluded that there have been relatively few primary prevention studies specifically targeting childhood obesity, but that there is evidence of modest short-term results. [332] The Cochrane report from 2001[1] assessed 10 studies, seven of which were long term (longer than 12months). The main points from seven of the long-term studies described by the Cochrane review are summarised in Table 4. The authors of the review concluded that the strategies that focused on reducing sedentary behaviour and increasing physical activity were the most fruitful. They also stated that there was limited high quality evidence and there was a need for well designed studies with a range of interventions. [1]

Very few intervention studies have been conducted in the United Kingdom. The Active Programme Promoting Lifestyle Education in School (APPLES) included 634 children aged between 7 and 11 years from 10 schools in Leeds.[334] This study aimed to reduce risk factors associated with obesity and involved teacher training, changes to school meals and increased physical activity. It was successful in implementing changes at school level, but even following intensive education only achieved very modest behavioural changes with the children. Vegetable consumption increased by 50% but there was also a fall in fruit consumption and an increased consumption of high sugar foods. Although the children did not change their behaviour, those that participated in the education had a greater knowledge and awareness about healthy nutrition.[335]

The Planet health study from America was an intensive school based education programme, and was successful in reducing obesity in girls but caused no change with boys.[336] This study included 1295 students from 4 schools in Massachusetts with a two-school year follow-up period (18 months). Health sessions were included in the curriculum, and focused on decreasing television watching, and consumption of high-fat foods, with promotion of fruit and vegetable consumption and physical activity. A reduction in television viewing was effective amongst the girls but not boys in this study. Each hour reduction in television corresponded with a reduction in obesity prevalence amongst the girls. [336]

Very few obesity prevention programmes have assessed the cost effectiveness of their interventions. The researchers from Planet health have completed such an assessment, and have shown their intervention was cost effective. They calculated that the intervention cost $33 677, and would prevent 1.9% of female students becoming overweight as adults. An estimated 4.1 QALY's would be saved, with a net saving of $7313 for each QALY saved.[337]

Another large intervention study was the Kiels Obesity Prevention Study (KOPS) in Germany. This study included younger children aged between 5-7 years and the education messages were given both to the children and parents. Again the message focused on increased fruit and vegetable consumption, with decreases in high fat foods and television watching. After 12 months there was no difference in the prevalence of overweight and obesity between the control and intervention group, although the fat mass measured using skin fold thickness was significantly less in the intervention group.[338]

A school-based programme in Singapore showed modest results in reducing obesity and overweight amongst both genders.[339] This programme was based in primary, secondary and university schools. The "Trim and Fit" interventions were very intensive and included changes to food sold at school canteens and extra nutrition education was incorporated into the formal school curriculum. The project was supported by the Ministry of education who provided intensive teacher training, with focused information on home economics and physical education.[27] In addition, any overweight children participated in an extra exercise and health education programme. Obese children received even more input and were referred to the school health services student health center for follow-up with dietitians and doctors. Over an 8-year period between 1992 and 2000, the prevalence of obesity decreased from 16.4% to 14.6% for 11-12 year olds and from 15.5% to 13.1% for 15-16 year olds. There are no control figures for this programme but adult obesity in

Singapore did increase from 5.1% to 6.0% between 1992-1998.[27] This programme is one of the most intensive long-term interventions, and one of the very few with government support.

Although childhood obesity prevention is a public health priority, there is a lack of evidence providing clear direction for prevention interventions and policies. As stated in the Cochrane review, there is a definitive need for further research to determine cost effective health promotion strategies.[1]

Table 4. Summary of Cochrane review (2001) long-term interventions.[1]

Study name	Location & Cohort	Intervention	Results
Apples Study Sahota (2001)[334]	Leeds UK 10 schools N=634 age range 7 to 11 Cluster RCT 1 year follow-up	Combined dietary & physical activity - Whole school approach. - Modification of school meals. - Development of school action plans to improve nutrition education and promote physical activity. - Additional teacher training.	- No change in BMI between Control (C) & Intervention (I) group. - Intervention children significantly higher vegetable intake. - Overweight children in Intervention group increased sedentary behaviour but obese children in this group also increased self worth scores.
Donnelly (1996)[340]	Nebraska, USA 2 schools N=338 Grades 3-5 RCT 2 year follow-up	Combined dietary & physical activity - Changes to food supply and nutrition education, with a physical activity intervention. -Existing staff resources.	- No difference in changes to BMI and physical fitness between C & I groups. - Significant increase in HDL cholesterol in I group. - Significantly better nutrition knowledge for I group.
Planet health Gortmaker (1999)[336]	Massachusetts, USA 4 schools N= 1295 Mean age 11.7 years Cluster RCT 18 months follow-up	Combined dietary & physical activity - Used teachers, to promote four subjects, decreasing TV viewing, decreasing high fat food intake, increase fruit and vegetable consumption and increase moderate and vigorous physical activity.	- Obesity reduced in intervention girls but not boys. - Intervention children watched less television. - Intervention girls increased fruit and vegetable consumption and reduced total energy intake. - No changes in BMI reported.

KOPS Mueller (2001)[338]	Kiel, Germany 32 schools N=1640 Ages 5-7years Cluster RCT One year follow-up	Combined dietary & physical activity - Education by skilled nutritionist and teachers. - Education given to parents and children, encouraged consumption of fruit and vegetable, decease in high fat foods, decrease TV viewing and promotion of activity for 1 hour per day. - High-risk families were given additional support.	- Significant decrease in triceps skinfold thickness in intervention group. - No difference in BMI between intervention & control group. - Significant increases for intervention group with nutrition knowledge, fruit and vegetable consumption. - Significant decreases for intervention group for high fat foods and TV watching.
Simonetti (1986)[341]	Italy 3 schools N-1321 Age 3-9 RCT 1 year follow-up	Dietary versus control - Assessed effectiveness of two levels of intensity focused on obesity prevention: -MA (multimedia-Action) involved printed leaflets, audiovisual aids, and qualified staff input. -WA (written action) pamphlet distribution only.	- Reduction of obesity by 12.2% and overweight by 12.1% for the MA group.

Epstein[331] (2001)	Buffalo, USA Families with obese and non-obese children N=26 Age range 6-11 RCT	Dietary versus control - Parents received the education. - Education focused on increased fruit and vegetable consumption or decreased high fat and sugary foods.	- No significant difference in percentage overweight in either group. - Both groups decreased high fat and sugary foods. -Fruit and vegetable group increased intake of fruit and vegetable consumption.
Mo-Suwan (1998)[342]	Thailand 2 kindergardens N=292 Mean age 4.5 RCT	Physical activity versus control - For 29.6 weeks a specially designed exercise programme was conducted 3 times a week. This included a 15-min walk before class and a 20-min aerobic dance session after the afternoon sleep.	- After 29 weeks, an almost significant (p=0.057) reduction in prevalence of obesity for intervention children. - In exercise intervention group, baseline obesity was 12.9%, at 29.6 weeks it was 8.8% and 6 months later 10.2%.

1.1 Hypothesis

Childhood obesity is increasing and there is a need for interventions to halt the year on year increase. There are a number of known causative factors. To date schools are seen to be best placed for interventions to promote health and prevent obesity. Currently there is limited evidence regarding the effectiveness of interventions. There is evidence that sugar-sweetened carbonated drinks are associated with increased obesity and therefore this thesis will address the hypothesis that a specific school based intervention focusing on reducing the consumption of carbonated drinks will be effective in preventing obesity.

This thesis describes a study, which developed and expanded over time. The initial idea was born following a question raised in clinical practice about increasing adult obesity and concern about the levels of obesity in the next generation. This led to literature searches following which a pilot study was conducted. The project developed naturally into a large randomized controlled trial, which was completed over one school year. Subsequently, 2 years after completion of the original study, further anthropometric measurements were taken to evaluate how the children had progressed, and to assess if the original project had any lasting impact. For this reason some methods used in analysis may be different to what would be used if the project at conception had been viewed as a large RCT with data collected over a number a years.

Chapter 2 describes a small pilot study conducted to assess local prevalence of overweight and obesity in school children aged 7 to 11 years old. In addition, surveys were conducted to assess the drink consumption, physical activity and screen watching (television/computer) of these same children. These results were published in Diabetes and Primary Care in 2002.

Chapter 3 will describe the Christchurch Obesity Prevention Programme in schools (CHOPPS). This was a large cluster randomised control trial, designed to assess the hypothesis that a specific school-based intervention could prevent further obesity. This is the first study of this kind to address the question that a targeted intervention focusing on reducing the consumption of a known causative factor, sugar-sweetened carbonated drinks, could be a means to preventing further obesity in children aged 7 to 11 years old. The results of this study were published in the BMJ in 2004 (Appendix VI).

Chapter 4 discusses the history of growth monitoring, and a small survey conducted as part of the CHOPPS project to assess how the children felt about being measured. In addition, the new government policy of measuring children in schools will also be described.

Chapter 5 will discuss results from surveys completed after the RCT, assessing knowledge gain following the intervention, and the participants' perceptions of the project.

Chapter 6 will describe the longitudinal results taken 2 years following the completion of the CHOPPS project. These results were published in the BMJ in 2007 (Appendix V11).

Chapter 7 provides a reflective view over the changes that have happened in the decade after the completion of the CHOPPS project.

Chapter 2.

Childhood obesity: a big problem for small people

2.1. Introduction

As described in Chapter 1, the worldwide prevalence of obesity is increasing in both adults and children. Obesity in childhood is known to be an independent risk factor for adult obesity,[152; 153] and obese children who progress to become obese adults have a far greater risk of serious health problems.[159] In the United Kingdom the incidence of overweight children has increased since the mid 1980's. In 1994, according to national figures, 9% of boys were overweight compared to 5% in 1984. The percentage of overweight girls was 9% in 1984 but this rose to 13% in 1994. [229]

As previously described there are a variety of environmental and social factors that may be contributing to this rise in obesity. David Ludwig and colleagues have shown that childhood obesity is associated with the consumption of sugar-sweetened drinks.[310] Children consume these drinks in addition to their normal energy intake with a resultant total energy intake that exceeds their requirements. Researchers have shown that children, who drink an average of 9oz (one and a half cans) of soft drink per day, have an energy intake that is 10% higher than other children who are non-consumers of soft drinks. [308] The latest National Food Survey for children in the UK (2000) has shown that soft drinks are one of the main sources of added sugars in children's diets and that the proportion of sugars provided by drinks increases with age, rising from 27% for boys aged 4-6 years to 42% for boys aged 15-18 years. This same survey found that over a period of one week only 46% of boys and 51% of girls consumed fruit juice whereas two-thirds of both boys and girls consumed regular carbonated soft drinks. Only half of children consumed tap water on a regular basis.[292]

With the increasing consumption of sugar-sweetened fizzy drinks, there is an additional concern regarding the number of these drinks that contain caffeine. Researchers have shown that the physiological consequences of a caffeine containing soft drink (48mg of caffeine) on an average 6-year-old child weighing 20kg, are equal to an adult drinking two cups of filter coffee (170mg caffeine). [343] In a small study from Canada, 18 fit young adult males underwent glucose tolerance tests, following either placebo or caffeine ingestion. The addition of caffeine caused both the insulin and glucose levels to become raised. The authors suggest that caffeine is associated with an increase in insulin resistance.[344] In an editorial on caffeine, Biaggioni and Davis describe how caffeine is the most consumed drug in western society, and there is controversy regarding any potential health consequences. While the controversy remains, caffeine is still readily accessible to children in many soft drinks.

As discussed in section 1.2.5.2 there is evidence that television viewing is associated with increased obesity.[278] Time spend watching television not only reduces children's activity levels, but researchers have found that children are more likely to snack while watching television and increase their daily energy intake.[281] In addition an American survey found that children who have a television in their own room, watch significantly more television than those that share a television with their family.

2.2 Aims

The aim of this pilot study was to assess the prevalence of overweight and obesity in primary school children from the local community and evaluate how these results compared with the national average. In addition, I wanted to survey some of the specific lifestyle factors that have been associated with obesity in this same cohort of local children; in particular the consumption of carbonated drinks; physical activity and television watching. I was also interested to assess what proportion of soft drinks favored by children contained caffeine.

2.3 Methods

2.3.1 Study Sample

A local junior school was approached and agreed to participate in the survey. The school served the mixed social class population of the surrounding areas and admitted pupils for years 3 to 6. Permission was sought from the head teacher, board of governors and local council. Ethical approval was also obtained from the Local Research and Ethics Committee (REC reference number: 49/01/E). This committee requested that we obtain not only parental but the children's own written consent to participate in the survey.

2.3.2 Measurements

Anthropometric measurements were obtained, including:

- Height (without shoes, to the nearest 0.1cm, Ultrasonic Height measure)
- Weight (in light clothes, to the nearest 0.1kg, Seca medical scale – 770, scale calibrated and checked annually).

Using the age and gender specific Body Mass Index (BMI) centile charts, the prevalence of overweight and obesity was established.[213] As described in section 1.2.2 overweight and obesity in children can be classified using a variety of different cut-off points. Comparisons between different studies can be misleading due to the lack of agreement around the standard definition for assessing and evaluating childhood overweight and obesity. Therefore for this survey the rates of overweight and obese children were compared using three different methods:

1. The British BMI chart where the 91st centile defines overweight and the 98th centile defines obesity. [213]
2. The recent internationally agreed cut-off points for BMI (IOTF). These new cut-off points for overweight and obesity in children are based on international data and are linked to the adult cut-off points for overweight (BMI>25kg/m^2) and obesity (BMI>30kg/m^2).[197]
3. The commonly used epidemiological cut-off points where the 85th centile is the cut-off for overweight and 95th for obese. [216]

2.3.3 Lifestyle measures

In the study by Ludwig and colleagues, consumption of sugar-sweetened drinks was assessed through a youth food-frequency questionnaire (YFFQ). [310] This questionnaire focused on evaluating how frequently certain drinks were consumed over a 30-day period. Unfortunately the authors of this study were unable to share this validated questionnaire with me.

Collection of dietary data is fraught with difficulties and there are a variety of different methods of collecting the data including; recall after a 24 hour period, food frequency checklists, weighed records and estimated diet records.[345] A yearlong evaluation of the effectiveness of these different methods in adults concluded that a 7-day estimated record or open-ended food diary was the most precise. The disadvantage of this method is the considerable time required for coding and analysis.[345] Assessing dietary intake in children is complicated by the child's developmental stage and cognitive ability. In addition it is acknowledged that degrees of under-reporting and even over-reporting (phantom foods) varies with age and method of dietary survey used.[346] An Australian study of over two hundred primary schools students aged 11 and 12 years old, assessed the validity of a number of different methods. The food frequency methods scored poorly, while 2 and 3 day diet records achieved a good agreement with the reference method.[347] A similar study was conducted in America amongst girls aged 9 and 10 years old. This study assessed the validity of 24-hour recall, 3-day food record and a 5-day food frequency questionnaire. There were errors with all methods but the 3-day food record achieved the most accurate results. [348]

In view of the above evidence and lack of a validated diary, I designed a 3-day drinks diary, with assistance from dietetic colleagues. The aim was to create a simple and colourful one-page diary (Appendix I). According to Campbell et al the ideal diary is completed over three days, including one weekend day to provide best estimates of actual intake.[1] The children were each given their own diary and were asked to write in every drink they had over the 3-day period, from a Thursday to Saturday. On the back of the diary a simple pictorial guide of drinks of different volumes was also provided. Prior to the pilot study, the diary was trialed in 10 children to assess usability and ease of understanding; in addition the parents of the children confirmed the accuracy of the data provided.

The children were also asked to complete 3-day activity diaries (Appendix II). They recorded length of television watching and time spent playing computer games. Physical activity was also recorded.

2.4 Study population

A local junior school from Christchurch, Dorset was selected for this pilot study. The area of Christchurch covers 50square kilometers (19.5 square miles), and has a small population of 54 thousand, with a density of 891 people per square mile, which is twice the density of England.[349] Christchurch has the highest proportion of retired people in the United Kingdom and the lowest proportion of 0-44 years old.[349] The levels of deprivation within the community also vary considerably, with one ward consistently rated in the top 20% of most deprived wards in the UK and yet another ward is rated among the 25% least deprived. There are seven junior schools and three secondary schools within the locality.[349]

2.5 Results

Of a possible 278 children aged 7 to 11 years old, parental consent was obtained from 56% (157). Four children withheld their own consent and four were absent on the day measurements were taken. Overall, measurements were obtained on 54% (149) of the children including 77 girls and 72 boys. The results of the prevalence of overweight and obesity are listed in Table 5 and 6, showing variation in results using the different methods described above.

Table 5. Prevalence of Overweight in children aged 7 to 11 years old (excluding obese)

	IOTF[197]	>91st [213]	>85th [216]
Girls (n=77)	19 (25%)	10 (13%)	16 (21%)
Boys (n=72)	14 (19%)	9 (13%)	8 (11%)

*Data shown as number (%)

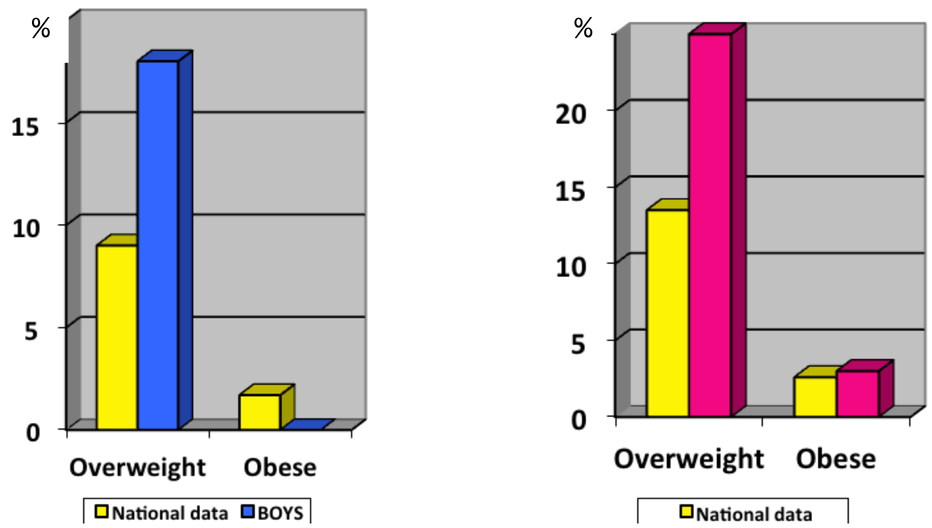
Table 6. Prevalence of Obesity in children aged 7 to 11 years old

	IOTF [197]	>98th [213]	>95th [216]
Girls (n=77)	2 (3%)	2 (4%)	6 (8%)
Boys (n=72)	0 (0%)	4 (6%)	10 (14)%

*Data shown as number (%)

A comparison of this data with the national average of childhood overweight and obesity from 1994 is shown in Figure 14, both using the internationally agreed cut-off points (IOTF)[197] for BMI.

Figure 14. Comparison of the prevalence of overweight* and obesity* in local children in 2001 and the national results from 1994[229]



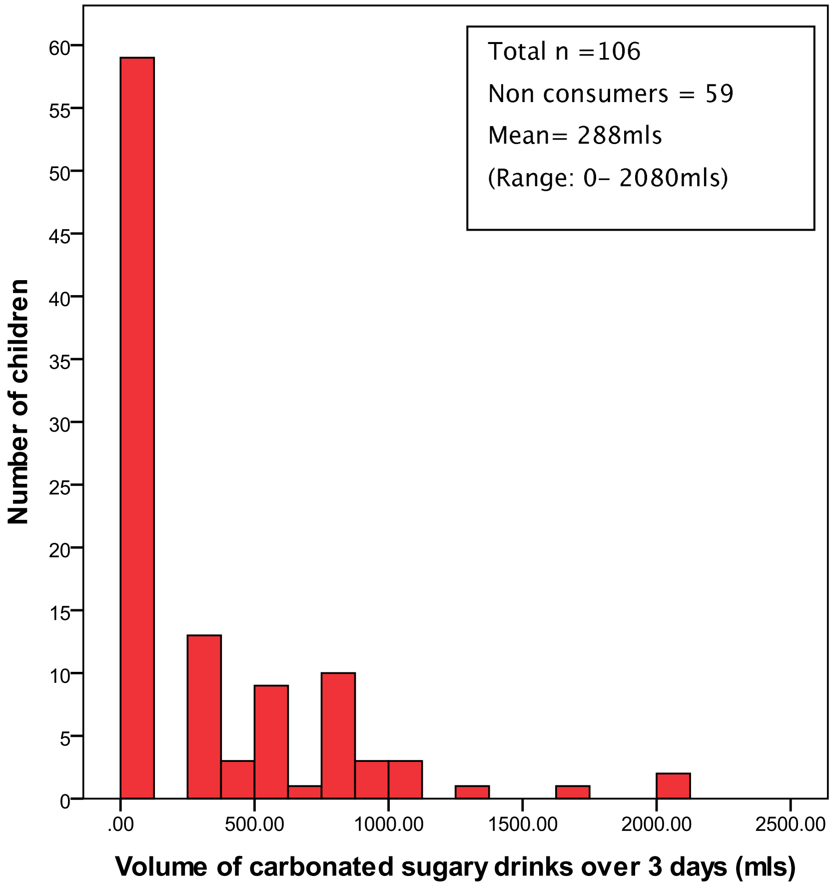
* using the internationally agreed cut-off points (IOTF)[198] for BMI

Drink and activity diaries were returned and completed by 71% (n=106) of the participating children. Over the 3-day period 51% of those that returned the diaries consumed varying amounts of fizzy drinks, with 43% drinking the sugar-sweetened variety in very varying amounts (figure 15). Of the 46 children that drank these drinks, their daily average consumption was approximately a glass (221mls) of a sugar-sweetened fizzy drink each day. Drinks containing caffeine were consumed by 31% of the children with an average daily consumption of 176mls. Diet carbonated drinks were consumed by 10 children. There was no correlation between BMI and consumption of carbonated sugar drink consumption ($r=0.06$; $p=0.72$).

The children also recorded how much time they spent watching television and were asked if they had access to a television in their own bedroom. 41% of the children had a television in their own room, and these children watched an average of 83 minutes of television per day, which was 22% more than the children that shared a television with their family, these children watched just over an hour each day (65 minutes)($p= 0.051$, 95% CI -0.10; 36.63). When this same data is assessed according to gender the difference is more apparent amongst girls. Girls with their own TV watched 97.96 minutes per day compared to those girls sharing with other family members, who watched 67.78 minutes per day ($p=0.04$, 95% CI 1.7, 62.63). Surprisingly there was no correlation between BMI and time spent watching television ($r=0.2$; $p=0.07$).

The data from the physical activity records was difficult to interpret as children had included inappropriate forms of activity. Children included a wide array of activities, and it was difficult to standardise the information for analysis Therefore data from this survey was not included in any analysis.

Figure 15. Consumption of sugar sweetened drinks (pilot study).



2.6 Discussion

The results of this pilot study showed that there was a high prevalence of childhood overweight and obesity in children in the local area, with a higher prevalence than the national averages from 1994.[229] Unfortunately, consent was only received from just over half of the possible sample. The cause of this low return rate was unknown but parents of more overweight children may be less inclined to allow their children to participate.

Obtaining accurate dietary data is notoriously difficult, and some research suggests that there is a tendency for respondents to under report energy intake, and that under reporting is found to be greater in obese and overweight individuals.[1] The accuracy of diaries is questionable but the data received did show that a proportion of the children consumed sugar-sweetened drinks on a regular basis, with slightly less consuming the caffeine containing varieties and even less of the diet varieties. The lack of a correlation between drink consumption and BMI, could be explained by the poor return rate of the drink diaries and that perhaps those children who were larger were less likely to record what they consumed.

The data received on television watching confirms previous research[279], showing that children with a television in their own room watch more television than those that share a television with their family. A national survey from the United States found that 67% of children watched 2 hours of television per day. Amongst this cohort the average time spent viewing was just over an hour for those sharing a television and 1.4 hours for those with their own television. Viewing time may be effected by seasons, and may also increase with age. This pilot study was completed in summer and it would be interesting to repeat this survey in winter.

The data received on physical activity was very difficult to interpret, as the children had different understandings of what constituted activity and this was a major failing of the diary. The diary included examples of what activities to record. The children included normal activities and outdoor play, but some even recorded the time it took for them to walk from the car into the school, and one child spent 2 hours saving snails! Assessing physical activity in children is difficult and many studies use accelerometers.[273;350] Various methods are used with adults and researchers from Denmark have had limited success developing a physical activity scale.[351]

2.7 Implications

The prevalence of overweight and obesity amongst the local community of children was higher than the national averages from 1994,[229] and this highlighted the need for preventative strategies. The children in this community demonstrated similar lifestyle habits seen in other surveys, and regularly consumed carbonated drinks and watched television. A previous school based intervention has focused on television watching and achieved some success in girls,[336] these results suggest that it may be appropriate to target a different intervention, focusing on reducing the consumption of carbonated drinks.

Completing the pilot study was important in planning for the main study. Insight on the school environment and how the study could be best integrated causing with the least disruption was invaluable. Following the pilot study the drinks diaries were amended to include a greater variety of drinks. In addition the pilot study demonstrated the difficulties in obtaining consent. A greater effort was placed on reminders to parents and encouraging teachers to increase participation for the return of consent forms when the randomised controlled trial was commenced. Most importantly, the results from this pilot study were very useful in calculating the sample size for the randomised controlled trial. During the pilot study the children's height was measured using an Ultrasonic height measure. Following advice from the Child Growth Foundation, the Portable Leister height measure was used for the main study.

Chapter 3.

Preventing childhood obesity; a school-based intervention study.

3.1 Introduction

Childhood obesity is increasing both nationally[229] and locally, as seen in the pilot study. Clearly there is a need for interventions to try to promote a healthier lifestyle and prevent overweight and obesity from further increasing. As described previously, home and family interventions would be ideal and may potentially provide the best results, but are impractical for large-scale implementation of health education strategies.[325] Schools present an ideal environment where nutrition messages can be relayed to a large number of individuals but the effectiveness of previous school-based programmes has been limited. [352]

As described in Section 1.2.6.2 a number of school based interventional studies have been conducted. Some of these interventions, such as the Apples Study from Leeds, have included both dietary and physical activity interventions. The majority of such studies have a broad approach and focus on a variety of lifestyle aspects. The Planet Health study from America was successful in reducing television watching amongst girls and increased their fruit and vegetable intake. This study focused on four things, namely decreasing television watching and the consumption of high-fat foods, combined with the promotion of fruit and vegetable consumption and physical activity. Other studies that have focused purely on dietary aspects have focused on a number of factors in the diet, such as increasing fruit and vegetable consumption and decreasing the intake of fatty and sugary foods.[331;341;353] No studies to date have focused very specifically on one aspect of the diet.

In the United States of America, the consumption of carbonated drinks has increased by 500% and today more than 70% of adolescents in the United Kingdom drink these drinks on a regular basis.[292;305] Over half of the children in the pilot consumed these drinks, which have been associated with childhood obesity.[310] The aim therefore of the study was to determine if a specific, school-based educational initiative, which focused on reducing consumption of carbonated drinks, could be effective in preventing overweight and obesity in children.

3.2 Methods

3.2.1 Study Design

The study is a cluster randomised-controlled trial. This design is used when groups of individuals are randomised, rather than the individuals themselves. It is most appropriate when the evaluation is of an intervention that has encompassed a group as a whole. This form of randomisation can minimise the potential for contamination if the control and intervention groups are within the same environment, for example classes within a school.[354] Groups of subjects are randomly assigned to intervention conditions but observations are taken on individual subjects within the group.[355] The subjects within the group cannot be considered independent of one another and this is taken into account in the analysis. Unfortunately this may result in loss of power as randomisation is done according to cluster rather than individual and this is reflected in the sample size calculations.[356] Subjects within the same cluster are more likely to have similar results, this is known as the cluster effect.[354] This clustering effect needs to be taken into account when the data is analysed and this effect is referred to as the intracluster correlation. This is the comparison of the variance within the group, compared with the between-group variance.[357]

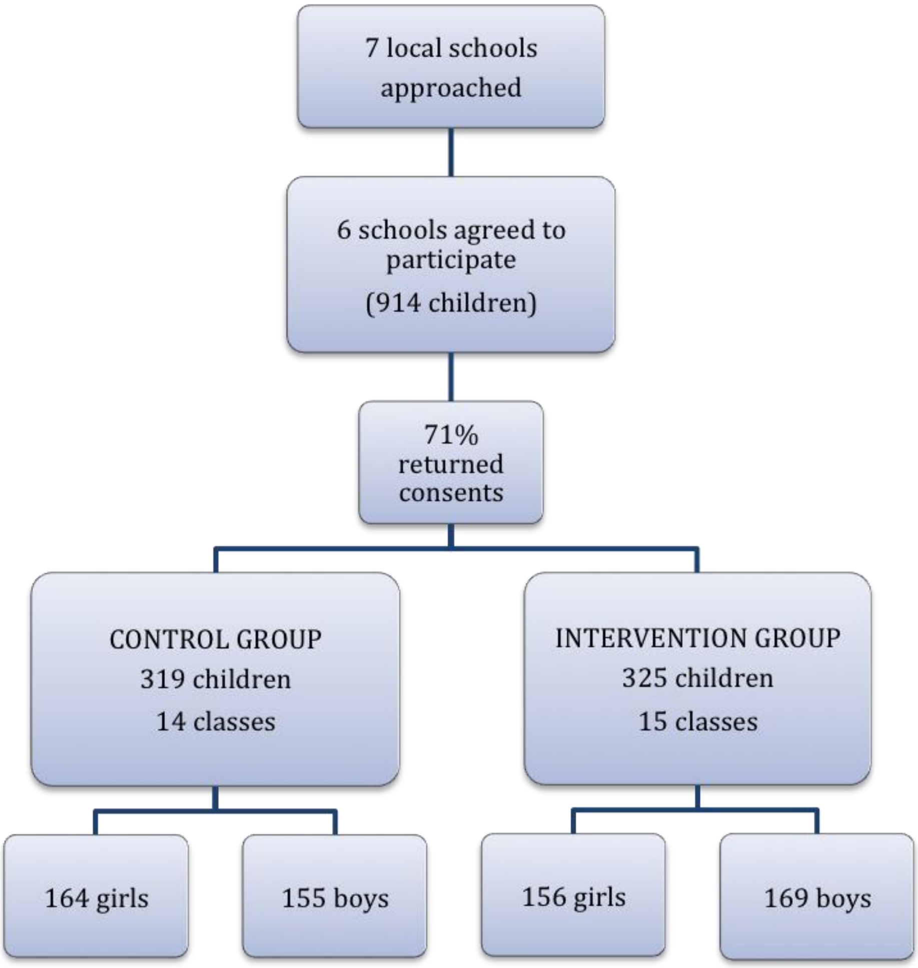
For the purposes of this study a cluster randomised trial methodology with classes as the clusters was chosen because:

(a) Randomising individuals would have been disruptive to the running of the schools.
(b) Randomising individuals could have resulted in substantial contamination between individuals in the same class.
(c) Randomising classes instead of year groups or schools maximised statistical power.

3.2.2 Study population

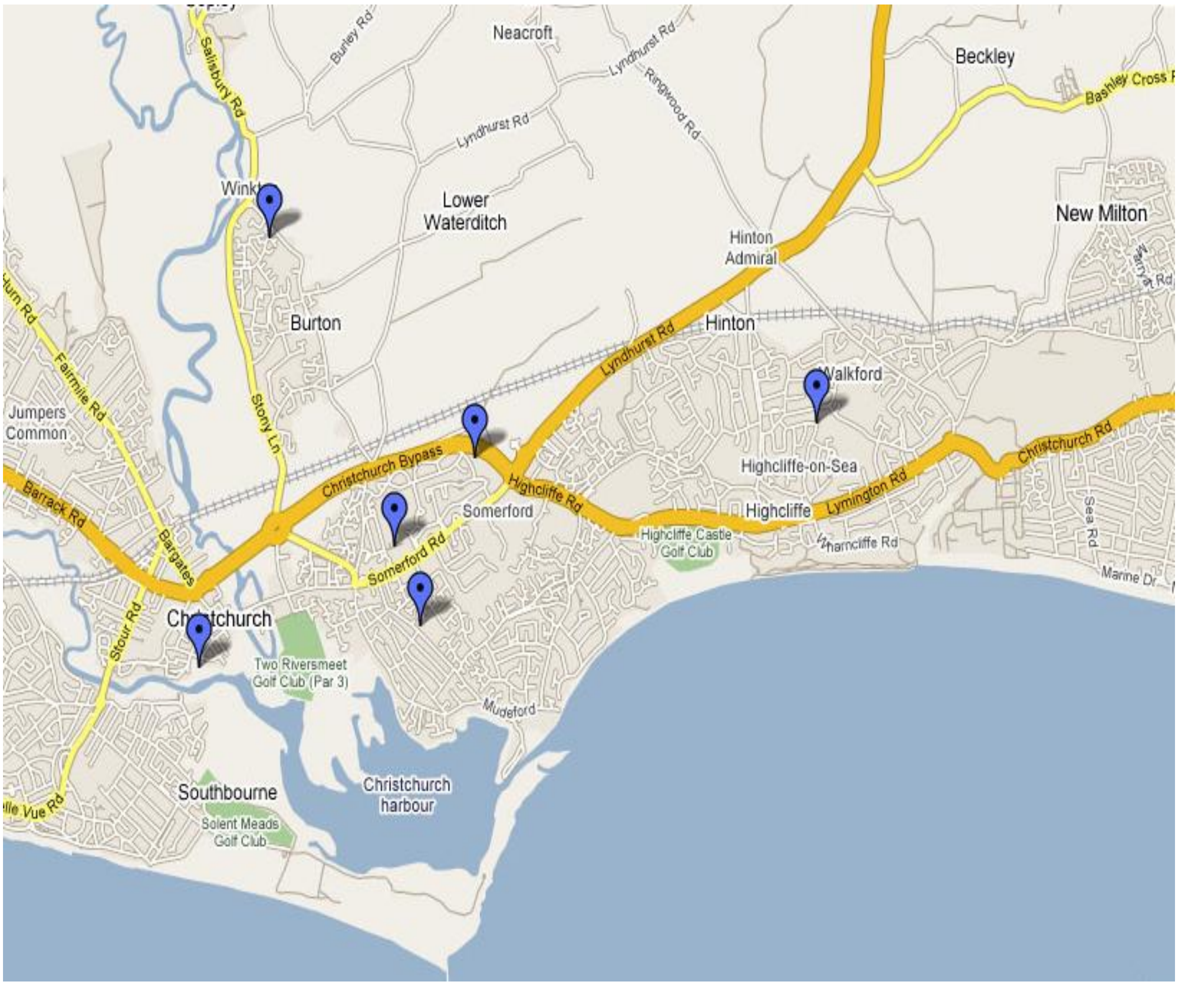
Children aged between 7 and 11 years in years 3, 4 and 5, attending schools within the Christchurch area were to be invited to participate in the study. These year groups were selected, as the children were old enough to complete the drinks diary and participate in the specific education programme. Children in year 6 were not included as they would be lost to follow-up the following September for the final measurements as they would have moved onto secondary school. The study design is shown in Figure 16. Each class was considered as a cluster, with 15 randomised to education and 14 as controls. In the final analysis 29 clusters were included; two clusters were excluded as these included mixed age classes.

