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Management of Obesity In Childhood

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EXECUTIVE SUMMARY

Obesity in childhood has been identified as a problem in many affluent societies, particularly in countries where children consume unhealthy foods, snacks or beverages every day. Obesity is usually defined as an excess of body fat which, results in significant impairment of health. Research in the UK suggests that the prevalence of overweight and obesity amongst children of all ages is increasing.

OBJECTIVE

To assess the safety, effectiveness, and cost implications of management of obesity in childhood

RESULTS

Prevention Programme

There is some evidence that multifaceted school based programmes that promote physical activity, modification of dietary intake, and targeting sedentary behaviour may help reduce obesity in school children, particularly girls. Multifaceted family based programmes involving parents, which increase physical activity, provide dietary education and target reductions in sedentary behaviour may help children to lose weight. There is also some evidence that family-based behaviour modification programmes, where parents take primary responsibility and act as change agents, may help children lose weight.

Screening Methods

There is sufficient evidence to conclude that BMI has high sensitivity and specificity in detecting overweight but not for detecting obesity.

There is insufficient evidence that the use of hydrodensitometry or air displacement plethysomography is effective in detecting body fat percentage.

With respect to MRI, there is evidence that MRI gives the best prediction of total body fat volume as well as patterns of intra-abdominal and subcutaneous fat distribution but the high cost of this procedure limits its use mainly to the research setting.

There is some evidence that Bioelectrical Impedance (BIA) is suitable for population screening especially for measuring fat free mass in children aged 10-19 years.

The evidence on the effectiveness of dual energy x-ray absorptiometry (DEXA) is inconclusive.

However, there is evidence that waist circumference is a simple and effective measure for trunk fat mass.

There is also some evidence that skin fold thickness measurement, especially of the triceps, is effective in the screening for obesity.

Treatment

There is evidence that surgery is a safe and effective treatment for morbidly obese children to induce weight loss and also reduction in obesity together with related co-morbidity.

With respect to pharmacological treatment, appetite suppressants and thermogenic drugs have not been approved for use in children. Digestive inhibitors like lipase inhibitors and fat substitutes are being used off label. There is some evidence suggesting that Orlistat may assist with weight loss in obese children, but insufficient evidence on the efficacy of Subutramine.

There also insufficient evidence to suggest dietary education, physical activity or a combination of both improves weight control.

RECOMMENDATION

Prevention

There is insufficient evidence to recommend in favour of or against community-based obesity prevention programs. However, in view of the major health risks associated with obesity, and the limited long-term effectiveness of weight-reduction methods, the prevention of obesity should be a high priority for health care providers.

Screening Methods:

BMI is recommended for detecting overweight, while skin fold thickness measurement, especially of the triceps, may be considered for screening for obesity.

Treatment:

There is insufficient evidence to recommend in favour of or against weight-reduction therapy because of a lack of evidence supporting the long-term effectiveness of weight-reduction methods. However, surgery is recommended for treatment of morbidly obese children.

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1. INTRODUCTION

Obesity in childhood has been identified as a problem in many affluent societies, particularly in countries where children consume unhealthy foods, snacks or beverages every day. Obesity is usually defined as an excess of body fat which, results in significant impairment of health (Burton, 1985).

1.1 Prevalence and Trends

Research in the UK suggests that the prevalence of overweight and obesity amongst children of all ages is increasing (Rudolf et al, 2001; Reilly & Dorosty, 1999; Reilly, Dorosty & Emmett, 1999) One study reported a substantial increase (between 1984 and 1994) in the prevalence of overweight and obesity amongst primary school children in England and Scotland. (Chinn & Rona, 2001) In addition, data from a large survey in England showed a rise in the prevalence of overweight from 14.7% to 23.6% and obesity from 5.4% to 9.2% between 1989 and 1998 in pre-school children. (Bundred, Kitchiner, Buchan, 2001) Data from the US National Health and Nutritional Examination Survey (NHANES IV) in 2002, showed an increase from 7.2% to 10.4% for children aged 2-5 years old, 11.3 to 15.3 for children aged 6-11 years and 10.5% to 15.5% for 12-19 years old using 95th percentile, compared to surveys in 1988-1994 and 1999-2000. (Chopra et al, 2002) The world wide prevalence of obesity in childhood has been said to vary from 2.6-3.6% in Finland, 10.8% in United States. 11.2 -12.5% in Navajo India schoolchildren, 7.56 in Indian children, 16.1% in Singapore schoolchildren, 14.3% in Thailand, and about 6.0% in Malaysia. (Kasmini et al, 1997)

1.2 Relation of Obesity to Health Outcomes

Obesity has become an increasingly important medical problem in children and adolescents. Among the most common conditions associated with primary childhood obesity, are those that affect the cardiovascular system like hypertension, hypercholesterolemia and dyslipidemia, the endocrine system such as type 2 diabetes mellitus, hyperinsulinism, insulin resistance, impaired glucose tolerance, as well as pulmonary complications (e.g. asthma, sleep apnea), growth acceleration, musculoskeletal problems and psycho-social problem like depression and low self esteem. (American Academy of Pediatrics, 2003; Kiess et al, 2001; Edmund, Waters & Elliott, 2000) It has also been shown that overweight children are likely to suffer from psychological problems. (Edmund, Waters & Elliott, 2000)

1.3 Prevention

Reviews of the literature have demonstrated that prevention of obesity is easier than treatment. In addition, prevention interventions in the health care, school and community settings have proven effective in preventing childhood overweight. National policy makers have been urged to consider prevention as the primary target to respond to the increasing rates of overweight and obesity among children and adolescents. Current prevention efforts by health care providers should focus primarily on anticipatory guidance with parents and children addressing knowledge, attitudes and beliefs about eating and activity behaviour. Research in this area has included the examination of many

issues like regular physical activity, reducing television viewing, and health promotion. (Rossner, 2002; Dietz & Gortmaker, 2001)

1.4 Treatment

Logically, for both children and adults, the best way to significantly reduce the prevalence of obesity is not through treatment, but prevention. However, experts have noted that the natural tendencies of children to move and be active and to know when they are satiated have been subverted early in life resulting in dysregulation of body weight. While prevention remains the key long-term strategy, the growth in the obesity epidemic among all populations makes it necessary to continue to examine a variety of treatment options. (National Institute for Health Care Management Foundation Forum, 2003)

2. TECHNICAL FEATURES

2.1 Assessment of Distribution of Body Fat

The level of fatness of a child at which there is acute morbidity or morbidity increases later in life is determined on an actuarial basis by direct measurements of body fat content, e.g. hydrodensitometry, bioimpedance, or dual energy absorptiometry (DEXA). However, body mass index (BMI) is easy to calculate and is now generally accepted for defining obesity in children and adolescents clinically. (Kiess et al, 2001) Recently, in vivo imaging techniques (e.g. MRI and CT) have allowed more accurate measures of body-fat distribution in children and adolescents.

2.1.1 Body Mass Index

The Body Mass Index (BMI) describes relative weight for height. For adult practice there is widespread agreement on the use of the calculation of weight (kg)/height (inches²) with the World Health Organisation using the cut-off values of BMI exceeding 25kg/m² as overweight, and defining obesity as BMI > 30kg/m². (<http://www.nhlbi.nih.gov>. 12 Dec 2002; Deurenberg & Yap, 1999)

However, BMI may not be a sensitive measure of body fatness in children and adolescents who are particularly short or tall for their age or have an unusual body fat distribution. It may also misclassify children and adolescents who have highly developed muscles. (National Health and Medical Research Council, 2002) In children less than eighteen years old, BMI is not a static measurement and varies from birth to adulthood. It also shows different values in boys and girls, as well as in different populations. In childhood, the BMI changes substantially with age. At birth, the median is as low as 13 kg/m², increasing to 17kg/m² at 1 year, decreasing to 15.5kg/m² at age 6, and then increasing to 21kg/m² at 20 years of age. Thus, a cut-off point related to age is needed to define child obesity, based on the same principle at different ages, for example, using reference centiles. In the United States, the 85th and 95th centiles of BMI for age and sex based on nationally representative survey data have been recommended as cut off points to identify overweight and obesity. (Rockville, 2001; Cole et al, 2000; Barlow & Dietz, 1998) Consequently, the interpretation of BMI in children and young people depend on

comparisons with population reference data, using cut off points in the BMI distribution or BMI percentiles (<http://www.sign.ac.uk>. April 2003).

2.1.2. *Body composition measurement techniques*

Densitometry

Measurement of body composition in children and adolescents has generally been based on measurements of body density, determined either by underwater weighing or air displacement plethysmography. Underwater weighing requires the subject to be completely submerged in water for several seconds while emptying the lungs by maximal exhalation. Based on assumed densities of fat mass and fat-free mass, body composition can be estimated. (Dietz & Bellizzi, 1997) Air displacement plethysmography, on the other hand, uses air rather than water displacement for measurement of volume. The subject is immersed in a closed air-filled anterior chamber which, is connected to a rear-measuring chamber via oscillating diaphragms. This newer technique using air rather than water displacement for measurement of volume is more practical for the paediatric population. This two-compartment model is used based on the different tissue densities of the fat and fat-free compartments of the body. If total body density and the specific densities of fat and fat-free mass are known, an equation can be generated for converting total body density to percentage of body fat based on the Archimedes principle. (Siri, 1961)

Magnetic Resonance Imaging

When the body is placed in a strong magnetic field, some nuclei will attempt to align with or against the magnetic field. Hydrogen protons in particular, have a high affinity for alignment with the magnetic field. Magnetic Resonance Imaging (MRI) is successful because the hydrogen found mainly in water is one of the most abundant unbound elements in the body. Having aligned the hydrogen protons in a known direction, a pulsed radiofrequency field is applied to the body tissues, causing a number of hydrogen protons to flip or absorb energy. When the radio frequency field is turned off, the protons gradually return to their previous positions, releasing in the process the energy that they absorb in the form of an RF signal. It is this signal that is used to develop the MR images by computer. To enhance contrast between lean and fat tissues, a second feature of the nuclei called relaxation time (T1) is used. The different T1 of fat and lean tissues provide high quality MR images.

Bioelectrical impedance

Bioelectrical impedance analysis (BIA) measures the impedance or opposition to the flow of an electric current through body fluids, contained mainly in the lean and fat tissue. Impedance is low in lean tissue, where intracellular fluid and electrolytes are primarily contained, but high in the fat tissue. Impedance is thus proportional to body water volume (TBW). A small constant current, typically 800 μ A at a fixed frequency, usually 50kHz, is passed between electrodes spanning the body and the voltage drop between electrodes provides a measure of impedance. The impedance of a biological tissue comprises two components, the resistance and the reactance. The conductive characteristics of body fluids provide the resistive component, whereas the cell membranes, acting as imperfect capacitors, contribute a frequency-dependent reactive

component. Impedance measurements made over a range of low to high (1 MHz) frequencies, therefore allow development of prediction equations, relating impedance measures at low frequencies to extra-cellular fluid volume and high frequencies to total body fluid volume. This is known as multi frequency bioelectrical impedance analysis.

