Screening and Interventions for Childhood Overweight: A Systematic Review for the U.S. Preventive Services Task Force

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Background

Obesity/overweight has been declared an epidemic[1-3] and a "public health crisis" among children worldwide[4] due to an alarming increase in its prevalence. Overweight in children (defined by experts as a body mass index (BMI) $\geq$ 95th percentile for age and sex)[5,6] aged 2 and older has at least doubled in the last 25 years (Figure 1). The age- and sex-specific mean BMI and the proportion of children with BMI $\geq$ 95th percentile increased markedly in children from the mid-1970s to the 1990s, with almost all of this increase occurring in children in the upper half of the BMI distribution.[7] Thus, about 50% of children appear to have "obesity susceptibility genes" that environmental changes have acted upon in the last 25 years.[8]

Since increases in mean BMI have occurred primarily due to increases in the upper half of the BMI distribution,[7,9] weight-related health consequences will become increasingly common in children. Childhood overweight and obesity's health consequences include pulmonary, orthopedic, gastroenterological, neurological, and endocrine conditions and cardiovascular risk factors.[4,10-15] Tables 1 and 2 contain the limited prevalence data for key morbidities and risk factors available from recent summaries. Rarely, severe childhood obesity is associated with immediate morbidity from conditions such as slipped capital femoral epiphysis,[16] while steatohepatitis and sleep apnea are more common.[17-21] Medical conditions new to this age group, such as Type 2 diabetes mellitus,[22] represent "adult" morbidities that are now more frequently seen among overweight adolescents.[23] Most medical complications, however, do not become clinically apparent for decades.[10]

Overweight is associated with a higher prevalence of intermediate metabolic consequences and risk factors, such as insulin resistance, elevated blood lipids, increased blood pressure, and impaired glucose tolerance.[24-29] Perhaps the most significant short-term morbidities for overweight/obese children are psychosocial and include social marginalization, self-esteem, and quality of life.[30-33] Risk factors for developing childhood overweight include increased parental adiposity, low parental education, social deprivation, and perhaps, infant feeding patterns, early or more rapid puberty, extreme birth weights, gestational diabetes, and various social and environmental factors, such as childhood diet or time spent in sedentary behaviors.[4]

Prior U.S. Preventive Services Task Force (USPSTF) Recommendations

The USPSTF makes recommendations about clinical preventive services to assist primary care clinicians using an explicit, evidence-based approach. In 1996, the USPSTF recommended periodic height and weight measurement for all patients (B recommendation).[34] Comparing height and weight measures against appropriate age and sex norms to determine further evaluation, intervention, or referral was recommended, using BMI (> 85th percentile) in adolescents, and weight and height (or length as appropriate) plotted on growth charts or compared to average weight tables for age, sex, and height in younger children. The USPSTF has not previously made separate recommendations about screening criteria or specific interventions for overweight or obesity in childhood populations. To assist the USPSTF in making its recommendation, the Oregon Evidence-based Practice Center undertook a systematic review and summary of the strength of the evidence concerning screening and interventions for overweight in childhood populations. We combined the findings of prior fair- or good-quality[35] systematic evidence reviews with fair- to good-quality studies not covered in these reviews or published subsequently.

Methods

Terminology

Since BMI is the primary clinical measure and a measure of relative weight, we have adopted the use of the term "overweight" in children as opposed to obesity.[7] Considering the limitations of BMI in defining adiposity and concerns about labeling (stigma or concern resulting from being labeled "obese") overweight is more accurate than obesity when the designation is based on a BMI value alone. Using accepted conventions, we use "overweight" to describe those with ≥ 95th percentile BMI for age and sex, and "at risk for overweight" to describe those in the 85th to 95th percentile for age and sex.[5,6]

Key Questions and Analytic Framework

We developed an analytic framework (Figure 2) and seven key questions (KQs), using USPSTF methods, to guide our literature search.[35] The first KQ examined direct evidence that screening to identify and treat overweight in children and adolescents improves age-appropriate behavioral, anthropometric, or physiologic measures. Because we found no evidence addressing this key question, we searched for indirect evidence for KQs 2 through 6 to estimate the benefits and harms of overweight screening and interventions. KQ2 concerned appropriate standards for overweight in children and adolescents, the overweight prevalence based on appropriate standards, and validity of clinical screening tests for predicting poorer health outcomes and obesity in adulthood. KQ3 examined adverse effects of screening for overweight. KQs 4 and 5 examined the efficacy of behavioral counseling, pharmacotherapeutic, and surgical interventions for improving age-appropriate anthropometric, physiologic, and health outcomes, and KQ6 addressed intervention-associated harms. The relationship between intervention-associated improvements in intermediate health measures and decreased morbidity in childhood or adulthood (KQ7) was examined only in the presence of adequate evidence for intervention efficacy (KQs 4 and 5). We did not examine KQ7 due to limited and inconsistent evidence for KQs 4 and 5.