Figure 16. Trial profile



Seven local junior schools were approached and informed of the study. After obtaining the Headmasters and Board of Governor's approval, six schools agreed to participate. Children that started in Years 3, 4 and 5 in September 2001 were invited to take part. Information leaflets and consent forms were sent to all parents. The children of the parents from whom consent was obtained, were asked to give their own consent. Consent was obtained from 71% of the children resulting in a total sample of 644 children.

Figure 17. Area of Christchurch, showing the locations of the six participating schools



3.2.3 Ethical approval

Ethical approval was granted by the East Dorset Local Research Ethics Committee (July 2001; REC reference number: 49/01/E). This ethic's board required that the children's own consent be acquired in addition to parental consent and a specific information leaflet was developed for the children. If a parent gave consent and the child did not, the child was then not included in the study. The researcher and any other health professional that assisted with measurements or education underwent the required police clearance.

3.2.4 Estimation of appropriate sample size

The main aim of this trial was to prevent overweight and obesity, by reducing the consumption of carbonated drinks. In initial discussions and statistical calculations, the main outcome measure of change in standardised z-score of BMI was used. In the original calculations a potential sample of 1600 children in 55 clusters was used, assuming all seven schools would participate. Using various values for the intra-cluster correlation coefficient, the potential to detect similar changes in BMI or z-score found in the Ludwig study[310] did not appear feasible with this size sample.

For this reason the primary outcome measure used for the sample size calculation was total carbonated drink consumption. In estimating the final sample size, data from a pilot study discussed in Chapter 2 was used.[358] The sample size calculation depends on the intra-cluster correlation[359], which is the proportion of variation in carbonated drink consumption that can be explained by variation between clusters. As no previous study had established this value, a range of likely values (0.1, 0.05, 0.01, and 0.001) was used in the calculations. Considering that six schools would be taking part in this trial there were a total of 31 classes/ clusters, with an average of 31 children per class. From the pilot study consent to participate was obtained from 54% of children, of whom 71% returned their drinks diary, giving a predicted average cluster size for the trial of 12 children per class. Also from the pilot study, the standard deviation consumption was 0.6 glasses per day, therefore a study of this sample size (31 clusters with an average size of 12) would have 90% power to detect average reductions each day of 0.29 glasses, 0.25 glasses, 0.21 glasses and 0.20 glasses respectively using intra-cluster correlations of 0.1, 0.05, 0.01 and 0.001. This is equivalent to 0.9, 0.7, and 0.6 glasses over 3 days.

3.2.5 Randomisation

Professor Peter Thomas completed the randomisation with no knowledge of the included schools or classes, ensuring an even balance of education and control classes within and between schools and year groups (see Table 7).

Table 7. Randomisation

	Year 3			Year 4			Year 5		
SCHOOL/ CLASS	1	2	3	1	2	3	1	2	3
School D	C			C			I		
School F	I			I			C		
School E	I	C		C	I		I	I	C
School A	I	C		I			C	I	C
School B	C	I		I	C		I	C	
School C	C	I		C	I		I	C	

C- Control; I- Intervention

The method of randomisation was divided into 3 stages, randomising each year group separately. The process of randomisation was as follows:

- Year 3: Half of the total classes must either be in the control or intervention group. Two schools had one class each, one randomised to each group. The remaining schools have two classes each, and were randomly allocated to either group.
- Year 4: Three schools had one class each, and each was randomised to either control or intervention. For the remaining three schools with two classes, each was randomly allocated to either the control or intervention group.
- Year 5: Two schools have one class, if the previous years were randomised to the same group, then the year 5 class was allocated to the other group. If the previous years were randomised to different groups, then the randomisation was done randomly. Two schools had two classes each randomly allocated to either the control or intervention group. The remaining two schools had three classes each, one was randomly allocated two control classes and one intervention, and the other two intervention and one control.

3.2.6 Data collection

3.2.6.1 Anthropometric measurements

Measurements of height, weight and waist circumference were taken at baseline, 6 months and 12 months. All measurements were taken by one single investigator (JJ) :

- Height, without shoes was measured by a single investigator to the nearest 0.1cm using the Portable Leister height measure (Child Growth Foundation, UK). This is a freestanding height measure, with a measuring range to 207cm.
- Weight, in light clothing, was recorded using the Seca 770 medical scales (Marsden, UK) to the nearest 0.1kg. This scale was calibrated annually.
- Waist circumference was measured using a steel tape measure according to the method described on the new waist circumference centile charts (designed and published by the Child Growth Foundation). Using this method the child should stand with their feet together, and weight evenly distributed with arms relaxed. The child should breathe normally and the waist measurement is taken at the end of a normal expiration. The waist is identified, as the point of flexure as the child bends to one side. For children in light clothing 1cm is be deducted from the measurement.[204;360]

Body Mass Index [weight (kg)/height (m)^2)] was calculated, and converted to standard deviation scores (SDS or z score) and centile values using the British 1990 growth reference disc (Child Growth Foundation, London).[361] The SDS or z score gives a numerical score showing the variance between the individual from the 50th centile for age and gender for the particular measurement. Overweight and obesity are described according to the British BMI centile charts, where the 91st centile describes overweight and the 98th obesity.[213] For comparison, overweight and obesity has also been described using the new internationally agreed cut- off points.[197]

3.2.6.2 Consumption of carbonated drinks

The baseline and 12 month consumption of carbonated drinks was assessed through 3-day drinks diaries; these were to be completed over two weekdays and one weekend day and took the format of a colourful, easy to complete one page 3-day chart (Appendix III). As previously described, research has shown that collecting dietary data in this way provides comprehensive results.[1] The diary had been piloted in the pilot study and was amended for the final study. The drinks diaries were developed in conjunction with local dietitians. An extensive list of drinks was tabulated and children were asked to indicate the volume of the drinks they consumed. A pictorial guide of volumes and glass sizes was printed on the back of each chart. Although information on a variety of drinks was obtained, the focus of the study was on carbonated drink consumption and this is what is reported.

3.3 Analysis

When analysing the results of cluster randomised controlled trials it is essential to take the clustered nature of the trial into account.[354] One of the suggested ways to analyse this type of data is to aggregate the data at the level of the cluster. If the clustering effect is ignored the P-values will be artificially raised and the confidence intervals will appear too narrow, which may result in misleading conclusions.[354]

Data were analysed using SPSS (version 11). Data for each cluster was derived, for interval scaled measurements, by averaging all the individual measurements for the children in the cluster. For dichotomous data the proportion of children exhibiting the particular characteristic within the cluster was used in the analysis. Using these summary measures with clusters as the unit of analysis, all measures were normally distributed and the independent samples t-test were used to establish statistical significance between intervention and control clusters, and the paired t-test to establish the statistical significance of changes within clusters.[359] Variation in cluster size was not particularly large and therefore it was not necessary to weight the analysis by cluster size. A p value of <0.05 was judged as significant. Data are shown as mean $\pm$ SD and mean difference (95% confidence for the difference). The intra-cluster correlation coefficient and 95% confidence interval were calculated using Searle's method with the adjustment for variable cluster size.[362]

3.4 Intervention

"*Ditch the Fizz*"

Anthropometric measures were taken from consented children only in both the control and intervention groups. As health education is a normal part of the school curriculum, all children in the intervention clusters participated in the education programme.

The primary objective of the intervention was to discourage the consumption of a single "unhealthy" substance (carbonated drinks) with a positive affirmation of a balanced healthy diet. The message covered all carbonated drinks (diet and sugary) to keep the message simple. Over the school year, the educator visited each class 4 times, for approximately an hour. Teachers assisted in each session and were encouraged to reiterate the message in other lessons. Group projects, games and classroom discussion were used.

3.4.1 Session 1

The initial session focused on the "balance of good health", and the promotion of drinking water in place of carbonated drinks. (Guide teaching plan- Appendix *IV*) . Fruit tasting was used to demonstrate natural healthy sweet tasting products. The high sugar content of many carbonated drinks was discussed. In addition each class was given a tooth immersed in a popular sweetened carbonated cola to assess the effects of these drinks on dentition. The children were given a leaflet (Appendix V), the front page showing *Sabrina, the teenage witch* drinking water (from a popular television program in 2001), and other activities, some of which were completed during the session.

3.4.2 _ Session 2- Music project

This session commenced with a recap of what we covered in the first session, with particular discussion on what had happened to the *class tooth*. Following this the music competition was introduced. Each class was given a copy of a song "*Ditch the Fizz"* and they were challenged to produce their own song/rap with a healthy drinking message. The idea for this project developed out of discussions with a music teacher. This teacher then wrote and recorded the song and also developed a music pack in line with the current school curriculum for the teachers. The pack included ideas on how the project could be best incorporated into the national curriculum. This involved additional time without the investigator present, with the majority of schools including it into their music programme for the term. A local radio station was involved and the winning school with the best rap was visited by staff from the radio station. The original music pack cannot be included due to copyright but two of the songs from the winning classes are included in Appendix VI.

3.4.3 Session 3 – Presentation of the music project

The educator visited each class and they presented their song/rap/dance. A winning class was selected and each child in that class was given a *Ditch the Fizz* t-shirt and as local radio station visited the school.

Once again the there was discussion with each class about the importance of healthy eating, and healthy drinking. Each class was then asked to produce a healthy eating poster that could be displayed at the hospital

3.4.3 Session 4

The final session involved group presentations of a classroom collage depicting what the children had learnt over the year. (Appendix VII- photos of some posters). The final session was then closed with a fun interactive classroom quiz based on a popular TV games show (Who wants to be a Millionaire), with healthy eating and drinking questions focusing on what was covered over the year (Appendix VII- Who wants to be a CHOPPS Champ?). Throughout the year, the children were encouraged to access further information through the CHOPPS link on the hospital internet site.

This intervention was very simple, with an underlying positive approach to healthy eating, while actively discouraging the children from drinking carbonated drinks. In accordance with local dental guidelines, children were discouraged from drinking all carbonated drinks, including diet drinks and advised to switch to water or fruit juice diluted 1:3 with water.

3.5 Results

Consent was received from 644 of 914 (71%) parents together with their children (320 girls). At baseline, the average age was 8.7 (SD 0.9, range 7.0 to 10.9) years. Over the school year, 7 children (6 boys) withdrew consent. Table 8 show the consents received as per each school.

The original publication of the CHOPPS project only presented the data analysed considering cluster analysis, addition analysis and discussion has been added following the VIVA examination.

Table 8. Consent return rate by school

School	Number consented (total children)*	Percentage
School A	81 (126)	64%
School B	154 (210)	73%
School C	152 (191)	80%
School D	85 (105)	81%
School E	116 (185)	63%
School F	59 (97)	61%

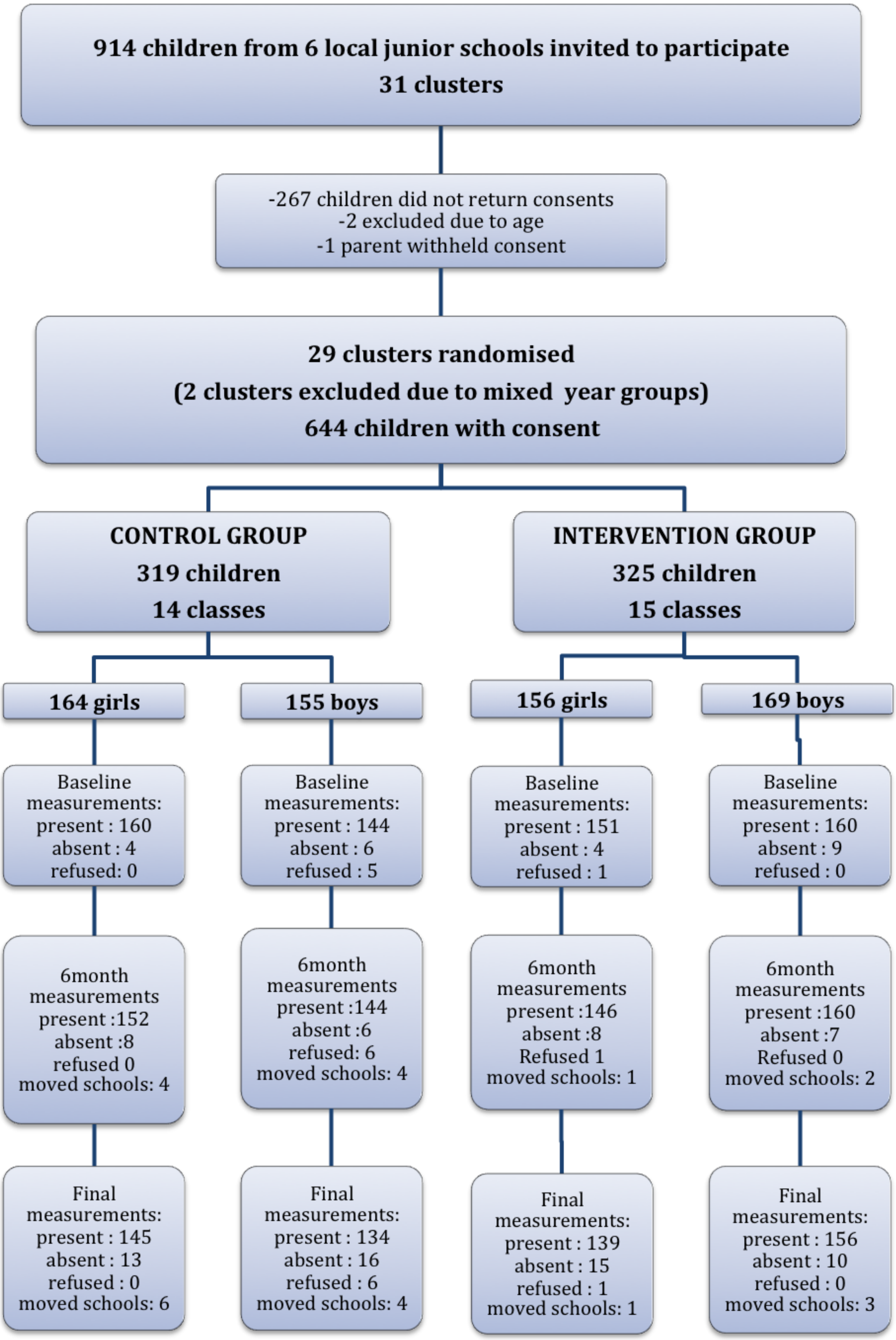
* A total of 647 forms were returned, one parent formally withheld consent and 2 children were excluded as baseline age was <7 or >11 years

At the time of consent neither parents nor children were aware of randomisation allocation. Average class (cluster) contained 22 children (range 10 – 29) children (Table 9). Figure 22 shows the trial profile and children present for anthropometric measurements.

Table 9. Cluster Properties

	Number of clusters per school	Average number of children in clusters (no of boys)
School A	4	20 (9)
School B	6	26 (13)
School C	6	25 (14)
School D	7	16 (9)
School E	3	28 (13)
School F	3	20 (9)
Total	29	22 (11)

Figure 18. Trial profile with anthropometric measurements



At baseline; the control and intervention group were similar, with no significant differences; in the distributions of age, gender, consumption of carbonated drinks, and percentage of children overweight or obese, as shown in Table 10. Of the participating children; 93% had a BMI measured at 6 months and 89% at 12 months (Figure 18).

Figure 19 shows the normal distribution of the age and gender specific BMI z score for all of the children measured at baseline (individual analysis).

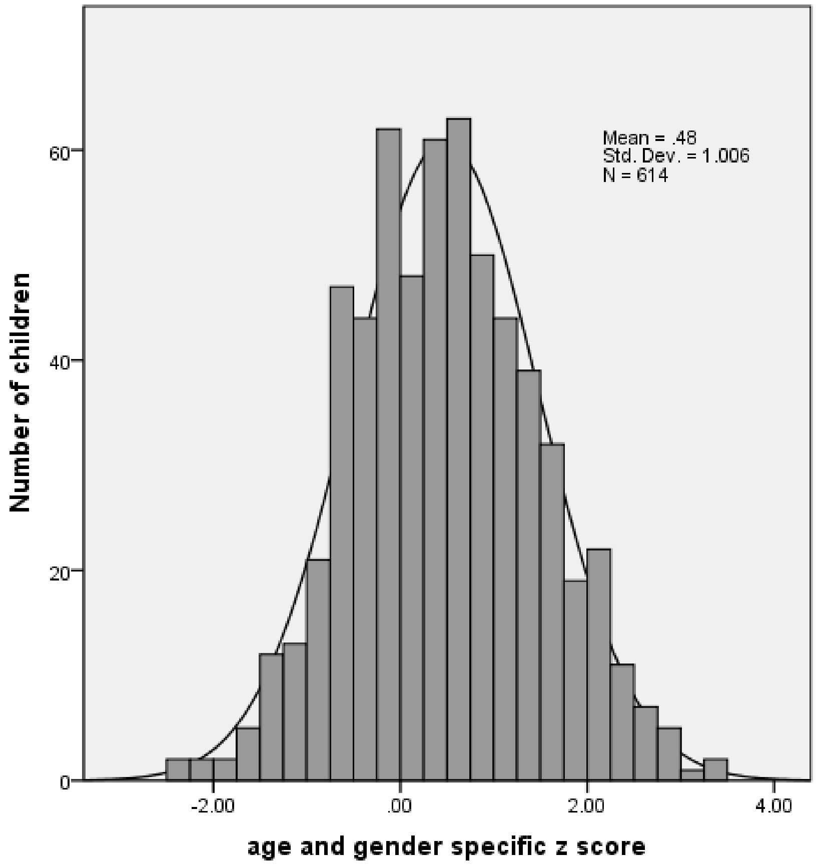
Table 10. Baseline age, prevalence of overweight and obesity*, mean consumption of carbonated drinks (overall means – individual analysis)

* Defined according to 1990 British Body Mass Index centile charts[213]

	Girls		Boys	
	Control n=164	Study n=156	Control n=155	Study n=169
Mean Age in years (SD)	8.7 (0.9)	8.7 (1.0)	8.6 (0.9)	8.7 (0.8)
No (%) overweight**	32 (20%)	29 (19%)	28 (18%)	32 (19%)
No (%) obese	12 (7%)	10 (6%)	10 (6%)	11 (7%)
Mean consumption of Carbonated drinks (glasses/3 days) (SD)	1.7 (2.0) n=95	2.2 (2.6) n=77	1.8 (2.0) n=89	1.6 (2.0) n=91

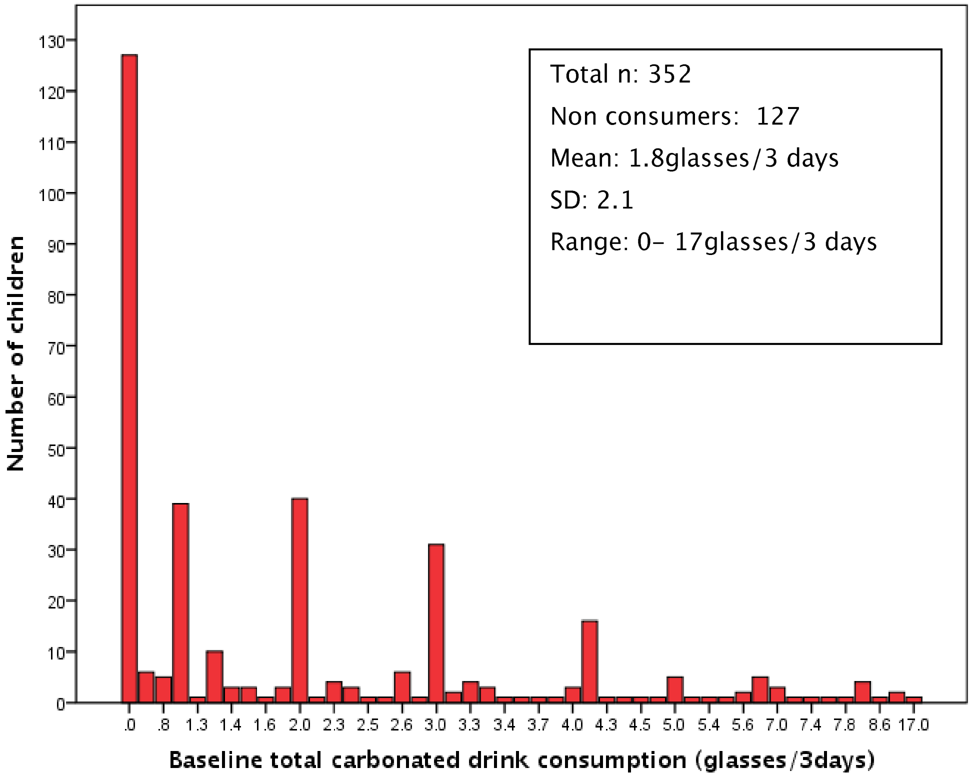
** All children >91st centile (inclusive of obese children)

Figure 19. Distribution of BMI z-score of all children measured at baseline (individual analysis).



The baseline consumption of carbonated drinks is shown in Figure 20. Of the 352 children that returned baseline drinks diaries, just over a third of the children (n= 132) did not consume any carbonated drinks. The average consumption was 1.8 glasses over the 3 days, but there was a varied distribution with a large range from 0-17 glasses over 3 days. The original study design was an intention to treat analysis; and it is important to acknowledge that any effect may be reduced, as we would not expect to see changes amongst the cohort of children that did not drink any carbonated drinks. The data from the pilot study suggested that 44% of that cohort did not drink carbonated drinks, so this was accounted for in the sample size equation for the main study. In addition we are not able to establish the effect amongst those children (n=292) that did not return diaries, and this have may resulted in a diluted effect size.

Figure 20. Baseline consumption of carbonated drinks (individual analysis)



Measurements were taken at baseline and 12-month, with change in anthropometric measurements, showing Body Mass Index, Z score (SDS) and percentage of children above the 91% centile are shown in Table 11. The intra-cluster correlation coefficient was 0.01 (95% CI -0.01, 0.06). After 12 months there was no significant change in the difference in BMI (Mean difference of 0.12; 95% CI -0.8, 0.34) or Z score (Mean difference of 0.04; 95% CI -0.04, 0.12). At 12 months, the mean percentage of overweight and obese children increased in the control clusters by 7.5%, compared with a decrease in the intervention group of 0.2% (Mean difference of 7.7%; 95% CI 2.2 to 13.1%, p=0.008) (Figure 21).

Table 11: Baseline and 12 month BMI, Z score (SDS)† and mean percentage > 91st centile.

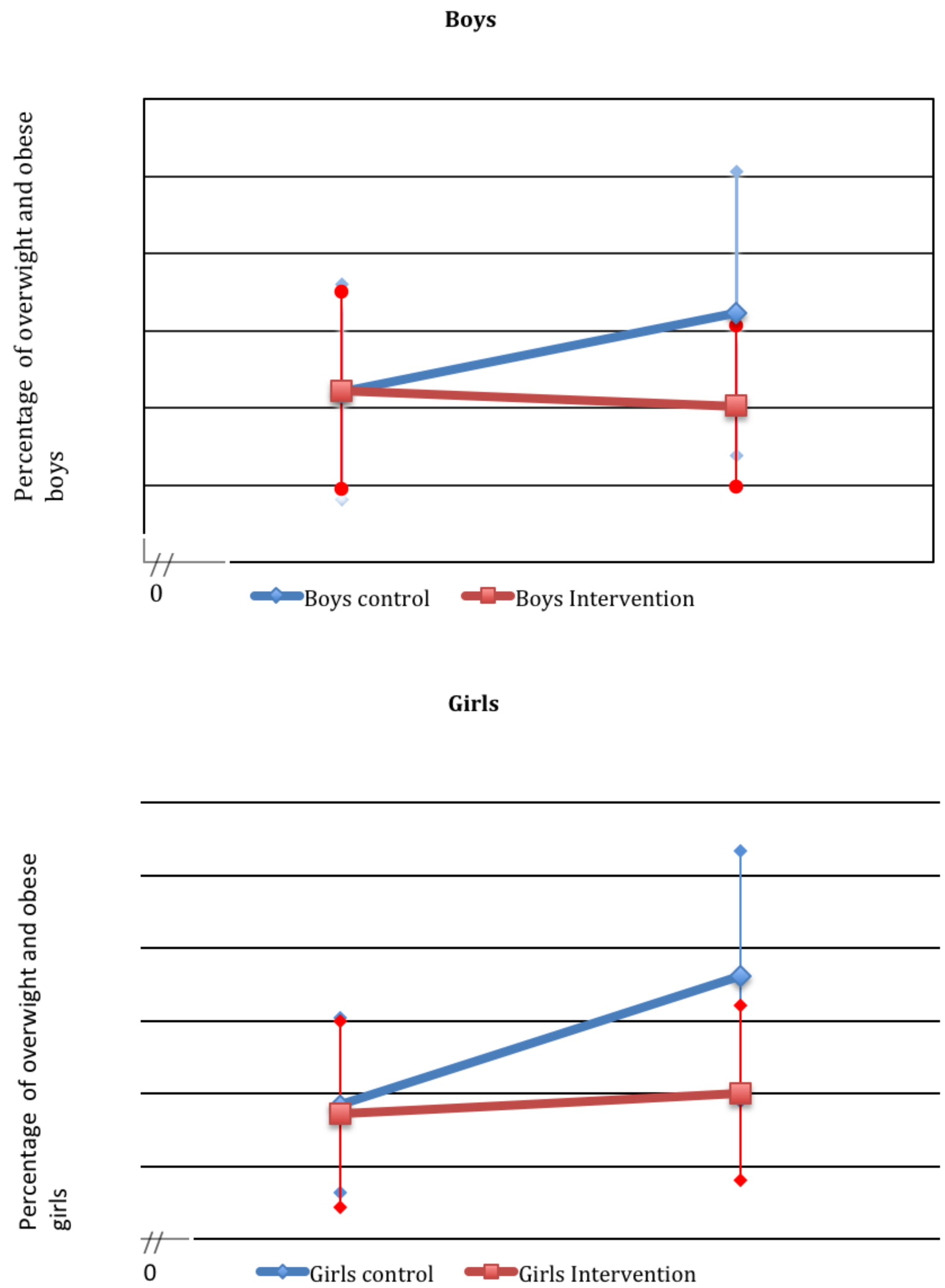
		Control clusters (n= 14)	Intervention clusters (n= 15)	Mean difference (95% CI)
Baseline*	Mean BMI (SD)	17.6 (0.7)	17.4 (0.6)	0.0 (-0.5, 0.5) p= 0.9
	Mean Z score (SDS)	0.47 (0.2)	0.50 (0.23)	-0.03 (-0.2, 0.13) p= 0.6
	Mean percentage >91st centile (Z score>1.34)	19.4 (8.4)	20.3 (6.3)	-0.9 (-6.6, 4.8) p=0.7
12 months*	Mean BMI (SD)	18.3 (0.8)	17.9 (0.7)	0.4 (-0.2, 1.0) p= 0.2
	Mean Z score (SDS)	0.60 (0.19)	0.48 (0.23)	0.12 (-0.04, 0.28) p= 0.14
	Mean percentage >91st centile (Z score>1.34)	26.9 (12.3)	20.1 (6.7)	6.8 (-0.7, 14.28) p=0.7
Change* over 12 months	Mean BMI (SD)	0.8 (0.3)	0.7 (0.2)	0.1 (-0.1, 0.3) p=0.2
	Mean Z score	0.08 (0.13)	0.04 (0.07)	0.04 (-0.04, 0.12) p=0.3
	Mean percent > 91st centile	7.5 (8.0)	-0.2 (6.3)	7.7 (2.2, 13.1) p= 0.008

* Based on maximum number of children in each cluster

The results in Table 11 are based on the maximum number of children in each cluster. When considering the change in prevalence of overweight in only those children present at baseline and 12 months, the results still remain significant. The change in prevalence in the control group is 6.4% and the intervention group also shows a slight increase of 1.6%, with a difference of 4.8 % (p=0.04; 95% CI 0.3, 9.3).

The distributions of BMI z-score (individual analysis) of the control and intervention group at baseline and follow-up are shown in Figures 22 and 23. There is greater similarity in the distribution in the study group, with similar means. The difference is more marked in the control group, with an apparent flattening of the curve and increased mean.

Figure 21. Change in prevalence of overweight and obesity from baseline to follow-up at 12 months according to clusters ‡

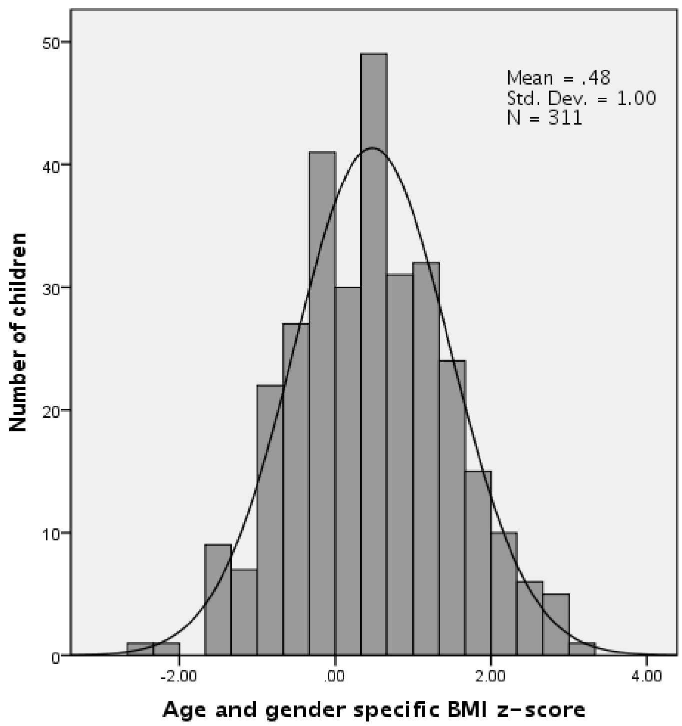


Age and gender specific body mass index converted to standard deviation score using revised 1990 reference standards.

Data shown as mean ±SE

Figure 22. Distribution of BMI z score of children in the study group measured at baseline and 12 months (individual analysis).