Dual energy x-ray absorptiometry

The dual energy x-ray absorptiometry (DEXA) instruments differentiate body weight into the components of lean soft tissue, fat soft tissue and bone. (<http://www.topendsports.com>, 27/10/2003) DEXA uses a whole body scanner and two different low-dose x-rays to read bone mass and soft tissue mass. It takes about 10 minute to do a body scan and provides a high degree of precision with a 2 - 3 percent margin of error. (<http://www.weight-loss-i.com> 27/10/03)

Waist circumference measure

In adults, waist circumference and BMI are interrelated, but waist circumference provides an independent prediction of risk over and above that of BMI. A man's body is typically more "apple" shaped and tends to collect fat around his waist and stomach area (beer belly). In contrast, women's bodies are more "pear" shaped as they tend to collect fat on their hips, buttock and thighs. It has been said that people with an "apple" body shape are more prone to develop diabetes and heart disease than those with a "pear" body shape. Waist circumference measurement is particularly useful in patients who have been categorized as overweight on the BMI scale, although increased waist circumference can also be a marker for increased risk even in persons of normal weight. However, there are no universally accepted cut-off points for waist circumference in children and adolescents, because the relationships between waist measure and metabolic complications in children and adolescents remain undefined. (National Health and Medical Research Council, 2002)

Skin fold thickness measure

The thickness of the subcutaneous fat tissue can be estimated by measuring skin folds. For the use of skin folds in the assessment of body composition the calibrated equipment and standardized sites of measurement are needed. The sites most commonly used are on the brachial triceps muscle, on the brachial biceps muscle, below the inferior angle of the scapula, and the top of the anterior superior iliac spine. The skin fold thickness is measured by grasping the skin and subcutaneous tissue between the thumb and fore finger, excluding the underlying muscle, and allowing the jaws of the caliper to impinge on the skin. Double readings need to be taken. (Taskinen, 2000) The measurement of skin-fold thickness depends on the skill of the examiner, and may vary widely when measured by different examiner. (<http://www.home.comcast.net>. 23/10/03) Thus, training is required to obtain accurate measurements, and these measurements should be carried out at the same time of the day. (<http://www.campbell.edu> 23/10/03)

3. OBJECTIVE

To assess the safety, effectiveness, and cost implications of management of obesity in childhood

4. METHODOLOGY

The detailed search strategy of each aspect is indicated in Appendix 1.

5. RESULTS

5.1 Effectiveness of a Prevention Programme

5.1.1 School Based programme

Health promotion

A school-based randomized controlled trial assessing the effect of reducing television viewing to prevent obesity found that at 7 months follow-up, the children in the intervention group had statistically significant relative decrease in body mass index, triceps skin fold thickness, waist circumference, and waist to hip ratio compared to the control group. The intervention group also reported statistically decreased television viewing and meals eaten in front of the television. Thus, it concluded that reducing television viewing may be a promising population-based approach to prevent childhood obesity. (Robinson, 1999)

Physical activity

A randomized controlled trial on the effect of a 30-week exercise programme on the obesity indices reported no statistically significant differences between the children who exercised and those in control group. However, a sex difference was observed in the body mass index in that girls in the exercise group had a lower likelihood of having an increasing BMI slope. It concluded that a school-based exercise programme can prevent BMI gain in girls and may induce a remission of obesity in pre-school children. (MoSuwam et al, 1998) Another randomized control trial evaluating a physical education programme designed to provide high level exercise for children in three 30-minute sessions per week over 18 months also reported no statistically significantly differences in the levels of obesity between those in the exercise group and those in the control group. (Sallis et al., 1993)

Multifaceted Interventions

An active programme promoting healthy lifestyles in school consisting of teacher training, modification of school meals, development of school action plans targeting the curriculum, physical education, tuck shops, and playground activities reported no difference in changes in BMI scores. (Sahota et al, 2001) The Kiel Obesity Prevention Study examined the combined effects of dietary education, exercise and decreased television viewing, and also found no significant differences in mean BMI scores in those with intervention and those without at 1 year follow-up. (Muller et al, 2001) However, a multifaceted "Planet Health" programme promoting physical activity, modification of

dietary intake, and reduction of sedentary behaviour, found a reduction in obesity among girls in the intervention schools after 18 months, with fewer obese girls in the intervention group. (Gortmaker et al, 1999)

5.1.2 Family Based Intervention

Health promotion

A randomized controlled trial focusing on obesity prevention stressing the importance of eating a low fat, low cholesterol diet and increased activity found a statically significant difference in the percentage of daily calories from fat at the end of the 12-week study in the intervention group. (Stolley & Fitzgibbon, 1997) Another randomized control trial of 26 families with non-obese children of obese parents were randomized to encouraging fruit and vegetables intake or decreased intake of high fat/high sugar foods, showed a significant decrease in percentage overweight in parents in the increased fruit and vegetables group, but no significant overweight in the children at 1-year follow-up. (Epstein et al, 2001)

Physical activity and health promotion

Two randomized controlled trials comparing the effect of increased physical activity with decreasing sedentary behaviour and diet modification, reported weight loss, in the children with intervention at 1 year follow up. However, children in the reduced sedentary behaviour had a statically significant greater reduction in percentage of overweight. (Epstein et al, 1995) In the other trial all groups either having high or low increased physical activity, high or low sedentary behaviour showed decreases in percentage overweight at 6 and 24 months. Although not statistically significant. (Epstein et al, 2000)

Behaviour modification programme

Parents as agents of change

A randomized controlled trial evaluating the effect of targeting obese children and their parents for mastery of diet, exercise, weight loss, and parenting skills over 2 years, found that at 6 months and 12 months follow up, children with intervention had a statistically significant relative weight reduction. However, this result was not maintained at 2 years (Epstein et al, 1994). Another randomized controlled trial examined the effects of parents taking responsibility for their children's behaviour change, reported a significant decrease in obesity at one year follow-up, although there was a statistically significant greater reduction in the parent-led intervention group, (Golan et al, 1998).

Family based behaviour modification programmes

A study on children receiving either conventional treatment or family therapy as an adjunct to conventional treatment, found a significant smaller increase in BMI scores in the family therapy group at 12-month follow-up. (Flodmark et al, 1993) A study in Australia, where overweight children were randomly assigned to either behaviour management plus relaxation placebo or a combined behaviour cognitive self management approach showed a statistically significant reduction in percentage overweight for children in both groups. However, there was no statistically significant difference at either 3 or 6 months' follow-up. (Duffy & Spence, 1993) Another RCT compared four

different behaviour modification programmes (summer camp training, advice in a single session, group outpatient, individual outpatient) for obese children showed statistically significant reduction in mean percentage overweight in those on outpatient programmes at 6 and 12 months' follow-up. (Breat, Van Minckel & Van Leeuwen, 1997). A 6-month family based behaviour weight control programme comparing parent and children problem-solving, child problem- solving, and "standard" family based treatment with no problem-solving had a larger decrease in BMI in the "standard" group compared to the parent and child group at 24 months' follow-up. (Epstein et al, 2000) Another study on obese children receiving "mixed" behaviour treatment (a mixture of individualized plus group therapy) or "group" behaviour treatment (that did not involve individual therapy), showed statistically significant reduction in percentage overweight and BMI, although there were no significant differences between the groups. (Goldfield et al, 2001)

Behaviour modification without parental involvement

A randomized controlled trial of a 6-week inpatient rehabilitation programme for children and adolescents, comparing a three-part cognitive-behaviour programme with a programme providing muscle relaxation training with both intervention groups receiving the same diet and exercise programmes, found that the percentage of overweight was reduced over the course of a year, although the differences between the groups were not statistically significant. (Warschburger et al, 2001)

5.2 Screening Methods

5.2.1 Body Mass Index

Shorter children have been found to have a lower BMI and BMI index deviation score compared to tall children. (Mulligan & Voss, 1999)

With total body fat and percent body fat as dependent variables and BMI and age as independent variables, BMI was strongly associated with total body fat. (Pietrobelli et al, 1998) A positive correlation was also found between BMI and percent body fat, although there was poor association in children less than 10 years old. (Wildham et al, 2001; Luciano et al, 2001; Pietrobelli et al, 1998)

It has been shown that for children aged 9 - 12 years, BMI for age is significantly better than weight for height and the Rohrer index (RI) for age, in detecting overweight.. However, for children and adolescents aged 2 - 19 year, the performance of BMI for age is better than that of RI for age in predicting underweight and overweight, but is similar to weight for height. (Mei et al, 2002, Laurence et al, 2002)

A study in Germany showed that BMI has limited usefulness in individual children. (Schaefer et al, 1998) When the 75th BMI percentile was used, it was able to detect 15% of the most obese children with sensitivity of 82%, and specificity of 85%. (Schaefer et al, 1998) However Cole et al (2000) proposed a cut-off point of 25 kg/m² and 30kg/m² to detect obesity, corresponding to the 98th centile.

BMI percentiles have been found to have a high specificity but a low sensitivity in detecting excess adiposity in 8 - 12 year old children, with sensitivity of 39% and 65%,

and specificity of 99% and 95% respectively when 95th percentile and 85th percentile of BMI were used. (Bedogni et al, 2003) The current definition of obesity based on BMI (95th centile) has moderately high sensitivity (88%) and high specificity (94%) which, does not differ significantly between boys and girls. (Reilly et al, 2000) A study in Brazil found that using BMI to screen for overweight or obesity in adolescents can generate a high percentage of false-positives for Niteroi boys and an even higher percentage of false-negatives for Niteroi girls. (da Veiga, Dias & dos Anjos, 2001)

A study showed that BMI can be used to screen children for obesity with a higher sensitivity range from 83-85 % and 62-80%, and specificity range of 95-98% and 96-97%, but not in identifying overweight children. (Mast et al, 2002) Similarly, another study found that screening for childhood obesity using BMI is specific, and can have moderately high sensitivity if an appropriate cut-off is chosen. (Reilly et al, 2000) The specificities of the BMI relative to the triceps skin fold thickness and percentage of fat were found to be high for detecting obesity, but in contrast, sensitivities were variable ranging from 20% to 75% for the risk of overweight, again indicating that BMI was a poor predictor of the risk of overweight. (Malina & Katzmarzyk, 1999) It has also been found that the percentage of body fat associated with an obese BMI tended to be higher in peri-pubertal males (34-36%) than in younger (24-30%) or older males (27-30%). Thus, the percentage of body fat values associated with BMI classifications of overweight and obesity vary considerably with age in growing children, particularly in girls aged 3-18 years. (Taylor et al, 2002)

BMI has also been found to present good correlation with the other methods independent of ethnicity among 10 and 11 year olds, but underestimates obesity among young people aged 16 -17 years. (Sampei et al, 2001)

5.2.2 *Body Composition Techniques*

Densitometry

Effectiveness

In evaluating the various methods for predicting body fat, Bray et al (2002) found that hydrodensitometry provided a specificity of more than 90% and a sensitivity of more than 80%. However this method has some limitations for children including practical problems like being laborious can be frightening for children as well as theoretical problems which require additional knowledge of the specific densities of fat and fat-free mass in children at different stages of maturity, gender and ethnicity. (Garon, 1998)

A prospective study comparing air displacement plethysmography with hydrodensitometry found that the former was more readily accepted and had better precision for fat mass, being also more accessible, reproducible, non invasive and at a relatively low cost. The theoretical limitations associated with hydrodensitometry are also applicable to plethysmography. (Dewit et al, 2000) However, body density estimated from the air displacement plethysmograph was significantly higher than the estimated from hydrodensitometry. (Lockner et al, 2000)

Cost

Apart from the fact that measurement of body composition using hydrodensitometry may not be practical in the paediatric population, the equipment is also expensive, costing USD 30, 000. (Bjontorp, 1992)

Magnetic Resonance Imaging

Effectiveness

Studies have shown that intra-abdominal adipose tissue in childhood has a significant relationship with dyslipidaemia and glucose intolerance. (Bjontorp, 1992) It has been found that there is a distinct contrast between adipose tissues and lean tissues on the magnetic resonance imaging (MRI) The MRI measurement has also been found to have good reproducibility and reliability. (Rose et al, 1992) In a prospective assessment of abdominal fat development in young adolescents using MRI, Fox et al, (2000) reported a similar finding that MRI provides insight into the complex nature of fat distribution during the pubescent years not detected by skin fold. MRI can also monitor changes in the visceral (intra-abdominal) adipose tissue and subcutaneous adipose tissue separately. A study in Hong Kong using whole body multi-section MRI to estimate total body fat and percentage body fat in children and comparing with other clinical methods, found that MRI gave the best prediction of total body fat volume. (Chan et al, 1998)