Review methods are summarized below and further detailed elsewhere.[36]

Literature Search Strategy

We developed literature search strategies and terms for each KQ and conducted four separate literature searches (for KQs 1 and 2; for KQs 4, and 5; for KQ 3; and for KQ 6) in Medline, PsycINFO, CINAHL, and the Cochrane library, to update the literature from previous good-quality systematic reviews (KQs 4, 5, and 6) or to comprehensively examine literature from 1966 to the present (KQs 1, 2, and 3). Literature searches were extensively supplemented with source material from experts in the field, bibliographies of included trials, and other reviews. We also conducted limited hand searching of pediatric obesity-focused editions of selected journals. A single investigator reviewed abstracts. A second investigator reviewed all excluded abstracts for all KQs, except KQ2. Due to this search's large yield, we conducted blinded dual review for a random subset (27%), with acceptable agreement (97.5%) between reviewers. Inter-reviewer discrepancies were resolved by consensus.

Article Review and Data Abstraction

Using pre-specified inclusion criteria[36] we reviewed 2,162 abstracts and 353 complete articles for KQ1 and 2, 949 abstracts and 198 complete articles for KQs 4 and 5, and 1,176 abstracts and 36 complete articles for KQs 3 and 6. We included 0 articles for KQ1, 41 articles for KQ2, 0 articles for KQ3, 22 articles for KQs 4 and 5, and 4 articles for KQ6. Two investigators quality rated all included articles and those excluded for quality reasons, using the USPSTF criteria.[35]

One primary reviewer abstracted relevant information from included studies into standardized evidence tables.[36] To be within the USPSTF scope, interventions needed to be conducted in primary care or feasible for primary care conduct or referral (defined elsewhere),[36] and were categorized as pharmaceutical, surgical, or behavioral counseling interventions. Abstracted behavioral counseling intervention details included setting, type of professional delivering the intervention, parent/family participation, intervention components, number and type of contacts, and intervention duration.[37] Comprehensive behavioral treatments were those using a combination of behavioral modification (e.g., self-monitoring, stimulus control, cognitive-behavioral techniques), dietary modification (e.g., Traffic Light Diet,[38] reduced glycemic load, reduced fat or kilocalorie diets), and physical activity components (broadly specified as aerobic, callisthenic, lifestyle, or decreased sedentary behaviors).[37]

Studies had to report weight outcomes, preferably as BMI or BMI percentile changes, to be included. We also recorded all reported behavioral, physiological, and health outcomes specified on our analytic framework (Figure 2).

Literature Synthesis

There were insufficient homogeneous studies for any key question to allow quantitative synthesis. To better illustrate the study participants' degree of overweight and the treatment impact of clinical interventions on overweight, we converted baseline measures and outcomes to BMI percentiles and plotted results on CDC growth charts. Treatment effects that were typical of interventions in this age group (10-20% reduction in percent overweight after one year) were modeled and plotted for 8, 10, and 12 year old girls. We plotted reported mean BMI treatment effects at 6 or more months for six trials in adolescents included in our review (one adolescent trial did not report BMI or percent overweight outcomes). These methods are described in more detail elsewhere.[36] Using the USPSTF approach,[35] we summarized the overall quality of the evidence for each key question.

Results

Key Question 1. Is there direct evidence that screening (and intervention) for overweight in children/adolescents improves age-appropriate behavioral or physiologic measures, or health outcomes?

Our searches found no studies addressing this key question, nor did examination of all individual trials included in previous systematic evidence reviews.[39-43]

Key Question 2a. What are appropriate standards for overweight in children/adolescents and what is the prevalence of overweight based on these?