Baseline



12 months

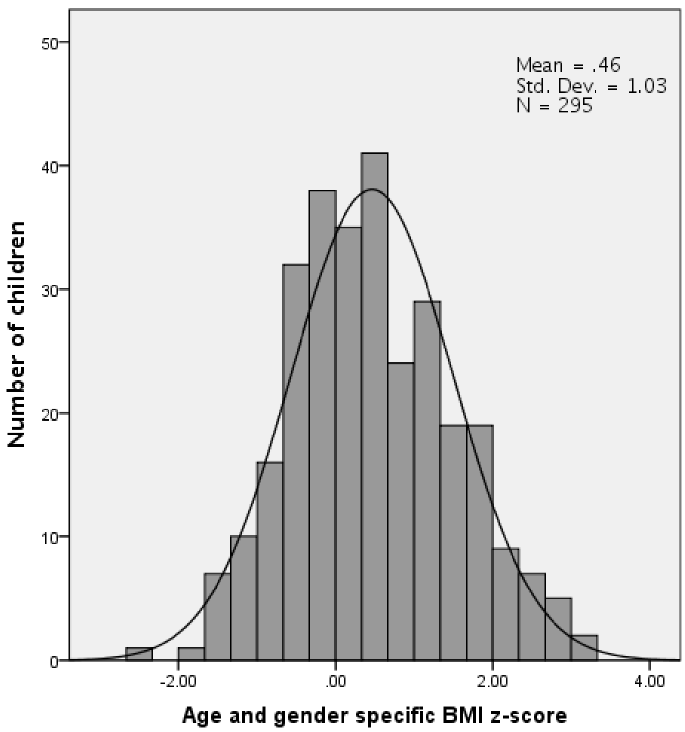
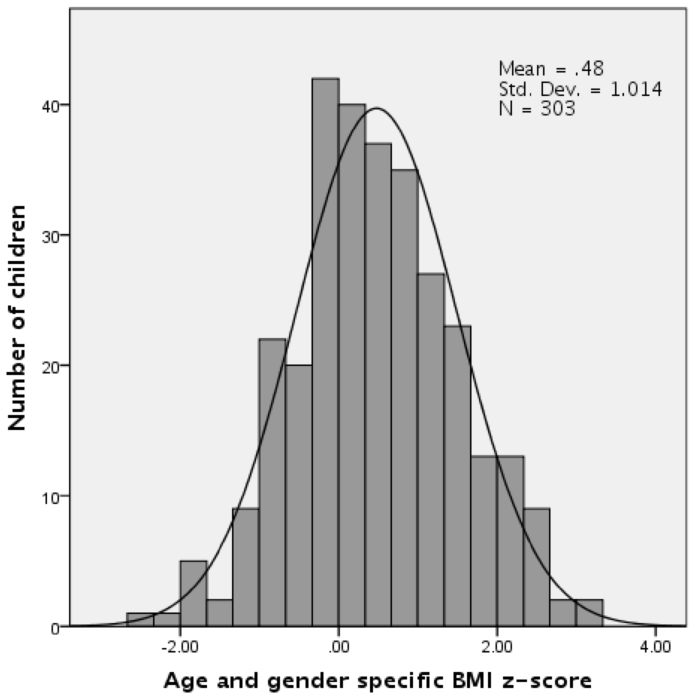
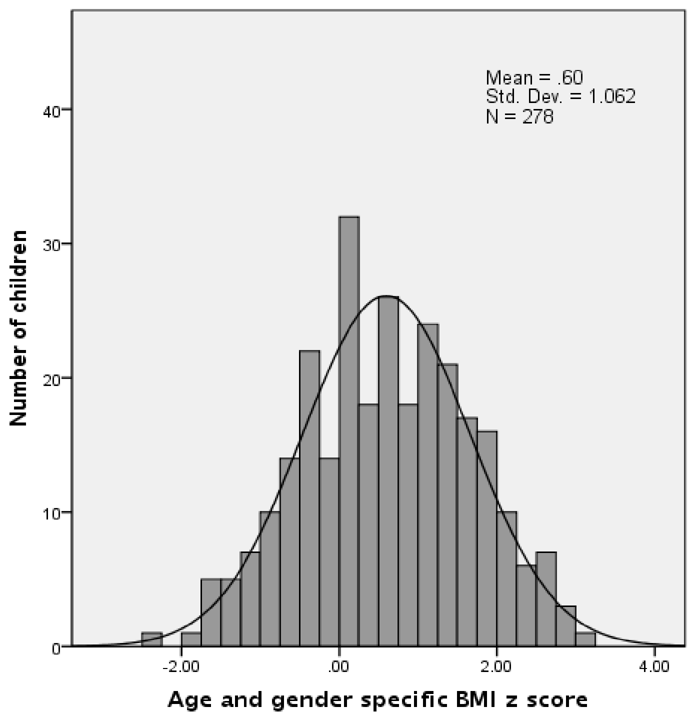


Figure 23. Distribution of BMI z-score of children in the control group measured at baseline and 12 months (individual analysis).

Baseline



12 months



As previously seen in the pilot study, assessing and comparing prevalence rates between studies is influenced by different methods used to classify overweight in children. Table 12 shows alternative methods of assessing rates of overweight and obesity in our population using baseline and 12months follow-up anthropometric measurements.

Table 12. Prevalence of overweight and obese children (individual analysis)*

			IOFT Cut off points[197]	1990 British centile chart[213]	British waist circumference centile charts[204]
Boys	Baseline overweight	Control	33 (18.8)	28 (18.0)	28 (20.3)
		Intervention	34 (20.1)	32 (19.2)	34 (21.5)
	Follow-up Overweight	Control	39 (22.2)	33 (25.6)	33 (25.0)
		Intervention	31 (18.3)	31 (19.9)	35 (22.6)
	Baseline Obese	Control	3 (1.7)	10 (7.0)	14 (9.9)
		Intervention	7 (4.1)	11 (6.9)	15 (9.5)
	Follow-up Obese	Control	3 (1.7)	12 (9.0)	14 (10.4)
		Intervention	6 (3.5)	11 (7.1)	13 (8.4)
Girls	Baseline overweight	Control	46 (28.0)	32 (20.1)	38 (24.4)
		Intervention	43 (27.6)	29 (19.2)	33 (22.1)
	Follow-up overweight	Control	50 (29.6)	37 (28.3)	52 (36.9)
		Intervention	39 (23.1)	29 (20.9)	40 (29.6)
	Baseline Obese	Control	12 (7.3)	12 (7.5)	17 (10.7)
		Intervention	9 (5.7)	10 (6.6)	15 (9.9)
	Follow-up Obese	Control	11 (6.3)	13 (9.0)	27 (19.0)
		Intervention	8 (4.7)	9 (6.5)	16 (11.5)

*Data shown as number (%)

3.5.2 Consumption of carbonated drinks

Baseline drinks diaries were returned by 55% of the children, and 56% completing the final diary, with 36% returning both. BMIs were similar between those children returning drinks diaries and those failing to [17.3 (SD 2.3) versus 17.5 (SD2.4) respectively, p= 0.3]. Of the children that returned their initial drinks diaries at baseline, 19% were overweight; identical to the rate seen in children that did not return diaries.

Consumption of drinks is shown in Table 13. The intra-cluster correlation for carbonated drink consumption was -0.009 (95% CI; -0.03, 0.05), suggesting total independence between members of each cluster. At 12 months, consumption of carbonated drinks decreased in the intervention group compared to the control group (mean difference 0.7, 95% CI 0.1,1.3, p= 0.03). In both groups, water intake also increased, but there was no difference between intervention and control clusters. The data were also analysed by (a) considering cluster analysis, including the classes that returned both drinks diaries (n=22) and (b) individual analysis of children that completed both diaries n=235, ignoring clusters. The results were comparable, with a mean difference of 0.7 glasses (95% CI (0,1; 1.1), p= 0,02) for the individual analysis and of 0.7 glasses (95%CI (0.1; 1.3), p= 0.03) for the clusters.

There was no relationship between reported consumption of carbonated drinks and changes in BMI at baseline and after 12 months.

Table 13. Changes in consumption of drinks over 12 months‖

		Mean baseline (SD)	Mean 12months (SD)	Mean change (95% CI)	Significance (2 tailed)
Total carbonated drink consumption	Control clusters n=14	1.6 (0.6)	1.8 (0.6)	+0.2 (-0.2, 0.5)	0.4
	Intervention Clusters n=15	1.9 (0.5)	1.3 (0.6)	-0.6 (-1.0, -0.1)	0.02
	Difference in consumption			0.7 (0.1, 1.3)	0.03
Sugar-sweetened carbonated drink consumption	Control clusters n=14	1.1 (0.6)	1.2 (0.5)	+0.01 (-0.3, 0.4)	0.9
	Intervention Clusters n=15	1.2 (0.3)	0.9 (0.6)	-0.3 (-0.6, 0.1)	0.2
	Difference in consumption			0.07 (-0.4, 0.5)	0.8
Diet carbonated drink consumption	Control clusters n=14	0.4 (0.3)	0.6 (0.3)	+0.1 (-0.1,0.4)	0.3
	Intervention Clusters n=15	0.7 (0.3)	0.4 (0.2)	-0.3 (-0.6, -0.06)	0.7
	Difference in consumption			0.6 (0.2, 1.1)	0.005
Caffeine containing carbonated drink consumption	Control clusters n=14	0.7 (0.4)	0.6 (0.5)	-0.1 (-0.3, 0.1)	0.4
	Intervention Clusters n=15	0.8 (0.3)	0.6 (0.3)	-0.2 (-0.4, 0.1)	0.2
	Difference in consumption			-0.02 (-0.4, 0.3)	0.8
Water	Control clusters n=14	2.9 (0.3)	5.1 (2.0)	+2.2 (0.9, 3.5)	0.003
	Intervention Clusters n=15	3.1 (1.1)	4.3 (2.0)	+1.1 (0.2, 2)	0.02
	Difference in consumption			0.3 (-1.3, 1.9)	0.7

‖ Units: glasses over 3 days (unit of analysis is the cluster). All available data has been used in analysis.

3.6 Discussion

This study has demonstrated that a simple schools-based educational initiative with a focused message of reducing the consumption of carbonated drinks has had a significant and positive impact on reducing the consumption of these drinks and on the percentage of 7-11 year olds within this cohort becoming overweight or obese. This is the first interventional study that has focused on reducing the consumption of carbonated drinks as means to preventing obesity.

As described in section 1.2.6.2 there have been a number of previous school-based interventional studies. One schools-based American study has shown benefits in terms of reducing obesity rates, but this was limited to girls and was related to reduced watching of television.[336] Prior to this study, the Apples project from Leeds was the only other large school- based randomised controlled trial focusing on obesity prevention in the United Kingdom. This study was an intensive and multi-facetted project which resulted in an increase in consumption of vegetables but no change in prevalence of obesity.[334] The CHOPPS project was different to both of these studies in that the intervention focused particularly on just one aspect of the diet, namely discouraging the consumption of carbonated drinks. The intervention was very simple in its approach and involved no additional teacher training. It was designed to be easily transferable and could be implemented on a wider scale using a health educator working in a number of schools.

As with many previous school-based studies, this project did not yield a significant difference in BMI between the control and intervention group (Table 11). Over the 12 months BMI increased in both groups, as would be expected as the children are growing. The age and gender specific z score moved in different directions for the two groups. In the control group the z score increased from 0.47 to 0.6 whereas the z-score for the intervention decreased slightly from 0.5 to 0.48, although the difference between the groups at 12 months was not significant. As previously described, the potential difficulties in achieving a significant difference in BMI or z score was recognised during the original sample size calculations. Possibly a longer time interval may be necessary to effectively assess the impact of the intervention on the z score or BMI. The ideal situation would be to have a much larger sample with many more clusters. As previously described the use of BMI has limitations[22] and may not accurately assess for more subtle changes in body composition.

The baseline measurements from Table 13 serve to highlight that children in the age range of 7 to 11 years old have a preference for the sugar containing carbonated drinks compared to diet versions of these drinks. In addition, a large proportion of the drinks consumed contain caffeine as also seen in the pilot study. Overall the change in carbonated drink consumption was significant, with decreases in the consumption of both the sugar containing and diet versions of these drinks in the intervention group. During the education the children were discouraged from drinking both the diet and sugar containing drinks. As seen in Table 13, the greatest difference between the control and intervention group is seen in the diet drinks. Potentially this could be due to contamination, as those children in the control group were aware that the intervention focused on carbonated drinks and obesity and some may have changed their choice of drink to the diet variety.

Following this project, researchers from America have conducted an intervention pilot study with 103 adolescents.[363] Over a 6-month period the adolescents in the intervention group were supplied with diet versions of their usual sugar containing carbonated drink. The consumption of sugar containing carbonated drinks decreased by 82% in the intervention group. For the groups as a whole there was no significant change in BMI, but when those individuals with the higher baseline BMI's were considered, the difference in change in BMI was significant; with a decrease in the intervention group of -0.63 ± 0.23 kg/m^2 while the BMI in the heavier adolescents in the control group increased ($+0.12 \pm 0.26$ kg/m^2), with a mean difference between the groups of -0.75 ± 0.34 kg/m^2.

As discussed in section 1.2.5.6 the exact mechanism by which these drinks increase the likelihood of obesity is not fully understood but the two interventional studies above both suggest that preventing consumption of sugar sweetened drinks can play a role in obesity prevention.

The main reason for this association may simply be related to an imbalance of energy in and energy out. These drinks are calorific, with a low satiety, and add to the calorie intake of the consumer without any nutritional benefits. Children have difficulty in compensating for additional calories, particularly if these additional calories are in liquid form. [317] Research has show that very young children (pre-school age) are able to effectively compensate for addition calories in either a solid or fluid form, by eating less at their next meal.[364;365] Once the children reach the age of 9 and older this ability to compensate, particularly to liquid calories has been lost.[366] The reasons for this change in ability to compensate are not fully understood but it is suggested that as the children grow older they eat in response to social cues rather than to physiological ones. [317]

James Hill's concept of the energy gap and that small changes in energy intake and output may have a major impact on obesity risk was discussed in section 1.2.5.6.[262] This theory considers that a reduction by a small amount of calories (100 kilocalories per day) can be a means to preventing further obesity. [315] Although this is thought to be higher for obesity prevention in children with a reduction of 200 kcal/day needed to have a similar preventative effect.[316] At baseline the average consumption of sugar containing carbonated drinks was over 400mls for 3 days for the CHOPPS cohort. This amounts to 210 calories over 3 days. Unfortunately I do not have any additional dietary information as to whether the children altered their intake of other foods on days when they consumed carbonated drinks. Although 3-day food and drink diaries are recognised for assessing dietary intake, there are shortcomings and the children may not have accurately portrayed their actual intake.

As discussed in section 1.1.6.1.2 the glycaemic index of certain foods and drinks is associated with changes in overall calorie intake.[106] Low GI diets lower post-prandial glucose and insulin responses whereas high GI diets stimulate lipogenesis and cause increased adipocyte size.[107] Sugar containing carbonated drinks have a high GI and as seen in the previously described study of obese boys, ingestion of high glycaemic foods can be followed by increased calorie intake, when compared with ingestion of low or medium GI foods. This suggests that the rapid absorption of glucose after a high GI load, can promote excessive food intake.[108]

Research has also shown that the consumption of types and amount of food may occur as a response to the environment or other foods consumed. As described previously adolescents were found to eat additional calories while watching television and that the average teenager watches between 19-25 hours of television per week with an energy intake of 156Kcal per hour.[281] This suggests that children and adolescents, as may adults, eat by association. By focusing on reducing carbonated drink consumption there may be a reciprocal effect and reduction in the additional foods that the individuals may eat with the drink.

At the end of the 12-month intervention there were also significant increases in the consumption of water in both the control and intervention groups. This may be related in part to an initiative in many local schools to increase water consumption during the school day, as local teachers felt that this was beneficial in improving the children's concentration levels during the school day. The majority of schools began providing water fountains and some even allowed children to keep water bottles on their desks during lesson time. The effect of this is evident in both the intervention and control group where a significant increase in water consumption was evident after 12 months. This increase may also indicate a degree of contamination between the groups.

There are a numbers of limitations to this study. Some contamination may have occurred as randomisation was according to classes and not schools, and transferral of knowledge may have happened outside the classroom, although this should have been minimised by the cluster randomisation design.[367] The schools understood that the project was part of a trial but also had their own agenda and wanted to meet the healthy schools targets. They were enthusiastic and keen to share some of the work done in the classrooms. On visiting one school following an education initiative, the researcher found a whole display in the school foyer titled “Ditching the Fizz.” In addition, further contamination occurred after the music project as many of the classes did their rap or songs at the school assembly. Unfortunately the researcher had no control over these events but it is important to acknowledge that they did occur. Randomisation by school would have reduced the chance of this occurring but a much larger sample of schools would be required.

The original sample size calculated following pilot study[358] was based on 31 clusters and unfortunately due to mix year groups in one of the schools, only 29 clusters were included in the final study. This reduction in sample size is another limitation of the study and unfortunately could not be foreseen.

Assessing the consumption of carbonated drinks was central to this study. As previously described, it is recognised that obtaining dietary data can be difficult, and respondents are often found to underreport intake, especially those that are overweight[1]. Following the pilot study the drinks diary was amended to try and make it easier to complete, in addition it was recognized that reminders and encouragement from teachers could help promote a higher return rate. The researcher’s time and access to the children was limited and therefore it fell to the teaching to staff to assist with reminding the children to complete and return the diaries and this varied between schools.

Just over half of the children returned either the first or final drinks diary or just over a third of all the children completed both. This is a major limitation of the study. This low return rate may have resulted in a response bias; though the proportion of overweight was similar for returnees and non-returnees. Researchers from the Apples project in Leeds had similar difficulties in obtaining dietary data, and they used both 24 hour recall and 3 day diaries.[368] Obtaining reliable diary data from children is challenging.

The main objective of the study was to reduce the consumption of carbonated drinks. The validity of evaluating the full effect of the intervention was reduced by the poor return rate of the drinks diaries. In addition to a low return rate, only two thirds of the children were found at baseline to consume any carbonated drinks. It is recognized that missing data can bias studies using an intention to treat design [369]. The CHOPPS education programme was designed as a positive specific health message, and any long-term effects on children who at the time did not drink carbonated drinks but may have been discouraged from having them in the future cannot be assessed.

In summary, this study has shown for the first time that a specific school-based intervention focusing on decreasing the consumption of carbonated drinks has been effective in preventing further obesity in a cohort of 7 to 11 year old children after a 12-month period.

Chapter 4.
Keeping track of childhood obesity

4.1 Introduction

The causes of obesity are numerous and may be confounded by society's lack of perception of overweight. As described previously a study has highlighted the lack of insight that adults have concerning their own weight and that of their children.[282] Health care professionals may also be naive to the problem of childhood obesity, as some still view the issue as largely a cosmetic problem.[370] Prior to the commencement of the CHOPPS project, growth monitoring in schools had decreased and in many localities did not occur at all. In the next chapter I will discuss the history of growth monitoring and some results from a small survey conducted as part of the CHOPPS project to determine the childrens' views on being measured. I will then also describe how recently this issue has received a great deal of interest and how subsequently growth monitoring has been reintroduced nationally.

It is a century since the government in 1907 recognised the importance of good health in children and introduced the School Health Service (SHS), with a role of providing periodic medical inspections.[371] Since this time growth monitoring has been conducted in both the developed and developing worlds. Even with this routine practice, a recent Cochrane report has concluded that there was insufficient evidence to show that growth monitoring was of any benefit to child health in either developed or developing countries. [372]

In 1986 the Joint Working Party on child health surveillance reviewed the UK practices regarding child surveillance, and made recommendations for future practice.[373] Before this original report, surveillance and screening varied throughout the UK, and many Health Authorities were unable to specify their own monitoring programmes or even comment on the effectiveness of them. Research completed by the Wessex Growth Study[374] concluded that a single measurement at school entry was the most important marker for growth problems, and that additional later measurements were unnecessary.[375] Recommendations from the British Paediatric Association suggested intermittent weight measures for babies at clinic visits; length at 6-8 weeks for low birth weight children, with no further measures unless indicated until school entry. At this time height and weight was also to be recorded, and stored so that Body Mass Index can be calculated and used as a public health indicator.[376] The report did acknowledge the increasing prevalence of obesity but did not recommend the screening of individual children. No further screening was suggested in primary and secondary schools, and the role of child health surveillance fell to primary care. This report noted that children between the ages of 5 and 14, see their general practitioner on average twice per year, and it was hoped that each contact would be used as a screening opportunity.[376]

Historically, children were monitored to assess for growth problems related to height but with the increasing prevalence of obesity there has been growing support for screening to assess weight. Both the International Obesity Taskforce and the Child Growth Foundation support regular growth monitoring in school children.[377] The Royal College of Paediatrics and Child Health, and National Obesity Forum have also released guidelines to help the management of overweight and obesity in children.[378] A study from the United States found that the use of a school-based health report card increased parent's awareness of their children's overweight problem and actively promoted parental interventions to try and find solutions.[379] This is pertinent as it has been established that a proportion of parents with overweight children fail to recognise that there is a problem.[282] If an effective support system was established to help children assessed as being overweight or at risk of overweight, screening could be an invaluable tool in improving the health of some children.

4.2 Survey

Very little is known about children's perceptions of their own growth monitoring. Following the completion of the CHOPPS project the children were asked to complete a simple (unvalidated) questionnaire concerning their views on the project, and to assess for any knowledge gained. As part of the questionnaire, the children were also asked how they had felt about being measured (Appendix IV). The questionnaire used a simple 3- point likert scale with the three options including; very much, some of the time and not at all.

4.3 Results

A good proportion of the sample participated, with 417 of 644 (65%) children completing the questionnaire in part (mean age of 9.7 years). The results of the specific question regarding to measuring are shown in Figure 24, and the difference in responses between the genders or between the control or intervention group (Figure 25) and age groups (Figure 26).

Figure 24. The children (n=404) responses to whether they enjoyed being measured or not.

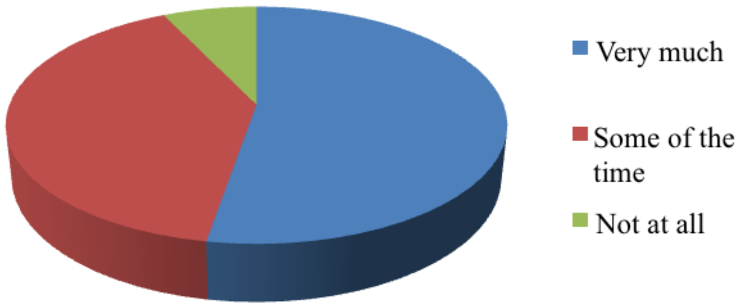


Figure 25. The children's responses (n=404) according to gender and control or intervention group.

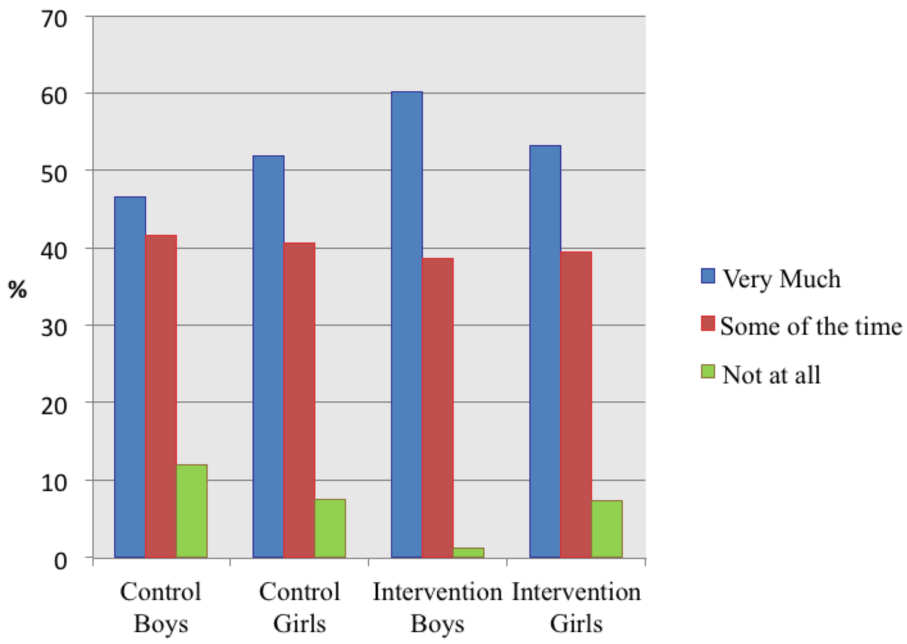
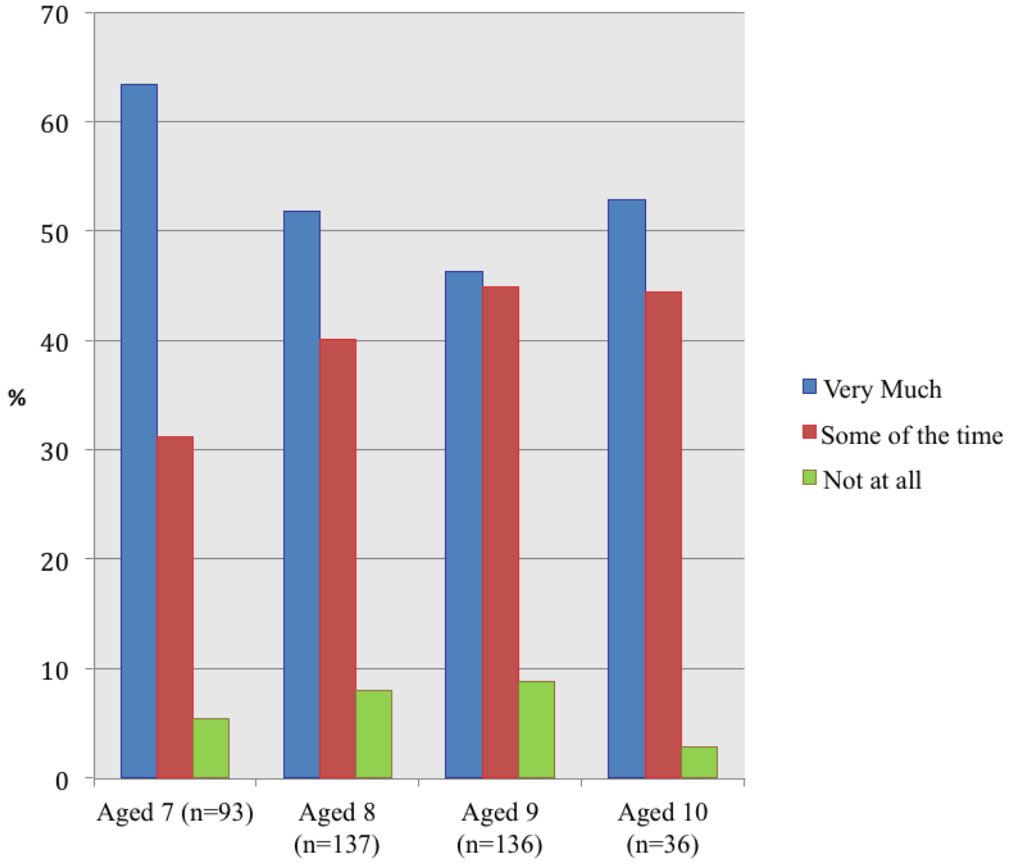


Figure 26. The children's responses (n=402) according to age group.



383 children completed this specific question and were measured at baseline, 29 children (7.6%) did not enjoyed being measured. Of these 29 children, 45% (n=13) were overweight (>91st centile). The pie charts (Figures 27 and 28) below show the difference in response for those below and above the 91st centile. Using pearsons Chi-squared test, the difference of the responses between those above and below the 91st centile was tested, this showed that that if you were overweight you more likely not to enjoy being measured (Chi-squared 17.34, df 2, $p< 0.01$).

Figure 27. Responses of children (n=307) with a centile score of less than the 91st centile at baseline

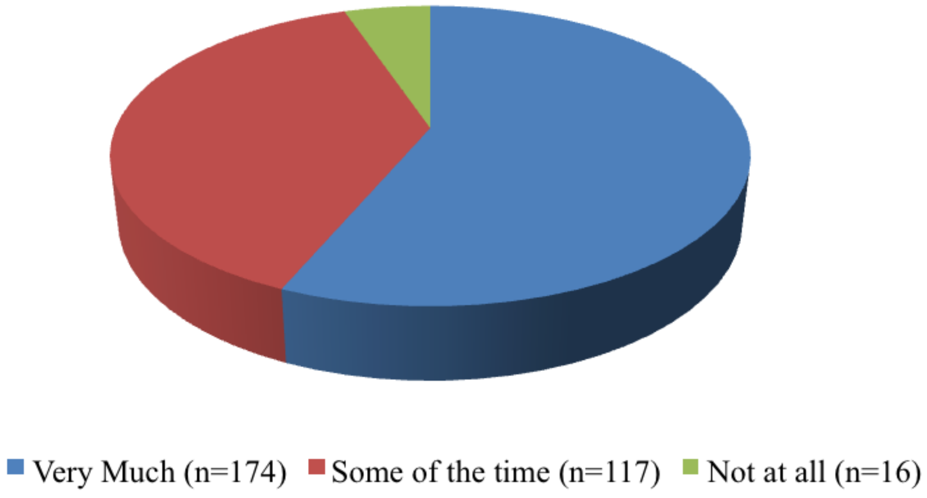
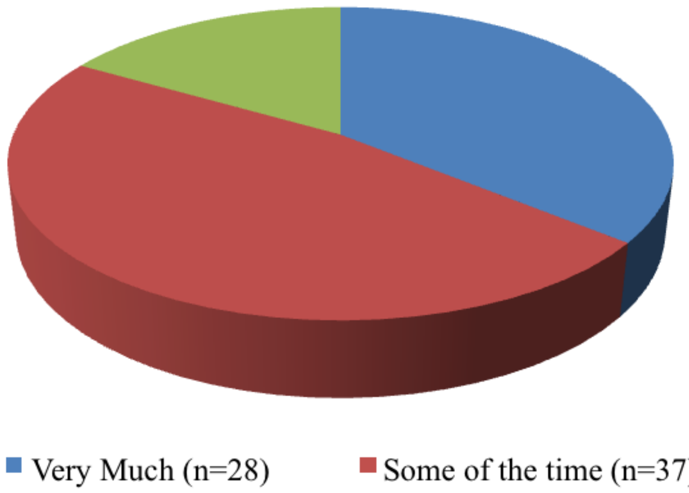


Figure 28. Responses of children (n=78) with a centile score of greater than the 91st centile (overweight) at baseline.



Of this sample of 383 children, 25 (10 boys) fell above the 98th centile and were classified as obese. Of these 25 children; 10 enjoyed being measured very much and another 10 enjoyed it some of the time. Of the 13 children that were overweight and did not enjoy being measured; 5 were obese, all of whom where girls with the remaining 8 (4 boys) in the overweight range.

A total of the 29 children did not enjoy being measured, 12 were boys in the control group. Table 14 shows the centile ranges for the 29 children who did not enjoy being measured. The teachers also completed a questionnaire and 75% felt that the children were not self-conscious when they were measured.

Table 14. Centile ranges for the children (n=29) who did not enjoy being measured

Centile Range	Girls	Boys
0-24.99	0	3
25-49.99	3	0
50-74.99	1	5
75-90.99	3	1
91-97.99 (Overweight)	4	4
>98 (Obese)	5	0

4.4 Discussion

The initial analysis of this very simple survey shows that a small minority of children (7.6%) did not enjoy being measured, and this is a positive outcome for those in public health where measuring children in schools has now become an annual event. There was little difference in the response between the girls in the control and intervention group but there is marked variation in boys between the control and intervention group (Chi-squared = 9.67, df= 2, p= 0.008). Eleven boys from the control group did not enjoy being measured compared with only one in the intervention group. These eleven boys were from different schools and classes so peer influence could not have accounted for this response, and they are also from different centile groups.

Further analysis of the responses suggests that overweight children are more sensitive to being measured compared to those who are not overweight. Although in contrast to this, a far greater number of overweight children actually enjoyed being measured, against those who did not. The responses of the most obese children were very interesting with the majority favourable to the experience. This may indicate that these children are simply not worried or uncomfortable or secondly that they may not be aware of their weight and therefore do not feel self conscious. Of the obese children who were least favourable to the experience, all were girls possibly suggesting a gender difference in awareness to body image, although the results were similar for gender in the overweight group. When age was considered, the youngest children (age 7) were the most positive in their response but there was little difference in response from those between the aged of 8 to 10 years.

Reassuringly, this survey suggests that the majority of children are not threatened by health screening and that by far the majority enjoyed the experience and many were found to be curious about their own growth. This survey has limitations, as the questionnaire used was not a validated tool. It does highlight that in children of this age measuring is not intimidating for the majority but sensitively is essential and is required for all sizes.

As part of the governments *Choosing Health* White paper, a consultation was undertaken in a three schools from different areas and environments to gain a better understanding about children's reactions to measuring in schools.[380] The youngest children aged 4 and under did not have a good understanding of what measuring involved. Those age five had a better understanding and children between the ages of 5 and 8 years were mostly likely to view it a as a normal part of growing up. The oldest primary school aged (9-10 years) children showed more sensitivity and awareness and were more likely to be concerned about the results. The report recommended that the children needed to be kept fully informed about any process and results, and that sensitivity and the environment were important to reduce anxiety. Generally this report concluded that measuring would be well received by primary school children. [380]

In January 2006 the Department of Health published guidelines for Primary Care Trusts on how to measure the height and weight of children between 4 and 11 years.[381] It was proposed that children with their parents consent, in reception (ages 4-5) and year 6 (10-11 years) would be measured. The aim was that this data would form a baseline for population monitoring. This new government policy was widely debated, with many concerns from school nursing quarters that there were not the resources to implement the policy and to manage those found to be a risk [382] The primary aim of the plan, known now as the National Children Measurement Programme (NCMP) which was launched in 2007 was and remains population monitoring. The threshold cut-off points used for overweight are the 85thcentile and 95thcentile for obesity from the British 1990 growth reference curves.[383] In February 2007, the first results for Dorset were published.[384] In that year Dorset achieved 81% (n= 6240) participation, the results are shown in Table 15. This survey found that the prevalence of overweight and obesity was higher amongst boys than girls. Compared to other localities in Dorset, Christchurch was found to have the highest proportion of overweight children in the 10-11 age group. The most recent data for England, Dorset and Christchurch are shown in Table 16.[385]

Table 15. National Child Measurement Programme 2005/2006 survey for Dorset

	Overweight (>85thcentile)	Obese (>95th centile)	Overweight & Obese
Age 4-5	12.9%	8.1%	21.0%
Age 10-11	11.8%	15.0%	26.8%

Table 16 National Child Measurement Programme 2009/2010 survey for England, Dorset and Christchurch.