Bioelectrical impedance

Effectiveness

Bioelectrical impedance (BIA) impedance analysis has been found to be the least acceptable method for predicting fatness. (Bray et al, 2002) Another study also found that BIA has a low correlation with total body fat use in children aged 8-12 years, and thus does not recommend it be used alone in estimating total body fat. (Chan et al, 1998) However, it has been found that BIA correlated better than anthropometric indices in estimation of free fat mass, fat mass and percent body fat. (Tyrrell et al, 2001) It has also been shown that BIA is well suited for estimating fat free mass of children aged 10-19 years. (Heyward, 1998)

In one study significant bias was found for some sub-groups with a greater loss of precision in specific age groups and pubertal stages, suggesting that BIA prediction models may not be appropriate for individual evaluation, but may be suitable for population studies. (Horlick et al, 2002)

A study comparing percentage of fat mass measured by BIA and DEXA found that a mean difference of 4.48 and a 12% lower estimate of fat mass by BIA. However, while these differences were not affected by age and body fat, there were gender differences, where BIA underestimated percentage of body fat 3 times higher in boys than girls. (Eisenkolbl, Kaerasurya & Widhalm, 2001)

In another study the calculation of body composition with bioelectrical impedance spectroscopy (BIS) was found not to be superior to BIA, although BIA overestimated fat mass in lean subjects, and underestimated fat mass in overweight subjects more than BIS, compared to DEXA. (Fors et al, 2002)

The mean difference of estimation of total body fat of children between using BIA or skin fold thickness measurements was found to be 4.6% for boys and 7.81 for girls. (Hammond, Rona & Chinn, 1994)

Cost

The cost of BIA equipment ranges from RM 18,000 to 22, 000 per unit depending on the model. Cost of electrode per patient is RM 6.60.

Dual energy x-ray absorptiometry

The fat mass estimated by dual energy x-ray absorptiometry (DEXA) has been found to be significantly lower than that measured by skin fold thickness and by bioelectrical resistance. (Goran et al, 1996) Another study showed that DEXA tends to underestimate lean body mass and overestimate body fat compared to BIA. (Bolanowski & Nilsson, 2001) It has also been found that the percentage of fat mass measured by DEXA could be under or overestimated by 6.7%. (Wong et al, 2002) A study found that body fat percentage measured by DEXA classified 17.1% of males and 19.8% of females as obese. (Taylor et al, 2002)

Comparison of Dual energy x -ray absorptiometry with bioelectrical impedance and skin fold thickness

A comparative study of BIA and DEXA for assessment of body composition in children found close correlation in the percentage of fat, free fat mass and body fat content. However, in the underweight group, the percentage of fat value determined by BIA tended to be greater than that determined by DEXA, while in the overweight group, the BIA value was lower. The same trend was also seen in obese children before and after therapy with exercise and diet. Thus, while BIA seems to be a reasonable method for daily clinical use, attention should be paid to the interpretation of percentage of fat values in under-weight and overweight children. (Okasora et al, 1999) Another study also found that the fat mass estimated by DEXA was significantly lower than that estimated by BIA and skin fold thickness. (Goran et al, 1996) It has also been found that the percentage of fat value measured by DEXA is higher than those derived from skin fold thickness measurement and BIA, the values for BIA being significantly smaller than the others. It has thus been suggested that these methods should not be used interchangeably. (Gutin et al, 1996)

Cost

The cost of the DEXA equipment is in the range of a minimum of RM 100, 000 per unit.

5.2.3 Waist circumference

A cross sectional study found that children with 33 percent or more body fat and a waist circumference of 71 cm. or more, were likely to have an adverse cardiovascular risk profile, while children with 20 per cent or less body fat and a waist circumference of 61 cm. or less were likely to have a healthy cardiovascular risk profile. (Higgins et al, 2001). Another cross sectional study demonstrated that waist circumference was the best simple measure of fat distribution that was not affected by race, gender and adiposity. (Daniels, Khoury & Morrison, 2000) The 80th percentile for waist circumference correctly

identified 89% of girls and 87% of boys with high trunk fat mass (sensitivity), and 94% of girls and 92% of boys with low trunk fat mass (specificity). The waist performed significantly better as an index of trunk fat mass than did waist hip ratio or the conicity index, and it was concluded that the waist circumference provides a simple, yet effective, measure of truncal adiposity in children and adolescents. (Taylor et al, 2000) Another comparative study of 4 commonly used waist circumference levels - lowest ribs, narrowest waist, midpoint between lowest rib and iliac crest and immediately above the iliac crest found that in all 4 sites, the measurement reproducibility was high. Waist circumference values were significantly correlated with fatness, and correlation was higher than with total body fat in both sexes. However, these values differ in magnitude depending on sex. (Wang et al, 2003)

5.2.4 *Skin-fold thickness measurement*

It has been shown that in adolescents aged 10-15 years the triceps skin fold thickness gives the best results for obesity screening. BMI and upper arm girth were reasonable alternatives except in the 14-15 year olds where they were marginally able to discriminate obesity. (Sardinha et al, 1999) It has also been found that skin fold measurement gives a reasonably good prediction of total body fat. (Chan et al, 1998)

5.3 **Treatment of Obesity**

5.3.1 *Surgery*

Laparoscopic gastric banding is found to be a safe and effective method of weight loss in morbidly obese adolescents with BMI falling from a pre-operative median of 44.7 to 30.2 kg/m² at 24 months following surgery. (Dolan et al, 2003; Stanford et al, 2003) In a recent long term follow-up study of 10 severely obese adolescents undergoing gastric bypass, surgery provided satisfactory weight loss in nine of these subjects. These adolescents were able to maintain their weight loss for as long as 10 years and weight loss in these adolescents significantly improved both severe sleep apnea and hypertension. (Strauss, Bradley & Brolin, 2001) In reviewing a 20-year database (1981 – 2001) on bariatric surgery, Sugerman et al, (2003) identified 33 adolescents patients who had been treated surgically, and found that at post-operative follow up of 5-10 years, five patients had regained all or most of the weight, while the remaining patients maintained significant weight loss for up to 14 years after surgery. This review concluded that surgery in adolescents is safe and is associated with significant weight loss as well as correction of co-morbid conditions and improved self-image and socialization

5.3.2 *Pharmacological treatment*

Surgical procedures and drugs used in adult obesity are not generally recommended in children and adolescents. Appetite suppressants and thermogenic drugs have not been approved for use in children. Digestive inhibitors like lipase inhibitors and fat substitutes have been used in children and adolescents in off-label use, and in only a few clinical studies. (Kiess et al, 2003)

A study on Orlistat treatment in obese pre-pubertal children showed that those who were treated with Orlistat had mild and tolerable gastrointestinal side effects. No negative

effects on psychological or physical well being were detected, and psychological evaluation demonstrated an increased avoidance of fattening food, body shape pre-occupation and oral control. It was also found that they were able to lose 4.0 kg in weight. However, its true benefit versus conventional therapy remains to be determined. (Norgren et al, 2003, McDuffie et al, 2002)

The addition of Sibutramine to a comprehensive behavioral program induced significantly more weight loss compared to behaviour therapy and placebo. However, it has been recommended that medications for weight loss should be used only on an experimental basis in adolescents and children until more extensive safety and efficacy data are available. (Berkowitz et al, 2003)

5.3.3 *Combined dietary education and physical activity*

A COCHRANE Review found that 3 of the 4 long term studies showed no difference in overweight, whereas, one study reported an improvement in favour of the intervention group. (Campbell et al, 2003)

5.3.4 *Dietary education*

A COCHRANE review found that in 2 studies of dietary education alone, the multimedia action strategy appeared to be effective but not other education strategies. (Campbell et al, 2003)

5.3.5 *Physical activity*

A COCHRANE Review found that long term studies showed a slightly greater reduction in obesity in the intervention group, but this was not shown in short term studies. (Campbell et al, 2003)

6. CONCLUSION

6.1 **Prevention Programme**

There is some evidence that multifaceted school based programmes that promote physical activity, modification of dietary intake, and targeting sedentary behaviour may help reduce obesity in school children, particularly girls. Multifaceted family based programmes involving parents which, increase physical activity, provide dietary education and target reductions in sedentary behaviour may help children to lose weight. There is also some evidence that family-based behaviour modification programmes, where parents take primary responsibility and act as change agents, may help children lose weight.

6.2 **Screening Methods**

There is sufficient evidence to conclude that BMI has high sensitivity and specificity in detecting overweight but not for detecting obesity.

There is insufficient evidence that the use of hydrodensitometry or air displacement plethysmography is effective in detecting body fat percentage. Similarly, there is

insufficient evidence that skin fold thickness is an effective measure for screening for obesity.

With respect to MRI, there is evidence that MRI gives the best prediction of total body fat volume as well as patterns of intra-abdominal and subcutaneous fat distribution but the high cost of this procedure limits its use mainly to the research setting.

There is some evidence that Bioelectrical Impedance (BIA) is suitable for population screening especially for measuring fat free mass in children aged 10-19 years.

The evidence on the effectiveness of dual energy x-ray absorptiometry (DEXA) is inconclusive.

However, there is evidence that waist circumference is a simple and effective measure for trunk fat mass.

There is also some evidence that skin fold thickness measurement, especially of the triceps, is effective in the screening for obesity.

6.3 Treatment

There is evidence that surgery is a safe and effective treatment for morbidly obese children to induce weight loss and also reduction in obesity together with related co-morbidity.

With respect to pharmacological treatment, appetite suppressants and thermogenic drugs have not been approved for use in children. Digestive inhibitors like lipase inhibitors and fat substitutes are being used off label. There is some evidence suggesting that Orlistat may assist with weight loss in obese children, but insufficient evidence on the efficacy of Subutramine.

There also insufficient evidence to suggest dietary education, physical activity or a combination of both improves weight control.

7. RECOMMENDATION

7.1 Prevention:

There is insufficient evidence to recommend in favour of or against community-based obesity prevention programs. However, in view of the major health risks associated with obesity, and the limited long-term effectiveness of weight-reduction methods, the prevention of obesity should be a high priority for health care providers.

7.2 Screening Methods:

BMI is recommended for detecting overweight, while skin fold thickness measurement, especially of the triceps, may be considered for screening for obesity.

7.3 Treatment:

There is insufficient evidence to recommend in favour of or against weight-reduction therapy because of a lack of evidence supporting the long-term effectiveness of weight-reduction methods. However, surgery is recommended for treatment of morbidly obese children.

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APPENDIX 1

SEARCH STRATEGY

1. Body Mass Index

The electronic databases of MEDLINE, HEALTHSTAR, EMBASE, COCHRANE library, BONDELIER IOTF site, health technology assessment site, GOOGLE site were searched from 1990-2003, using the following key words *obesity, cost effectiveness, screening, body mass index, sensitivity, specificity, diagnosis, assessment*. . The studies were limited to human subjects, aged 0-18 years old.

2. Body Composition Techniques

2.1 Densitometry

The initial search using MEDLINE, COCHRANE, Health Technology Assessment database, WHO web site, International Obesity Task Force (IOTF) site, National Heart Lung and Blood Institute, GOOGLE search engine were search, using the following keywords *obesity, body composition, densitometry, effectiveness, sensitivity, specificity, diagnosis, assessment, measurement, fat mass, free fat mass, body fat either singly or in combination*. Limit to children aged 0-18 years and last 10 years publication. A total of 284 titles were obtained but only 9 were found to be relevant and the abstracts were reviewed. Of these 4 were found to be relevant and full articles obtained.