Eight nationally representative health examination surveys that included children have been conducted in the United States since 1963.[44,45] These surveys have gathered a variety of anthropometric measures on a range of ages (2 months to 18 years), providing growth references[46] and trend analyses of changes within the population over time. In order to provide useful trend analyses, measures must be valid, gathered consistently in surveys, and must use a single source for comparison. Due to these limitations, almost all data on prevalence and trends in US children are based on BMI measures calculated from standardized weight and height information.[47]

BMI measurements for an individual, or to determine population prevalence, must be compared to a reference population to determine the age- and sex-specific percentile ranking. Although multiple reference datasets to determine childhood BMI percentiles are available, where possible we used the CDC's 2000 gender-specific BMI growth charts (for ages 2-19 years).[48] Prevalence estimates and trend information are taken primarily from the NHANES program conducted from 1971-2000 which provides the most comprehensive data available on boys and girls aged 6 months through 19 years, with recent over-sampling of black and Mexican American children. These prevalence estimates use the CDC 2000 gender-specific BMI growth charts as their reference dataset to assign BMI percentiles.

Prevalence

Using BMI $\geq$ 95th percentile, overweight prevalence in 1999-2002 was 10% in two- to five-year-olds and 16% in those six years and older[49] (Figure 3). For children two to five years of age, the prevalence was similar between all racial/ethnic subgroups and both sexes, but was lower than the prevalence in older children in the same racial/ethnic subgroups. Among children 6 to 11 years, differences were seen between racial/ethnic subgroups, with significantly more Mexican American (21.8%) and non-Hispanic black (19.8%) children categorized as overweight compared with non-Hispanic whites (13.5%) ($p<.05$). Sex-specific differences were also apparent, with the highest prevalence of overweight in 6- to 11-year-olds among Mexican American boys (26.5%), which was significantly higher than non-Hispanic black boys (17%), non-Hispanic white boys (14%), and Mexican American girls (17.1%), and similar to that of non-Hispanic black girls (22.8%). Among youth aged 12 to 19 years, significantly more non-Hispanic black (21.1%) and Mexican American (22.5%) children had overweight BMI measurements than non-Hispanic whites (13.7%) ($p<.05$), with no differences between males and females.

Key Question 2b. What clinical screening tests for overweight in childhood are reliable and valid in predicting obesity in adulthood?

We found 19 fair- or good-quality longitudinal cohort studies (in 20 publications) that reported on BMI and other weight status measurements in childhood and adulthood.[50-69] BMI measurements in childhood and adulthood correlated with each other as well as, or better than, childhood and adult correlations for other overweight measures, such as Ponderal Index or skinfold measurements. Table 3 illustrates that BMI tracking from childhood to adulthood varies by age.[50-52,55,62,63] Single BMI measures track reasonably well from childhood and adolescence (ages 6 to 18) into young adulthood (ages 20 to 37), as evidenced by longitudinal studies showing low to moderate ($r = 0.2$-0.4) or moderate to high (0.5-0.8) correlations between childhood and adult BMI measures. Increased tracking ($r \geq 0.6$ or elevated odds of adult obesity) is seen in older children (after age eight),[55] particularly with sexual maturity,[70,71] in younger children (ages 6 to 12) who are more overweight (usually above the 95th or 98th percentile),[36,72] and in children with an obese parent.[12,56] Data on tracking for children before the age of 12 are not extensive. Sex differences in tracking are not consistent across ages or within age categories. Limited data are available comparing white and black children. Table 4 illustrates the probability of adult obesity (BMI $\geq$ 30 kg/m2) at various BMI percentiles in children of various ages taken from our larger report.[36] A 50% or greater probability of adult obesity is generally seen for children age 13 or older with BMI measures $\geq$ 95 percentile. Combining younger and older children in these analyses may obscure the increased probability of adult obesity with older age of childhood overweight.

Key Question 2c. What clinical screening tests for overweight in childhood are reliable and valid in poor health outcomes in adulthood?

Although many (n=11) US studies[50,54,57,65-67,73-77] examined the risk associated with childhood overweight and adult outcomes – including socioeconomic outcomes, mortality, and a range of adult cardiovascular risk factors and morbidities – studies rarely controlled for adult BMI, a critical confounder.[36] In one that did, the apparent association between elevated BMI at age 10 and several elevated adult cardiovascular risk factors (total cholesterol, LDL and HDL cholesterol, insulin, systolic and diastolic blood pressure) in the Bogalusa Heart cohort study was eliminated after controlling for adult BMI.[57]

Key Question 3. Does screening have adverse effects, such as labeling or unhealthy psychological or behavioral consequences?