	Overweight(>85thcentile)		Obese (>95th centile)		Overweight & Obese	
	Reception	Year 6	Reception	Year 6	Reception	Year 6
England	13.3%	14.6%	9.8%	18.7%	23.1%	33.4%
Dorset	13.6%	13.5%	7.2%	14.0%	20.8%	27.5%
Christchurch	15.5%	14.2%	7.9%	14.2%	23.4%	28.4%

The latest data from the NCMP (2009/10) very worrying shows that a third of children aged 10-11 years in England are overweight or obese. Comparatively the number of obese children in year 6 is double that of those in reception. Also there are more overweight than obese children in reception but this changes in year 6, where more children are obese that those that are overweight.[385] This could suggest that more children are moving from the healthy range to the overweight weight group but also that those already overweight tend to become even bigger and move to the obese range. The difference between those in reception and those in Year 6, suggests that these school years are a vital time in which interventions need to be engaged in the school environment.

As previously described, many parents, especially those of overweight children fail to identify that their children have a problem.[386] Further research has shown that this is the same for adult's perception of their own weight. A comparison of two populations surveys completed in 1999 and 2007 found that increasing numbers of people failed to recognise that they were overweight.[387] This survey also found that normal weight women were less likely to wrongly classify themselves as overweight. The authors describe how this has implications for public health, where health promotion messages are focused at the overweight but this will have limited success if the individuals themselves do not perceive that they are at risk. The NHS has developed an information webpage regarding the National Child Measuring Programme.[388] There are 8 comments on this webpage, of these five are from angry parents whose children have been classified as overweight, these parents feel that the classification is unfair and do not recognise that their child is at risk.

Over the last ten years public consciousness and discussion around obesity has increased greatly due to many national initiatives. The Department of Health now has data on the extent of the problem in children. Unfortunately it seems that many overweight adults and parents of overweight children do not recognise that they are at risk, and this makes the effectiveness of public health interventions more difficult. The majority of the children that participated in the CHOPPs project were happy to be measured but these results may have been different, if they or their parents were aware of where they may have fallen on the centile ranges.

Chapter 5.

Nutrition Education in Schools – Time well spent?

5.1 Introduction

A systematic report into the effectiveness of school based health promotion in 1997 concluded that most children were unimpressed with the health education they received in schools. The authors felt that this was primarily due to the mixed messages the children were exposed to in the school environment. Vending machines had become a norm in many school corridors and some schools lacked adequate play and sports facilities.[389] Since the early nineties the UK government has recognised the need to promote public health from early life,[390] and the Centre of Disease Control and Prevention in America also recognised that school based interventions had the potential to influence lifelong patterns and behaviours.[391] Evidence suggests that children learn eating habits as they mature and initially parental and family influences are key[392] but as children grow older environmental influences, especially the social school environment plays an important role in the child's choices, and by adolescence the social environment and peers become the main influences.[393]

A governmental review in 1999 concluded that school health promotion initiatives were inconsistent in their ability to impact on children's health. In general the review found that interventions increased the children's knowledge but did not change their behaviour or attitudes.[394] This was further confirmed during the Active Programme Promoting Lifestyle Education in School (APPLES), from Leeds.[334;335] The aim of this intervention was to test using a whole school approach if obesity risk factors could be reduced. Ten schools were involved, with five in the intervention arm. These schools participated in the programme which involved teacher training, changes to school meals and a number of school action plans, which were aimed at promoting healthy eating and encouraged increased exercise. The other 5 schools continued with the normal nutrition education included in the school curriculum. The results showed an improvement in nutritional awareness but the interventions were ineffective in changing the children's behaviour significantly. Positively the children's vegetable consumption increased but their consumption of high sugar drinks and foods increased, while their consumption of fruit decreased, in conjunction with their decreasing activity levels.[335] The project highlighted the difficulties in achieving behaviour change even when nutritional awareness has increased and a whole school approach has been adopted.

In chapter 3 the Christchurch Obesity Prevention Project in Schools (CHOPPS) was described in detail. This study showed that an increase in obesity could be prevented through a targeted intervention, which focused on decreasing the consumption of carbonated drinks. The education intervention in the CHOPPS project was in addition to what is normally taught in the curriculum and unfortunately due to the study design a whole school approach could not be adopted. This study was a cluster randomised controlled trial and for the study to have sufficient power, randomisation was with classes and not schools. The education initiative was therefore very focused in the intervention classes and any crossover into the general school environment was discouraged. The rest of this Chapter will describe and discuss the results from a simple questionnaire (Appendix IV) used to assess if the children gained any knowledge from the intervention and how they felt about participating in the project. In addition the teachers participating in the CHOPPS project were also asked to complete a questionnaire (Appendix V) and this will also be discussed.

5.2 Methods and Analysis

All children and teachers participating in the CHOPPS project were asked to complete a questionnaire (Appendix IV & V). These questionnaires where completed in class, and were distributed at the time that the final 12 month anthropometric measurements were taken. The return rate did depend on attendance on that specific date and the individual teacher's willingness to encourage the completion of the forms.

The questionnaires were developed with assistance from my dietetic colleagues and Ruth Angel, a former teacher and Health Promotion Specialist. Following the initial draft, the questionnaires where piloted on children of a similar age as those participating in the project to assess for age appropriateness and readability of the questions. Each questionnaire was on one double-sided A4 sheet. The first part of the children's questionnaire consisted of 10 multiple choice nutrition questions. These questions focused on the main points covered during the 12-month intervention, the majority of the questions focused on drinks, as this was the main focus of the CHOPPS project. Four subjective questions were included on the back of the sheet, in the form of a 3-point likert scale. There were also three open-ended sentences for the children to complete if they wished to express any additional comments. The teacher's questionnaire included five questions, using a 5-point likert scale and further questions asking for comments about the project.

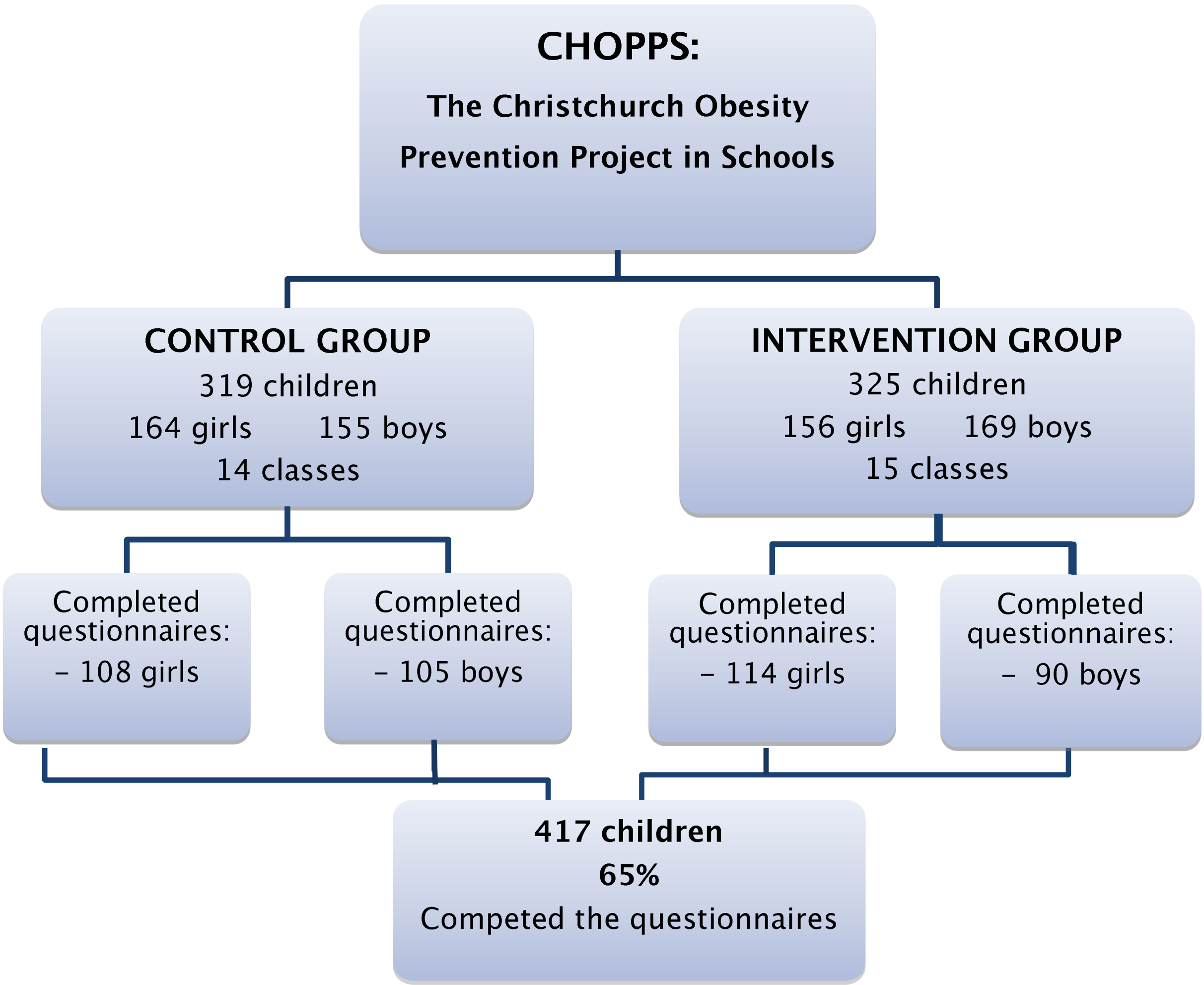
As described in Chapter 3, the data was analysis using SPSS (Version 11). The data was assessed for significance using individual analysis and to conform to the original design of the study cluster analysis was also considered, where each cluster was derived by averaging the individual results for the children in the cluster. The independent samples t-test was used to establish statistical significance between the control and intervention clusters. A p value of <0.05 was judged as significant.

5.3 Results

5.3.1 Children's knowledge questionnaire

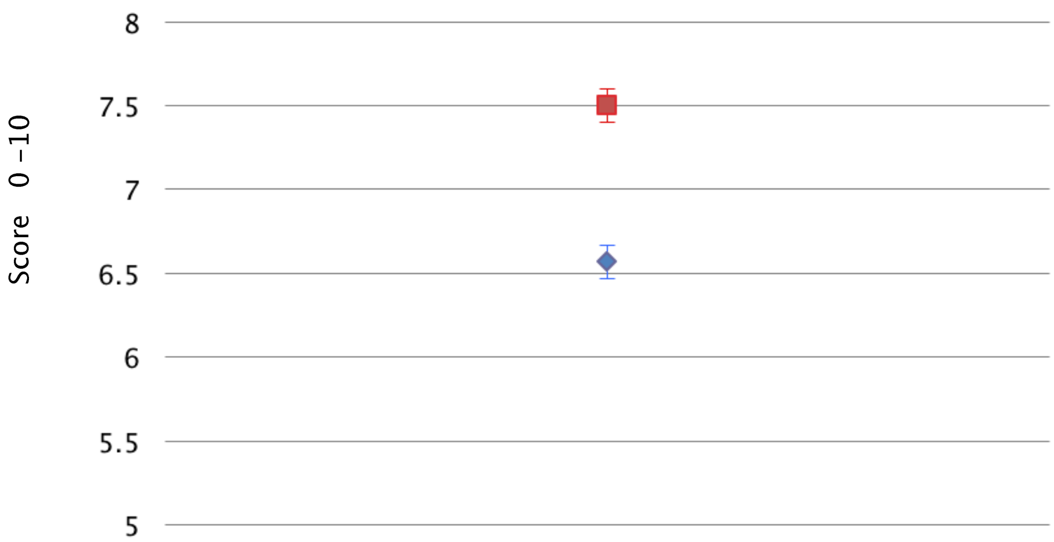
Figure 29 demonstrates the return rate of the knowledge questionnaires from the children (mean age of 9.7 year, SD 0.9), showing a similar return rate between the control and intervention groups and for both genders.

Figure 29. Trial profile demonstrating number of questionnaires completed by the children



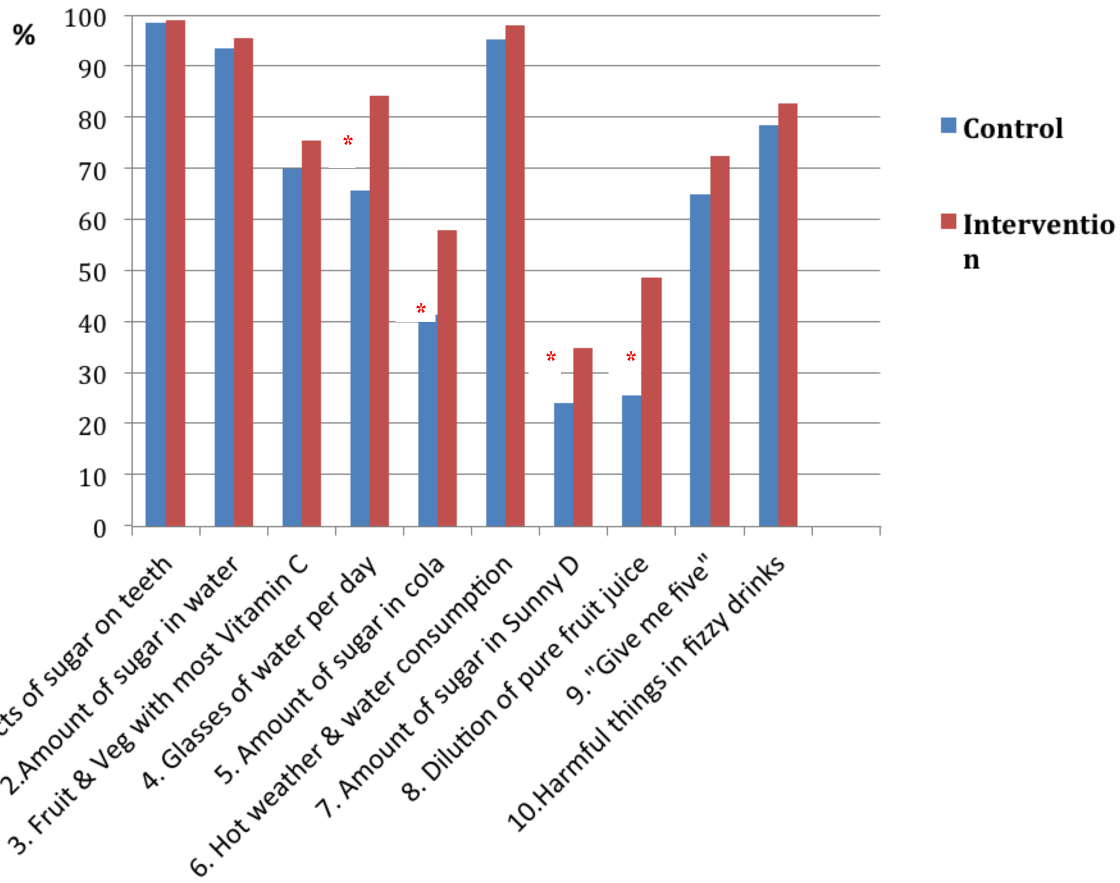
The average results for the control or intervention group for the knowledge questionnaire are shown in Figure 30. The difference between the control and intervention groups were significant (p=0.00; 95%CI -1.22; -0.62) using individual analysis and this remained significant when cluster analysis was considered (p=0.00; 95% CI -1.54; -0.56).

Figure 30. Mean result for the knowledge questionnaire for the control and intervention group. (maximum possible score 10)



Data shown as mean ±SE

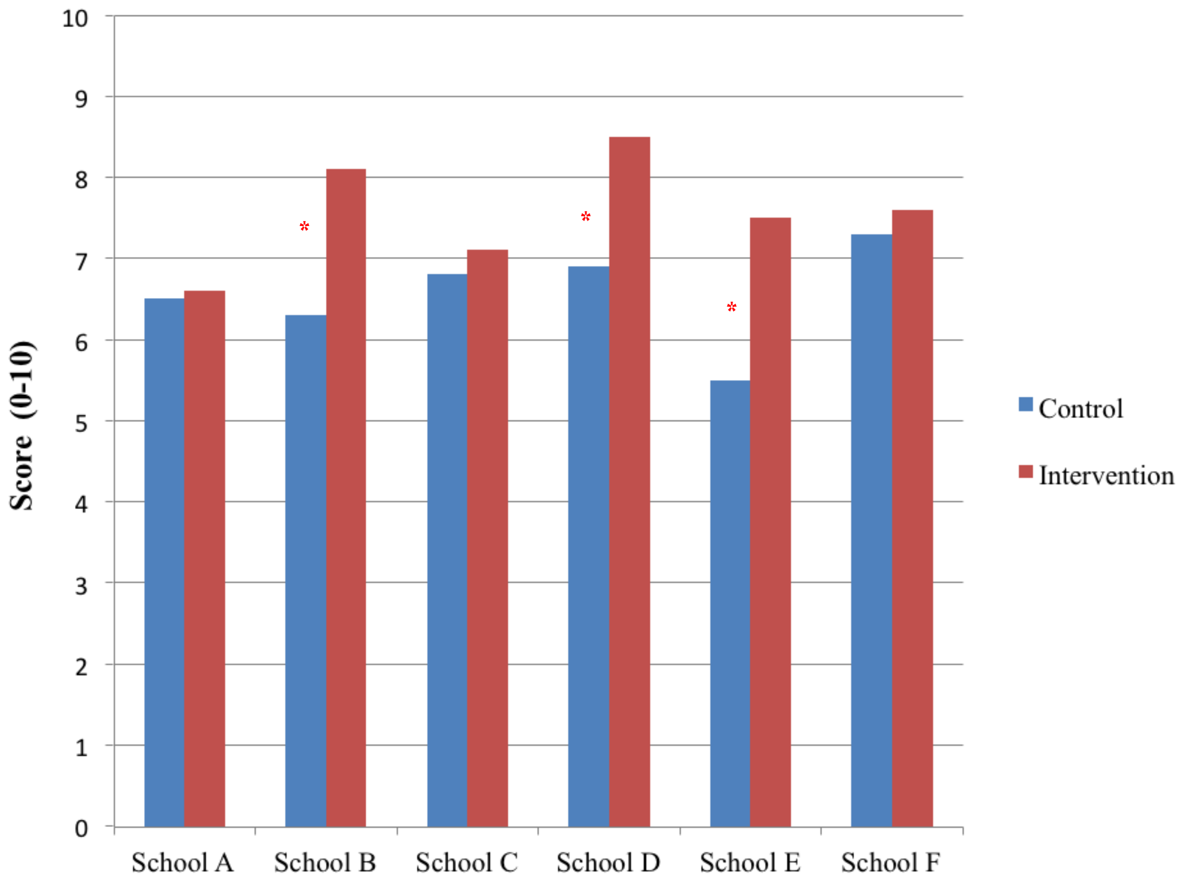
Figure 31. Results from specific questions on the knowledge questionnaire (shown as valid percent correct)



* detonates significant difference

Figure 32 shows the results of the knowledge questionnaire according to individual schools. In three of the schools the difference between the control and intervention group were significant (Schools B, D and E). Further analysis has also confirmed that in all schools the significant results were evident in the 3 separate year groups.

Figure 32. Knowledge questionnaire results according to school



* denates significant difference

The children's perception of their knowledge gain is shown in Figure 33, and the majority of children in the intervention group felt that they learnt a lot, this was significantly more than those in the control group. There was no significant difference between the control and the intervention group when asked if they enjoyed the project (Figure 34)

Figure 33. Children's perception of their knowledge gain following the intervention.

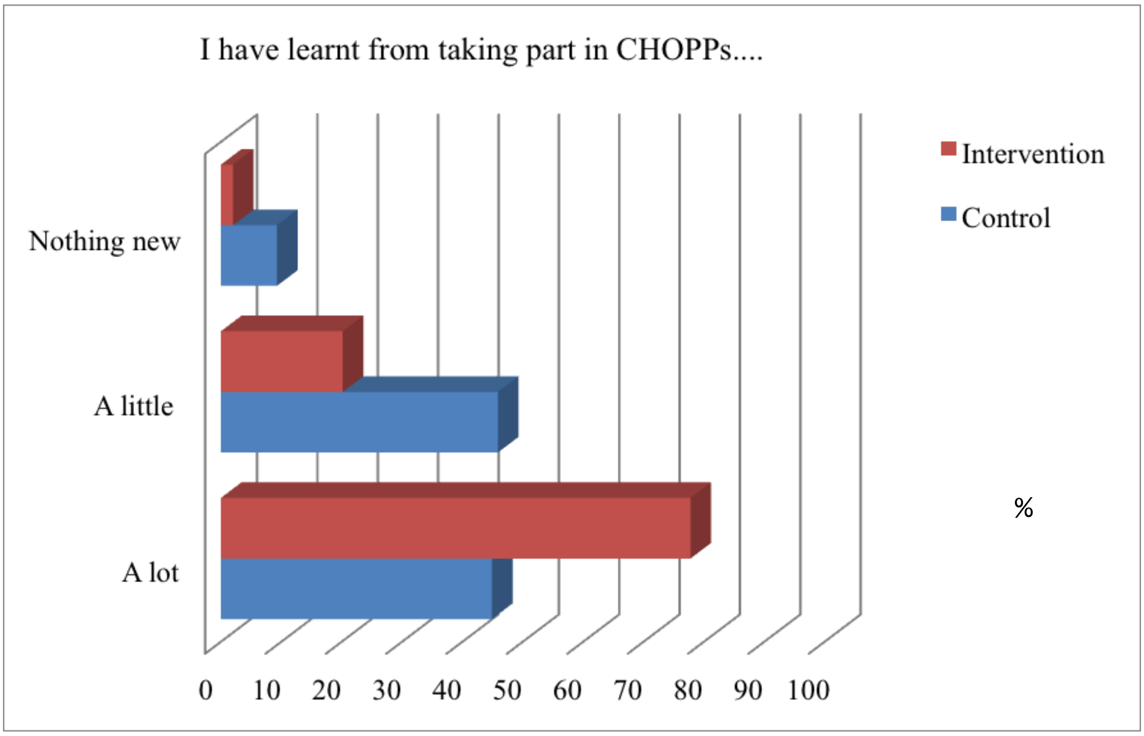
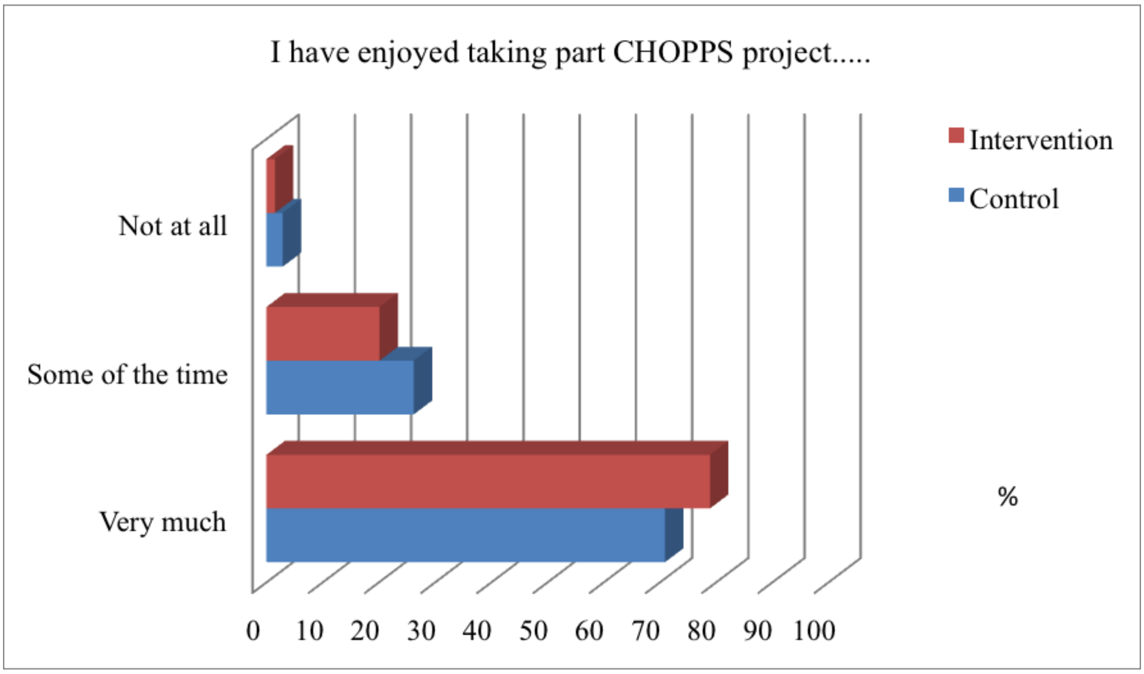


Figure 34. Children's responses as to whether or not they enjoyed participating in the CHOPPS project.



Some additional comments from the children:

I liked.....

"..seeing how much I weighted"

"the project because we made a rap"

"missing parts of lessons"

"getting a badge at the end"

Next time I hope ....

" You show pictures of people who don't eat the right things, plus a child in a dentist chair having a tooth taken out!"

5.3.2. Teachers questionnaires

Only 12 out of the possible 29 teachers returned questionnaires. These were returned from five of the six schools, with teachers from both control and intervention classes returning forms from four schools, while one intervention teacher from the other school returned a form.

The majority of the teachers' responses were very positive. 83% felt that the project was worthwhile; while 2 of the 12 teachers felt that the project had been too time consuming and had interfered with their lessons. The majority of teachers (92%) felt that more time should be given to nutrition education. In relation to the actual intervention, all of the teachers agreed that it was appropriate for their year groups.

The teachers were also asked for additional comments. A few are included below:

"Project certainly made the children think about eating and drinking healthier options. Perhaps the parents need educating!!!"

"Perhaps we could flag up in a little more detail the physical effects of eating the wrong type of food e.g biological diagrams showing the amazing work the body does in the digestive system, how much sugar/fat can thicken the blood, with repercussion for our health when we are older."

"The children enjoyed being part of something"

"The children loved seeing Janet and making up the rap but I'm not sure if many will change their unhealthy diets- we need to educate the parents too!

"To come in more frequently as children need regular continuity. They forget easily"

"I think for this to be truly effective there needs to be more active participation from parents/carers as they decide what to give children in lunch boxes, etc."

"A cross curricular approach involving music, poetry and art generates the most interest."

"The children learnt more in the interactive parts of the project i.e. placing food on the pie charts, the quizzes and writing their own rap"

"Prior knowledge of what is to covered would be helpful- linked to curriculum."

"It was effective when the children were faced with the stark results of poor nutrition/eating wrong foods & drinks e.g. the experiment earlier this year when a tooth was placed in a saucer of coke. Hard- hitting!"

"Visits were far apart, so continuity for the children was difficult"

5.4 Discussion

Previous studies have shown that even with increased nutritional understanding, behaviour change is difficult to achieve.[335] The initial results from the CHOPPS project suggested that a proportion of the children may have reduced their consumption of carbonated drinks. The aim of these questionnaires was to gain insight into any possible education gains from the intervention and also to achieve a better understanding of how those included in the project had felt about the experience.

This questionnaire is limited as it was not validated. A further limitation was that the administration and collection of the questionnaires was restricted to a single visit and was dependent on a third party to administer and collect the questionnaires.

The results of the knowledge questionnaire showed that the children in the intervention group scored significantly higher on the nutrition education questionnaire compared to those children who did not participate in the additional education programme. This does not indicate that they necessarily changed their behaviour but it does show that knowledge was gained. The targeted message from this intervention focused on decreasing the consumption of carbonated drinks. In Chapter 3, the results from the 3-day drinks diaries indicated that children in the intervention group decreased their consumption of carbonated drinks when compared to the control group. This suggests that the knowledge gain may have resulted in changed behaviour for a proportion of the children participating in the project, although a significant correlation could not be calculated to confirm this.

It is interesting to note that the specific questions pertaining to drink consumption covered during the education programme demonstrated significant differences in the number of correct answers between the two groups (Figure 31). These questions were also generally less well answered by both groups. It is likely that these messages were totally new to the children and may not have been covered in previous nutrition lessons as part of the core curriculum. The question relating to the national *5 a day* campaign promoting intake in fruit and vegetables was well answered by both groups with almost two thirds of all children answering this question correctly. This suggests that children are aware of the importance of fruit and vegetable consumption but worryingly national statistics show that 10% of all children don't eat any fruit and vegetables, and 74% do not eat any citrus fruit and 58% no green leafy vegetables. [292]

The researcher/educator of the CHOPPS project was not blinded to the schools and over the time developed a subjective perception of each school's involvement and enthusiasm for the project. The results of the knowledge questionnaire (Figure 32) according to each school are very interesting. In general the schools were very positive and enthusiastic about the project, with the exception of School A. This was the only school where the teachers did not participate during the lessons and generally seemed unenthusiastic about the project, and the researcher assumed that there would be no further reiteration of the messages following the class visit. Therefore the results between the control and intervention group at this school showing little difference in the results questionnaire were not surprising. The lack of significant result for School C and F was disappointing, as both of these schools were very enthusiastic but one possible explanation may be contamination between control and intervention groups. As much as the researcher endeavoured to ensure that this did not happen, the schools had their own motivation and ideas for involvement in the project. The headmaster from School C insisted that the intervention classes present the "rap" following the music project to the whole school, and when visiting School F, the researcher found a large display about the project in the foyer of the school. Obviously it was very encouraging that these schools were so enthusiastic about the project but it makes it more likely that contamination may have occurred. As these schools were motivated they may also generally have spent more time during normal lessons on nutrition education. Schools B, E and D were all enthusiastic and the results from School E were most encouraging. This school is situated in an area of deprivation and historically has not responded well to outside projects. These points highlight the difficulties in undertaking research in the community where the researcher is dependent on other people to ensure that the research remains uncontaminated. The potential for contamination could have been reduced if randomisation had been done by school and not class, but this would have required a larger sample with more schools.

It is reassuring that the children, especially those in the intervention group felt that they had learnt something from the project and that the intervention children responses were significantly higher than those in the control group. One of the teachers commented that the children enjoyed being part of something and this can also be seen in the children's response to the question as to whether they enjoyed taking part in the project, a similar response was received from both the control and intervention group. Although the response rate from the teachers was very poor, it is encouraging that the majority of those that did complete the evaluation felt that the project was worthwhile. The poor return rate from the teachers was due to difficulties in locating the specific teachers that had participated as the forms were distributed 12 months after the project commenced during the following school year, and a number of the teachers had moved within the school and some had also changed schools or gone on maternity leave.

The amount of nutrition education in the national curriculum varies throughout the United Kingdom and it is no longer evident as a distinct subject.[390] In primary schools in England, the topic of nutrition is included in the subjects of; Design and Technology (food technology), Science, and Personal and Social Health Education (PSHE). In secondary education, the topic is covered in Design and Technology (food technology); Personal and Social Health Education (PSHE) and Home Economics.[395] Science is a compulsory subject for all children in the Key Stages 1 & 2 (Primary School education) and all children at this level have a statutory entitlement to learn about basic nutrition, but this is the only time when the subject of food and nutrition is compulsory.[390] Advocates of nutrition education feel that the subject should not only focus on the science of nutrition information but that those skills essential for food preparation and be taught along with an understanding of the social and cultural aspects of food.[396] An overwhelming majority of the teachers that participated in the CHOPPS project felt that more time should be given to nutrition education. There is evidence that suggests that nutrition education can also be effectively included in the framework of other subjects such as maths and language, but unless this become mandatory in the curriculum it is dependent on teacher motivation and enthusiasm.[396]

For over two decades the school environment has not reinforced the nutrition information taught in schools in the United Kingdom. In 1980 the Education Act removed the obligation of schools to provide school meals and the meals provided no longer had to be at a set price or meet a specific nutritional standard. The public awareness of the situation in schools increased during the television series *Jamie's School Dinners.* Through these programmes the celebrity chef Jamie Oliver highlighted the poor quality of school dinners and the basic lack of understanding of the importance of healthy eating amongst school children. The series culminated in a new school meal standards and pledge from the government for £280 million to help improve the situation.[397] In 2006 new nutritional standards for school meals were introduced and this has been followed by even more stringent standards which were introduced in primary schools in September 2008 and in secondary and special schools in 2009.[398] On paper these standards appear very positive but as a parent of a child attending a middle class church school with very few children receiving government funding for their meals, the reality is different. In this environment healthy cooked school meals are only possible if parents are willing to pay £2.50 everyday for each child, and as such in the current economic climate the postcode lottery of social provision has even extended to school meals.

An ideal setting would be a school that provided healthy school meals and that the messages discussed in the classroom were extended to the school environment. This would promote what is often termed a settings approach to health promotion and schools have long been recognised as the ideal environment in which to target a large audience. [396] It is thought that this can only be effective if the school follows a whole school approach and that the environment and educational messages are conductive to promoting a healthy lifestyle.[390]

A number of teachers commented that they felt that the parents also needed to be included and educated. Evidence suggests that family involvement is beneficial for younger children, but when considering adolescents community partnerships are the most effective.[396] The WHO has reviewed the evidence on health promotion in schools and concluded that initiatives focusing on improving mental health, healthy eating and physical activity are more effective than those aimed at reducing substance abuse and suicide.[399] The report concluded that programmes need to be sustained, multi-factorial and be adopted by the whole school, ensuring changes within the school environment. An American study assessing the effectiveness of a short term school based programme versus a home based programming involving parents in a large sample of 7 to 9 year old children, found that those children in the school based programme gained more knowledge but those in the home based programme were more likely to change their behaviour.[400] A further point raised by the teachers participating in the CHOPPS project was that they felt that more regular input was necessary and that continuity was important. Ideally the nutrition messages should be incorporated into different areas in the curriculum.