2.2 Magnetic Resonance Imaging (MRI)

An electronic search was conducted using the MEDLINE database using the following keywords *obesity, body composition, MRI, effectiveness, sensitivity, specificity*, limit to children aged 0-18 years and last 10 years publications. This yielded a total of 133 titles; 11 were thought are relevance and the abstracts was reviewed. Of these 4 were found to be relevant but full articles could only be obtained for 3.

2.3 Bioelectrical Impedance

Publish literature from 1993- 2003 was identified by PUBMED, health technology assessment database, ITOF, COCHRANE database, GOOGLE search using the following keywords *obesity, childhood obesity, bioelectrical impedance, body fat, body composition, sensitivity, specificity, diagnosis, assessment, measurement, free fat mass, fat mass*, were either singly or in combination. Limit the publication to children aged 0-18 year and human studies.

2.4 Dual Energy Absorptionmetry

Literature search using PUBMED, health technology assessment sites, COCHRANE database, ITOF site, national heart, lung and blood institute site. Canadian task force on prevention health care sites, American Association of clinical Endocrinologists/ American College of Endocrinology (AACE/ACE) sites GOOGLE from 1993 -2003 with the keywords *childhood obesity, dual energy absorptionmetry, body fat, free fat mass, fat mass, measurement, diagnosis, assessment, evaluation* were used either singly or in combination. Limit to publication of children aged 0-18 year old and human studies

3. **Skin-Fold Thickness Measure**

An electronic search using PUBMED, health technology assessment sites, IOTF sites, CDC sites, GOOGLE national heart, lung and blood institute site. Canadian task force on prevention health care sites, American Association of clinical Endocrinologists/ American College of Endocrinology (AAACE/ACE) sites from 1993 -2003 with the following keywords *childhood obesity, skin-fold thickness measure, diagnosis, measurement, assessment, body fat, fat mass, body composition* were use either singly or in combination, and limit publication to children aged 0-18 year old and human studies.

4. **Waist Circumference**

A literature search using PUBMED, health technology assessment site IOTF sites, CDC sites, GOOGLE national heart, lung and blood institute site. Canadian task force on prevention health care sites, American Association of clinical Endocrinologists/ American College of Endocrinology (AAACE/ACE) sites from 1993 -2003 with the following keywords *childhood obesity, overweight, waist circumference, measurement, assessment, body fat, fat mass*, were use either singly or in combination, and limit publication to children aged 0-18 year old and human studies.

5. **Prevention and Treatment**

An electronic literature search using PUBMED, COCHRANE, IOTF sites, OVID , Canadian Task Force on prevention health care sites, GOOGLE from 1993 –2003 with the following keywords *childhood obesity, prevention, treatment, health promotion, family-based programme, school-based programme, behaviour modification, parent, children, pharmacology, surgery, physical activity, exercise, dietary modification* were used either singly or in combination, and limited publication to children aged 0-18 year old and human studies. In addition, cross references were searched.

APPENDIX 2

LEVELS OF EVIDENCE SCALE

Level	Strength of Evidence	Study Design
1	Good	Meta-analysis of RCT, Systematic reviews.
2	Good	Large sample of RCT
3	Good to fair	Small sample of RCT
4		Non-randomised controlled prospective trial
5	Fair	Non-randomised controlled prospective trial with historical control
6	Fair	Cohort studies
7	Poor	Case-control studies
8	Poor	Non-controlled clinical series, descriptive studies multi-centre
9	Poor	Expert committees, consensus, case reports, anecdotes

SOURCE: ADAPTED FROM CATALONIAN AGENCY FOR HEALTH TECHNOLOGY ASSESSMENT (CAHTA), SPAIN

EVIDENCE TABLE : SCHOOL BASED PROGRAMME

No	Author, Title, Journal	Study design, sample size, follow up	Characteristic & Outcomes	Grade & Comments
Health Promotion				
1	Robinson TN. (1999) Reducing children's television viewing to prevent obesity: a randomized controlled trial. <i>JAMA</i> . 282 (16), Oct 27, pp 1561-7.	Randomized controlled school-based trial conducted from September 1996 to April 1997	Compared with controls, children in the intervention group had statistically significant relative decreases in body mass index (intervention vs control change: 18.38 to 18.67 kg/m ² vs 18.10 to 18.81 kg/m ² , respectively; adjusted difference -0.45 kg/m ² [95% confidence interval [CI], -0.73 to -0.17]; P = .002), triceps skinfold thickness (intervention vs control change: 14.55 to 15.47 mm vs 13.97 to 16.46 mm, respectively; adjusted difference, -1.47 mm [95% CI, -2.41 to -0.54]; P=.002), waist circumference (intervention vs control change: 60.48 to 63.57 cm vs 59.51 to 64.73 cm, respectively; adjusted difference, -2.30 cm [95% CI, -3.27 to -1.33]; P<.001), and waist-to-hip ratio (intervention vs control change: 0.83 to 0.83 vs 0.82 to 0.84, respectively; adjusted difference, -0.02 [95% CI, -0.03 to -0.01]; P<.001). Relative to controls, intervention group changes were accompanied by statistically significant decreases in children's reported television viewing and meals eaten in front of the television. There were no statistically significant differences between groups for changes in high-fat food intake, moderate-to-vigorous physical activity, and cardio-respiratory fitness. CONCLUSIONS: Reducing television, videotape, and video game use may be a promising, population-based approach to prevent childhood obesity.	Good
Physical Activities				
1	Mo-suwan L, Pongprapai S, Junjana C, Puetpaiboon A. (1998) Effects of a controlled trial of a school-based exercise program on the obesity indexes of preschool children. <i>Am J Clin Nutr</i> . 68(5), Nov, pp 1006-11.	Randomised controlled trial N=292	At the end of the study, the prevalence of obesity, using 95th percentile National Center for Health Statistics triceps-skin-fold-thickness cutoffs, of both the exercise and control groups decreased. That of the exercise group decreased from 12.2% at baseline to 8.8% (Wilcoxon signed-rank test, P = 0.058), whereas that of the control group decreased from 11.7% to 9.7% (Wilcoxon signed-rank test, P = 0.179). A sex difference in the response of body mass index (BMI) to exercise was observed. Girls in the exercise group had a lower likelihood of having an increasing BMI slope than the control girls did (odds ratio: 0.32; 95% CI: 0.18, 0.56). In conclusion, our study suggests that a 29.6-wk school-based exercise program can prevent BMI gain in girls and may induce a remission of obesity in preschool-age children.	Good

No	Author, Title, Journal	Study design, sample size, follow up	Characteristic & Outcomes	Grade & Comments
2	Sallis JF, McKenzie TL, Alcaraz JE, Kolody B, Hovell MF, Nader PR. (1993) Project SPARK. Effects of physical education on adiposity in children. <i>Ann N Y Acad Sci.</i> 699, Oct 29, pp127-36.	Randomised Controlled Trial N= 550 Children	At no measurement point were there significant group differences in total skinfold. At both fifth grade measurement points for boys and girls, however, there was a trend for the control group to have higher skinfold values than the two intervention groups. At the final measure, the difference between the highest and lowest groups was about 3 mm for girls and 2 mm for boys. BMIs were significantly lower at some measurement points for boys and girls, but this could be due to increased lean body mass in intervention students. After two years, there was a trend for the children exposed to the PE intervention to have lower levels of body fat, but the differences were not significant.	
Multicomponent program				
1	Braet C, Tanghe A, Bode PD, Frnackx H, Winckel MV (2003) Inpatient treatment of obese children: a multicomponent programme without strigent calorie restriction <i>Eur J Pediatr</i> 162 (6), Jun, pp 193-6	38 patient treatment consist of 10 month inpatient program focussing on attaining a healthy lifestyle by increasing physical activity and offering a healthy diet.	All patient loss weight during treatment, in contrast to non-treatment group The children treated develop higher self esteem and were more capable of coping with external eating stimuli At 6 months follow up, a median increase in the adjusted BMI of +6% was found , with a additional increase of +4% at 14 month follow up	Poor
2	Eliakim A, Kaven G, Berger I, Friedland O, Wolach B, Nemet D (2002) The effect of combined intervention on body mass index and fitness in obese children and adolescents- a clinical experience <i>Eur J Pediatric</i> 161(8), Aug, pp 449-54	Longitudinal non randomised N= 177 obese children	Body weight and BMI were significantly reduce and endurance time significantly increased following the 3 months intervetntion. Obese children who continued the programme for 6 months maintained the decrease in BMI and further improved endurance time. In contras obese children who did not participate in the structure programme gained weight, increase their BMI and improve fitness less significantly, Combine structured multidisciplinary intervention for childhood obesity results in decreased body weight, decreased BMI and improve fitness	Poor

No	Author, Title, Journal	Study design, sample size, follow up	Characteristic & Outcomes	Grade & Comments
3	<p>Muller MJ, Asbeck I, Mast M, Langnase K, Grund A (2001)</p> <p>Prevention of obesity -more than an intention. Concept and first results of the Kiel Obesity Prevention Study (KOPS)</p> <p><i>Int J Obes Relat Metab Disord</i> 25 suppl 1, May, pp S66-74</p>	<p>RCT</p> <p>N= 297</p> <p>F/up: 1 year</p>	<p>There were no statically significant differences in mean BMI scores between the two group. '</p> <p>There were significant differences in terms of triceps skinfold thickness in the intevention group.</p>	Good
4	<p>Sahota P, Rudolf MC, Dixey R, Hill AJ, Barth JH, Cade J (2001)</p> <p>Randomised controlled trial of primary school based intervention to reduce risk factors for obesity</p> <p><i>BMJ</i> 323(7320), Nov 3, pp 1029-32</p>	<p>Randomised controlled trial</p> <p>N=10 primary school in leeds - 634</p>	<p>Intervention :teacher training, modification of school meals, development of school action plans targeting the curriculum, physical education, tuck shops and playground activities</p> <p>There were no different in change in BMI scores between the two group</p>	Good
5	<p>Gortmaker SI, Cheung LWY, Peterson KE, et al (1999)</p> <p>Impact of a school based interdisciplinary intervention on diet and physical activity among urban primary school children: eat well and keep moving</p> <p><i>Arch Pediatric Adolescent Med</i>, 153, pp 975-83</p>	<p>RCT</p> <p>N=1295</p> <p>F/up: 18 months</p>	<p>Change in prevalence of obesity in girls in the invention group compare to control</p>	Good

No	Author, Title, Journal	Study design, sample size, follow up	Characteristic & Outcomes	Grade & Comments
6	Neumark-Sztainer D, Story M, Hannan PJ, Rex J. (2003) New Moves: a school-based obesity prevention program for adolescent girls. <i>Prev Med.</i> 37(1,Jul pp 41-51.	Randomised Controlled Trial N= 6 school – 201 school girls F/up = 8 months	The feasibility of implementing New Moves was high, as indicated by strong satisfaction among participants, parents, and school staff, and by program sustainability. Participants perceived a positive program impact on their physical activity, eating patterns, and self-image. Girls in the intervention significantly progressed in their stage of behavioral change for physical activity from baseline to follow-up. However, for the majority of outcome variables, differences between intervention and control schools at post intervention and follow-up were not statistically significant. CONCLUSIONS: New Moves was well received and fills a needed niche within school physical education programs. An expanded intervention and evaluation is needed to enhance and assess long-term program effectiveness.	Good