We found no direct evidence on the harms of screening. Potential harms include labeling, induced self-managed dieting with its negative sequelae, poorer self-concept, poorer health habits, disordered eating, or negative impacts from parental concerns.[5,13,32,78-84]

Key Question 4. Do interventions (behavioral counseling, pharmacotherapy, or surgery) that are feasible to conduct in primary care settings or available for primary care referral lead to improved intermediate behavioral or physiologic measures with or without weight-related measures?

Behavioral counseling interventions

The most extensive treatment literature for childhood overweight involves behavioral counseling interventions. Behavioral counseling interventions included behavioral modification, special diets, and/or activity components delivered to children and/or parents as individuals or in groups by primary care clinicians or related healthcare staff to help patients adopt, change, or maintain health behaviors affecting overweight and related outcomes.[85]

We considered all trials published since 1985 from Western industrialized nations (n = 22 from 23 publications) that addressed interventions feasible for primary care conduct or primary care referral (including one that combined comprehensive behavioral treatment with pharmacotherapy, described separately below) (Table 5).[86-108] We limited our search to post-1985 trials given the dramatic increases in overweight in children that occurred during the 1980s and 1990s, suggesting a very different treatment environment.[1,8,109] A previous good-quality systematic review including 16 of these trials concluded that this behavioral counseling treatment literature is limited, due to marginal quality trials employing small sample sizes of primarily white, school-age children receiving short-term, non-comparable, non-generalizable interventions.[40] These trials typically tested intensive, often family-based, interventions conducted in specialty obesity clinic settings to address overweight in school-aged children who were about 40-50% above ideal weight. Figure 4 models the short-term (1 year) results from these types of studies when translated to BMI percentiles.

Figure 5 demonstrates results from all behavioral counseling studies in adolescents[86,88,104,105,107,108] that reported, or could be translated into, BMI percentiles. Most studies addressed extremely overweight patients, with short-term results showing modest to no change in BMI percentiles. Only two good-quality studies in adolescents were particularly relevant to primary care.[105,108]

One short-term, primary care conducted trial used a computer-based approach to generate tailored plans for counseling obese (above the adult BMI cutoff of 30) adolescents (ages 12 to 16) showed small, but significant improvements[105] (Figure 5). Another internet-based, short-term trial targeting 57 overweight (mean BMI 36.37 kg/m^2), non-Hispanic black, females aged 11 to 15 years with at least one obese biological parent resulted in statistically significant differences in weight and BMI.[108] Although both trials showed small but statistically significant benefits in BMI measures at 6-12 months, it is not clear that these BMI changes would have clinical benefits.

Considering other intermediate outcomes in addition to weight, over half (n=13) of fair- or good-quality trials[86,88-94,97,99,104,105,108] reported intermediate behavioral (n=11) or physiological (n=7) measures (Table 5). Two good-quality trials[105,108] reported behavioral changes, but no physiological outcomes. While one[108] indicated reduced total daily energy intake in the active treatment group, neither indicated changes in physical activity. One fair-quality study reported reductions in targeted dietary components (fat or glycemic load of diet) but not kilocalories,[88] while other fair-quality studies[89-94,99,104] measured changes in eating behaviors, physical activity, and sedentary behaviors, but did not provide a clear picture due to differences in subjects, interventions, and measures.

No good-quality trials of behavioral treatment reported intermediate physiologic outcomes, such as lipids or lipoproteins, glucose tolerance, or blood pressure or physical fitness measures. Only one trial of at least fair-quality reported intermediate physiologic measures. An intensive six-month behavioral weight-control program comparing a reduced glycemic load (RGL) diet with a reduced fat (RF) diet, increased insulin resistance scores (measured by the homeostatic model) significantly less in the RGL than RF group (-0.4 +/- 0.9 vs. 2.6 +/- 1.2, p=0.03).[88] Insulin resistance increases with sexual maturation, however, which was not assessed. These results are further limited by baseline differences between groups and lack of consideration of physical activity as a confounder. Among the fair-quality studies that measured physical work capacity or physical fitness, most reported some improvement when physical activity or sedentary behaviors were addressed in the intervention.[89,90,93,94]