In summary these simple questionnaires have shown that the specific intervention of the CHOPPS project resulted in increased knowledge and the additional nutrition education was positively received by both the children and teachers. These results are reassuring and if a similar method was adopted and extended to a whole school approach with additional family involvement as suggested in the literature [399;400] potentially better results could be achieved and behaviour change may become a reality. Importantly any educational messages and changes need to be continued and reiterated. In the next Chapter the longitudinal results of CHOPPS project will be discussed.

Chapter 6.

Longitudinal results from the Christchurch Obesity Prevention Programme in Schools

6.1 Background

As described in the previous Chapters the increase in childhood obesity is of both national and international concern. The CHOPPS project was completed in September 2002 and after this time further increases in childhood obesity were evident in the national population with increases in childhood obesity from 9.9% in 1995 to 13.7% in 2003.[401] The extent of the problem was acknowledged by the British government, which set a target of halting the increasing trend in children under the age of 11 by 2010.[402] In 2006 a governmental publication forecast that there could be even further increases, and predicted that 19% of boys and 24% of girls under 10 years of age could be obese by 2010.[403]

As previously discussed; numerous studies have been conducted with the aim of preventing obesity in children and young adults, many of which have been schools based.[332;404] The revised Cochrane review from 2005 [405] considered 22 studies; including 10 long-term and 12 short-term projects, most of which were school-based and focused on multiple interventions while some had more specific approaches. This review concluded that in most cases the interventions did not significantly impact on the weight status of the children. The review suggests that one of the reasons for the disappointing results might relate to the length of the projects, which may be too short to significantly impact on the children's size. The review suggests that any further research should be of a greater length and that the interventions should be more intense.

As described in detail in Chapter 3, the CHOPPS project was commenced in August 2001 and was completed over 1 school year. The project was based in six junior schools in Christchurch, Dorset; and included children aged 7 to 11 years old. The intervention focused on discouraging children from consuming carbonated drinks, and involved one hour of additional health education during each of the four school terms. The original project produced a modest reduction in the number of carbonated drinks consumed, and a statistically significant reduction in the number of children becoming overweight or obese.[406]

6.2 Aims

Further anthropometric measures were taken two years after completion of the original project (3 years post baseline), to assess for any longitudinal effects.

6.3 Methods

6.3.1 Participants and methods

In the original project, the children in the three year groups attended junior schools in Christchurch, Dorset. Three years post baseline, the two older year groups had subsequently progressed to secondary schools and were tracked using school leaving lists, with the majority attending 3 local secondary schools. 511 children were tracked with 90 children from the original sample moving out of the area and 43 attending secondary schools which were either outside of the project locality or had less than 6 children from the original project attending (Figure 35), 67% of the original sample were measured at 3 years. The East Dorset Research and Ethics Committee granted ethics approval for these additional measurements

6.3.2 Outcome measures

Anthropometric measures of height (without shoes) to the nearest 0.1cm were measured using the Portable Leister height measure (Child Growth Foundation) and weight (in light clothing), measured to the nearest 0.1kg on medical scales (Seca 770, Marsden). Body Mass Index (weight (kg)/(height (m)^2)) was converted to standard deviation scores (SDS or Z-scores) and to centile values using the 1990 growth reference disc (Child Growth Foundation).[213] The Z-score accounts for the child's age and gender and represents the deviation compared to an average child of the same gender and age. Waist circumference was measured identifying the waist as the point of flexure as the child bends to one side; one centimeter was deducted to account for clothing. Waist circumference was converted to Z- scores using the 2001 McCarthy references for waist circumference.[204] Change in BMI Z-score and prevalence of overweight were the primary outcome measures. One researcher (JJ) was responsible for taking all the anthropometric measures, as per the previous study to ensure standardization of measurements. In many cases the original classes/clusters were no longer intact and therefore the researcher was unaware of which children had been part of the intervention or the control group. As with the previous study, overweight and obesity are defined using the 1990 British centile charts, where children above the 91st centile are classified as overweight and those greater than the 98th centile are obese.

6.3.3 Statistical methods

6.3.3.1 Sample size calculation

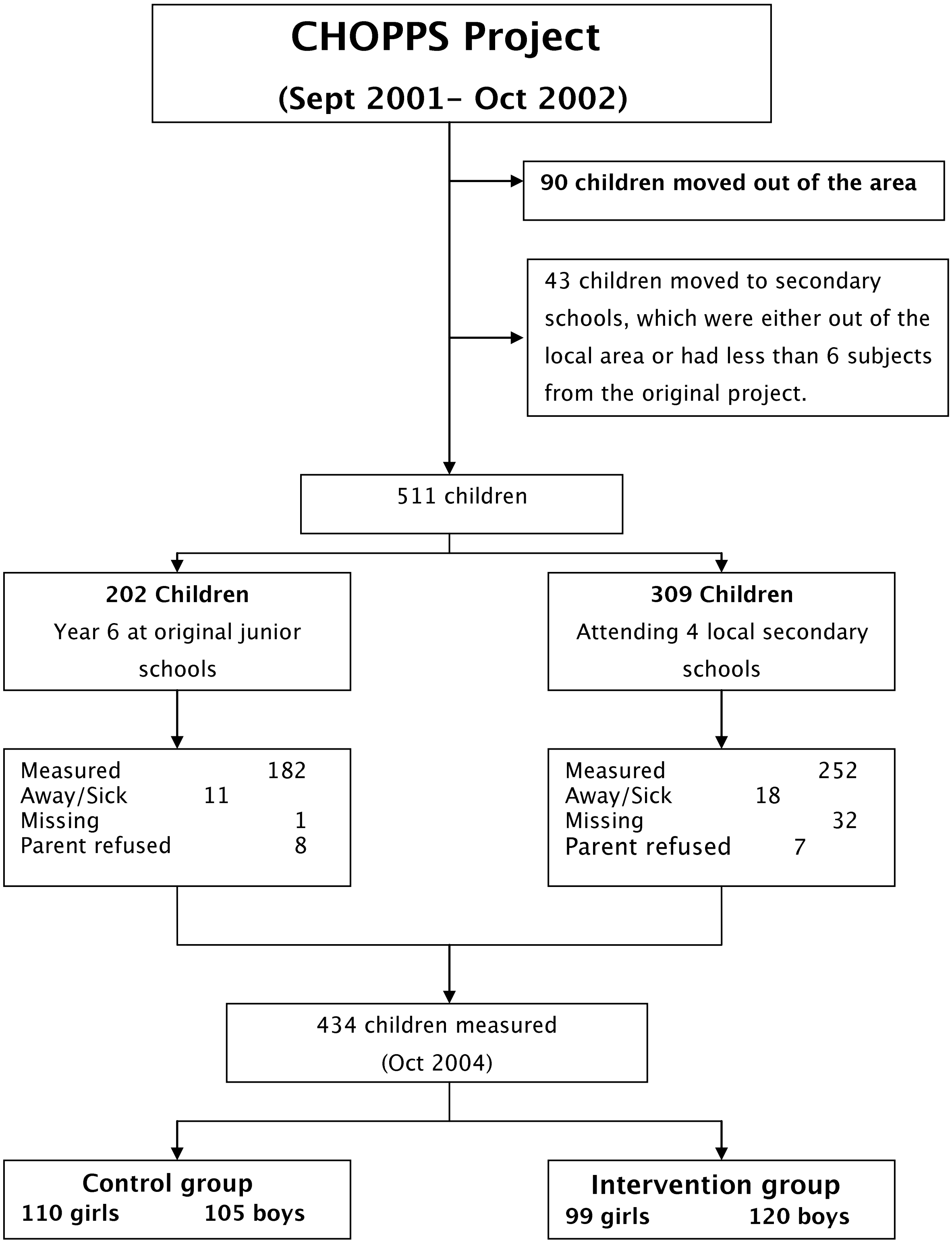
The original aim of the first study was to prevent overweight and obesity by reducing consumption of carbonated drinks. The calculated sample size of 376 was based on changes in carbonated drink consumption. This sample size had 90% power to detect mean differences in Z- score for BMI of 0.49, 0.42, 0.35 and 0.34 (assuming intra cluster correlations of 0.1, 0.05, 0.01 and 0.001 respectively) between the intervention and control groups. In the event 434 children had measurements made at 3 years post baseline and using data from the 12-month follow-up the sample size calculation can be refined. In the original 12-month follow-up the intra cluster correlation for the change in Z-score over 12 months was -0.003 (assumed to be 0) and the SD was 0.44 in both groups combined. Thus at 3 years with a sample size of 434 and assuming a SD of 0.44 and an intra cluster correlation coefficient of 0, the study has 90% power to detect differences in Z-score of 0.14 between the control and intervention groups.

6.3.3.2 Analysis

The original design was a cluster randomised controlled trial, with class being the cluster. Data were aggregated for each cluster and the 2 sets of clusters compared using the independent samples t-test. Subsequently with the longitudinal data at 3 years post baseline, and the nature of the school environment with the progression of children to different schools, the clusters did not remain intact and a proportion of children have been lost in follow-up. This resulted in some clusters having fewer children in them, and so reducing the validity of the original method of analysis for the follow-up data.

The interval scaled data in this chapter have therefore been analysed with MLwiN (Version 2) using multilevel models to take into account variance within clusters. For binary data a logistic model was implemented using the same software. This has resulted in the12-month analysis presented here not being identical to that in the original report. A 5% significance level is used.

Figure 35 Trial Profile for 3-year follow-up data



6.4 Results

In the original CHOPPS project; baseline anthropometric measures were obtained from 644 (321 girls) children. 434 (209 girls) children were re-measured 3 years later. There was no significant difference in the baseline Z-scores between children in the control and intervention groups that were present; n=418 (Mean difference of 0.07; 95% CI -0.11, 0.26) or those who were missing, n = 196 (Mean difference -0.15; 95% CI -0.45, 0.15). At the start of the CHOPPS project in September 2001, the average age was 8.6 (range 7.0 to 10.9) years and 11.6 at 3 years follow-up (range 10.0 to 13.9). The number of children tracked from each of the original schools is shown in Table 17.

Table 17. Children tracked from original schools and percentage measured at 3years.

School	Number Tracked (number consented at baseline)	Percentage	Number measured at 3 yrs (%)
School A	48 (81)	58%	34 (42%)
School B	121 (154)	78%	109 (71%)
School C	140 (152)	92%	119 (78%)
School D	85 (85)	100%	73 (86%)
School E	63 (116)	54%	49 (42%)
School F	55 (59)	93%	50 (91%)
Total	511 (647; 644 final sample: 2 excluded due to age and one withdrew consent)	79%	434 (67%)

Table 18 shows the body mass indices, centile Z- scores (SDS) and waist circumference Z-scores (SDS) at baseline, 12 months and 3 years follow-up. The data shows that there is a difference in BMI between the groups at both 12months and 3 years, but this difference was evident at baseline but was not significant. More importantly the change in BMI from baseline is not significant. This result is again seen with the BMI Z-score, although there is a marginally significant difference in change of BMI z score at 3 years but as this was not evident at 12months, and appears to be more of a chance finding. There was no evidence of any difference between the groups when waist circumference was assessed. The data have also been analysed for each measure of change from baseline using baseline values, gender and secondary schools as covariates/ cofactors, and this has made no material difference to the significance levels or mean changes between control and intervention group.

Table 19 shows the change in prevalence of overweight and obesity using the 1990 British centile charts, considering children above the 91st centile as overweight. As previously reported, at 12 months there was a significant difference between the control and intervention group but at 3 years post baseline the difference was smaller and no longer statistically significant.

Table 18: Change in BMI, centile SDS (z-score) and waist SDS (z-score) at 12 months and 3 years post baseline

		Control	Intervention	Mean difference (95% CI) p value
BMI*	Baseline n=486	17.5 (2.36)	17.2 (2.14)	0.24 (-0.16, 0,64) p=0.24
	12 months n=474	18.3 (2.85)	17.8 (2.45)	0.59 (0.11; 1.06) p=0.02
	3 years after baseline n=434	19.7 (3.36)	19.0 (3.21)	0.68 (0.06; 1.30) p=0.03
Change in BMI from baseline**	After 12 months n=455	0.71 (1.45)	0.62 (0.79)	0.10 (-0.11; 0.31) p=0.36
	3 years n=418	2.14(1.64)	1.88 (1.71)	0.26 (-0.07; 0.58) p=0.12
BMI Z-score (SDS)*	Baseline n=486	0.53 (0.98)	0.44 (0.98)	0.08 (-0.09; 0.26) p=0.36
	12 months n=474	0.63 (1.07)	0.44 (1.01)	0.20 (0.01; 0.38) p=0.04
	3 years n=434	0.63 (1.12)	0.39 (1.17)	0.24 (0.02; 0.46) p=0.03
Change in BMI Z-score (SDS)** from baseline	After 12 months n=455	0.05 (0.57)	0.03(0.30)	0.02 (-0.06; 0.11) p=0.6
	3 years+ n=418	0.10 (0.53)	-0.01 (0.58)	0.10 (-0.00; 0.21) p=0.06
Waist circumference SDS (z-score)*	Baseline n=486	0.85 (0.94)	0.83 (0.91)	0.03 (-0.14; 0.19) p=0.76
	12 months n=474	0.99 (0.93)	0.88 (0.87)	0.11 (-0.05; 0.27) p=0.19
	3 years n=434	0.96 (1.22)	0.80 (1.07)	0.15 (-0.06; 0.37) p=0.17
Change in waist (z-score) circumference from baseline**	After 12 months n=455	0.08 (0.64)	0.08 (0.47)	0.01 (-0.09; 0.12) p=0.81
	3 years n=418	0.099(0.99)	0.01(0.66)	0.09 (-0.06; 0.26) p=0.25

* Based on maximum number of children in each cluster + Primary outcome
** Based on children with data at baseline & 12months or 3 years

Table 19 Prevalence of overweight at 12 months and 3 years post baseline.

	Control	Intervention	OR (95%CI)	p value	Risk difference*
Baseline n= 486	20.6%	17.4%	0.79 (0.50; 1.26)	p=0.33	3.2% (-4.23, 10.6%)
12 months n= 474	28.5%	18.7%	0.58 (0.37; 0.89)	p=0.01	9.8% (1.83, 17.8%)
3 years+ n= 434	30.2%	25.6%	0.79 (0.52; 1.21)	p= 0.28	4.6% (-4.3%, 13.5%)

*Risk difference calculated assuming the intra cluster correlation is 0.

+ Primary outcome

6.5 Discussion

Schools have long been acknowledged as providing the ideal environment for public health initiatives and the recent UK Obesity guidelines from NICE highlight the important role that schools can play in promoting healthy lifestyles.[407] Unfortunately there remains limited long-term evidence of their effectiveness. [405]

The original CHOPPS project was a simple 12-month school-based intervention, which focused on reducing carbonated drink consumption. At one year significant differences in the proportion of overweight children in the control and intervention group were found.[406] Two years after the completion of the study this difference is no longer significant, and the number of overweight children has increased in both groups although the prevalence still remains higher in the control group. In the 3-year follow-up, BMI was lower in the intervention group but this is a continuation of the observed differences seen at baseline. The only difference approaching statistical significance was for the change in centile Z-score but given the lack of a trend at 12 months this may well be a chance finding. The study had sufficient power to detect a difference of 0.14 or more, and the observed difference of 0.10 was smaller. In addition the CHOPPS study was originally powered to detect differences in fizzy drink consumption, and not change in BMI Z score.

There are a number of limitations to the study. Following the completion of this project there is now further evidence as to the effectiveness of the different measures of adiposity. Tim Cole and colleagues assessed the measures of BMI, BMI%, BMI z-score and BMI centile in an observational study of 135 children aged between 29 to 68 months in an Italian kindergarden. [408] They concluded that BMI Z score was best in determining adiposity for one-off measures and that when change in adiposity was being considered BMI or BMI% were better measures, due to the within-child variability over a period of time. Researchers from Bristol Childhood Obesity Unit assessed these same measures in a cohort of 92 children with a mean age of 12.8 years.[409] These researchers assessed the measures against a validated measure of actual percentage fat loss, and differed from the Cole group in that they were assessing children in a weight management programme looking for improvements over time and not just the reproducibility of the measures over 9 months. The Bristol group concluded that BMI Z score was the best marker for changes in adiposity. They also stated that any childhood obesity interventions should aim to demonstrate a fall of a least 0.6 BMI SDS to be certain to be reducing adiposity. This is in-line with other research which has shown that reductions of a minimum BMI SDS of 0.5 produce improvements in blood pressure, lipids and insulin resistance[410] and that inversely, increases in BMI SDS of 0.5 increase the risk of developing the metabolic syndrome.[411] This recent evidence highlights the insufficient power that the CHOPPS project had to demonstrate sufficient changes in adiposity that could be related to a definite reduction in fat percentage.

A further limitation was the proportion of children lost to follow-up; although 79% of the original cohort were tracked at 3 years, only 67% of the cohort were measured at this time. One of the problems was gaining access to the students, particularly those now in secondary school, where each student has their own timetable and it is more intrusive to remove the students from the classroom. Table 16 shows the number of children from individual schools who were originally consented and then tracked and measured at follow-up. There is a large variation between schools, and two schools in particular have a resultant lower percentage of children measured at follow-up. Only 42% of the original cohort from school A was measured at follow-up. This school is situated very close to the boundary of another locality and a good proportion of the children subsequently moved to secondary schools outside of the original area. In addition a 42% follow-up rate was only achieved from School E, which as previously described is situated in an area of social deprivation, and there is naturally a great deal of movement within this local community. The children that attended the particular secondary school in this area were also less likely to keep their appointments for measuring.

As described the natural progression of children through school resulted in disruption within original clusters and therefore a different method of analysis from the original study was necessary. The original datasheet was also analysed using MLWin and displayed the same conclusions as per the original method of analysis. A further limitation was the lack of data collected at 3 years on carbonated drink consumption; this would have added greatly to the study and could have provided some interesting information on any changed drinking behaviours in the children. Unfortunately this data was not obtained due to financial and time limitations. In addition it would have been valuable if information on the socio-economic status and pubertal stage of these children had been collected.

The CHOPPS project was different from many other school based interventions in that the intervention was specific, discouraging the consumption of carbonated drinks while promoting a healthy diet based on the balance of good health. The strength of such a focussed intervention has been questioned.[412] The simplicity of the intervention does not discount from the complex issues that cause obesity but was an attempt to find a simple focussed intervention with reiteration of one main point with a background message promoting healthy eating. A recent pilot study including 39 subjects was conducted to compare the effectiveness of simple dietary messages against combination messages. All the subjects within this pilot lost weight and there was no significant difference between the groups, but the more simple approach was found to be effective and had collective effects on other areas of the diet that had not been included in the intervention.[413] Further research is being conducted on the effectiveness of single simple messages as means to promote weight loss.[414]

6.5.1 Sugar -sweetened drinks

A number of recent studies have further confirmed the relationship between carbonated drinks and obesity,[311;363;415-417] while a systematic review of 30 studies[418] and meta-analysis of 88 studies have also confirmed this association.[419] In addition the role of these drinks as a causative agent of obesity is also recognised by the World Health Organisation.[5]

The PREMIER trial has recently provided convincing evidence of the direct association of sugar sweetened drinks on weight.[420] This was a prospective study of more than 800 adults that assessed the effect of beverage consumption on weight loss over 18months. The authors examined changes in beverage consumption against weight loss and found that a reduction in liquid calories had a greater impact than solid calories on weight loss. In addition, when different liquid calories were examined the greatest effect was seen from a reduction in calories from sugar-sweetened drinks. This study found that a daily reduction of one serving of these drinks, had an average weight loss of 0.5kg at 6months and 0.7kg at 18months.[420] There are a number of possibilities why the calories from sugar-sweetened drinks have a greater effect on weight than other liquids. Liquids, which contain fibre, protein or fat, may increase satiety; and research suggests that calcium containing drinks may support weight loss by increased lipolysis and thermogenesis. [421] Popkin discusses the evolution of man and how water has always been essential for life, and that physiologically humans have separate hunger and thirst mechanisms. With this in mind he describes how the human body has not evolved to compensate for the inclusion of calorific fluids which have become part of daily living over the last 30-40years, and as such this has a negative effect on our energy balance.[422]

Forshee and colleagues[423] have reviewed the literature on sugar-sweetened drinks; BMI and children and adolescents. They found 12 studies to review and following a comprehensive examination of this literature and they concluded that the association between these drinks and BMI was very weak. These authors concluded that reducing sugar- sweetened drinks consumption would not have a great effect on overall BMI.[423] This review only included studies focusing on children and adolescents. Excluding this review, there is a now a plethora of evidence linking soft drink consumption to increasing obesity, and there is agreement in the literature that even with its limitations the CHOPPS project has added to the scientific discussion[424;425]

As previously discussed there a number of hypotheses as to why sugar-sweetened drinks contribute to increasing obesity. One reason for this association may relate to the high Glycaemic Index of these drinks, and that they provide “empty” calories.[310] In addition the lack of mastication could possibly result in reduced exocrine and endocrine reactions which are associated with the ingestion of solid foods which often contain more calories.[426] This may be linked to the physiological effect on satiety from energy, which is ingested in liquid form and is different to that from solid foods, and this may in part be due to faster transit times and reduced gastric distension. Therefore the additional energy from these drinks may not be detected as easily by the body and individuals may not compensate for this additional energy by consuming less later.[427]

There is considerable debate in the literature regarding High Fructose Corn Sugar (HFCS) and its association with obesity.[321;428-430] It is the preferred sweetener for food manufactures as it provides better flavour enhancement, texture, and consistency in foods in comparison to sucrose.[431] HFCS is chemically similar to table sugar and is composed of 50% glucose and 50% fructose. It is used as a sweetener, as it also has preservative properties and is a more economical option for manufactures than sugar.[430] Studies that have compared glucose and HFCS have found that consumption of HFCS results in decreased levels of insulin and leptin, which are integral components of the energy balance system and with prolonged consumption it could contribute to weight gain.[432] HFCS, or isoglucose as it is often called in Europe is used widely in America and is the sweetener of choice in most calorie containing drinks, and until this year the European Union had imposed strict production quotas on the product.[433] The American Medical Association has recently stated that as the composition of HFCS is similar to sucrose, it is unlikely to cause more obesity than sucrose and that there is currently insufficient evidence to restrict the use of the product.[431] Clearly more research is needed especially as the use of HFCS is likely to increase in Europe.

In addition to the impact of these drinks on weight gain, there is also evidence of a link to increased cardiovascular risk.[434] Consumption of sugar-sweetened drinks results in a rapid increase in blood glucose and insulin concentrations, added to this is the high glycaemic load that occurs when significant volumes are consumed. A high glycaemic load has been shown to increase appetite and therefore promote weight gain.[106] In addition an increase in glycaemic load can intensify levels of inflammatory biomarkers such as C-reactive protein, increasing the risk of cardiovascular disease and type 2 diabetes.[435] Malik and colleagues conducted a meta-analysis on 11 studies on the link with between sugar-sweetened drinks; type 2 diabetes and the metabolic syndrome. They found that individuals who consumed more than a serving a day were 26% more likely to develop diabetes than those that consumed less than one serving a month, and the risk of developing the metabolic syndrome was increased by 20% for those that drank more than a serving a day.[429]

Evidence suggests that it would be beneficial for the whole population to decrease soft drink consumption, as these drinks have a high energy intake with little nutritional benefit.[419] Recently the School Food Trust has launched a consultation document on the draft Code of Practice for drinks provided in schools.[436] The key messages in the new code of practice are that drinks provided in schools should positively support the nutritional health of the children, and that the available drinks should be unsweetened, unfortified, additive free with no preservatives, flavouring and colorants.

6.5.2 School- based interventions

The original aim of this project was to assess if a simple focussed intervention could be effective, in a debate where previous multi-faceted interventions had shown limited success.[1] There is discussion in the literature regarding the effectiveness of a specific interventions, such as the one conducted in the CHOPPS project and a report suggests that such specific interventions may ignore different interlinking influences.[412]

Following the CHOPPs project, there have been two other school based interventional studies, which have also adopted a focused approach of reducing sugar-sweetened drinks. The largest took place in Brazil and included a large cohort of 1140 children between the ages of 9-12 years.[437] The educational intervention took place over 7 months and included similar strategies as the CHOPPS project using music and quizzes and games and also encouraged teachers to continue the message. On conclusion there was a significant difference in the amount of carbonated drinks consumed between the controls and intervention classes. Unfortunately there was no overall difference in BMI, although there was a significant change amongst the most overweight girls. The authors recognised that their results may have been confounded by the increased consumption of juice instead of carbonate drinks, and in particular one juice which contains even more calories than a regular soda. Although the CHOPPs project focused on "Ditching the Fizz", the children were also made aware of other high sugar non fizzy drinks which were best to avoid. As with the CHOPPS project the Brazilian study may have achieved better results had the intervention been continued but it is reassuring that there was a change in the most overweight girls and this is not totally dissimilar to the reduction in obesity seen in the CHOPPs project after 1year.

A smaller study was conducted in Canada and included a totally different approach using a peer educator intervention amongst an older group of 113 students with a mean age of 14 years.[438] The authors believed very strongly in the effect of peer influence, and the invention took place over 6 weeks, with a single and a multiply peer intervention tested against the 2 control classes. After 3 months there was significant difference in the consumption of carbonated drinks between the control and intervention classes but there was no continuation of this evidence a year after the study was completed. This study did not consider weight/BMI and the number of subjects was limiting.

None of the above studies with interventions, which focussed on reducing the consumption of sugar-sweetened/carbonated drinks, have shown any long-term success. This situation is mirrored in the majority of the multi-faceted interventions too.[425] The Pathways project in the United States was a large multi-component intervention which took place over three years.[439] This study included 1704 children from 41 schools and included interventions on dietary intake and physical activity in the school environment and also included a program, which involved the families. On conclusion there was no significant difference in anthropometric changes between the control and intervention group, in addition motion sensor data showed similar levels of activity in both groups. Positively there were significant changes in reduction of fat intake and nutrition knowledge was improved in the intervention group. These results are disheartening, as this intervention took place over three years and was intense, encompassing both the school and the family environment. The researchers concluded that longer or even more intense interventions may be required to have a significant impact on obesity.[439]

The Kiel Obesity Prevention Study (KOPS) is a longitudinal study including children from 32 schools in Germany. It commenced in 1996 and was completed in 2009. The intervention focussed on first grade children, aged 6 and the aim was to determine if a low intensity school based intervention could be effective, with a more intensive family based intervention for at risk children.[440] The school intervention took place over 2-3 weeks with six different units of nutritional messages, each followed by 15 minutes of activity. The family intervention included three to five consultations with the family unit. The initial sample from 1996-1999 included 2440 children, and produced promising results with an improvement of health related behaviour and a significant difference in fat mass between the control and intervention children.[441] The longitudinal 4-year data showed limited success in the prevalence of overweight when the whole cohort was assessed but subgroup analysis found that girls, and children from high socio-economic status (SES) had the best results. The researchers found that SES was the greatest determinant of success, especially when considering the family intervention where a low SES was the biggest barrier to improvements.[442] The researchers argue that their results suggest that school based interventions cannot replace treatment of obesity and that it is critical to consider SES in planning of treatments or interventions for obesity. [442]

The Ballabeina study is a very recent study from Switzerland which focused on preschool children and included multidimensional lifestyle interventions.[443] In view of the latest national results from the National Child Measuring Programme as discussed in chapter 4, which found that 23% of 4 year olds were overweight or obese, this would seem a prime target population. The Ballabeina study included a diverse population with a high proportion of migrant children. The intervention lasted one school year and was intense and included four exercise sessions of 45 minutes every week, in addition there were 22 education sessions on health eating, screen/media use and sleep. The parents were also invited to 3 interactive sessions over the year and additional information was given as leaflets. The preschool environment was also adapted to promote activity. As with so many previous studies this intervention was effective in increasing aerobic fitness and motor agility but no difference was seen in BMI, but there were significant differences in waist circumference and body fat. The authors also commented how their study shows the difficulties in achieving behaviour change even with such young children. [443] Prior to this study Reilly and colleagues had conducted a less intense intervention with preschool children in Glasgow and had predominantly focused on increased physical activity.[444] The results from this intervention were disappointing as there was little change in physical activity or BMI, and Reilly concluded that future interventions would need to include home and the wider community, with additional input on dietary interventions too. Essentially the Ballabeina study encompassed these suggestions and unfortunately the results are not conclusive for any effect on adiposity.

While there are calls for interventions which adopt a whole school approach and to be inclusive of both dietary and physical activity components,[445] the most recent Cochrane report concluded that interventions which focused on either dietary or physical activity achieved the best results. Most interventional studies do improve either the level of nutrition knowledge or have a positive impact on activity but as yet there is very limited success on reducing adiposity. [425] Van Sluijs and colleagues conducted a review of studies, which focused on promoting physical activity. Their review does not discuss any anthropometric improvements, but the effectiveness of interventions to increase activity. This review concluded that multi-component intervention involving the community, school and family were the most likely to achieve the best results.[446] More recently the same author has looked at the effectiveness of family and community interventions and has subsequently found limited evidence of success. [447]

The Cochrane report published in 2005 discusses the lack of studies in the subject area of preventing childhood obesity.[405] The authors suggest that this may be due to perceived difficulties in achieving change in a climate of excessive food and a sedentary nature. Another possible inhibitory factor may be concern over the perceived association between eating disorders and obesity prevention, for which there is no conclusive evidence, this concern is further diluted by the contrasting alarm about the increasing levels of obesity. The lack of evidence was also highlighted by Sharma,[448] in a review including all studies outside of the USA between 1999-2005, the author discusses the lack of available evidence in a field of such international importance. The difficulties of conducting such studies are further highlighted by the disappointing results from some of the studies above, especially the Pathways study above, which was a long-term project (3 years) and encompassed both the school and family environment.

6.5.3 Conclusion

The original CHOPPS project provided hope that a simple intervention could be beneficial in preventing obesity. Unfortunately the results showed no continued effect two years after the intervention was stopped. In addition it is unclear from the literature whether simple single interventions or multi-component interventions achieve the best long-term results. Preventing childhood obesity continues to be a challenging area of research.

Chapter 7.

A Decade later...

In 2001 Muller and colleagues published an article called "*Prevention of obesity - is it possible?* "[449] This article highlighted the lack of research in the area of obesity prevention; this was the same year that the CHOPPS project commenced. Ten years later, the solution still remains unclear, even though the subject has received a great deal more attention and the number of studies seeking effective interventions is increasing. The paucity of evidence of effective interventions is a concern, and raises the question as to why a solution is so hard to find. The following chapter will look back over the time since the original CHOPPs project began and will discuss the progression of obesity and attempts by the government and private sector to make an impact and halt the ever increasing tide of obesity.

7.1 The size of the problem in 2011.

At the time when the CHOPPS project was developed at the start of the decade, one in five adults in the United Kingdom were obese. The prevalence was higher amongst women at 21%, while 17% of men were considered obese. [10] The latest data available from the Health survey for England suggests that in 2009, 22% of men and 24% of women are now obese. Interesting the proportion of overweight men (44%) is greater than that of women (33%).[450] Waist circumference which is considered a good indicator of health risk factors[25;26] was found to have increased by 15% in the 16 year period from 1993-2009. Very worryingly only 31% of men and 41% of women have a BMI within the ideal range. The foresight review has predicted that over the next four years, the prevalence of obesity will increase with 36% of men and 28% women obese by 2015.[451] Historically a higher proportion of women were more obese than men and though the increasing trend is still continuing with women, it is escalating at a much greater rate in men.

In 2006 the then Government proposed a target to halt the year on year increase in childhood obesity by 2010.[452] At a similar time a document prepared for the Department of Health predicted that by 2010; 19% of boys and 24% of girls under the age of 10 years would be obese.[234] Table 20 shows the percentage of overweight and obese children age 2-10 years between 1995 to 2009. There was a marked increase in obesity between 1995 to 2005, after which the trend appears to be flattening out or even decreasing.[453]

Fortunately the possible figures predicted for 2010 were not realized, with actual obese figures for 2009 of 15.2% of girls and 13.7% of boys aged 2-10. The latest results from the Health Survey for England (HSE) show that a third of children under 15 years of age are overweight or obese. [453] The data received from the National Child Measuring Programme (NCMP) suggests there is a worrying increase in obesity between children starting school in reception and those moving on to secondary school aged 10-11, with fewer than 10% of reception children obese, while almost 20% of children in year 6 are obese.[388]

Table 20. Percentage of overweight including obese children aged 2-10 by survey year.[453]

	1995	1997	1999	2001	2003	2005	2007	2009
% overweight and obese	23.1	23.8	28.8	28.5	28.7	31.9	29.2	28.3

In looking to the future, Stamatakis and colleagues have predicted that the number of obese children will continue to rise with possibly 10.1% of boys and 8.9% of girls obese by 2015.[454] These authors do note the levelling off of obesity levels after 2005. This phenomenon has also been seen in other developed countries. In the United States Ogden and colleagues found no significant trend in the BMI of children between 1999 and 2006.[455] The reversing of the increasing trend or stabilization of this trend has also been seen in other European countries. There is a suggestion that this stabilisation may be due to the increased media attention that the subject has received,[454] in addition there have been a number of governmental and private sector initiatives that have been introduced over the last decade.