EVIDENCE TABLE :FAMILY BASED INTERVENTION

No	Author, Title, Journal	Study Design, Sample Size, Follow up	Characteristic & Outcomes	Grade & comment
Health Promotion				
1	Stolley MR, Fitzgibbon ML. (1997) Effects of an obesity prevention program on the eating behavior of African American mothers and daughters. <i>Health Educ Behav</i> , 4(2): Apr, pp 152-64	Clinical Trial N=12 weeks	Results showed significant differences between the treatment and control mothers for daily saturated fat intake and percentage of calories from fat. Differences among treatment and control groups were also noted for the daughters on percentage of daily calories from fat. Implications of the findings for developing culturally specific health risk reduction programs are discussed.	Fair

No	Author, Title, Journal	Study Design, Sample Size, Follow up	Characteristic & Outcomes	Grade & comment
2	Epstein LH, Gordy CC, Raynor HA, Beddome M, Kilanowski CK, Paluch R. (2001) Increasing fruit and vegetable intake and decreasing fat and sugar intake in families at risk for childhood obesity. <i>Obes Res.</i> 9(3), Mar, pp 171-8.	Clinical Trial- Randomised controlled trial Families with obese parents and non-obese children	Changes over 1 year showed that treatment influenced targeted parent and child fruit and vegetable intake and high-fat/high-sugar intake, with the Increase Fruit and Vegetable group also decreasing their consumption of high-fat/high-sugar foods. Parents in the increased fruit and vegetable group showed significantly greater decreases in percentage of overweight than parents in the decreased high-fat/high-sugar group. DISCUSSION: These results suggest that focusing on increasing intake of healthy foods may be a useful approach for nutritional change in obese parents and their children.	
Health promotion & Physical activity				
1	Epstein LH, Valoski AM, Vara LS, McCurley J, Wisniewski L, Kalarchian MA, Klein KR, Shrager LR. (1995) Effects of decreasing sedentary behavior and increasing activity on weight change in obese children. <i>Health Psychol.</i> 14(2), Mar, pp 109-15.	Randomised Controlled Trial N= 31 Families	Significant decreases in percentage overweight were observed after 4 months between the sedentary and the exercise groups (-19.9 vs. -13.2). At 1 year, the sedentary group had a greater decrease in percentage overweight than did the combined and the exercise groups (-18.7 vs. -10.3 and -8.7) and greater decrease in percentage of body fat (-4.7 vs. -1.3). All groups improved fitness during treatment and follow-up. Children in the sedentary group increased their liking for high-intensity activity and reported lower caloric intake than did children in the exercise group. These results support the goal of reducing time spent in sedentary activities to improve weight loss.	Good
2	Epstein LH, Paluch RA, Gordy CC, Dorn J. (2000) Decreasing sedentary behaviors in treating pediatric obesity. <i>Arch Pediatr Adolesc Med.</i> 154(3), Mar, pp 220-6.	Randomised Controlled Trial N= 90 families	Results during 2 years showed that targeting either decreased sedentary behaviors or increased physical activity was associated with significant decreases in percent overweight and body fat and improved aerobic fitness. Self-reported activity minutes increased and targeted sedentary time decreased during treatment. Children substituted nontargeted sedentary behaviors for some of their targeted sedentary behaviors. CONCLUSION: These results support reducing sedentary behaviors as an adjunct in the treatment of pediatric obesity.	Good

No	Author, Title, Journal	Study Design, Sample Size, Follow up	Characteristic & Outcomes	Grade & comment
3	Johnson WG, Hinkle LK, Carr RE, Anderson DA, Lemmon CR, Engler LB, Bergeron KC. (1997) Dietary and exercise interventions for juvenile obesity: long-term effect of behavioral and public health models. <i>Obes Res.</i> 5(3), May, pp :257-61.	Clinical Trial	Nutrition and eating habit and follow by exercise and exercise follow by nutrition and eating habit change participants evidenced modest, yet significant, reductions in weight and blood lipids, and the impact of these two interventions endured at a five-year follow-up. In contrast, information control participants displayed stable weight and blood lipids during the course of the program, and most remained morbidly obese at follow-up. Improved nutrition, increased physical activity and fitness were significantly correlated with weight and lipid reductions.	Poor

EVIDENCE TABLE: BEHAVIOR MODIFICATION PROGRAMME

No	Author, Title, Journal	Study Design, Sample Size, Follow up	Characteristic & Outcomes	Grade & comment
<u>Parents as change agents</u>				
1	Epstein LH, McKenzie SJ, Valoski A, Klein KR, Wing RR. (1994) Effects of mastery criteria and contingent reinforcement for family-based child weight control. <i>Addict Behav.</i> 1994 Mar-Apr, 19(2), pp 135-45.	Randomised Controlled Trial N= 39 F/up : 2 year	Results showed significantly better relative weight change at 6 months and 1 year for children in the experimental compared to the control group, but these effects were not maintained at 2 years. These results suggest the introduction of mastery criteria and contingent reinforcement for mastery can improve outcome during treatment in behavioral treatments for childhood obesity.	Good
2	Israel AC, Guile CA, Baker JE, Silverman WK. (1994) An evaluation of enhanced self-regulation training in the treatment of childhood obesity. <i>J Pediatr Psychol.</i> 19(6), Dec, pp 737-49.	Randomise controlled trial N= 34 F/up : 3 year	Children in both conditions achieved a significant reduction in percentage overweight and triceps skin-fold during the 6-month treatment period. Overall, the follow-up period of 3 years was characterized by increases above posttreatment levels. There was, however, some suggestion in the 3-year follow-up results and the long-term patterns over a 6 1/2-year period of the benefits of the enhanced child involvement approach. Findings are discussed in terms of suggestions for reconsideration of treatment goals, improved interventions, and refinements in the assessment of self-regulatory behavior.	Good

No	Author, Title, Journal	Study Design, Sample Size, Follow up	Characteristic & Outcomes	Grade & comment
3	Golan M, Weizman A, Apter A, Fainaru M. (1998) Parents as the exclusive agents of change in the treatment of childhood obesity. <i>Am J Clin Nutr.</i> 67(6), Jun, pp 1130-5.	Randomised Controlled Trial N= 60 F/up: 1yrs	The dropout rate was nine times greater in the control group (n = 9) than in the experimental group (n = 1). Mean percentile weight reduction was significantly (P < 0.03) higher in children in the experimental group (14.6%) than in the control group (8.1%). CONCLUSIONS: Treatment of childhood obesity with parents as the exclusive agents of change was superior to the conventional approach, as indicated by the dropout rate and the percentage weight loss of the children during the 1-y intervention	Good
Family based behaviour modification programme				
1	Flodmark CE, Ohlsson T, Ryden O, Sveger T. (1993) Prevention of progression to severe obesity in a group of obese schoolchildren treated with family therapy. <i>Pediatrics.</i> 91(5), May, pp 880-4.	Clinical Trial N=1774 F/up: 1year	At the 1-year follow-up, when the children were 14 years of age, intention-to-treat analyses were made of the weight and height data for 39 of 44 children in the two treatment groups and for 48 of the 50 control children. The increase of BMI in the family therapy group was less than in the conventional treatment group at the end of treatment, and less than in the control group. Moreover, mean BMI was significantly lower in the family therapy group than in the control group (P < .05), and the family therapy group also had fewer children with BMI > 30 than the control group. The reduction of triceps, subscapular, and suprailiac skinfold thicknesses, expressed as percentages of the initial values, was significantly greater in the family therapy group than in the conventional treatment group, and their physical fitness was significantly better . Family therapy seems to be effective in preventing progression to severe obesity during adolescence if the treatment starts at 10 to 11 years of age.	Fair
2	Duffy G, Spence SH. (1993) The effectiveness of cognitive self-management as an adjunct to a behavioural intervention for childhood obesity: a research note. <i>J Child Psychol Psychiatry.</i> 34(6), Sep, pp 1043-50.	Randomised Controlled Trial N= 27	Evaluations following the eight treatment sessions revealed a significant reduction in percentage overweight for children in both experimental groups and improvements were maintained at 3- and 6-month follow-ups. Both conditions were also effective in reducing the number of high-risk foods consumed. No difference in outcome was found between treatments at the post-treatment assessment or 3- and 6-month follow-ups. Although a reduction in percentage overweight of around 9% was found for both procedures, subjects in general remained considerably overweight.	Good to fair

No	Author, Title, Journal	Study Design, Sample Size, Follow up	Characteristic & Outcomes	Grade & comment
3	<p>Braet C, Van Winckel M, Van Leeuwen K. (1997)</p> <p>Follow-up results of different treatment programs for obese children.</p> <p><i>Acta Paediatr.</i> 86(4), Apr, pp 397-402.</p>	<p>Clinical Trial</p> <p>N= 259</p> <p>F/up: 1 year</p>	<p>A progressive and significant loss of weight for all therapeutic conditions was noticeable. The reduction continued at least 6 months after completing therapy. The control group, however, showed weight evolution in the opposite sense. CONCLUSIONS: A replication of the positive effect of CBT was found in a broad sample of clinically obese children, even without strict diet prescription. Our hypothesis that group approach will result in a better outcome is borne</p>	Poor
4	<p>Epstein LH, Paluch RA, Gordy CC, Saelens BE, Ernst MM. (2000)</p> <p>Problem solving in the treatment of childhood obesity.</p> <p><i>J Consult Clin Psychol.</i> 68(4), Aug, pp 717-21.</p>	<p>Randomised Controlled Trial</p> <p>N= 67 Families</p> <p>F/up: 2 year</p>	<p>The standard group showed larger body mass index (BMI) decreases than the parent + child group through 2 years, with significant differences in the percentage of children who showed large BMI changes. Significant statistical and clinical improvements were observed over time in child behavior problems and parental distress. Parent problem solving increased in the parent + child condition relative to the other conditions, whereas child problem solving increased equally in all conditions. The bulk of evidence suggests that problem solving did not add to treatment effectiveness beyond the standard family-based treatment.</p>	Good
5	<p>Goldfield GS, Epstein LH, Kilanowski CK, Paluch RA, Kogut-Bossler B. (2001)</p> <p>Cost-effectiveness of group and mixed family-based treatment for childhood obesity.</p> <p><i>Int J Obes Relat Metab Disord.</i> 25(12), Dec, PP 1843-9.</p>	<p>Randomised Controlled Trial</p> <p>N= 31 families</p> <p>F/up:1 year</p>	<p>A significant reduction in percentage overweight and Z-BMI was found for both types of intervention over time, though there were no significant differences between interventions.</p>	Good

No	Author, Title, Journal	Study Design, Sample Size, Follow up	Characteristic & Outcomes	Grade & comment
No parental involvement				
1	<p>Warschburger P, Fromme C, Petermann F, Wojtalla N, Oepen J. (2001)</p> <p>Conceptualisation and evaluation of a cognitive-behavioural training programme for children and adolescents with obesity.</p> <p>Int J Obes Relat Metab Disord.25 Suppl 1, May, pp S93-5</p>	N= 197	<p>Pre- vs post-intervention-tests showed significant improvements in self-reported eating behaviours for the EG compared with the CG (F=6.38, P<0.05); these changes were independent of age and sex. The weight status measured as the percentage of overweight dependent on height was reduced in both groups immediately after the intervention and at follow-up (F=16.51, P<0.01). Reduction in the prevalence of obesity tended to be higher in the EG than in the CG (15% vs 10%). Self-reported quality of life increased from before the intervention to follow-up more in the EG than in the CG (F=3.27, P=0.08). In all, the acceptance of the behavioural patient education programme was good. CONCLUSION: In summary, evaluation results indicate that the cognitive-behavioural training programme is a promising approach to alter obesity-related habits and to reduce somatic and psychosocial consequences. Long-term effects after two years are expected to underscore these results</p>	Poor