Pharmacotherapy

One randomized placebo-controlled trial of sibutramine within a comprehensive behavioral treatment program in adolescents showed superior weight change outcomes after six months (4.6 kg greater weight loss, 95% CI 2.0-7.4 kg) in an intent-to-treat analysis[86] (Figure 5). With continued use, weight loss at six months was maintained through 12 months. It is not clear that the additional short-term weight change achieved by adding sibutramine to a comprehensive behavioral treatment program in adolescents[86] would provide a net benefit, since changes in serum lipids, serum insulin, serum glucose, and HOMA (homeostatic model of insulin sensitivity) did not differ between groups. Among all trial completers (63-76% of all participants) at 12 months, significant improvements from baseline were seen in high-density lipoprotein cholesterol, serum insulin, and HOMA. Blood pressure was not improved, and in some cases increased blood pressure was a reason for discontinuation. The rate of adverse effects and discontinuation was fairly high (12% discontinued and 28% reduced the medication) (see also KQ 6).

We found no evidence for metformin use for weight loss/disease prevention in normoglycemic obese adolescents with weight outcomes after more than three months, nor did we find acceptable evidence on alternative or complementary therapies.

Surgery

No acceptable quality evidence is available in adolescents evaluating surgical approaches to overweight. There are no controlled treatment outcome data on bariatric surgery approaches in adolescents.

Key Question 5. Do interventions lead to improved adult health outcomes, reduced childhood morbidity, and/or improved psychosocial and functional childhood outcomes?

Behavioral counseling interventions

Few (n = 3) studies reported health outcomes as defined in our analytic framework,[94,104,107] and only two were rated at least fair-quality (Table 5). In one fair-quality trial, depression scores measured using reliable and valid instruments showed improvement from baseline in treated adolescent girls but not controls, while reliably measured self-esteem scores improved from baseline in both groups.[104] In a second fair-quality study, significantly fewer children aged 8-12, receiving comprehensive behavioral treatment, had elevated total behavior problem scores or elevated internalizing behavior problem scores at 24 months' follow-up than at baseline.[95]

Key Question 6. Do interventions have adverse effects, such as stigmatization, binging or purging behaviors, eating disorders, suppressed growth, or exercise-induced injuries?

Adverse effect reporting for behavioral counseling interventions was limited to 3 of 22 intervention trials.

Behavioral counseling interventions

Potential eating problems or weight management behaviors were the only harms addressed in two trials. One good-quality trial reported no adverse effects on problematic eating (using validated measures for dietary restraint, eating disinhibition, problematic weight management behaviors, weight concerns, and eating disorder psychopathology) after primary care-based comprehensive behavioral treatment in 37 of 44 adolescent trial completers.[105] One fair-quality trial reported no effect on eating disorder symptoms, weight dissatisfaction, or purging/restricting behaviors in 47 8-12 year-olds in a family-based comprehensive behavioral treatment program, using a reliable measure (Kids' Eating Disorder Survey).[95,110] Differences between boys (no effect) and girls (elevated total scores) were not significant, but may be revealed in studies with larger sample sizes.

Pharmacotherapy

In the placebo-controlled phase of the sibutramine trial,[86] 44% (19/43) of patients in the active medication group reduced or discontinued the medication due to elevated blood pressure, pulse rate, or both, which were the main adverse events reported.

Surgery

We attempted to estimate the rate of harms from the uncontrolled cohort literature, but found loss to follow-up (25-60% at 4-24 months),[111-113] and inadequate reporting prevented us from making reasonable estimates of surgery-associated harms.

SUMMARY OF EVIDENCE QUALITY

Table 6 summarizes the overall quality of evidence, according to USPSTF criteria,[35] for each key question addressed in this review (see Appendix). The overall evidence is poor for the direct effects of screening (and intervention) programs (KQ1), screening harms (KQ3), and bariatric surgery (KQs 4, 5). The overall evidence is fair-to-poor for behavioral counseling interventions (KQs 4, 5) due to small, non-comparable, short-term studies with limited generalizability that rarely report health or intermediate outcomes, such as cardiovascular risk factors. Trials are particularly inadequate for non-whites and children aged two-five. Fair-to-poor evidence is available for behavioral counseling intervention harms due to very limited reporting (KQ6). Fair evidence supports childhood BMI as a risk factor for adult overweight, although data are limited in non-whites (KQ2b), and data addressing BMI as a risk factor for adult morbidities generally do not control for confounding by adult BMI (KQ2c). Good evidence is available for overweight prevalence based on BMI measures in all groups, except Native Americans and Asians (KQ2a).