The predications in the Stamatakis article, described above for 2015 seem less than current rates and this is due to different classifications of obesity. Stamatakis and colleagues are using the International cut-off points for obesity[197] whereas data from the HSE is presented using the 85th and 95th centiles for overweight and obesity. As discussed in the pilot study for the CHOPPS project (Chapter 2), the lack of absolute agreement of the classification of overweight and obesity can be confusing. At the time of the CHOPPS project we decided to use the 91 and 98th centiles as these had been in use for some time, these cut-offs now seem almost obsolete in the literature with the most commonly used parameters being the 85th and 95th centiles. Also previously, children classified as obese, were counted in the overweight statistics whereas this practice is not commonly seen now unless stated.

There are huge implications on the health service for those already obese even if the numbers are not increasing at the exponential rate that they were. In 2004, 314 000 deaths were attributed to obesity, this is 6.8% of all deaths for that year. The number of hospital admissions where obesity is cited as the main cause has increased 10 fold in the last decade. The number of women admitted with obesity as the primary diagnosis is double that of men, and worryingly the age band with the greatest number of admissions with this primary diagnosis is for those aged 35 to 44 (3132 admissions), followed then with 3076 admissions of patients aged between 45 to 54. Apart from the secondary causes of obesity the direct cost of treating obesity has also risen with many more patients opting for bariatric surgery as a treatment. In 2009/10 there were nationally over 7000 admissions for bariatric surgery. In addition to surgical interventions many more people are receiving prescribed treatments for obesity (notably for Orlistat and Sibutramine), since the year 2000 the prescriptions for these drugs have increased nine-fold, with the total prescription costs for obesity drugs of almost £47 million in 2009.

7.2 Policies and Plans to combat the problem.

In the early 1990's the then government recognised the issue of obesity and set a target of decreasing the prevalence rates for men from 7% to 6 % and for women from 12% to 8% by 2005. [456] These targets were clearly not achieved and in 2001, the government published a report "*Tackling Obesity in England*".[10] This report highlighted the magnitude of the increasing trend in obesity and emphasised the physical implications to individuals and also the spiralling cost to the health service. Prior to 1999 there were no national guidelines on how to manage the problem. This report recommended that local strategies were needed, in conjunction with a national appraisal of the effectiveness of interventions. It was also recognised that the National Institute for Clinical excellence should develop guidelines for the management of obesity. Some of the further policies and governmental documents focusing on obesity in the last decade are described in Table 21.

Table 21. Reports and policies affecting obesity in the United Kingdom after 2000.

Document title	**Principle findings, suggestions or aims.**
Food for Life, [457] Soil Association (2003)	- First report on the state of school meals in the UK
Adolescent Health,[458] British Medical Association (2003)	- Reviewed the main priorities for adolescent health of which included; nutrition, exercise and obesity. - Recognised the need for early prevention and that multi-disciplinary teams may be helpful in prevention and treatment.
Diet, Nutrition and the Prevention of Chronic Diseases,[5] WHO (2003)	- Recognition of the global problem of obesity - Discussion on all possible causative factors and preventive strategies. Called for nutrition (along with tobacco and alcohol) to be placed on the forefront of public health policy programmes.
An approach to Weight Management in Children and Adolescents (2-18years) in Primary Care.[378] Royal Collage of Paediatics and Child Health and National Obesity Forum; 2003	- Guidelines to help the management of overweight and obesity in children
Obesity, [459] House of Commons Health Committee (2003-2004)	- Recognised that multifaceted solutions are needed. - Encouraged working with industry to reduce promotional advertising by the food industry for unhealthy products, and promote healthy pricing schemes. - Focused on improving nutrition in schools, and promoting physical activity - Review of treatment options for already obese

Choosing Health, DOH (2004)[233]	- One of the shared priorities for action included was reducing obesity and improving diet and nutrition. This was to be done through a number of ways o A campaign to raise awareness of the health risks of obesity o Improved food labeling o Partnerships with industry o Restriction on advertising and promotion of unhealthy foods and drinks to children by 2007 o Promote National Healthy schools scheme
The NHS Improvement Plan, [460] DOH (2004)	- Multi-agency coordination needed to address issue of obesity - Aim to stop increasing trend of childhood obesity by 2008.
National Service Framework for Children, Young People and maternity Services, [461] DOH (2004)	- Ten year plan, with ten standards to improve the health of children. - Standard 1 focused on promoting health and healthy lifestyles
Healthy living blueprint for Schools, [462] Defra (2004)	- To ensure schools promoted a healthy lifestyle - To improve nutrition education in schools - To improve the standards of school meals, and ensure that water is freely available - To promote physical activity
Preventing childhood obesity, [463] BMA (2005)	Recommendations; - A sustained and consistent education programme about healthy living is necessary for the whole population. - National Obesity Council to improve collaboration between stakeholders - Nutrition in schools must be improved - Healthcare professional working with obese children need training and support - Funding is required for recreation facilities

	- Ban on advertising of unhealthy food items - Improvements in food labeling is needed, and regulation thereof - Research into the area should be facilitated
Turning the Tables: Transforming School meals[464] School Meals Review Panels (2005)	- A report to make recommendations on developing and implementing the new nutritional standards for school lunches
Nutritional Standards for School Lunches and other school Food[465] DfES (2006)	- Final standards stipulating the quality and nutrient values of schools meals. - Clarification on all other foods and drinks available in school. For example, no confectionery and no fizzy drinks - These standards were to be in place by September 2008 for primary schools and September 2009 for secondary and special schools.
Tackling Child Obesity– First Steps[452] The Audit Commission, the Healthcare Commission and the National Audit Office (2006)	- The three involved agencies all hold the target to reduce the increase in childhood obesity by 2010. - The main programmes to improve children's health are: o Improving schools meals o Increasing physical activity (School Sport Strategy) o Healthy Schools Programme o Play o Obesity campaign - There is recognition of the limited evidence for the effectiveness of the multi-faceted approach, for this very complex problem - Baseline data was to be obtained through the new measurement programme

Measuring childhood obesity: Guidance to primary care trusts,[381] DOH (2006)	- Guidelines for Primary Care Trusts on how to measure the height and weight of children between 4 and 11 years - All children to be measured in reception and Year 6.
Obesity: the prevention, identification, assessment and management of overweight and obesity in adults and children[407] NICE (2006)	- Comprehensive guidelines on all aspects of obesity, from measuring, through to treatment and possible prevention.
Tackling Obesities: Future Choices-Project report[466] Foresight (2007)	- Forecasts that nearly 60% of the population could be obese by 2050. - Obesity is a complex multifaceted problem with a number of causes. - Substantial degree of intervention is needed to have an effect. - There is a need for a system wide approach, involving stakeholders inside and outside the government. Any interventions need to be long-term and sustained, with continuous evaluation.
PSA Delivery agreement 12: Improve the Health and wellbeing of children and Young People[467] HM Government (2007)	- Aim to reduce childhood obesity levels in 2020 to that of those in 2000. - Increase breastfeeding - Increase take up of school- meals
The "Healthy Living" Social Marketing initiative: A review of the evidence[412] DOH (2008)	- Must aim to reduce the impact of the obesogenic environment, which will require input from a wide range of stakeholders and it will take unprecedented changes to have an impact.

Healthy weight, Healthy Lives: A cross-government strategy for England [468] DOH, Dept for children, schools and Families. (2008)	- Aim for the UK to be the first major nation to reverse the trend of obesity especially in children, with the initial focus of reducing levels by 2020 to 2000 levels. - Additional funding of £372million available to promote and maintain the interventions for maintenance of healthy weight. -

The parliamentary concern over the trend of increasing obesity is emphasised by the sheer number of reports that have been commissioned over the last decade. A very significant amount of resources have been invested to find a solution. The difficulties in achieving this has be highlighted by the government's amendment on the previously set target of reducing childhood obesity by 2010 to 2000 levels, this has now be made as a target for 2020. In summery the concerns from many of the reports are that it is an enormous challenge to find a solution for a problem with so many inter-linking causes. Essentially no obvious solution is evident and more research is needed.

7.2.1 Changes in schools

One of the areas that has received a good deal of attention and a degree of success has been school meals. As discussed in Chapter 5, this issue was made very public by the celebrity chef Jamie Oliver, although it was originally highlighted in the "*Food of Life*" document from the Soil association.[457] Subsequently the government has committed investment into this area and the new standards for school meals; and food and drinks in school were legislated in 2007. [469] These new standards define the types of food that the children should be given and the nutrient standards, which must be met with these meals. In addition the Food standards for food and drinks give guidelines on portion size and types of drinks that may be made available, and no sugary soft drinks may be supplied.

Even with all the changes and investment into schools meals, a recent governmental report has described that only 41% of children in English primary schools eat school meals.[470] There are numerous reasons for this low-up take. Firstly, some children feel stigmatized if they are entitled to a free school meal, and conversely many parents whose children do not qualify for the free-school meals feel that the meals are too expensive. To qualify for free school meals, the child's annual family income must be below £16 000. Children cite limited food choice and queuing time as other reasons why they do not eat school meals. Many children bring in their own school lunches and although the schools make suggestions, there is no control over what the children bring in. In some areas it has been found that almost a quarter of secondary students leave the school premise at some point and purchase foods from local convenience stores. The true value and effect of the new standards will only be assessed in a number of years.[470]

Apart from government intervention and funding, other organisations are also working to improve children's nutrition. The *School Food Trust* is a charity and was established in 2005. Its main aim is for all children to have a balanced diet and receive cooking and nutrition education that will help them throughout life.[471] This charity advises the government and also works at local level with individual schools. The *Food for Life Partnership* is another active group that encourages schools and communities to work together to cook and grow produce and raise awareness of a better food culture. [472] Another charity, which helps to fund original research and support students working in the field of child nutrition, is the Organix Foundation. [473]

7.2.2 Change4Life.

In January 2009, the government launched a national campaign, called Change4Life in an attempt to reduce childhood obesity. The main message of the campaign is two-fold, that obesity prevention is best achieved by having less calories and being more active, with a catchy slogan "*eat better, move more, live longer.*"[474] The aim of the programme was to make parents more aware of the issues around childhood obesity and to provide a helpline and website with information. Resources were also made available for health care professionals. In addition the campaign planned to work with commercial partners including supermarkets and the media to encourage them to sign up to the terms of engagement and support the campaign. [474]

The initial focus of the Change4Life campaign was families with children aged 5-11years. One year after the launch all of the initial targets had been achieved, with 88% of all mothers with children under the age of 11 aware of the campaign.[475] The campaign promotes eight behaviours including; 5 A day, Sugar Swaps, Me size meals, Snack check, Cut back fat, Meal time, 60 Active minutes and Up and about. Over the first year public awareness increased in the majority of these behaviours. Another success has been the support from commercial partners, with some supermarkets selling family bikes at cost price (Asda), others selling lower cost fruit and vegetables (Tesco), and some have even provided free swimming for their customers (British gas). In addition seven sub-brands have been have developed, such as dance4life, swim4life, walk4life etc.

The programme expanded with a sister campaign in 2010 called start4life, which promotes breastfeeding, healthy weaning and active play. In addition a campaign focused at adults was launched in February 2010. One of the biggest messages in this campaign was the "swap it, don't stop it", which is seen as a more positive behaviour change.[475] The *Change4Life* programme continues to grow and develop. In one of the latest campaigns, it was joined with *Sportacus* (a super-fit healthy action hero), from the popular childrens show *Lazy Town*, to encourage children between the ages of 2-5 to eat more healthy and be more active.[476]

It is complex to assess the total effectiveness of this campaign. Many families that have signed up claim to have changed some of their behaviours. A pilot study which measured purchasing behaviour using the Tesco club card found that of the 10 000 families engaged in the programme, a good proportion had changed their purchasing behaviour. The most marked behaviours changes were switching to low fat milks and low sugar drinks. [475] In the year following the campaign, the results from the NCMP shown a flattening of the obesity trend in children under 11 years, this is positive sign and it will be very interesting to see if this changes in the coming years.

7.2.3 Healthy Towns

Over the last decade huge amounts of effort, research and resources have gone into finding a solution for the worldwide obesity problem. Although the latest adult obesity figures are cause for concern, it is very heartening to see the levelling of the trend of childhood obesity. Previously this thesis has described a number of interventions and projects, most with very limited success. The most successful intervention to date, which has the greatest potential for longevity was developed in France and has now spread worldwide to include 500 town in 6 countries. [477] This large scale, multifaceted, multistakeholder approach is called the *'Ensemble Prévenons l'Obésité Des Enfants'* (EPODE, *Together Let's Prevent Childhood Obesity*)

The initial project started in 1992 as a school-based nutrition information programme in two towns in Northern France (Fleurbaix and Laventie) and was originally called the Fleurbaix- Laventie Ville Sante (FLVS) study.[478] Over the years the intervention developed to include the wider community, so that the towns' populations as a whole were exposed to nutritional and exercise information. The two town councils fully supported the project and mobilised to improve sporting facilities, arrange family activity day and employed sports educators to promote activity in schools. In addition the local press also supported the project with numerous articles and press releases each year; in addition there were a number of television and radio reports about the project. Local stakeholders, including doctors pharmacists and shopkeepers hosted family activity days promoting a healthy lifestyle. Over the years the communities as a whole embraced this project.[478]

To assess the effectiveness of this project children aged 5 -12 years were measured in 1992, 2000, 2002 and annually after this. Two other towns, Bois-Grenier and Violaines, which are in a similar area and have similar demographics, were selected as comparison towns. The intervention period of 12 years is long and the results are interesting. There was a continued initial increase in obesity in the intervention towns but after a few years this started to reduce, so that when the intervention towns were compared with non-intervention towns in 2004 there was a very significant difference in the prevalence of obesity. The prevalence of obesity in the intervention towns was 8.8% while in the non-intervention town it was 17.8% ($p<0.0001$). There are a number of methodical limitations to the design of the study but the results show conclusively that a community intervention has been successful in reversing the trend of increasing obesity. Importantly this study has highlighted the long period of intervention (10 years plus) required to achieve effective results.[479] The study also showed that school interventions alone were not sufficient to achieve change and that it is essential to involve the wider community

In 2004, the EPODE Campaign was launched. This involved 10 towns in different regions in France which after expressing interest were then selected for their diversity.[480] This project continued for 5years and as with the FLVS study it attempted to include the communities as a whole. Interventions took place in schools; stakeholders arranged family activity days and leaflets were distributed. Children between the ages of 5 to 12 years were measured annually, and school doctors were involved in communicating the results to their patients. Any overweight children were advised to see their own doctors. By 2007, 113 towns had committed to the campaign, which received support from the French Ministry for Health and family. In addition EPODE has a number of private sector supporters, which include; group Ferrero, APS (insurance company), Nestle and the Carrefour Internationals Foundation. [480]

Since its inception the EPODE campaign had spread to six countries (France, Belgium, Spain, Greece, South Australia and Mexico) and by 2010, 527 communities are involved. [477] In 2008 the UK government was keen to follow the French lead and developed the *Healthy Towns* schemes. Nine towns were given "Healthy Towns" status and the government put £30million pounds investment in this scheme. The towns in England include; Dudley, Halifax, Sheffield, Tower Hamlets (London), Thetford (Norfolk), Middlesbrough, Manchester, Tewkesbury and Portsmouth. [481] The Healthy Towns scheme is also part of the Change4life campaign and the original campaign and funding are set to conclude at the end of 2011. A further thirteen towns have also been given seed funding for smaller scale initiates as part of the Health Town Scheme. It is reassuring that the government is investing in the obesity crisis and time will tell if these campaigns are to be effective. Importantly as seen with the FLVS study these projects need commitment for the long-term for any success to be realised.

7.3 Conclusion

Ten years after the original CHOPPS projected commenced, the problem of obesity remains an international concern. The trend of increasing adult obesity has continued and is predicted to continue. It is expected that in the near future well over a third of men and a quarter of women will be obese in the United Kingdom. [466] Childhood obesity levels have increased too but positively in the last few years there has been some leveling off[453]. In the last decade there has been a plethora of guidelines, committees and interventions to attempt to manage this escalating problem. Governmental targets, set to halt the trend of increasing obesity have not been achieved, and have had to be delayed[467]. In general there is now also a better understanding that obesity is a complex problem with inter-linking causes and an acknowledgement that it will be challenging to find a solution[452;468;482].

Schools have experienced some significant changes in the last decade with initiatives to improve the health of children. The UK Obesity Guidelines from NICE have further clarified the importance of the school environment in health promotion[445]. Following Jamie Oliver's school meal campaign, there is new legislation regarding food in schools.[465] As yet it is too early to fully evaluate the effect of these initiatives. Parental awareness has also increased with the new weighing and measuring programme for children in reception and year 6[381].

There has been an increase of research into interventions within the school environment as a means to prevent increasing obesity. As yet no specific study has provided significant long -term results [425]. There is also disagreement in the literature regarding the best approach for school-based interventions. Some researchers favour the whole school approach, while others focus on specific target areas [405;412]. Often the lack of success of these studies is blamed on short intervention periods and lack of follow-up. Unfortunately there have been a number of studies [71;443;483] which have been multi-faceted and long-term (more than a year), encompassing both the school and family environment, and they have still failed to achieve significant results.

The CHOPPS project was a school-based intervention, which focused on reducing consumption of carbonated drinks. The effect of carbonated drinks as a causative factor of obesity has gained more credence in the last decade[5;418;419]. This project was the first school-based intervention with a targeted education programme that focused on reducing carbonated drink consumption. The trial included over 600 children from 6 schools and was successfully completed over one school year. The programme was positively received by both the teachers and children and resulted in an increased level of nutrition knowledge. The initial results at one year suggested that the intervention had been successful and increasing obesity had been prevented. Unfortunately these results were not repeated when longitudinal data was collected two years after completion of the original study.

Following CHOPPS there have been two other interventional studies[437;438] which have specifically focused on reducing the consumption of carbonated drinks. Neither of these yielded significant results. The larger study from Brazil which followed similar educational initiatives as the CHOPPS project was only 7months long[437]. This is unfortunate as the CHOPPS project, which lasted a year, had highlighted that the intervention period needed to be longer. The CHOPPS project showed that there is value in a targeted approach. Perhaps an ideal study could include a rolling programme focusing annually on changing behaviour on different known obesity causative factors (i.e. reducing carbonated drink consumption, increasing activity, reducing screen interaction). Ideally any intervention would need to be continued for a number of years to fully evaluate its effect.

The government's Change4Life campaign is a national long-term initiative focusing on improving the health of children. Hopefully an initiative that is so wide reaching and long-term may have an impact but as yet it is too early to assess the effects of this programme.

The greatest success story to date is the Fleurbaix- Laventie Ville Sante (FLVS) study[478] from France. This was a multifaceted, large-scale project that focused on involving the whole community to encourage change. The long-term results (12 years) from this project show that this approach can reduce obesity. This initiative has now extended internationally and is now know as the EPODE (*Ensemble Prévenons l'Obésité Des Enfants*) campaign. The UK government has started the Healthy Towns scheme, which mirrors aspects of the EPODE campaign and as the FLVS study showed it may be some time before its effectiveness can truly be evaluated.

Ten years after the CHOPPS project, the evidence of the effectiveness of school based interventions in reducing BMI remains very limited. Many school based interventions have shown changes in behaviors and have improved levels of nutrition education but the long term effect on BMI has been lacking. Obesity is a complex condition and the evidence suggests that perhaps a multifaceted whole community approach may achieve the best results, although there may still be value in a long-term targeted approach.

Appendix

I. 3-Day drink diary (Pilot study)

II. 3-Day activity diary (pilot Study)

III. 3-Day drink diary (RCT)

IV. Session 1- Plan of education

V. Session 1 – Class room leaflet

VI. Session 2&3 – Music project

VII. Session 4 – Who wants to be a CHOPPS Champ questions

VIII. Session 4 – Photo of posters

IX Survey questionnaire

X. Teacher questionnaire

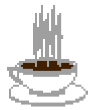
XI. James J, Thomas P, Kerr D. Childhood obesity: a big problem for small people. Diabetes and Primary Care 2002;4(3):26.

XII. James J, Thomas P, Cavan DA, Kerr D. Preventing childhood obesity by reducing consumption of carbonated drinks: cluster randomised controlled trial. BMJ 2004;328:1237-9.

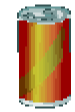
XIII. James, J. Kerr, D. (2005) Prevention of Childhood Obesity by reducing Soft drinks. International Journal of Obesity 29, S54- S57

XIV. James, J. Thomas, P. Kerr, D. Preventing childhood obesity: 2- year follow-up results from the Christchurch Obesity Prevention Programme in Schools (CHOPPS). BMJ 2007; 335: 762-764.

I. 3-Day drink diary (Pilot study)



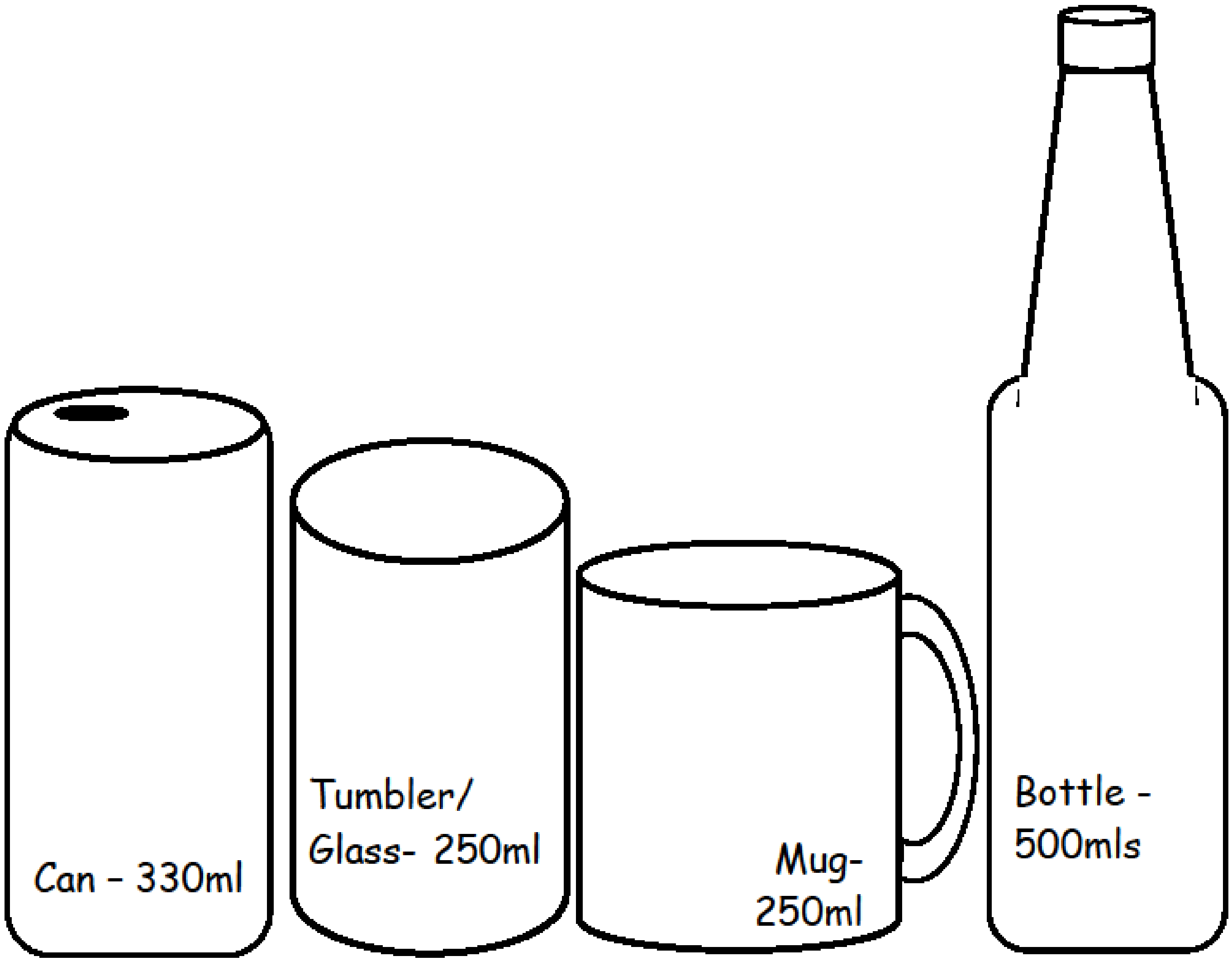
What did you drink today ?



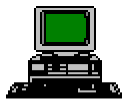
Write down how many of each drink you have each day.
Write in the amount, using the sizes on the back as a guide for example ½ can of Coke or 1 mug of tea

		Day 1	Day 2	Day 3
Type of Fizzy drink? Write in the full name e.g. 1 tumbler of Fanta or 1 can of Caffeine free diet Coke				
Hot Chocolate				
Tea				
Coffee				
Water	Still			
	Sparkling			
	Flavoured			
Fruit Drinks	Fresh Fruit Juice			
	Squash / Cordial			
	Sunny delight / Fruit drink			
	Fruit Juice + water			
	Fruit Juice + lemonade			
Milk	Plain			
	Flavoured			
Other drink not listed (Please write in the name of the drink)				

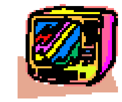
I. 3-Day drink diary (Pilot study) continued



II. 3-Day activity diary (pilot Study)

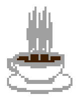


What did you do today?

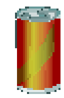


	Day 1	Day 2	Day 3
How much time did you spend watching television today? Please write in the name and length of each program. For example: The Simpsons - 30 minutes Do you have your own television in your bedroom. (circle the correct answer) YES NO			
How much time did you spend playing sport or being active today? Write down what the activity was and for how long you did it. Some examples - □ 20 minutes - swimming lessons □ 1 hour - riding my bike □ 15 minutes- Playing ball games outside □ 40 minutes - Football			
How much time did you spend playing computer games today? (Include in this time you spend playing Playstation and gameboy)			

III. 3-Day drink diary (RCT)



What do you drink each day?



PLEASE RECORD EVERYTHING YOU DRINK FOR THURSDAY, FRIDAY AND SATURDAY.

For example:

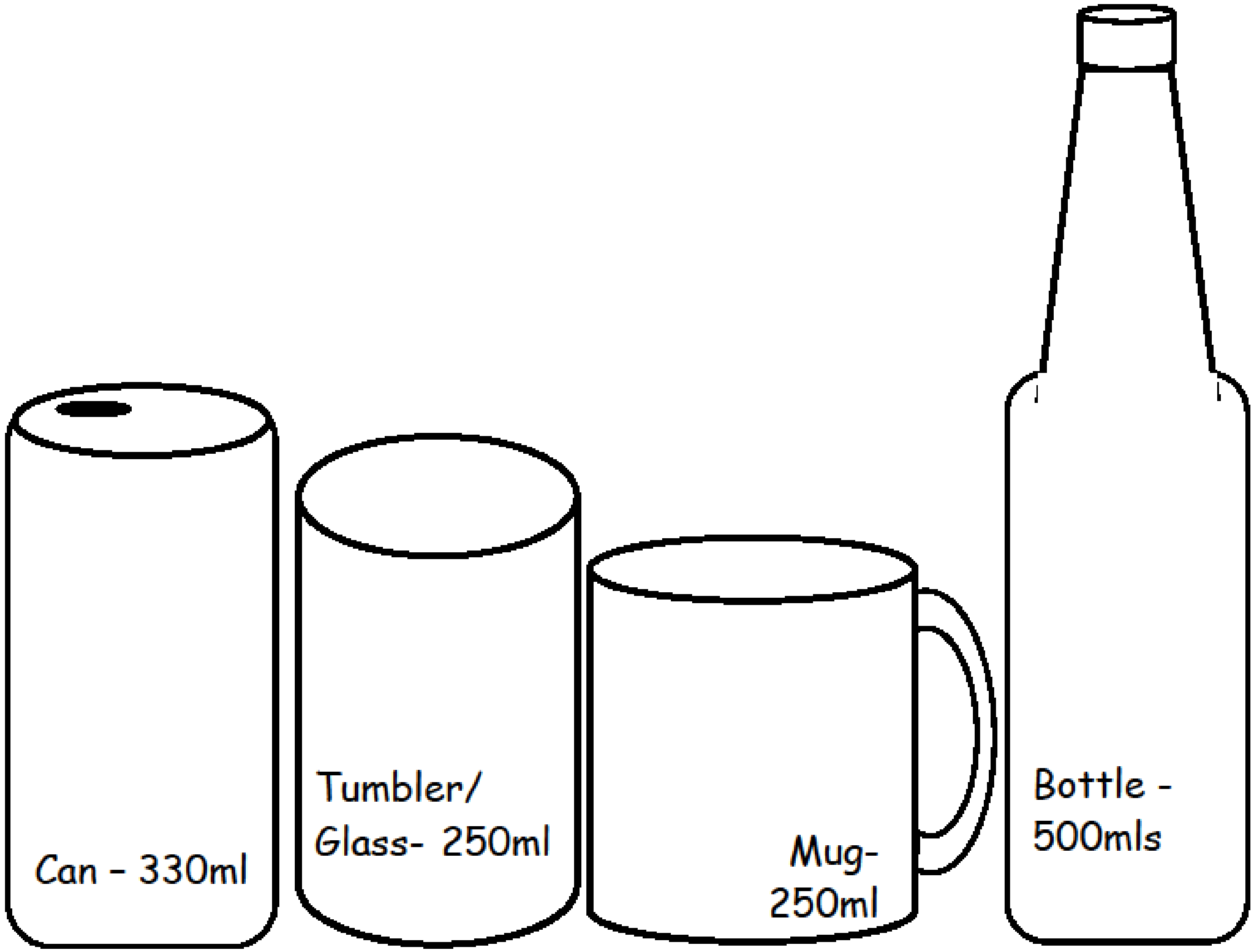
DRINK	AMOUNT -THURSDAY	AMOUNT- FRIDAY	AMOUNT -SATURDAY
Coke	1 can + half a glass	1 small can	2 bottles

DRINK	AMOUNT -THURSDAY	AMOUNT- FRIDAY	AMOUNT -SATURDAY
Regular milk			
Semi-skimmed milk			
Skimmed milk			
Flavoured milk			
Low-fat flavoured milk			
Tap Water			
Bottled Water			
Coke or Pepsi			
Diet – Coke or Pepsi			
Caffeine free Diet coke			
Pepsi Max			
Dr Pepper			
Diet Dr Pepper			
Lilt or Sprite or 7 Up			
Diet - Lilt, Sprite or 7Up			
Fanta or Tango			
Diet- Fanta or Tango			
Other fizzy drinks			
Sunny- Delight			
Squash			
Diet squash			
Fruit juice			
Fruit juice mixed with water			
Ribena			
Tooth-kind Ribena			
Hot Chocolate			
Coffee			
Tea			
Other			

LOOK AT THE BACK OF THE SHEET FOR A GUIDE TO AMOUNTS.

2nd Diary

III. 3-Day drink diary (RCT) continued



CHOPPS
Plan of Initial Education

Introduction

- Aim – To establish the base level of the classes nutrition education and to introduce the discussion of a healthy diet
- Introductory Questions:
    - What does healthy mean?
    - Why is it important to follow a healthy diet?
    - What constitutes a healthy diet?

Balance of Good Health

Classroom exercise:

Balance of good health mat placed on floor – each child given a different type of food to place on mat.

Main elements to cover - Ensure understanding of different food groups
- Encourage 5 fruits and Vegetables a day
- Water is central to the whole diet
-Sugary food should only make up a very small part of our diet.

Tasting of Fruits

Melon, mango, pineapple, kiwi

Issue to cover: That it is important to try and taste new and different fruits
That fruit is sweet and is also healthy.
We should all eat 5 fruit and vegetables each day.

Water

Refer to attached pamphlet, which is given to each child

Each child is to decide how many teaspoons of added sugar the drinks on the second page contain. The child who knows the correct answer first wins a bottle of water.

- Sunny Delight – 5 tsp
- Water – 0tsp
- Coke – 7tsp
- Milk – 0tsp

Issues to cover: That sugar has no nutritional benefits.
: That some drinks contain added sugars and chemicals that are harmful.
: Children are encouraged to drink water, or fruit juice (no added sugar) diluted with water, 1:3.

Group work:

Children working in groups of 4-6, to discuss what they could do to encourage people to drink more water.

- Make posters coving issues discussed in class
- Write poems

This is the time when we can elevate how successful the education has been.

Conclusion

Possible effects of sugary drink on teeth discussed.
Each class left with a tooth and bottle of Coke. The coke should be changed and replaced on a daily basis. Class to meet in one week to discuss effects on tooth.

Children encouraged to visit the BDEC website.

How do the Aboriginal people in Australia and the Bushman in South Africa store their drinking water?

Visit the BDEC website for the answers and more fun !

www.b-dec.com

Did you know?