EVIDENCE TABLE – BMI

No	Author, Title, Journal,	Study design, sample size, follow-up	Outcome& Characteristics	Grade & Comments
1	<p>Cole TJ, Bellizi MC, Flegal KM, Dietz WH (2000)</p> <p>Establishing a standard definition for child overweight and obesity worldwide: International survey</p> <p><i>British Medical Journal</i> 320, May 6, pp 1240-1243</p>	<p>Cross sectional studies. It is an international survey involving six countries i.e. Brazil, Great Britain, Hong Kong, Netherlands, Singapore, US</p> <p>Sample size: 98, 876 males and 94, 851 Females</p>	<p>The results is to develop cut off points for obesity and weight for obesity by sex between in children 2-15 years old defined to pass through body mass index at 25 and 30/kgm² at age 18</p> <p>This is an average data from all the countries.</p>	Fair

No	Author, Title, Journal,	Study design, sample size, follow-up	Outcome& Characteristics	Grade & Comments
2	Mulligan J, Voss LD (1999) Identifying very fat and very thin children: test of criterion standards for screening test <i>British Medical Journal.</i> 319, Oct 3, pp 1103-1104.	Cross sectional studies. Samples: children aged 2.9 years old.	Shorter children have lower body mass index and lower body mass index deviation score compared to the tall children This study will identify a disproportionately tall apparently overweight children and under detecting shorter overweight children	Fair
3	Laurence ZM, Strawn M G Pietrobelli A, Goulding A, Goran MI, Dietz WH (2002) Validity of body mass index compared with other body composition of screening indexes for assessment of body fatness in children and adolescents <i>American Journal of Clinical Nutrition.</i> 75 (6), Jun, pp 978-85	Retrospective data. Sample size : first data study was 11096 and the second data study was 920.	The Sensitivity and Specificity of the study was determined by constructing a receiver operator curve (ROC) to classify underweight and overweight. BMI is better than weight for height and RI for age in detecting overweight when skinfold thickness was used as standards. However there were no difference in underweight children. The percentage body fat and total fat mass were determined by dual energy x-ray absorptiometry The skinfold thickness was based on average of triceps and subscapular skinfold thickness BMI is better than RI for age in detecting overweight in children aged 3-19 years old but no difference between BMI for age and weight for overweight and underweight. When % body fat or total fat mass was used as standards BMI was significantly better	Poor Abstract
4.	Pietrobelli A, Faith MS, Allison DB, a Gallagher D, Chiumello G, Heymsfield. S (Body mass index as a measure of adiposity among children and adolescents: A validation study <i>J. Pediatr</i> 998, 132, pp 204-10	Cross-sectional study. N= 198 healthy Italian children aged: 5-19 yrs old	BMI was strongly associated with TBF ($R^2=0.85$ for boys and 0.89 for girls) BMI and PBF are correlated (R 0.63 for boys and 0.69 for girls) Confidence limits on BMI fatness association were wide. Age is a significant covariate in all regression models. There is a need to be cautious when interpreting BMI across age and when predicting specific TBF or PBF	Fair

No	Author, Title, Journal,	Study design, sample size, follow-up	Outcome& Characteristics	Grade & Comments
5	Sardinha LB, Going SB, Texeira PJ, Lohman TG (1999) Receiver Operating Characteristic analysis of body mass index, tricep skin fold thickness and arm girth for obesity screening in children and <i>Am J of Clin Nutrition.</i> 70, pp 1090-95	Cross sectional study N= 165 Portugese boys and 163 girls aged 10-15 years old Dual energy X-ray absorptiometry was used a criterion method that estimate percentage of body fat	The aims of the study are to assess the usefulness of BMI, tricep skin-fold thickness and upper arm girth for screening of obesity by using a health related definition of obesity (>25% of body fat in boys and >30% body fat in girls). The results showed that True positive rates range from 67-87% in girls and 50-100% in boys. False positive rates range from 0-19% in girls and 5-26% in boys. In children age 10-11 yrs old Area under the Curve (AUC) for ROC was almost 1. For older boys and girls, AUC for tricep skinfold thickness were similar to or greater than AUC for BMI and upper arm girth BMI and upper arm girth were reasonable alternatives except in 14-15 yrs old where they marginally able to discriminate obesity.	Fair
6.	Stephen R Daniels, Philip R Koury, John A Morrison (1997) The utility of body mass index as a measure of body fatness in children and adolescents: Differences by race and gender <i>Pediatrics</i> , 6, pp 804-7.	Cross sectional study Sample size of 192 healthy subjects (100 boys and 100 girls)	The results showed that BMI was significantly and positively correlated with age, stage of maturation and all anthropometric variables in each race and sex group. Maturation age has a strong correlation with BMI than age. Percent body fat-BMI relationship was dependent on stage of sexual maturation, gender (for equivalent BMI, girls have greater amount of body fat than boys.), race (White more fat than blacks) and waist: hip ratio. (central obesity has greater fat than peripheral obesity	Fair
7	Wildham K, Schonegger K, Huemer C , Auterith A (2001) Does the BMI reflect body fat in obese children and adolescents? A study using the TOBEC method <i>Int J Obes relat Metabolic Disorder.</i> 25 (2), Feb, pp 279-85	Cross sectional study Sample size :204 obese children and adolescents (105 boys , 99 girls) aged 6-17 years TOBEC (total body electrical conductivity) was used to measure fat	The results showed that BMI and Percentage body fat is positively correlated ($r=0.65$, $p=0.001$; boys $r=0.63$ and girls $r=0.68$ There was poor association in children >10 years old. It may be useful in epidemiological study but limited in older age group >10 Years old.	Fair

Deleted:

No	Author, Title, Journal,	Study design, sample size, follow-up	Outcome& Characteristics	Grade & Comments
8	<p>Sarria A, Moreno LA, Garcia Llop, Fleta J, Morrellone Mp, Bueno M (2001)</p> <p>Body mass index, triceps skinfold and waist circumference screening for adiposity in male children and adolescents</p> <p><i>Acta Paediatr.</i> 90 (4), Apr, pp387-92</p>	<p>Cross sectional study</p> <p>N= 175 male volunteers aged 7-16.9 years old.</p>	<p>The aim of the study was to evaluate the screening performance of BMI, triceps skinfold thickness and waist circumference for excess TBF%. The results showed that the area under curve calculated were BMI=0.86, Triceps =0.9, waist circumference =0.88</p> <p>The point of ROC closest to 1 correspond to 70th percentile for BMI, 75th percentile for triceps skinfold and 70th percentile for waist circumference</p> <p>BMI, triceps and waist circumference can predict total fat content</p>	Fair
9	<p>Daniels SR, Khoury PR, Morrison JA (2000)</p> <p>Utility of different measures of body fat distribution in children and adolescents</p> <p><i>Am J Epidemiol.</i> 152 (12), Dec 15, pp 1179-84</p>	<p>Cross sectional study</p> <p>N= 201 children and adolescents aged 7-17 years old</p>	<p>The aim is to evaluate various methods evaluating body fat distribution compared to dual energy x-ray absorptiometry.</p> <p>Age was an important determinant of fat distribution than pubertal maturation.</p> <p>There was a greater deposition of body fat with increasing age</p> <p>Multiple regression demonstrated that waist circumference was the best simple measure of fat distribution which were not affected by race , gender and adiposity</p>	Fair6
10	<p>Schaefer F, Georgi M, Wuhl E, Scharer K (1998)</p> <p>Body mass index and percentage fat mass in healthy German schoolchildren and adolescents</p> <p><i>Int J Obesity Relat Metab Disorder.</i> 22 (5), May, pp 461-9.</p>	<p>Cross sectional observational study</p> <p>Sample size: 2554 healthy schoolchildren and adolescents 6-19 years old</p>	<p>BMI has limited usefulness in individual children</p> <p>BMI predicted PFM in girls (r=0.84), obese child (r=0.58) but not leaner in two third of male population</p> <p>75th BMI appropriate cut-off points can screen 15% of most obese children (sensitivity 82%, specificity 85%)</p>	Fair

No	Author, Title, Journal,	Study design, sample size, follow-up	Outcome& Characteristics	Grade & Comments
11	<p>Mast M, Langnase K, Labitzke K, Bruse U Preuss U Mueller MJ (2002)</p> <p>Use of BMI as a measure of overweight and obesity in a field study on 5-7 year old children</p> <p><i>Eur J Nutr</i> 41 (2), April, pp:61-7</p>	<p>Cross sectional study</p> <p>N= 2286 children</p> <p>BMI was compared to anthropometric measures (TSF, BSF, SIF, SSF) and bioelectrical impedance (BIA) 90th and 97th BMI percentile were used as cut off points or obesity and overweight.</p>	<p>The aims are to examine the use of BMI in comparison with estimates of percent mass to screen for overweight and obesity in children</p> <p>BMI is low in sensitivity to identify overweight children when compared with two estimates of % fat mass</p> <p>The specificity of BMI was 93 to 95 %.</p> <p>BMI has higher sensitivity to screen for obese children. Boys: Sensitivity 83-85%, Girls 62-80%</p> <p>The specificity for boys: 95-98% . and specificity for girls 96-97%</p> <p>BMI only identified obese but not overweight children</p> <p>BMI can be used to screen for obese children.</p>	Fair
12	<p>Luciano A, Piccoli A, Bonetti P, Romano R, Bolognani M, Castellarin A, Zoppi G (2001)</p> <p>BMI centile as an indicator of degree of obesity in childhood.</p> <p><i>Ped Med Chir.</i> 23 (3-4), may – Aug, pp 183-5</p>	<p>Cross sectional study</p> <p>N=70 males aged 9.7+/- 2.75 years and 55 females aged 9.9 +/- 3 years</p> <p>The aims are to evaluate BMI centile as an indicator of obesity in childhood</p>	<p>The results showed that the linear regression analysis and correlation between percentage fat mass and BMI centile were significant in males (p=0.000, r=0.6) and females (0.0000, r=0.7) in both obese and non obese subjects</p> <p>BMI is reliable, easy to use indicator of degree of obesity in childhood</p>	Fair

EVIDENCE TABLE: COMBINATION MEASURE

No	Author, Title, Journal,	Study design, sample size, follow-up	Outcome& Characteristics	Grade & Comments
1	Chan YL, Leung SS, Lam WW, Peng XH, Mereweli C (1998) Body fat estimation in children by magnetic resonance imaging bioelectrical impedance, skinfold and body mass index: a pilot study <i>J Paediatric Child Health</i> , 34 (1), Feb, pp 22-8	Case study	BMI and bioelectrical impedance (BEI) together gave the best prediction of total body fat as measured on MRI from the equation	Poor
2	Chan YL, Leung SS, Lam WW, Peng XH, Mereweli C (1998) Body fat estimation in children by magnetic resonance imaging bioelectrical impedance, skinfold and body mass index: a pilot study <i>J Paediatric Child Health</i> . 34 (1), Feb, pp 22-8		BEI and skinfold were not significant different but their results were not interchangeable	

EVIDENCE TABLE – MRI

No	Author, Title, Journal	Study Design, Sample Size, Follow up	Characteristic & Outcomes	Grade & comment
1	Ross R, Leger L, Morris D, de Guise J, Guardo R. (1992) Quantification of adipose tissue by MRI: relationship with anthropometric variables. <i>J Appl Physiol.</i> ; 72(2), Feb, pp 787-95.	N=27	The single best predictor of total adiposity was waist circumference ($R^2 = 0.92$). For visceral AT volume, WHR was the strongest anthropometric correlate. When controlled for age and adiposity, however, WHR explained only 12% of the variation in absolute visceral AT and less than 1% of the variation in visceral-to-subcutaneous ratio. Age was a better predictor of visceral-to-subcutaneous ratio than level of adiposity or WHR. The results of this study demonstrate that MRI offers a reliable measure of regional and total AT distribution in humans and, thus, is of value as a research tool.	Poor