Conclusions

Overweight has at least doubled in children and adolescents in the US over the last 25 years, and is particularly common among racial/ethnic minorities. This increase represents a major public health concern with the potential for future health risks and growing burdens on the healthcare system. In terms of evidence, however, little has changed since a 1998 Journal of Pediatrics editorial concluded that, "In the case of obesity, the primary care physician is left in the uncomfortable (but familiar) position of needing to do something now for the patient and family seeking help, regardless of the uncertainty about the nature of the disease and the absence of a cure."[114] Given the nature of the problem, effective solutions will likely require substantial collaboration between the medical and public health communities.[115] Further understanding of how to expand the appropriate role of the clinician in community public health, such as through advocating necessary environmental and political changes, would be helpful.[116,117]

A major limitation to clinicians addressing overweight in children, most of whom are not morbidly overweight, is the uncertain criteria for determining clinically significant overweight. Although BMI is the best clinically available measure of overweight, uncertainty in its application to individual patients remains due to limited knowledge of BMI's current and future health impacts and the possible limits in the applicability of current BMI cut-points, particularly for minority race/ethnicity. Understanding normal variations in body composition with age, sex, race/ethnicity, sexual maturity, and other factors will be critical to accurately defining unhealthy excess fat or other components of overweight, and appropriate measurement methods. Similarly, as has been done elsewhere, examining the sensitivity and specificity of BMI percentile cutoffs for identifying overweight children using large, representative samples of US children of all ages and races/ethnicities would increase our understanding of BMI as a screening tool.[118]

The risk for overweight children becoming overweight or obese adults has been judged as the best available criterion to judge the clinical validity of BMI in the pediatric age group.[119] Adult BMI has been clearly associated with morbidity and mortality – particularly at higher BMI levels – although there is no single threshold for increased health risks.[120] Adolescents who are at or above the 95th percentile for age- and sex-specific BMI clearly have an increased probability of adult obesity, and early interventions would be potentially very beneficial. Recent intervention research targeting this age group primarily addresses those who are very overweight, with some studies showing short-term (6-12 month) weight-related improvements. The treatment evidence in this age group could be strengthened by larger trials testing generalizable interventions that can demonstrate sustained effects on overweight status and on weight-related outcomes. Many trials in adolescents have specifically targeted minorities[107,108] or enrolled reasonable proportions in their studies,[86,102,105]and this should continue. Trials among mildly overweight adolescents, as well as those more severely affected, are needed. With limited to no evidence available, experts agree that surgical approaches should be considered only in adolescents with extreme and morbid obesity, and pharmacologic approaches should be limited to a second-tier approach after failed behavioral counseling.[111,121]

In contrast, current data suggests that a substantial proportion of children under age 12 or 13, even with BMIs above the 95th percentile, will not develop adult obesity. Children aged 8-12 have been the most studied for behavioral overweight treatment, but we still have very limited information about interventions that would be applicable to primary care. No current randomized controlled trial for clinical interventions of any type is available in children two to five years old.

For all ages, there is very limited evidence for behavioral or other overweight treatment that is feasible for primary care delivery or referral. Few studies have taken place in primary care — most have been conducted in research or specialty obesity clinics using intensive, comprehensive behavioral treatment. Experts have cautioned that behavioral therapy represents an expertise-driven approach to improving diet and physical activity using behavioral principles, and not simply an add-on to a diet and exercise plan.[122] If larger studies confirm that behavioral skills and approaches are key to treatment success, creating referral clinics or involvement of clinic team members with behavioral medicine/psychology weight management expertise will be critical.

Experts recommend referring certain children to pediatric obesity treatment centers for expert management. These include children who are massively overweight (defined through clinical judgment)[5] or who have BMI exceeding the 95th percentile with associated severe morbidities that require immediate weight loss. In asymptomatic children with a BMI $\geq$ 95th percentile, experts also recommend an in-depth medical assessment to detect treatable causes of obesity, risk factors, and co-morbidities. For children whose BMI falls between the 85th and 95th percentiles for age and sex, they also recommend clinical evaluations for secondary effects of overweight, such as hypertension and hyperlipidemia. We did not find adequate evidence meeting our criteria to address the impact of BMI screening and/or treatment of overweight (or at risk for overweight) on any of these risks factors or morbidities.