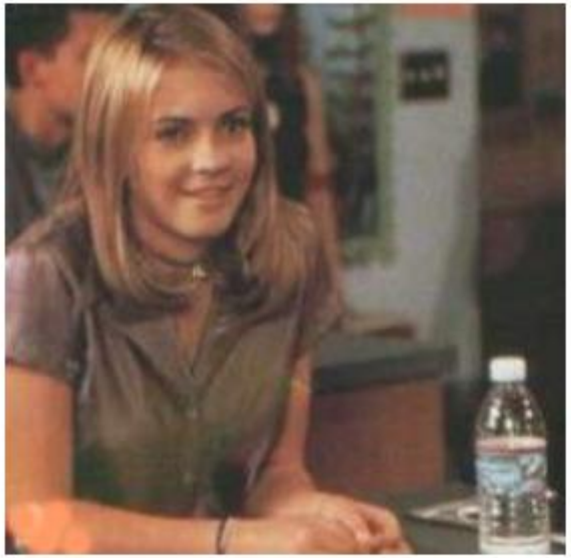
Nine out of every ten 15 year olds have five of their teeth filled!

Record what happens to the class tooth after one week in a glass of fizzy cola.

____

____

Water...is good enough for me



What about you ?

Can you guess how many teaspoons of sugar each of the following drinks contain?

____

____

____

____

How can we encourage people to drink more water?

BE HEALTHY

Chorus

Drink plenty of water every day
Eat less sugar, fight tooth decay
Ease up on those fizzy drinks
Stop, take a moment and THINK!

Verse 1

Ditch those chips and eat them in their jackets
Try not to eat processed food in packets
Five pieces of fruit and veg a day
Will help you go the right way

CHORUS

Verse 2

Watch how many sweets you eat for treats
Chocoholics don't forget your meat
Fish is good to eat regularly
Poach it, bake it and grill it for tea

CHORUS

Verse 3

Balance your diet, eat healthily
Remember to look after yourself and you'll see
Skin will glow and teeth will be white
Guess what everyone, you're trying to do it right.

CHORUS

KEEPING HEALTHY

Dr Pepper, Iron Bru
Coca Cola aren't good for you.
Drink the water,
Ditch the fizz,
Healthy drinks are the bizz.
Don't get fat
Let's stay thin
Put fizzy drinks in the bin.

Chorus

Eat fresh fruit, don't hesitate
Come and get it don't be late.
Come and join the healthy gang
Eat more veg the doctor sang.
Choke the coke, try not to smoke
Ask your pa to ditch the car.
If you listen to our song
You really won't get it wrong.

Save your mum and walk to school
Stretch those legs that's the rule.
Jump and run all you like,
Cycle round on your bike
Take the plunge and use the pool
Being a swimmer is really cool.
Don't laze around watching T.V
Get outside and stretch those knees

Chorus

Sweets and cakes are things of the past
Stay thin and healthy and you'll go far.
Fruit and veg are the way to go
So eat your greens and you will grow.
Healthy eating is so much fun
Even if you are down and glum
It will make you scream and shout
So jump for joy and wriggle about.

Chorus

Written by 5M
Highcliffe Junior School

Who wants to be a CHOPPS Champ ??
Questions

1- Name one substance that you can drink, wash with and even swim in?
a) Water b) Milk c) Cola d) Orange juice

2- What vegetable helps you to see in the dark?
a) Turnips b) potatoes c) carrots d) broccoli

3- What can sugar do to your teeth ?
a) make them pink b)make them decay and rot
c)make them shiny d) make them strong

4- How many teaspoons of sugar, are there in a glass of water?
a) 10 b)1/2 c)0 d)2

5- Which fruit or vegetable contains the most Vitamin C?
a)Bananas b)Oranges c) Cauliflower d) Carrots

6- How many glasses of water should you drink each day?
a) none b) 4 c)8 d) 12

7- How many teaspoons of sugar, are there in glass of Cola?
a) 0 b)12 c)7 d)3

8- When the weather is hot, do you need to drink…..?
a) no water b)more water c)less water d) Cola

9- How many teaspoons of sugar, are there in a glass of Sunny Delight?
a)3 b)5 c)7 d)9

10- When we dilute pure fruit juice with water, how much of the glass should be fruit juice?
a) all b)a third ($^1/_3$) c)a half ($^1/_2$) d)one quarters ($^1/_4$)

11- How many portions of fruits and vegetables should we eat each day?
a)none b)5 c)7 d)3

12- Which two things in most fizzy drinks are harmful to your teeth?
a)sugar & water b) sugar & fizz c)fizz & water d)water & fizz

13- On the balance of good health, which two food groups are the largest?
   a) Fruits & Vegetables, and Energy giving foods
   b) Protein and Diary food
   c) Dairy food and Sweet foods
   d) Energy giving foods and protein foods

14-Which vitamin or mineral is found milk?
   a) Iron   b)vitamin C   c)calcium   d) Vitamin E

15- Which of these food types are high in Fibre?
   a) Sweet and chocolates
   b) Fruit and Vegetables
   c) Meat and Fish
   d) Milk and Cheese

16- What is the name of the natural sugar that is found in fruit?
a) fructose   b) sucrose   c) glucose   d) lactose

VIII. Session 4 – Photo of posters in waiting room

CHOPPS

I would like to see how much you now know about healthy eating and drinking.

Your name______________________ Class _______________________

Please put a circle around the <u>right</u> answer.

1- What can sugar do to your teeth?
   a) make them strong b) make them decay and rot
   c) make them shiny d) make them healthy

2- How many teaspoons of sugar, are there in a glass of *water*?
   a) 10 b) $^{1}/_{2}$ c) 0 d) 2

3- Which fruit or vegetable contains the most Vitamin C?
   a) Bananas b) Oranges c) Cauliflower d) Carrots

4- How many glasses of water should you drink each day?
   a) none b) 4 c) 8 d) 12

5- How many teaspoons of sugar, are there in glass of *Cola*?
   a) 0 b) 12 c) 7 d) 3

6- When the weather is hot, do you need to drink.........?
   a) no water b) more water c) less water d) Cola

7- How many teaspoons of sugar, are there in a glass of *Sunny Delight*?
   a) 3 b) 5 c) 7 d) 9

8- When we dilute pure fruit juice with water, how much of the glass should be fruit juice?
   a) all b) a third ($^{1}/_{3}$) c) a half ($^{1}/_{2}$) d) one quarter ($^{1}/_{4}$)

9- How many portions of fruit and vegetables should we eat each day?
   a) none b) 5 c) 7 d) 3

10-Which two things in most fizzy drinks are harmful to your teeth?
   a) sugar & water b) sugar & fizz
   c) fizz & water d) water & fizz

Please turn the page over

IX. Survey questionnaire continued

Please put a circle around the words that show how <u>you</u> feel about the sentences written below.
For example –
I really like to go swimming.

A lot	Sometimes	Never

1- I have enjoyed taking part in the CHOPPS project.

Very much	Some of the time	Not at all

2- I enjoyed having my height and weight measured.

Very much	Some of the time	Not at all

3- I have learnt from taking part in the CHOPPS project

A lot	A little	Nothing new

4- I drink fizzy drinks

Never	Sometimes	Whenever I can

Finish the sentences, with how you feel about the CHOPPS project.

I liked

It would be better if

Next time I hope

Thank you for taking part in the CHOPPS project
Janet James

CHOPPS

Teacher Evaluation Form

School________________________________ Class ______________________________

Please tick the box that best describes how you feel about the CHOPPS Project:

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
The project was a worthwhile experience for the children	☐	☐	☐	☐	☐
The education was appropriate for my year group.	☐	☐	☐	☐	☐
The project was too time consuming and interfered with normal lessons.	☐	☐	☐	☐	☐
I felt that the children were self conscious about being measured.	☐	☐	☐	☐	☐
I feel that more time should be given to nutrition education.	☐	☐	☐	☐	☐

Please describe which part of the education programme was most effective and why?

____

____

____

Please describe which part of the education programme was least effective and why?

____

____

____

Please turn the page over

X. Teacher questionnaire continued

How did the children respond to the CHOPPS project?

____

____

____

What changes could be made for the future?

____

____

____

Any other comments

____

____

____

____

____

____

Thank you for your time and participation in the CHOPPS project.

Janet James

Childhood obesity: a big problem for small people

Janet James, Peter Thomas and David Kerr

Introduction

Obesity is a major public health concern, with an ever-increasing prevalence in adult and child populations. The recent appearance of type 2 diabetes in children further emphasises the importance of the issue. As overweight children tend to become overweight adults, preventive strategies for diabetes should focus on this new generation of patients. This article examines the prevalence of obesity in young children in an English seaside community, providing an insight into certain lifestyle factors that could be contributing to the problem.

Obesity continues to increase in both adult and child populations throughout the world, with the prevalence having trebled over the past 20 years (Bourne et al, 2001). Currently, in the UK, one in four women and one in five men are obese (Bourne et al, 2001). The health and financial implications of this are huge; in 1998, 6% of all deaths in the UK were attributed to obesity, compared with 10% from smoking and 1% from road traffic accidents. Obesity is also responsible for 1.5% of NHS expenditure, and accounts for 18 million sick days per year (Bourne et al, 2001). For a condition that, in most circumstances, is either preventable or reversible, the current health and economic costs are excessive.

The link between obesity, diabetes and cardiovascular disease is well documented (Chan et al, 1994). Worryingly, type 2 diabetes, a disease previously only seen in older adults, is starting to appear in children (Fagot-Campagne and Venet Narayan, 2001). Insulin resistance, a precursor of diabetes, has also been reported in obese children as young as five, irrespective of their ethnic origins (Sinha et al, 2002).

The next generation

Until recently, the prevalence of obesity among British school children was thought to be low. Body mass index (BMI), which assesses both height and weight, is used to classify obesity:

$$\text{BMI} = \frac{[\text{weight (kg)}]}{[\text{height (m)}]^2}$$

A child's position on a BMI centile chart indicates the child's 'thinness' or 'fatness' with respect to his/her age (Cole et al, 1995). The incidence of overweight children, using the definition of overweight and obesity proposed by the International Obesity Task Force (IOTF; Cole et al, 2000), has increased substantially since the mid-1980s. In 1994, 9% of boys were overweight, compared with 5% in 1984 (Chinn and Rona, 2001). The percentage of overweight girls was 9% in 1984 but reached 13% within the decade.

Obesity in childhood is known to be an independent risk factor for adult obesity (Campbell et al, 2002), and children who progress to become obese adults have a far greater risk of serious health problems, with a twofold risk of dying prematurely (before the age of 60) from ischaemic heart disease (Gunnell et al, 1998). Fortunately, if a child loses weight and becomes a slim adult, this could effectively protect him/her from the development of components of the metabolic syndrome and subsequent raised cardiovascular risk (Vanhala et al, 1998).

Contributory factors

There are a variety of environmental and social factors that might contribute to the rise in obesity, although, in general, the cause is predominately environmental rather than genetic.

Sugar-sweetened drinks

One important factor might be increased consumption of sugar-sweetened drinks (Ludwig et al, 2001). Children consume these drinks in addition to their normal

ARTICLE POINTS

1. Obesity is on the increase in adult and child populations.
2. The causes are multifactorial and related to changing lifestyles.
3. The appearance of type 2 diabetes in children recently emphasises the importance of this issue.
4. Consumption of caffeinated sugar-sweetened drinks is increasing in children.
5. Interventions need to be found to reduce childhood obesity.

KEY WORDS

- Childhood
- Obesity
- Sugar-sweetened drinks
- Caffeine
- Diabetes

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PAGE POINTS

1 Soft drinks are one of the main sources of added sugars in the diets of children.

2 A direct correlation has been shown between adiposity and television in children.

3 Schools provide an ideal environment to relay nutrition messages to a large number of individuals.

4 The aim of the study was to evaluate the prevalence of overweight and obesity among primary school children in a local community.

energy intake, and consequently have a total energy intake that exceeds their requirements (Ludwig et al, 2001). For example, children who drink an average of 270ml of soft drink per day have an energy intake that is 10% higher than that of their counterparts who do not consume soft drinks (Harnack et al, 1999).

The latest National Food Survey for children in the UK (Gregory and Lowe, 2000) has shown that soft drinks are one of the main sources of added sugars in the diets of children, and that the proportion of sugars provided by these drinks increases with age, rising from 27% for boys aged 4–6 years, to 42% for boys aged 15–18 years. This same survey found that, over a period of one week, only 46% of boys and 51% of girls drank fruit juice, whereas two-thirds of boys and girls consumed regular carbonated soft drinks. Only half the children surveyed drank tap water on a regular basis.

Caffeine

With the increasing consumption of sugar-sweetened fizzy drinks, there is also concern regarding their caffeine content. The physiological consequences of a caffeine-containing soft drink (48mg of caffeine) in an average 6-year-old child weighing 20kg are equal to those in an adult drinking two cups of filter coffee (170mg caffeine) (Goldstein and Wallace, 1997). Studies have shown that, following an oral glucose tolerance test, the addition of caffeine causes a rise in insulin and glucose, which is suggestive of a caffeine-associated increase in insulin resistance (Graham et al, 2001).

Screen-watching

'Screen watching', including television, hand-held computer games and personal computers, are very much part of our modern lifestyles. An American study has shown a direct correlation between adiposity and television watching in children (Crespo et al, 2001). However, the study failed to determine conclusively whether watching a lot of television caused obesity or whether obese children just watched more television.

Aim of the present study

Clearly, there is a need for interventions to promote a healthier lifestyle and prevent the prevalence of overweight and obesity from increasing further.

Schools provide an ideal environment in which to relay messages on nutrition to a large number of individuals (Atkinson and Nitzke, 2001). The aim of this study was to evaluate the prevalence of overweight and obesity in primary school children in our local community. We also wanted to gain insight into certain lifestyle factors, including preferred drinks and screen-watching behaviour.

Study subjects

A local junior school, from a middle class, southern English seaside community, was contacted, and permission was sought from the head teacher, board of governors and local council for the school to participate in the study. Ethical approval was also obtained from the local research and ethics committee, and written consent was obtained from each child and his/her parents.

Children were measured for height (without shoes, to the nearest 0.1cm) and weight (in light clothes, to the nearest 0.1kg). The prevalence of overweight and obesity in this population was established using the age- and gender-specific BMI centile charts.

Methods

Comparison of the results of different studies can be misleading because of the lack of agreement on a standard method for assessing and evaluating childhood overweight and obesity. There are three recognised methods for comparing rates of overweight and obesity in children:

- The British BMI chart, in which the 91st centile defines overweight and the 98th centile defines obesity (Cole et al, 1995).
- The recent internationally agreed cut-off points for BMI devised by the IOTF. These cut-off points for childhood overweight and obesity are based on international data and are linked to the adult cut-off points of overweight (BMI >25kg/m^2) and obesity (BMI >30kg/m^2) (Cole et al, 2000).
- The commonly used American definition of the 85th centile for overweight and the 95th centile for obese (Barlow and Dietz, 1998).

The children were also asked to complete 3-day drink and activity diaries. Dietary data can be collected using a variety of methods, including recall after a 24-hour period, and food frequency check-lists. To obtain best estimates of actual intake, data should be collected in a diary over 3 days, including one weekend day (Campbell et al, 2002).

In the current study, children were each given their own diary and wrote down every drink they consumed over the 3-day period, from Thursday to Saturday. They also recorded each television programme they watched and for how long they watched it.

Results

Weight

Of a possible 278 children between the ages of 7 and 11 years, parental consent was obtained for 56%. Four children with-held their consent. Overall, measurements were obtained for 54% of the 278 children, including 77 girls and 72 boys. The prevalences of overweight and obesity found by this study are shown in *Tables 1* and 2. The three definitions for establishing overweight and obesity are listed, highlighting the different results obtained when different definitions are used.

Our data were compared with the national average for childhood overweight and obesity from 1994 (*Figure 1*), using the internationally agreed cut-off points (from the IOTF) for BMI in both cases. Interestingly, when this method was used, none of our boys was obese but we had far greater rates of overweight than the national averages and a higher proportion of obese girls.

Drinking behaviour

Drink and activity diaries were returned and completed by 71% (n=108) of the participating children. Over the 3-day period, 52% (95% confidence interval; 43–61%) of the children consumed varying amounts of fizzy drinks, the majority drinking the sugar-sweetened variety. Forty-three per cent of the children drank just over one glass of a sugar-sweetened fizzy drink each day. One third of the children regularly drank caffeine-containing sugar-sweetened fizzy drinks. *Figure 2* shows the average volume of fizzy, sugar-sweetened drinks (caffeine- and non-caffeine-containing) consumed on a daily basis; the standard deviation (SD) of 128 demonstrates the huge variation in the volumes consumed by the children.

Television scores

The children also recorded how much time they spent watching television and were asked whether they had access to a television in their own bedroom. Forty-one per cent had a television in their own room and these children watched an average of 83 minutes (SD50) of television per day, which was 22% more than that watched by children who shared a television with their family (P=0.05, using independent samples t-test).

Discussion

Our data from a small sample of children showed that there is a significant problem of childhood overweight and obesity in our local area. Unfortunately, we only succeeded in obtaining consent from just over half the

PAGE POINTS

1. Over a 3-day period, children recorded every drink they had and how much television they watched.
2. Measurements were obtained for 149 children, aged between 7 and 11 years.
3. Forty-three percent of the children drank just over one glass of sugar-sweetened fizzy drink each day.
4. Compared with children who shared a television with their family, those with a television in their own room watched 22% more television per day.

Table 1. Prevalence of overweight status (95% confidence interval) in children aged 7–11 years

Subject	International Obesity Task Force	>91st centile (British)	>85th centile (American)
Girls (n=77)	22% (14%, 33%)	14% (8%, 24%)	21% (13%, 31%)
Boys (n=72)	18% (11%, 29%)	13% (7%, 22%)	11% (6%, 20%)

Table 2. Prevalence of obesity in children aged 7–11 years

Subject	International Obesity Task Force	>98th centile (British)	>95th centile (American)
Girls (n=77)	3% (1%, 9%)	4% (1%, 11%)	8% (4%, 16%)
Boys (n=72)	0% (0%, 5%)	8% (4%, 17%)	13% (7%, 22%)

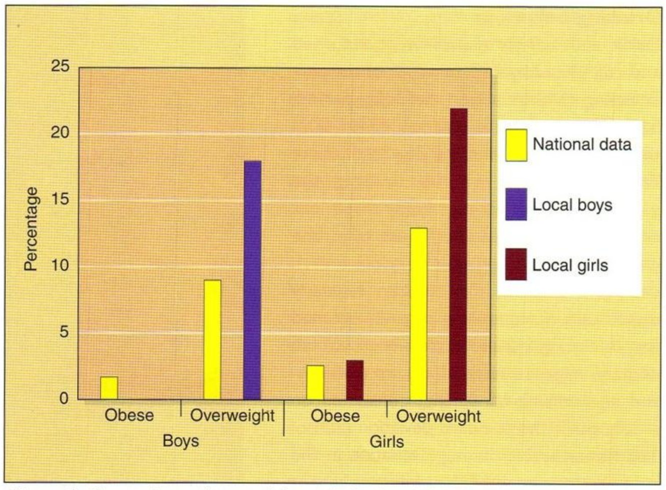

Figure 1. Comparison of overweight and obesity with UK national averages from 1994 and current local averages. (Data from the new international cut-off points (International Obesity Task Force) were used to determine overweight and obesity.)

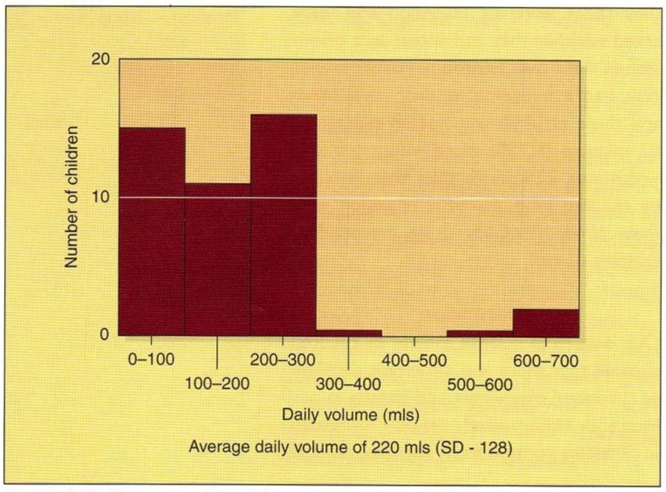

Figure 2. Daily consumption of fizzy sugar-sweetened drinks.

sample. The cause of this low return rate is unknown, but parents of more overweight children might have been less inclined to allow their children to participate.

Diet diaries

Diet diaries are fraught with difficulties: there is a tendency for respondents to under-report energy intake, and under-reporting is greater in obese and overweight individuals (Campell et al, 2002). Hence, the accuracy of diaries is debatable; however, they still showed that a large proportion of the children consumed sugar-sweetened drinks on a regular basis, highlighting the need for education on this issue.

How to deliver education

The home is an ideal environment for health education and could potentially provide the best results. However, this is impractical for large-scale implementation of health education strategies (Fruhbeck, 2000).

Schools provide an environment in which the nutrition message can be relayed to a large number of individuals, but the effectiveness of a school-based programme is controversial (Atkinson and Nitzke, 2001).

Previous studies

A recent school-based study in Leeds that aimed to the reduce risk factors of obesity successfully implemented changes at school level, but, following intensive education, achieved only very modest behavioural changes in the children (Sahota et al, 2001). Although the children did not change their lifestyles, those who participated in the education had a greater knowledge and awareness about healthy nutrition.

The Planet Health Study from America, another intensive school-based education programme, successfully reduced obesity in girls but had no effect in boys (Gortmaker et al, 1999). Conversely, a school-based study in Singapore showed very impressive results in reducing obesity and overweight among both genders (Mui Toh, 2002). The interventions in this study were intensive and included changes to the food sold in school canteens and extra education on nutrition in the classroom. In addition, overweight children participated in an extra exercise and health education programme.

All these studies took a very broad approach and focused on all areas relating to a healthy diet and increased exercise. Clearly, there is a need for interventions to promote a healthier lifestyle and prevent childhood overweight and obesity.

Conclusion

Childhood obesity is a significant problem, and can be attributed to the unhealthy lifestyles that children are adopting today. It is a multisystem disease, with potentially devastating medical and psychosocial consequences, including a clustering of risk factors for the later development of cardiovascular disease and diabetes. It is essential to promote health education, and schools provide an in ideal environment for this. Childhood obesity is a major public health issue, and interventions need to be found to try to combat the problem. ■

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PAGE POINTS

1 Childhood obesity can be attributed to the unhealthy lifestyles that children are adopting today.

2 It has potentially devastating medical and psychosocial consequences, including a clustering of risk factors for the development of cardiovascular disease and diabetes.

3 There is a clear need for interventions to promote a healthier lifestyle and prevent childhood overweight and obesity.

Sonnet to the NSF

While pondering over the delay of the promised NSF, a Shakespearean-like sonnet came to mind:

MYTHS & MAGIC

The editor of Diabetes and Primary Care gives his apologies to the Bard.

Dedication to the NSF:

Shall I compare thee to this new delay?
Thou art more lowly and more desperate.
Rough estimates that you'd be out in May,
And summer's lease hath all too short a date.
Sometime too hot the eye of Hope doth shine,
And often is our expectation dimmed;
And NSF new dates again defined,
By chance, for Labour's changing course is dim;
But thy eternal summer shall now fade
You'll lose possession of that care thou knowst;
Now shall Health lag, we wonder, new-delayed,
When your infernal lies in time are grossed:
So long as men can breathe and eyes can see,
So long we wait, and soon it's 2K3.

Shakespeare's original:

Shall I compare thee to a summer's day?
Thou art more lovely and more temperate.
Rough winds do shake the darling buds of May,
And summer's lease hath all too short a date.
Sometime too hot the eye of heaven shines,
And often is his gold complexion dimm'd;
And every fair from fair sometime declines,
By chance or nature's changing course untrimm'd;
But thy eternal summer shall not fade
Nor lose possession of that fair thou ow'st;
Nor shall Death brag thou wander'st in his shade,
When in eternal lines to time thou grow'st:
So long as men can breathe or eyes can see,
So long lives this, and this gives life to thee.

Hippocrates

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Primary care

Preventing childhood obesity by reducing consumption of carbonated drinks: cluster randomised controlled trial

Janet James, Peter Thomas, David Cavan, David Kerr

Abstract

Objective To determine if a school based educational programme aimed at reducing consumption of carbonated drinks can prevent excessive weight gain in children.
Design Cluster randomised controlled trial.
Setting Six primary schools in southwest England.
Participants 644 children aged 7-11 years.
Intervention Focused educational programme on nutrition over one school year.
Main outcome measures Drink consumption and number of overweight and obese children.
Results Consumption of carbonated drinks over three days decreased by 0.6 glasses (average glass size 250 ml) in the intervention group but increased by 0.2 glasses in the control group (mean difference 0.7, 95% confidence interval 0.1 to 1.3). At 12 months the percentage of overweight and obese children increased in the control group by 7.5%, compared with a decrease in the intervention group of 0.2% (mean difference 7.7%, 2.2% to 13.1%).
Conclusion A targeted, school based education programme produced a modest reduction in the number of carbonated drinks consumed, which was associated with a reduction in the number of overweight and obese children.

Introduction

Obesity in children has reached epidemic proportions.[1] Ultimately energy imbalance is the reason for excessive weight gain, whether the main cause is genetic, endocrinal, or idiopathic.[2] A contributory factor seems to be the consumption of carbonated drinks sweetened with sugar.[3] These have a high glycaemic index and are energy dense. Children who drink one regular carbonated drink a day have an average 10% more total energy intake than non-consumers.[4] In the United Kingdom more than 70% of adolescents consume carbonated drinks on a regular basis.[5]

Although school or family based programmes that promote physical activity, modification of dietary intake, and reduction of sedentary behaviours may help reduce obesity in children, few have been effective.[6] Recently the United Kingdom based active programme prompting lifestyle in schools (APPLES) reported the effects of multiple interventions on obesity in children.[7] The programme included teacher training, modification of school meals, action plans within the curriculum, changes to the tuck shop, physical education, and playground activities. Despite these initiatives there was only a modest increase in consumption of healthy foods such as vegetables without any change in obesity rates. In contrast, there is a paucity of studies on single factors considered to be important in obesity in children. We aimed to determine if a school based educational programme for reducing consumption of carbonated drinks could prevent excessive weight gain in children.

Participants and methods

The Christchurch obesity prevention project in schools (CHOPPS) took place between August 2001 and October 2002 over one school year. The project was based in six junior schools in children aged 7 to 11 years.

Outcome measures

Anthropometric measurements were taken at intervals of six months. Height (without shoes) was measured by one investigator (JJ) to the nearest 0.1 cm with the Portable Leister height measure (Seca, Marsden, United Kingdom). Weight (in light clothing) was measured to the nearest 0.1 kg on medical scales (Seca 770, Marsden). Waist circumference was measured according to published centile charts.[8] We converted body mass index (weight (kg)/(height (m)^2)) to standard deviation scores (or z scores) and to centile values using the British 1990 growth reference disc (Child Growth Foundation, London).[9]

The children completed diaries at baseline and at the end of the trial on drinks consumed over three days. Records were made over two weekdays and one weekend day. Collecting dietary data in this way has been shown to provide comprehensive results.[10]

Intervention

One investigator (JJ) delivered the programme to all classes. The main objective was to discourage the consumption of "fizzy" drinks (sweetened and unsweetened) with positive affirmation of a balanced healthy diet. We thought the children would respond best to a simple, uncomplicated message so they were told that by decreasing sugar consumption they would improve overall wellbeing and that by reducing the consumption of diet carbonated drinks they would benefit dental health. A one hour session was assigned for each class each term. Teachers assisted in the sessions and were encouraged to reiterate the message in lessons. The initial session focused on the balance of good health and promotion of drinking water. The children tasted fruit to learn about the sweetness of natural products. In addition, each class was given a tooth immersed in a sweetened carbonated cola to assess its effect on dentition. The second and third sessions comprised a music competition; each class was given a copy of a song (Ditch the Fizz) and challenged to produce a song or a rap with a healthy message. The final session involved presentations of art and a classroom quiz based on a popular television game

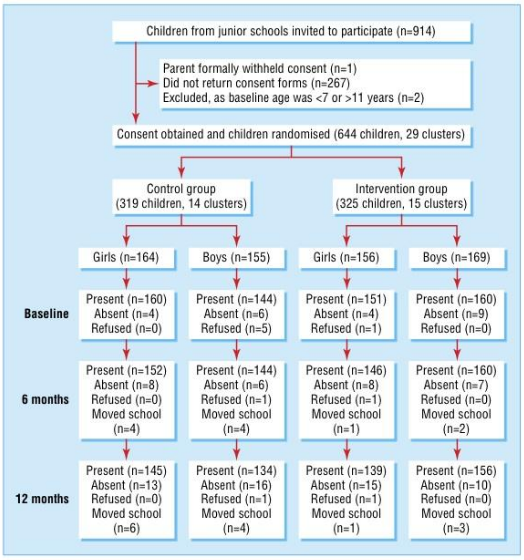

Fig 1 Trial profile for anthropometric measurements

show. The children were also encouraged to access further information through the project's website (www.b-dec.com).

Statistical methods

We undertook a cluster, randomised controlled trial.[11] Clusters were randomised according to a random number table, with blinding to schools or classes. Sample size was estimated based on data from a pilot study conducted in the same geographical area.[12] In the pilot, 54% (n = 149) of children gave consent, of whom 71% (n = 108) completed drink diaries. From this we predicted that we needed an average of 12 children in each class. The standard deviation of carbonated drink consumption in the pilot was 0.6 glasses (average glass size 250 ml) a day, therefore a study of this sample size (31 clusters with an average of 12 children) would have 90% power to detect average reductions each day of 0.9, 0.7, and 0.6 glasses over three days using intracluster correlations of 0.1, 0.05, 0.01, and 0.001. Data were analysed using SPSS (version 11) with a 5% significance level. Data for interval scaled measurements for each cluster were derived by averaging all individual measurements for the children in the cluster, and dichotomous data were derived by calculating the proportion in the cluster. These were our summary measures, with clusters as the unit of analysis. All measures were normally distributed. We used the independent sample *t* test to establish significance between intervention and control clusters and the paired *t* test to establish the significance of changes within clusters. Intracluster correlation coefficients and 95% confidence intervals were calculated by using Searle's method, with adjustment for variable cluster size.[13]

Results

The figure outlines the study design. Each of 29 classes (two of the 31 clusters were excluded because they were mixed age classes) was considered as a cluster. Fifteen were randomised to the intervention group and 14 to the control group. At the time of consent, parents and children were unaware of randomisation group. The average class size was 22 (SD 5) children (table 1). In total, 644 of 914 (70.5%) parents and children (320 girls) gave written consent. The average age at baseline was 8.7 (SD 0.9) years (range 7.0 to 10.9 years). Consent was withdrawn for six children (five boys) over the school year. Both groups were similar at baseline for distributions of age, sex, consumption of sweetened carbonated drinks, and percentage overweight or obese (table 2).[14] Body mass index was measured in 602 (93.5%) children at six months and 574 (89.1%) at 12 months.

Table 3 shows the body mass indices, z scores (SDS), and percentage of children above the 91% centile at baseline and 12 months and change in anthropometric measurements over 12 months. The intracluster correlation coefficient for body mass index was 0.01 (95% confidence interval −0.01 to 0.06). After 12 months there was no significant change in the difference in body mass index (mean difference 0.13, −0.08 to 0.34) or z score (0.04, −0.04 to 0.12). At 12 months the mean percentage of overweight and obese children increased in the control clusters by 7.5%, compared with a decrease in the intervention group of

Table 1 Cluster properties

School	No of clusters	Average No of children in clusters (No of boys)
A	4	20 (9)
B	6	26 (13)
C	6	25 (14)
D	7	16 (9)
E	3	28 (13)
F	3	20 (9)
Total	29	22 (11)

Table 2 Age, prevalence of overweight and obese children, and mean number of glasses of carbonated drinks consumed daily at baseline

	Girls		Boys	
Characteristic	Control group (n=164)	Study group (n=156)	Control group (n=155)	Study group (n=169)
Mean (SD) age (years)	8.7 (0.9)	8.7 (1.0)	8.6 (0.9)	8.7 (0.8)
No (%) overweight*	(20) 13	(19) 13	(18) 13	(21) 13
No (%) obese*	(12) 8	(10) 7	(10) 7	(11) 7
Mean (SD) consumption of carbonated drinks; No of glasses in three days†	1.7 (2.0);(n=5)	2.2 (2.6);(n=77)	1.8 (2.0);(n=89)	1.6 (2.0);(n=91)

*Defined according to 1990 British body mass index centile charts.[14]
†Average glass size 250 ml.

0.2% (mean difference 7.7%, 2.2% to 13.1%; fig 2). Assessing and comparing prevalence between studies is influenced by the methods used to classify overweight children (table 4).

Overall, 55.0% (338 of 615) of the children returned the first drink diary and 56.0% (321 of 574) returned the second; 36% (235) returned both. Body mass indices between those children who returned the diaries and those who did not were similar (17.3 (2.3) *v* 17.5 (2.4), respectively, P = 0.3 using the *t* test) Overall, 19.0% of the children who did or did not return diaries at baseline were overweight. Baseline consumption of carbonated drinks was similar between children who did or did not return diaries at 12 months (1.8 *v* 1.9 glasses, − 0.7 to 0.3 glasses).

The intracluster correlation for consumption of carbonated drinks was − 0.009 (− 0.03 to 0.05), suggesting independence between members of each cluster (table 5).[13] At 12 months, consumption decreased in the intervention group compared with the control group (mean difference 0.7, 0.1 to 1.3). Water intake increased in both groups, but there was no difference between intervention and control clusters.