No	Author, Title, Journal	Study Design, Sample Size, Follow up	Characteristic & Outcomes	Grade & comment
2	Fox KR, Peters DM, Sharpe P, Bell M. (2000) Assessment of abdominal fat development in young adolescents using magnetic resonance imaging. <i>Int J Obes Relat Metab Disord.</i> 24(12), Dec, pp 1653-9.	N= 42 children	Intra-abdominal fat and subcutaneous fat areas had significantly increased in boys and girls by the second measure. Boys had deposited greater amounts of fat in intra-abdominal depots so that their intra-abdominal/subcutaneous ratio had increased significantly from 0.31 to 0.39. This had reduced in girls from 0.39 to 0.35. However, patterns of change were variable within sexes. Truncal skin-fold sites (r = 0.54-0.70) emerged as the best field indicators of intra-abdominal fat deposition. CONCLUSIONS: Patterns of intra-abdominal and subcutaneous fat distribution are identifiable in pubescent children using magnetic resonance imaging. An acceptable indication is provided by truncal skin-folds.	Poor
3	Chan YL, Leung SS, Lam WW, Peng XH, Metreweli C. (1998) Body fat estimation in children by magnetic resonance imaging, bioelectrical impedance, skinfold and body mass index: a pilot study. <i>J Paediatr Child Health.</i> 34(1), Feb, pp 22-8.	N= Children aged 8-12 years	In children 8-12 years old, BMI gives a good estimation of the total body fat as measured on MRI. The estimation will be improved when both BEI and BMI are used in the prediction. Bioelectrical impedance has a low correlation with total body fat and its use alone in estimating total body fat is not recommended. Skinfold measurement also gives a reasonably good prediction of total body fat and addition of BMI and BEI does not improve the prediction. Both BEI and skinfold measurements give a modest prediction of %body fat measured by MRI method.	Poor

EVIDENCE TABLE - WAIST CIRCUMFERENCE

No	Author, Title, Journal	Study design, sample size, follow up	Outcomes & Characteristic	Grade & Comment
1	Daniels SR, Khoury PR, Morrison JA (2000) Utility of different measures of body fat distribution in children and adolescents <i>Am J Epidemiol.</i> 152 (12), Dec 15, pp 1179-84	Cross sectional study Sample size: 201 children and adolescents aged 7-17 years old	The aim is to evaluate various methods evaluating body fat distribution compared to dual energy x-ray absorptiometry. Age was an important determinant of fat distribution .than pubertal maturation. There was a greater deposition of body fat with increasing age. Multiple regression demonstrated that waist circumference was the best simple measure of fat distribution which were not affected by race , gender and adiposity	Fair

No	Author, Title, Journal	Study design, sample size, follow up	Outcomes & Characteristic	Grade & Comment
2	<p>Wang J, Thornton JC, Bari S, Williamson B, Gallagher D, Heymsfield SB, Horlick M, Kotler D, Laferrere B, Mayer L, Pi-Sunyer FX, Pierson RN Jr (2003)</p> <p>Comparisons of waist circumferences measured at 4 sites</p> <p><i>Am J Clin Nutr</i> 77(2), Feb, pp 379-84</p>	<p>Comparative study</p> <p>N= 111</p>	<p>All 4 sites, measurement reproducibility was high . WC value were significantly correlated with fatness, with trunk fat were higher than correlation with total body fat in both sexes</p> <p>WC values at the 4 commonly used anatomic sites differ in magnitude depending on sex, are highly reproducible, and are correlated with total body and trunk adiposity in a sex dependent manner.</p>	Fair
3	<p>Higgins PB, Gower BA, Hunter GR, Goran MI (2001)</p> <p>Defining health-related obesity in prepubertal children.</p> <p><i>Obes Res.</i> 9 (4), Apr, pp 233-40.</p>	<p>A cross-sectional analysis</p> <p>N= 87</p>	<p>The risk factors selected for analyses (i.e., fasting insulin, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, triglycerides, and total cholesterol/high-density lipoprotein cholesterol) were significantly related to percentage of body fat and waist circumference. Likelihood ratios were used to identify percentage of fat and waist circumference cut-points associated with adverse cardiovascular risk profiles. Two cut-points, an upper cut-point of 33% body fat and a lower cut-point of 20% body fat, were derived. Waist circumference cut-points indicative of adverse and normal risk-factor profiles were 71 cm and 61 cm, respectively. DISCUSSION: The data indicate that children with > or =33% body fat and children with a waist circumference > or =71 cm were more likely to possess an adverse CVD risk-factor profile than a normal risk-factor profile. The likelihood of children with < 20% body fat or a waist circumference < 61 cm possessing an adverse CVD risk-factor profile as opposed to a normal risk-factor profile was small. The cut-points describe an adequate health-related definition of childhood obesity.</p>	Poor

EVIDENCE TABLE :BIA

No	Author, Title, Journal	Study Design, Sample size, follow up	Outcomes & Characteristic	Grade & comment
1	Chan YL, Leung SS, Lam WW, Peng XH, Mereweli C (1998) Body fat estimation in children by magnetic resonance imaging bioelectrical impedance, skinfold and body mass index: a pilot study <i>J Paediatric Child Health.</i> 34 (1), Feb, pp 22-8		In children 8-12 year old, Bioelectrical impedance has a low correlation with total body fat and its use alone in estimating total body fat is not recommended	Poor
2	Hammond J, Rona RJ, Chinn S (1994) Estimation in community surveys of total body fat of children using BIA or skinfold thickness measurements <i>Eur J Clin Nutr,</i> 48 (3). Mar, pp 164-71	Cross section study Sample size: 75	The mean difference impedance minus skin-fold was 4.6% for boys and 7.81 for girls	Poor
3	Eisenkolbl J, Kaerasurya M, Widhalm K (2001) Under estimation of % fat mass measured by BIA 2000 M compared to DEXA in obese children <i>Eur J Clin Nutr</i> 55 (6), Jun, pp 423-9	Transversal study N=27	Mean difference between BF% by both methods was 4.48 SD, 2.93 results by BIA were lower by 12%. The lower & upper limit of the difference in 95% CI was 5.64 & 3.32. Differences were not affected by age & BF but by sex. Underestimation BF% by BIA is 3 x higher with boys than girls	Poor

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No	Author, Title, Journal	Study Design, Sample size, follow up	Outcomes & Characteristic	Grade & comment
4	Tyrrell VJ, Richards G, Hofman P, Gillies GF, Robinson E, Cutfield WS (2001) Foot to Foot BIA: a valuable tool for the measurement of body composition in children <i>Int J Obes Relat Metab Discord.</i> 25(2), Feb, pp 273-8	N= 28	BIA correlated better than anthropometric indices in estimation of free fat mass, fat mass & percent body fat	Poor
5	Iwata K et al (1993) Composition measured by BIA in children <i>Acta Paediatric Japan.</i> 35(5), Oct , pp 369-72	N= 1216	% body fat by BIA method were 8.6 +/- 4% in the junior males, 14.2 +/- 2.8% in junior females, 7.9% +/- 4.7 % in the senior male and 16.1 +/- 2.9% in the senior females	Poor

EVIDENCE TABLE - DXA

No	Author, Title, Journal	Study Design, Sample size, Follow up	Outcomes & Characteristic	Grade & Comment
1	Goran MI, Driscoll P, Johnson R, Nagy TR, Hunter G (1996) Cross calibration of body composition techniques against dual energy x-ray absorptiometry in young children <i>Am J Clin Nutr .</i> 63(3), Mar, pp 299-306	Evaluation study Sample size :98	Fat mass estimated by DXA was significantly lower than fat mass measure by skin-fold thickness Fat mass estimated by DXA was also significantly lower than fat mass measured by bioelectrical resistance (BR)	Poor

No	Author, Title, Journal	Study Design, Sample size, Follow up	Outcomes & Characteristic	Grade & Comment
2	Taylor RW, Jones IE, William SM, Goulding A (2002) BF% measured by DEXA corresponding to recently recommended BMI cutoffs for overweight & obesity in children & adolescents aged 3-18yrs <i>Am J Clin Nutr.</i> 76(6), Dec, pp 1416-21	N= 661	Measurement classified 17.1% of males and 19.8% of females as obese. The %BF associated with an obese BMI tended to be higher in peri-pubertal males(34-36%) than in younger (24-30%) or older males (27-30%) The %BF values associated with BMI classifications of overweight and obesity vary considerably with age in growing children particularly girls.	Poor
3	Schmelzle HR, Fusch C (2002) Body fat in neonates and young infants: Validation of skinfold thickness versus dual energy X-ray absorptiometry <i>Am J Clin Nutr</i> 76(5), Nov, pp 1096-100	Validation studies N= 104 term infants	Body fat measurement by SFT correlate with FM values determined by DXA	Poor
4	Bolanowski M, Nilsson BE (2001) Assessment of human body composition using DEXA and BIA <i>Med Sci Monit,</i> 7(5), Sep=Oct, pp 1029-33	N= 100	DEXA tend to underestimate Lean Body Mass & Overestimate body fat compared with BIA	Poor
5	Wong WW et al (2002) Evaluating body fat in girls and female adolescents: advantages & disadvantage <i>Clin Nutr</i> 76(2), Aug pp 384-9	Evaluation study N=141	% fat mass by DEXA could be underestimated or overestimated by 6.7%	Poor

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EVIDENCE TABLE - SKINFOLD THICKNESS

No	Author, Title, Journal	Study Design, Sample size, Follow up	Outcomes & Characteristic	Grade & Comment
1	<p>Sardinha LB, Goings SB, Teixeira PJ, Lohman TG (1999)</p> <p>Receiver Operating Characteristic analysis of body mass index, triceps skin fold thickness and arm girth for obesity screening in children and</p> <p><i>Am J of Clin Nutrition.</i> 70, pp 1090-95</p>	<p>Cross sectional study</p> <p>N= 165 Portugese boys and 163 girls aged 10-15 years old</p>	<p>The results showed that True positive rates range from 67-87% in girls and 50-100% in boys. False positive rates range from 0-19% in girls and 5-26% in boys. In children age 10-11 yrs old Area under the Curve (AUC) for ROC was almost 1. For older boys and girls, AUC for tricep skinfold thickness were similar to or greater than AUC for BMI and upper arm girth. In adolescents 10-15 yrs old tricep skinfold thickness gives the best result for obesity screening. BMI and upper arm girth were reasonable alternatives except in 14-15 yrs old where they marginally able to discriminate obesity.</p>	Fair
2	<p>Chan YL, Leung SS, Lam WW, Peng XH, Mereweli C (1998)</p> <p>Body fat estimation in children by magnetic resonance imaging bioelectrical impedance, skinfold and body mass index: a pilot study</p> <p><i>J Paediatric Child Health.</i> 34 (1), Feb, pp 22-8</p>	Evaluation study	Skin-fold measurement gives a reasonably good prediction of total body fat	Poor

No	Author, Title, Journal	Study Design, Sample size, Follow up	Outcomes & Characteristic	Grade & Comment
3	Goran MI, Gower BA, Treuth M, Nagy TR. (1998) Prediction of intra-abdominal and subcutaneous abdominal adipose tissue in healthy pre-pubertal children. Int J Obes Relat Metab Disord. 1998 Jun;22(6):549-58.	Cross-sectional N= 113	IAAT was most strongly correlated with abdominal skinfold ($r = 0.88$) and trunk fat by DEXA ($r = 0.87$), and SAAT with trunk fat by DEXA ($r = 0.96$), total fat by DEXA ($r = 0.93$) and waist circumference ($r = 0.93$). In stepwise regression, IAAT was best predicted by trunk fat from DEXA, total fat from DEXA, and abdominal skinfold ($R^2 = 0.85$); SAAT was best predicted by trunk fat from DEXA, body weight, waist circumference and abdominal skinfold ($R^2 = 0.96$). In the absence of DEXA data, IAAT was best predicted by abdominal skinfold, ethnicity and subscapular skinfold ($R^2 = 0.82$) and SAAT was best predicted by waist circumference subscapular skinfold, height and abdominal skinfold ($R^2=0.92$). The prediction equations with and without DEXA were successfully cross-validated in an independent sample of 12 additional measures of IAAT and SAAT. CONCLUSION: These data provide useful information that can help in the interpretation of anthropometric data with regard to body fat distribution. IAAT and SAAT can be accurately estimated in Caucasian and African-American prepubertal children from anthropometry with and without the availability of DEXA data	Poor
4	Wells JC. (2001) A critique of the expression of paediatric body composition data. ▼ <i>Arch Dis Child.</i> 85(1), Jul, pp:67-72.		Body fatness is generally expressed as a percentage of weight, while fat-free mass typically remains unadjusted for size. A more appropriate approach is to normalise both body fatness and fat-free mass for height. This recommendation is relevant both to studies comparing patients with controls and to the expression of new reference data on body composition which are needed to allow informative comparisons. The same approach is appropriate for the classification of childhood obesity.	