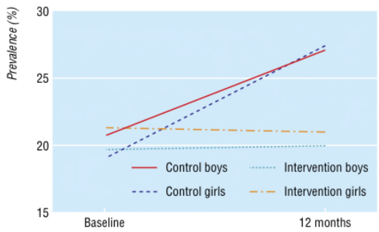

Fig 2 Mean change in prevalence of overweight and obese children from baseline to follow up at 12 months according to clusters

Table 3 Body mass indices, z scores (standard deviation scores), and mean percentages >91st centile at baseline and 12 months

Characteristic	Control clusters (n=14)	Intervention clusters (n=15)	Mean difference (95% CI)
Baseline*:			
Mean (SD) body mass index	17.6 (0.7)	17.4 (0.6)	0.0 (−0.5 to 0.5)
Mean (SDS) z score†	0.47 (0.2)	0.50 (0.23)	−0.03 (−0.2 to 0.13)
Mean percentage >91st centile (z score >1.34)	19.4 (8.4)	20.3 (6.3)	−0.9 (−6.6 to 4.8)
12 months*:			
Mean (SD) body mass index	18.3 (0.8)	17.9 (0.7)	0.4 (−0.2 to 1.0)
Mean (SDS) z score	0.60 (0.19)	0.48 (0.23)	0.12 (−0.04 to 0.28)
Mean percentage >91st centile (z score >1.34)	26.9 (12.3)	20.1 (6.7)	6.8 (−0.7 to 14.3)
Change over 12 months‡:			
Mean (SD) body mass index	0.8 (0.3)	0.7 (0.2)	0.1 (−0.1 to 0.3)
Mean z score	0.08 (0.13)	0.04 (0.07)	0.04 (−0.04 to 0.12)
Mean percentage >91st centile	7.5 (8.0)	−0.2 (6.3)	7.7 (2.2 to 13.1)

*Based on maximum number of children in each cluster.
†Age and sex specific body mass index converted to standard deviation score using revised 1990 reference standards.
‡Based on children with data at baseline and 12 months.

Discussion

A school based educational programme aimed at reducing the consumption of carbonated drinks to prevent excessive weight gain in children aged 7-11 year olds was effective. Our findings are important, especially as a recent Cochrane review has highlighted the lack of good quality evidence on the effectiveness of

Table 4 Prevalence of overweight and obese children (individual analysis). Values are numbers (percentages)

	Body mass index		
Characteristic	International Obesity Task Force cut off points[15]	1990 British centile charts[14]	British waist circumference centile charts[12]
Overweight boys			
Baseline:			
Control	33 (18.8)	28 (19.6)	28 (20.3)
Intervention	34 (20.1)	32 (19.2)	34 (21.5)
Follow up:			
Control	39 (22.2)	33 (25.6)	33 (25.0)
Intervention	31 (18.3)	31 (19.9)	35 (22.6)
Overweight girls			
Baseline:			
Control	46 (28.0)	32 (20.1)	38 (24.4)
Intervention	43 (27.6)	29 (19.2)	33 (22.1)
Follow up:			
Control	50 (29.6)	37 (28.3)	52 (36.9)
Intervention	39 (23.1)	29 (20.9)	40 (29.6)
Obese boys			
Baseline:			
Control	3 (1.7)	10 (7.0)	14 (9.9)
Intervention	7 (4.1)	11 (6.9)	15 (9.5)
Follow up:			
Control	3 (1.7)	12 (9.0)	14 (10.4)
Intervention	6 (3.5)	11 (7.1)	13 (8.4)
Obese girls			
Baseline:			
Control	12 (7.3)	12 (7.5)	17 (10.7)
Intervention	9 (5.7)	10 (6.6)	15 (9.9)
Follow up:			
Control	11 (6.3)	13 (9.0)	27 (19.0)
Intervention	8 (4.7)	9 (6.5)	16 (11.5)

Table 5 Changes in consumption of drinks over 12 months in control clusters (n=14) and intervention clusters (n=15)*. Values are means (SDs) unless stated otherwise

Type of drink	Baseline	12 months	Mean change (95% CI)	Difference in consumption (95% CI)†	P value‡
Total carbonated drinks:					
Control clusters	1.6 (0.6)	1.8 (0.6)	0.2 (−0.2 to 0.5)	0.7 (0.1 to 1.3)	0.4
Intervention clusters	1.9 (0.5)	1.3 (0.6)	−0.6 (−1.0 to −0.1)		0.02
Carbonated drinks with sugar:					
Control clusters	1.1 (0.6)	1.2 (0.5)	0.0 (−0.3 to 0.4)	0.1 (−0.4 to 0.5)	0.9
Intervention clusters	1.2 (0.3)	0.9 (0.6)	−0.3 (−0.6 to 0.1)		0.2
Diet carbonated drinks:					
Control clusters	0.4 (0.3)	0.6 (0.3)	0.1 (−0.1,0.4)	0.6 (0.2 to 1.1)	0.3
Intervention clusters	0.7 (0.3)	0.4 (0.2)	−0.3 (−0.6 to −0.1)		0.7
Carbonated drinks with caffeine:					
Control clusters	0.7 (0.4)	0.6 (0.5)	−0.1 (−0.3 to 0.1)	−0.0 (−0.4 to 0.3)	0.4
Intervention clusters	0.8 (0.3)	0.6 (0.3)	−0.2 (−0.4 to 0.1)		0.2
Water:					
Control clusters	2.9 (0.3)	5.1 (2.0)	2.2 (0.9 to 3.5)	0.3 (−1.3 to 1.9)	0.003
Intervention clusters	3.1 (1.1)	4.3 (2.0)	1.1 (0.2 to 2)		0.02

Cluster sizes are based on maximum number of children within each cluster.
*Units are number of glasses over three days (cluster is unit of analysis). All available data have been used in analysis.
†Based on children with data at baseline and 12 months.
‡Two tailed test.

interventions in this area on which to base national strategies or to inform clinical practice.[10]

At the end of our 12 month study both the intervention group and the control group showed a significant increase in consumption of water, in part related to the promotion of drinking water during school to "improve concentration." Alternatives to diet or sweetened, carbonated drinks are thought to be important in promoting dental health.[16] In accordance with local dental guidelines, the children were encouraged not to drink carbonated drinks but to switch to water or to fruit juice diluted 1:3 with water.

Limitations of study

Some limitations to our study may have occurred due to contamination, as randomisation was according to classes and not schools; transfer of knowledge may have taken place outside the classroom, although this would have been minimised by the cluster randomisation design.[17] Certain schools did change, encouraging consumption of water. This was seen in both the intervention group and the control group. We had two fewer clusters than anticipated owing to mixed year groups. The low return rate of drink diaries at baseline and completion may have resulted in a response bias; although the proportion of children who were overweight was similar in those who did or did not return the diaries. A further limitation was the use of the diaries over only three days. The validity of self collected dietary data can be questioned owing to a tendency for under-reporting of energy intake, particularly in those who are overweight or obese.[10]

Currently there is a plethora of guidelines on weight management in children, and obesity prevention is likely to be important within the United Kingdom based National Service Framework for children. Most studies on obesity prevention in children have been multifaceted.[18] However, only one school based US study has shown benefit for reducing obesity rates, although this was limited to girls and probably a consequence of watching less television.[19] A similar, intensive and multifaceted approach was used in the UK based active programme prompting lifestyle in schools study.[7] In that study, children's consumption of vegetables increased but there was no change in prevalence of obesity. Prevention programmes based in the home environment have had beneficial results, but this approach is often difficult to implement across whole populations and historically has mainly focused on people who are already overweight or obese.[18] Our intervention was simple, involved no teacher training, and could be easily implemented by a health educator working in several schools.

Small changes in energy intake and output seem to have a major impact on obesity risk. Theoretically, daily consumption of one can of a sweetened carbonated drink (0.50 MJ) over a 10 year period in a constant environment can add 50 kg of weight.[20] Conversely, reducing daily intake by a nominal amount of energy or by increasing energy output (the "energy gap") may help to prevent weight gain. Using data from national surveys, Hill and coworkers suggested that altering the energy gap by 0.42 MJ/day—that is, avoiding one can of sugar sweetened carbonated drink—would prevent excessive weight gain in most adult Americans.[21] To have a similar preventive effect in children the energy gap may have to be more than 0.84 MJ/day.[22]

Recently the World Health Organization recommended that free sugars should account for no more than 10% of daily energy intake.[16] This has not been universally accepted, particularly from within the food industry.[23] Reducing easy access to energy dense foods may help to limit the opportunities for overeating.[24]

The term "toxic environment" has been used to describe the myriad factors increasing a child's risk of becoming overweight or obese.[20] Although our targeted approach was modestly beneficial, other external influences on children's eating habits and leisure activities need to be debated widely in society. For most people, obesity still remains preventable.

We thank the headmasters, teachers, parents, and children at the participating schools, William Askew for writing and producing Ditch the Fizz, Julia Knott for help with data entry, Ruth Angel for discussion and advice, and the staff of the Bournemouth Diabetes and Endocrine Centre for help with anthropometric measurements.

Contributors: DK and JJ developed the original idea. JJ delivered the education programme, took the anthropometric measurements, and analysed the data. All authors contributed to writing the manuscript. PT provided statistical and methodological advice. DK directed the project; he will act as guarantor for the paper. DC obtained financial support.

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What is already known on this topic

Obesity in children is a major public health problem

Although the cause is multifactorial it has been linked to the consumption of sugar sweetened drinks

Previous school based interventions have been relatively ineffective in preventing obesity

What this study adds

A school based education programme to discourage children from drinking carbonated drinks reduced the number of overweight or obese children in a school year

Schools can have an important role in obesity prevention in children

analyses or interpretation. JJ received a research scholarship from the Florence Nightingale Foundation.

Competing interests: DK and DC each had a child attending one of the schools involved in the Christchurch obesity prevention project in schools.

Ethical approval: This study was approved by the East Dorset research and ethics committee.

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Amendment

The Results section of the abstract has been amended to read "Consumption of carbonated drinks over three days decreased by 0.6 glasses (average glass size 250 ml) in the intervention group" [not "decreased by 0.6 glasses ... a day"]. Figure 2 has been changed because an incorrect version of the figure was included in the original version; data used for the new version of figure 2 do not change the conclusions of the paper.

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PAPER

Prevention of childhood obesity by reducing soft drinks

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AIMS: The increasing prevalence of childhood obesity is a global problem. There are a variety of environmental factors that may be contributing to this increase. One such factor may be the increased consumption of soft drinks.
OBJECTIVE: This review will describe some of the latest research that has examined the association between obesity and the consumption of soft drinks.
RESULTS: The association between the consumption of sugar-sweetened drinks and childhood obesity has been established in three separate American studies. It has been found that children who consume these drinks have a higher energy intake and are more likely to become overweight. In adult women, the consumption of sugar-sweetened soft drinks has been associated with an increased risk of developing diabetes. In the United Kingdom, a school-based initiative focusing on reducing the consumption of these drinks has also been effective in preventing a further increase in obesity.
CONCLUSIONS: There is an association between obesity and consumption of soft drinks. Initiatives focusing on reducing the consumption of these drinks may help to prevent a further increase in childhood obesity.
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Keywords: childhood obesity; prevention; soft drinks; school-based intervention

Introduction

Childhood obesity is a major public health issue. The prevalence has increased in both the industrialised and developing world. In Thailand, the prevalence among 6- to 12-year-old children increased from 12.2 to 15.5% over a 2-y period from 1991 to 1993.[1] While a recent report suggested that one in four children in the United Kingdom are either overweight or obese.[2] The prevalence of obesity among children aged 2 to 10 has increased from 9.9% in 1995 to 13.7% in 2003, with obesity levels similar in both genders.

There are marked differences in prevalence of the problem between varying countries. A recent study comparing prevalence among adolescents between 13 European countries and the United States found that Ireland, Greece, Portugal and the United States had the highest rates, while the Czech Republic, Denmark, Flemish Belgium, France, Germany, Lithuania and Sweden had significantly lower levels of overweight adolescents.[3]

Being overweight or obese in childhood can have devastating metabolic, physical, psychosocial and economic consequences, particularly if the child becomes an obese adult.[4] Genetic or endocrine conditions are rarely implicated as the primary cause of childhood obesity and most children gain weight due to an imbalance between energy intake and expenditure.[5]

The current Western environment includes an abundance of palatable, relatively inexpensive, energy dense foods. Combined with this is often aggressive food marketing.[6] One of the most notable environmental changes over the last few decades has been food availability and portion size. In addition, there is a trend for increased consumption of food outside the home environment, and these foods tend to be highly calorific.[6] It is also commonplace to 'super size' fast food meals and drinks.[7] The fast food industry has been an international success with one fast food chain claiming to having 30 000 restaurants in 119 countries and serving an average of 47 million customers each day.[8]

In 1997, the National Diet and Nutrition Survey reported on the diets of United Kingdom young people aged between 4 and 18 y.[9] This highlighted a number of areas of concern; chocolate was consumed by more than 80% of children, 74% did not eat any citrus fruit and 58% did not eat any green leafy vegetables. Notably, the majority of young people consumed carbonated soft drinks, with the average weekly consumption 1500 ml for boys and 750 ml for girls.

The consumption of carbonated drinks has been implicated as a contributor to the obesity epidemic. In the United

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States, soft drink consumption has increased by 500% over the last 50 y[10] and represents the largest single food source of calories in the US diet,[11] often displacing other more nutritious drinks such as milk and fruit juice.[12] There is further concern that high consumption of these drinks will lead to excessive energy intake. The average adjusted energy intake is 10% higher for children who regularly consume carbonated drinks compared to nonconsumers.[12]

Methods

The consumption of soft drinks and its association with obesity has been highlighted in a number of recent research articles. The term soft drinks is used to include carbonated drinks and sugar-sweetened drinks. The results of these studies are described below.

Results

Ludwig *et al*[13] examined the relationship between the consumption of sugar-sweetened drinks and childhood obesity in 548 ethnically diverse children, over a period of 19 months. They reported that with each increased serving of sugar-sweetened carbonated drink, body mass index and frequency of obesity increased. The odds ratio of becoming obese increasing 1.6 times for each additional sugar-sweetened drink consumed each day.

A small longitudinal study was conducted over a summer camp and assessed sweetened drink consumption in 30 children aged 6–13 y.[14] Although the results were not significant, the authors found that increased consumption of sweetened drinks was associated with a higher total daily energy intake. The children who consumed the most sweetened drinks had the highest energy intake and also gained the most weight over the summer camp.

Schulze *et al*[15] used longitudinal data from the Nurses Health study II to examine the association between consumption of sugar-sweetened drinks, weight gain and risk of type II diabetes in women. This large study found that women who increased their sugar-sweetened soft drink consumption had also increased their total daily calorie intake, with most of the additional calories resulting from soft drinks. Women who consumed more than one soda a day had a significantly higher risk of developing diabetes than women who consumed less than one of these drinks a month.

Welsh *et al*[16] conducted a large retrospective study in children aged 2 and 3, to assess for any association between obesity and consumption of sweet drinks in this younger age group. This study found that daily consumption of one or more sugar-sweetened drink increased the chance of overweight among children already at risk of overweight, and continued the likelihood of remaining overweight among children already established as overweight. This relationship remained the same for all sweetened drinks including sodas and other sugar-containing drinks. When only fruit juices were considered, there was no significant association for the children who were normal weight or at risk of becoming overweight, although for children already overweight, the association was diminished but the results remained significant.

The CHOPPS project (Christchurch Obesity Prevention Project in Schools) conducted in the United Kingdom was a cluster randomised controlled trial including 644 children. The aim of this project was to determine if a specific, school-based educational initiative focusing on reducing consumption of carbonated drinks would be effective in preventing weight gain in children aged 7–11 y old.[17]

The primary objective was to discourage consumption of a single 'unhealthy' substance (carbonated drinks) with positive affirmation of a balanced healthy diet. Each term, a 1-h session was assigned for each class over the school year (four terms). Teachers assisted in each session and were encouraged to reiterate the message in other lessons. Group projects, games and classroom discussion were used. The initial session focused on the 'balance of good health', and the promotion of water drinking in place of carbonated drinks. Fruit tasting was used to demonstrate natural healthy sweet-tasting products. In addition, each class was given a tooth immersed in a popular sweetened carbonated cola to assess the effects of these drinks on dentition. The second and third sessions involved a music competition where each class was given a copy of a song 'Ditch the Fizz' and were challenged to produce their song/rap with a healthy drinking message. This involved additional time without the investigator present, with some schools including it into their music programme for the term. The final session involved group presentations of a classroom collage depicting what the children had learnt over the year. An interactive classroom quiz based on a popular TV games show was also used. Throughout the year, the children were encouraged to access further information through the CHOPPS link on the hospital Internet site.

After 12 months, the percentage of overweight and obese children increased in the control clusters by 7.5% compared with a decrease in the intervention group of 0.2% (95% CI 2.2–13.1%, $P=0.008$). Consumption of carbonated drinks decreased in the intervention group compared to the control group (95% CI 0.1–1.3, $P=0.03$). This specific health education initiative demonstrated that education promoting a reduction in the consumption of carbonated drinks prevented a further increase in the prevalence of childhood overweight and obesity.

Mechanisms of promoting obesity

Although there are likely to be many factors implicated in the development of obesity, growing evidence suggests a link between the consumption of soft drinks and obesity, especially in children.

Small changes in energy intake and output appear to have a major impact in obesity risk.[18] For example, the daily consumption of one can of a regular carbonated drink (120 kcal) over a 10-y period in a constant environment theoretically will have the potential to result in a 50 kg weight gain.[19] Reducing daily intake by a small amount of calories or by increasing energy output (the 'energy gap') may help to prevent weight gain. Using data from national surveys, Hill *et al*[19] have suggested that altering the energy gap by 100 kcal each day would prevent excessive weight gain in most adult Americans. For children, the energy gap may have to be more than 200 kcal/day to have a similar preventative effect.[20]

Another important factor is the glycaemic index (GI) or the rate of absorption of carbohydrate after a meal.[21] Low GI diets lower postprandial glucose and insulin responses, whereas high GI diets stimulate lipogenesis and cause increased adipocyte size.[22] The GI of the American diet has increased in recent years, and this may be contributing to the rising obesity epidemic.[21] The effect of GI on energy metabolism and voluntary food intake has been studied with a small sample of obese boys. On different days, the boys were given meals with varying GI's and their *ad libitum* food intake for a 5-h period was monitored. It was found that different meals that contained the same amount of energy but had varying GI's had very different effects on metabolism, perceived hunger and additional food intake. The voluntary food intake after the high GI meal was 53% more than after the medium GI meal, and 81% more than after the low GI meal. This suggests that the rapid absorption of glucose after a high GI meal can promote excessive food intake.[23] Another theory is that additional calories in liquid form are less satisfying than food solids. Children especially have difficulty in compensating for additional calories, particularly those calories in liquid form. Most individuals compensate for additional calories by consuming less at subsequent meals. Sweetened soft drinks have a high-energy intake but very low satiety value.[24]

The research by Schulze *et al*[15] also highlighted that the women who consumed the most sugar-containing drinks also tended to smoke more, have a higher calorie intake and do less physical activity. Perhaps the consumption of these drinks could also be marker of a tendency for an unhealthy lifestyle.[25]

Conclusions

The World Health Organisation's report on obesity in 1997 concluded that with the trends of increasing adult and childhood overweight and obesity, it was essential to focus not only on individuals with a high BMI and associated health problems. Preventive public health strategies that included populations as a whole are necessary to combat the problem.[26] Family-based approaches are best suited where the problem of overweight or obesity has already been recognised,[27] and education programmes and schools provide the ideal environment for prevention strategies.[28] James *et al*[17] have demonstrated that it is possible to prevent further increases in childhood obesity through a specific health education targeting a reduction in the consumption of carbonated drinks.

Current research suggests that the association between obesity and soft drinks occurs at all ages. The mechanism may not be fully understood, but there is evidence to suggest that preventing consumption of sugar-sweetened drinks has a major role to play in obesity prevention.

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RESEARCH

Preventing childhood obesity: two year follow-up results from the Christchurch obesity prevention programme in schools (CHOPPS)

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ABSTRACT

Objective To assess the long term effects of an obesity prevention programme in schools.

Design Longitudinal results after a cluster randomised controlled trial.

Setting Schools in southwest England.

Participants Of the original sample of 644 children aged 7-11, 511 children were tracked and measurements were obtained from 434 children three years after baseline.

Intervention The intervention was conducted over one school year, with four sessions of focused education promoting a healthy diet and discouraging the consumption of carbonated drinks.

Main outcome measures Anthropometric measures of height, weight, and waist circumference. Body mass index (BMI) converted to z scores (SD scores) and to centile values with growth reference curves. Waist circumference was also converted to z scores (SD scores).

Results At three years after baseline the age and sex specific BMI z scores (SD scores) had increased in the control group by 0.10 (SD 0.53) but decreased in the intervention group by −0.01 (SD 0.58), with a mean difference of 0.10 (95% confidence interval −0.00 to 0.21, P=0.06). The prevalence of overweight increased in both the intervention and control group at three years and the significant difference between the groups seen at 12 months was no longer evident. The BMI increased in the control group by 2.14 (SD 1.64) and the intervention group by 1.88 (SD 1.71), with mean difference of 0.26 (−0.07 to 0.58, P= 0.12). The waist circumference increased in both groups after three years with a mean difference of 0.09 (−0.06 to 0.26, P=0.25).

Conclusions These longitudinal results show that after a simple year long intervention the difference in prevalence of overweight in children seen at 12 months was not sustained at three years.

INTRODUCTION

Childhood overweight and obesity is an international problem, with 10% of school age children estimated to be overweight.[1 2] In the United Kingdom, obesity in children increased from 9.9% in 1995 to 13.7% in 2003.[3] Although the UK government has set an ambitious target of stopping this escalating trend by 2010, a recent publication forecasts that there could be further increases, with 19% of boys and 24% of girls aged under 10 predicted to be obese by 2010.[4]

Numerous studies have been conducted with the aim of preventing obesity in children and young adults, many of which have been based in schools.[5 6] A recent revised Cochrane review[7] considered 22 studies, including 10 long term and 12 short term projects, most of which were school based and focused on multiple interventions, while some had more specific approaches. The review reported that in most cases the interventions did not significantly affect of the weight of the children. One reason for the disappointing results might have been that most of the projects were too short in duration to be effective.

One school based intervention described by the Cochrane review as a good quality randomised controlled trial was the Christchurch obesity prevention project in schools (CHOPPS), also sometimes referred to as the "ditch the fizz" project. This project was started in August 2001 and was completed over one school year. It was based in six junior schools in southern England and included children aged 7-11. The intervention focused on discouraging children from consuming carbonated drinks and involved one hour of additional health education during each of the four school terms. The intervention is described in more detail elsewhere.[8] The original project produced a modest reduction in the number of carbonated drinks consumed and a significant reduction in the number of children becoming overweight or obese.[8] Further anthropometric measures were taken two years after completion of the original project (three years after baseline) to assess any longitudinal effects.

METHODS

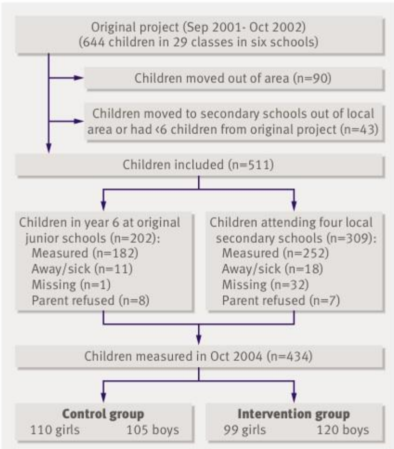
Two years after completion of the original project one investigator (JJ) took additional longitudinal measurements. She had also completed the original measurements and conducted the education programme. Because of lack of funding we were unable to collect further drink diaries at this time.

Several different methods are used to assess overweight and obesity in children. We defined overweight and obesity using the 1990 British centile charts, in which children above the 91st centile are classified as overweight.

In the original project, the children in the three year groups attended junior schools in Christchurch, Dorset. Three years after baseline, the two older year groups had progressed to secondary schools and were tracked using school leaving lists. Most were attending three local secondary schools. From the original sample, 90 children had moved out of the area and 43 were attending secondary schools that were either outside of the project area or had fewer than six children from the original project attending. We traced 511 children from the original sample and carried out measurements on 434, 67% of the original sample (figure).

Outcome measures

One investigator (JJ) took anthropometric measures of height (without shoes) to the nearest 0.1 cm using the Portable Leister height measure (Seca, Marsden) and weight (in light clothing) measured to the nearest 0.1 kg on medical scales (Seca 770, Marsden). We converted body mass index (weight (kg)/(height $(m)^2$)) to z scores (SD scores) and to centile values using the 1990 growth reference disc (Child Growth Foundation).[9] The z score (SD score) accounts for the child's age and sex and represents the deviation compared with an average child of the same sex and age. Waist circumference was measured at the point of flexure as the child bends to one side, with 1 cm deducted to account for clothing. Waist circumference was converted to z scores (SD scores) with the 2001 McCarthy references for waist circumference.[10] Our primary outcome measures were the change in BMI z score and the prevalence of overweight.



Trial profile for three year follow-up data

Statistical methods

The sample size of 376 calculated for the original project was based on changes in consumption of carbonated drinks. This sample size had 90% power to detect mean differences in z score (SD score) for BMIs of 0.49, 0.42, 0.35, and 0.34 (assuming intracluster correlations of 0.1, 0.05, 0.01, and 0.001, respectively) between the intervention and control groups. As we were able to gather data on 434 children three years after baseline and using data from the 12 month follow-up we can refine this sample size calculation. In the original 12 month follow-up the intracluster correlation for the change in z score (SD score) over 12 months was −0.003 (assumed to be 0) and the SD was 0.44 in both groups combined. Thus at three years with a sample size of 434 and assuming an SD of 0.44 and an intracluster correlation coefficient of 0, the study had 90% power to detect differences of 0.14 between control and intervention groups.

The original design was a cluster randomised controlled trial, with class being the cluster. Data were aggregated for each cluster and the two sets of clusters compared by using the independent samples *t* test. Subsequently, because of the nature of the school environment and the progression of children to different schools, the clusters have not remained intact and some children were lost to follow-up. This resulted in some clusters having few children in them, and so reducing the validity of that method of analysis for the follow-up data. We therefore analysed the interval scaled data in this paper with MLwiN (version 2) using multilevel models to take into account variance within clusters. For binary data we implemented a logistic model using the same software. This has resulted in the 12 month analysis presented here not being identical to that in the original report. We used a 5% significance level.

RESULTS

In the original project we collected baseline anthropometric measures from 644 children (321 girls). Of these, 434 children (209 girls) were re-measured three years later. There was no significant difference in the baseline z scores between children in the control and intervention groups who were present or missing at the final measurements. The average age was 8.6 (range 7.0-10.9) at the start of the project and 11.6 (10.0-13.9) at the three year follow-up.

Table 1 shows the BMIs, centile z scores (SD scores), and waist circumference z scores (SD scores) at baseline, 12 months, and three year follow-up. We also analysed data for each measure of change from baseline using baseline values, sex, and secondary school as covariates or cofactors. This made no material difference to the significance levels or mean changes between control and intervention group.

Table 2 shows the change in prevalence of overweight and obesity according to the 1990 British centile charts, with children above the 91st centile classed as overweight. As previously reported, at 12 months there was a significant difference between the control

Table 1 | Change in body mass index (BMI), centile SD scores (z scores), and waist SD scores (z scores) at 12 months and 3 years after baseline

	Control	Intervention	Mean difference (95% CI), P value
BMI*			
Baseline (n=486)	17.5 (2.36)	17.2 (2.14)	0.24 (−0.16 to 0.64), P=0.24
After 12 months (n=474)	18.3 (2.85)	17.8 (2.45)	0.59 (0.11 to 1.06), P=0.02
After 3 years (n=434)	19.7 (3.36)	19.0 (3.21)	0.68 (0.06 to 1.30), P=0.03
Change in BMI from baseline†			
After 12 months (n=455)	0.71 (1.45)	0.62 (0.79)	0.10 (−0.11 to 0.31), P=0.36
After 3 years (n=418)	2.14 (1.64)	1.88 (1.71)	0.26 (−0.07 to 0.58), P=0.12
Centile z score (SD score)*			
Baseline (n=486)	0.53 (0.98)	0.44 (0.98)	0.08 (−0.09 to 0.26), P=0.36
After 12 months (n=474)	0.63 (1.07)	0.44 (1.01)	0.20 (0.01 to 0.38), P=0.04
After 3 years (n=434)	0.63 (1.12)	0.39 (1.17)	0.24 (0.02 to 0.46), P=0.03
Change in centile z score (SD score)† from baseline			
After 12 months (n=455)	0.05 (0.57)	0.03 (0.30)	0.02 (−0.06 to 0.11), P=0.60
After 3 years‡ (n=418)	0.10 (0.53)	−0.01 (0.58)	0.10 (−0.00 to 0.21), P=0.06
Waist circumference z score (SD score)*			
Baseline (n=486)	0.85 (0.94)	0.83 (0.91)	0.03 (−0.14 to 0.19), P=0.76
After 12 months (n=474)	0.99 (0.93)	0.88 (0.87)	0.11 (−0.05 to 0.27), P=0.19
After 3 years (n=434)	0.96 (1.22)	0.80 (1.07)	0.15 (−0.06 to 0.37), P=0.17
Change in waist circumference z score (SD score) from baseline†			
After 12 months (n=455)	0.08 (0.64)	0.08 (0.47)	0.01 (−0.09 to 0.12), P=0.81
After 3 years (n=418)	0.099 (0.99)	0.01 (0.66)	0.09 (−0.06 to 0.26), P=0.25

*Based on maximum number of children in each cluster.
†Based on children with data at baseline and 12 months or 3 years.
‡Primary outcome.

and intervention groups but three years after baseline the difference was smaller and no longer significant.

DISCUSSION

A simple 12 month school based intervention focused on reducing consumption of carbonated drinks resulted in significant differences in the proportion of overweight children in the control and intervention groups.[8] Two years after the completion of the study, however, the difference was no longer significant, and the number of overweight children had increased in both groups, although the prevalence was still higher in the control group. In the three year follow-up, the only difference approaching significance was for the change in centile z score (SD score). Given the lack of a trend at 12 months this may well be a chance finding. The study had sufficient power to detect a difference of 0.14 or more, but the observed difference was only 0.10. The study was originally powered to detect differences in consumption of carbonated drinks, and so we cannot rule out a type II error.

The original project was different from many other school based interventions in that the intervention was specific and promoted a healthy diet based on the balance of good health. It focused specifically on discouraging the consumption of carbonated drinks. Several recent studies have further confirmed the association between these drinks and obesity,[11-15] as has a systematic review and meta-analysis of 88 studies.[16] The role of these drinks as a causative agent of obesity is also recognised by the World Health Organization.[17] One reason suggested for this association may relate to the high glycaemic index and that they provide "empty" calories.[18] The physiological effect on satiety from energy ingested in liquid form is thought to be different from that from solid foods and this may in part be due to faster transit times and reduced gastric distension.[19] Therefore the additional energy from these drinks may not be detected as easily by the body and individuals may not compensate for this additional energy by consuming less later.[19]

Limitations

A proportion of children were lost to follow-up; although 67% of the original cohort were measured at three years. Because of the natural progression of children at school, the original clusters did not remain intact and therefore we had to use a different method of analysis from the original study.

Unfortunately because of financial and time limitations we were not able to measure any further changes in consumption of carbonated drinks, or the socioeconomic status and pubertal status of these children.

The original project provided hope that a simple intervention could be beneficial in preventing obesity, but our new results show no effect two years after the end of the intervention. Evidence suggests that it would be beneficial for the whole population to decrease consumption of soft drinks, as these drinks have a high energy intake with little nutritional benefit.[16] The recent UK obesity guidelines from the National Institute for Health and Clinical Excellence (NICE) highlight the important role that schools can play in promoting healthy lifestyles.[20] Obesity is a complex condition, and another report suggests that specific interventions may ignore different interlinking influences.[21] It remains unclear whether specific interventions or those that focus on all aspects of the diet and physical activity are the most successful. Perhaps the true impact of any school based intervention can effectively be evaluated only if the interventions are continuous.

Table 2 | Prevalence of overweight at 12 months and 3 years after baseline

	Control (%)	Intervention (%)	Odds ratio (95% CI)	P value	Risk difference* (95% CI)
Baseline (n=486)	20.6	17.4	0.79 (0.50 to 1.26)	P=0.33	3.2% (−4.23% to 10.6%)
After 12 months (n=474)	28.5	18.7	0.58 (0.37 to 0.89)	P=0.01	9.8% (1.83% to 17.8%)
After 3 years† (n=434)	30.2	25.6	0.79 (0.52 to 1.21)	P=0.28	4.6% (−4.3% to 13.5%)

*Calculated assuming an intracluster correlation of 0.
†Primary outcome.

WHAT IS ALREADY KNOWN ON THIS TOPIC

The prevalence of childhood obesity is increasing

The UK government has set an ambitious target of halting the annual increase in childhood obesity by 2010

School based interventions show some success in prevention of obesity

WHAT THIS STUDY ADDS

The success of a school based intervention was not maintained two years after the end of the project

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Contributors: JJ and DK developed the original idea. JJ delivered the education programme, carried out the anthropometric measurements, and analysed the data. All authors contributed to writing the manuscript. PT provided statistical and methodological advice. DK directed the project and is guarantor.
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