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EVIDENCE TABLE : TREATMENT

No	Author, Title, Journal	Study Design, Sample Size, Follow up	Characteristic & Outcomes	Grade & comment
1	Campbell K , Water E, O'Meara S, Kelly S, Summerbell C (2003) Invention for preventing obesity in children Cochrane Database Sys Rev Vol 1,	Systematic Review	Three of the four long term studies that combined dietary education and physical activity interventions resulted in no difference in overweight, whereas one study reported an improvement in favour of the intervention group. In two studies of dietary education alone, a multimedia action strategy appeared to be effective but other strategies did not. the one long term study that only focussed on physical activity resulted in a slightly greater reduction in overweight in favour of the intervention group, as did two short term studies of physical activity. No generalised conclusions can be drawn. However, concentration on strategies that encourage reduction in sendatrary behaviours and increase in physical activity may be fruitful. The need for well-designed studies that examine a range of interventions remains a priority, although a number of importtant studies are underway	Good

EVIDENCE TABLE :SURGERY

No	Author, Title, Journal	Study Design, Sample Size, Follow up	Characteristic & Outcomes	Grade & comment
1	Dolan K, Creighton L, Hopkins G, Fielding G (2003) Laporoscopic gastric banding in morbidly obese adolescents <i>Obes Surg</i> , 13 (1), Feb, pp 101-4	Prospective study N=17 F/up: 25 months	BMI fell from a preoperative median of 44.7 to 30.2 kg/m ² at 24 months following surgery, 13 of 17 lost at least 50% of their excess weight and 9 of 11 patient had BMI > 35 kg/m ² at 24 months following surgery LAGB is a safe and effective method of weight loss in morbidly obese adolescents.	Poor

No	Author, Title, Journal	Study Design, Sample Size, Follow up	Characteristic & Outcomes	Grade & comment
2	Stanford A, Glascock JM, Eid GM, Kane T, Ford HR, Ikramuddin S, Schauer P.(2003) Laparoscopic Roux-en-Y gastric bypass in morbidly obese adolescents. <i>J Pediatr Surg.</i> 38(3), Mar., pp 430-3.	Review N=4	All procedures were completed laparoscopically. There were no complications. The average LOS was 2 days. Patients with greater than 20-month follow-up lost an average of 87% of their excess body weight and had nearly complete resolution of comorbidities (including hypertriglyceridemia, hypercholesterolemia, asthma, and gastroesophageal reflux disease). CONCLUSION: Laparoscopic gastric bypass is a safe alternative in morbidly obese adolescents who have not responded to medical therapy	Poor
3	Strauss RS, Bradley LJ, Brolin RE (2001) Gastric bypass surgery in adolescents with morbid obesity. <i>J Pediatr.</i> 138(4), Apr, pp 499-504.	Retrospective review N= 10 F/up = 1 year	The average weight before surgery was 148 +/- 37 kg. Postoperative recovery was uneventful in all adolescents; 9 of 10 adolescents had weight loss in excess of 30 kg (mean weight loss was 53.6 +/- 25.6 kg). Obesity related morbidities resolved in all adolescents. Five adolescents had mild iron deficiency anemia, and 3 adolescents had transient folate deficiency. Late complications requiring operative treatment occurred in 4 of the adolescents. CONCLUSION: Gastric bypass surgery was an effective method for weight reduction in morbidly obese adolescents. The procedure was well tolerated, with few unanticipated side effects. Gastric bypass remains a last resort option for severely obese adolescents for whom other dietary and behavioral approaches to weight loss have been unsuccessful.	Poor
4	Sugerman HJ, Sugerman EL, DeMaria EJ, Kellum JM, Kennedy C, Mowery Y, Wolfe LG.(2003) Bariatric surgery for severely obese adolescents. <i>J Gastrointest Surg.</i> 7(1), Jan, pp 102-7; discussion 107-8.	Review N= 33 adolescents	Regain of most or all of the lost weight was seen in five patients at 5 to 10 years after surgery; however, significant weight loss was maintained in the remaining patients for up to 14 years after surgery. Bariatric surgery in adolescents is safe and is associated with significant weight loss, correction of obesity comorbidity, and improved self-image and socialization	Poor

EVIDENCE TABLE :PHARMACOLOGICAL TREATMENT

No	Author, Title, Journal	Study Design, Sample Size, Follow up	Characteristic & Outcomes	Grade & comment
1	<p>Kiess W, Bottner A, Bluher S, Raile K, Seidel B, Kapellen T, Keller E, Kratzsch J. (2003)</p> <p>Pharmacoeconomics of obesity management in childhood and adolescence.</p> <p><i>Expert Opin Pharmacother.</i> 4(9), Sep, pp 1471-7.</p>	<p>Review</p>	<p>Surgical procedures and drugs used in adult obesity are not generally recommended in children and adolescents. Appetite suppressants and thermogenic drugs have not been approved for use in children. Digestive inhibitors such as lipase inhibitors and fat substitutes have been used in children and adolescents in off-label use and in only a few clinical studies. As obesity is the most common chronic disorder in the industrialised societies, its impact on individual lives, as well as on health economics, has to be recognised more widely. One should aim to increase public awareness of the ever increasing health burden and economic dimension of the childhood obesity epidemic that is present around the globe.</p>	Poor
2	<p>Norgren S, Danielsson P, Jurolid R, Lotborn M, Marcus C. (2003)</p> <p>Orlistat treatment in obese prepubertal children: a pilot study.</p> <p><i>Acta Paediatr.</i> 92(6), Jun, pp 666-70.</p>	<p>N= 11 healthy severe obese children</p> <p>F/up: 12 weeks</p>	<p>The participants were able to comply with the treatment, as indicated by pill counts and self reports, and expressed a desire to continue the treatment after the study period. Gastrointestinal side effects were mild and tolerable. No negative effects on psychological or physical well-being were detected, and the psychological evaluation demonstrated increased avoidance of fattening food, body shape preoccupation and oral control (p = 0.011). The median weight loss was 4.0 kg (range - 12.7 to +2.5 kg, p = 0.016) and was highly correlated to decreased fat mass (regression coefficient 0.953, p < 0.01). CONCLUSION: This pilot study indicates that obese prepubertal children were able to reduce their fat intake to avoid gastrointestinal side effects. Thus, orlistat may be suitable as a component in behaviour-modification programmes for obese children, and the results prompt a placebo-controlled investigation of its effectiveness in promoting weight loss.</p>	Poor

No	Author, Title, Journal	Study Design, Sample Size, Follow up	Characteristic & Outcomes	Grade & comment
3	<p>Berkowitz RI, Wadden TA, Tershakovec AM, Cronquist JL.(2003)</p> <p>Behavior therapy and sibutramine for the treatment of adolescent obesity: a randomized controlled trial.</p> <p><i>JAMA.</i> 289(14), Apr 9, pp 1805-12.</p>	<p>Randomized, double-blind, placebo-controlled trial</p> <p>N= 82 adolescents conducted from March 1999 to August 2002 at a university-based clinic for 6 months, followed by open-label treatment during months 7 to 12</p>	<p>In intention-to-treat analysis at month 6, participants in the behavior therapy and sibutramine group lost a mean (SD) of 7.8 kg (6.3 kg) and had an 8.5% (6.8%) reduction in BMI, which was significantly more than weight loss of 3.2 kg (6.1 kg) and reduction in BMI of 4.0% (5.4%) in the BT and placebo group. Significantly greater reductions in hunger (P =.002) also were reported by participants who received BT and sibutramine. From months 7 to 12, adolescents initially treated with sibutramine gained 0.8 kg (10.5 kg) with continued use of the medication, whereas those who switched from placebo to sibutramine lost an additional 1.3 kg (5.4 kg). Medication dose was reduced (n = 23) or discontinued (n = 10) to manage increases in blood pressure, pulse rate, or other symptoms. CONCLUSIONS: The addition of sibutramine to a comprehensive behavioral program induced significantly more weight loss than did BT and placebo. Until more extensive safety and efficacy data are available, medications for weight loss should be used only on an experimental basis in adolescents and children.</p>	Good
4	<p>McDuffie JR, Calis KA, Uwaifo GI, Sebring NG, Fallon EM, Hubbard VS, Yanovski JA. (2002)</p> <p>Three-month tolerability of orlistat in adolescents with obesity-related comorbid conditions.</p> <p><i>Obes Res.</i> 10(7), Jul, pp 642-50.</p>	<p>Clinical Trial</p> <p>N= 20 adolescents</p>	<p>Participants who completed treatment (85%) reported taking 80% of prescribed medication. Adverse effects were generally mild, limited to gastrointestinal effects observed in adults, and decreased with time. Three subjects required additional vitamin D supplementation despite the prescription of a daily multivitamin containing vitamin D. Weight decreased significantly (-4.4 +/- 4.6 kg, p < 0.001; -3.8 +/- 4.1% of initial weight), as did body mass index (-1.9 +/- 2.5 kg/m(2); p < 0.0002). Total cholesterol (-21.3 +/- 24.7 mg/dL; p < 0.001), low-density lipoprotein-cholesterol (-17.3 +/- 15.8 mg/dL; p < 0.0001), fasting insulin (-13.7 +/- 19.0 microU/mL; p < 0.02), and fasting glucose (-15.4 +/- 7.4 mg/dL; p < 0.003) were also significantly lower after orlistat. Insulin sensitivity, assessed by a frequently sampled intravenous glucose-tolerance test, improved significantly (p < 0.02). DISCUSSION: We conclude that, in adolescents, short-term treatment with orlistat, in the context of a behavioral program, is well-tolerated and has a side-effect profile similar to that observed in adults, but its true benefit versus conventional therapy remains to be determined in placebo-controlled trials.</p>	Fair

Appendix 1

LEVELS OF EVIDENCE SCALE

Level	Strength of Evidence	Study Design
1	Good	Meta-analysis of RCT, Systematic reviews.
2	Good	Large sample of RCT
3	Good to fair	Small sample of RCT
4		Non-randomised controlled prospective trial
5	Fair	Non-randomised controlled prospective trial with historical control
6	Fair	Cohort studies
7	Poor	Case-control studies
8	Poor	Non-controlled clinical series, descriptive studies multi-centre
9	Poor	Expert committees, consensus, case reports, anecdotes

SOURCE: ADAPTED FROM CATALONIAN AGENCY FOR HEALTH TECHNOLOGY ASSESSMENT (CAHTA), SPAIN