Experts emphasize talking to families about energy balance behaviors that may help prevent obesity and would also promote other aspects of health and likely cause no harms.[123] These behaviors include limiting television viewing, encouraging outdoor play, and limiting the consumption of sugar-sweetened soft drinks. For the interested clinician, pragmatic approaches for all children (particularly young children) that emphasize the "healthy lifestyle prescription" approach over targeting overweight identification seem appropriate since we found limited evidence for secondary prevention or treatment. However, clinicians should be aware that others have found limited evidence for the effectiveness of primary prevention in clinical settings.[124]

Given the current evidence, BMI measurement in older adolescents may provide an early and reasonable indication of future adult health risks due to obesity. BMI measurement in younger children should be performed as a growth-monitoring tool that may indicate future risk for adult overweight and its attendant morbidities, with reduced emphasis on defining current overweight. Children, particularly those under the age of 13, without clinical weight-related morbidities would not necessarily be labeled overweight, but might be considered "at risk" or "at high risk" depending on the BMI level. Experts recommend regular longitudinal monitoring and careful documentation of BMI in children and adolescents.[125] Such monitoring will likely prove even more valuable as our understanding grows about the predictive value of levels and patterns of growth and overweight status change over time and about effective ways to address patterns that indicate overweight that impacts current health or a high future risk of adult overweight.

Limitations of the Literature

In the absence of direct evidence of screening's impact on improved weight and health outcomes in children and/or adults, we have evaluated indirect evidence for screening and intervention. In the current literature, evidence linkages between screening and intervention are hampered by divergent definitions of overweight. It is important that a consistent definition of overweight be accepted to encourage rapid progress in our understanding of how to address this critical problem.

Limited evidence on normal body composition in children and adolescents, and lack of criterion standards for adiposity in children, hampered our ability to determine the test characteristics (sensitivity and specificity) of clinically feasible screening tests. Valid, feasible body composition measures in children are becoming established,[126] which should allow the examination of sensitivity and specificity of BMI percentiles and overweight in US populations, as elsewhere.[118] Similarly, clearly establishing current or future health consequences of elevated BMI (and other overweight measures) for boys and girls of all ages and racial/ethnic origins will enable future diagnostic research. By confining our review of childhood BMI and adult health consequences to longitudinal US studies, we gained some advantages from more similar overweight definitions, measurements, and reference standards,[72] but may have unnecessarily eliminated applicable data. Since the reviewed research was primarily in non-Hispanic whites, its applicability to minorities, in whom the prevalence of overweight is particularly increasing, may be limited.

We did not locate adequate longitudinal data relating childhood weight status to childhood health outcomes, and thus did not review it formally. Current literature is primarily cross-sectional, presents relative risks without absolute risks, or reports on the relationship of growth measures (or changes in them over time) to intermediate measures, such as blood pressure or lipids, rather than health outcomes.

Although we made an effort to comprehensively review several areas of the literature, some areas were not reviewed. We did not review any evidence on children under the age of two, although this is an active area for research. We did not attempt to examine risk factors for childhood overweight, but note that others have recently done so.[71] Similarly, research on changing children's daily life habits that might also affect or prevent pediatric overweight—such as changing dietary intake, increasing physical activity or limiting activities such as television viewing—that did not directly address weight effects were beyond our scope.

Future Research

There are critical research gaps in answering the most basic questions needed to enable clinicians to engage strategies to prevent current and future weight-related morbidities in children. Despite the fact that many of these gaps were pointed out over 10 years ago,[127] little subsequent research has addressed the most clinically relevant questions. In addition to the clinical research already underway to address childhood overweight prevention and treatment, we strongly urge the research community to prioritize research studies that will supply needed evidence to address the key questions formulated for this report in order to inform pragmatic clinical, as well as public health, prevention strategies. Some of these studies could involve reporting from existing good-quality cross-sectional and longitudinal cohort studies in addition to new studies and clinical trials. For a more complete list of research recommendations, please consult the full review.[36]

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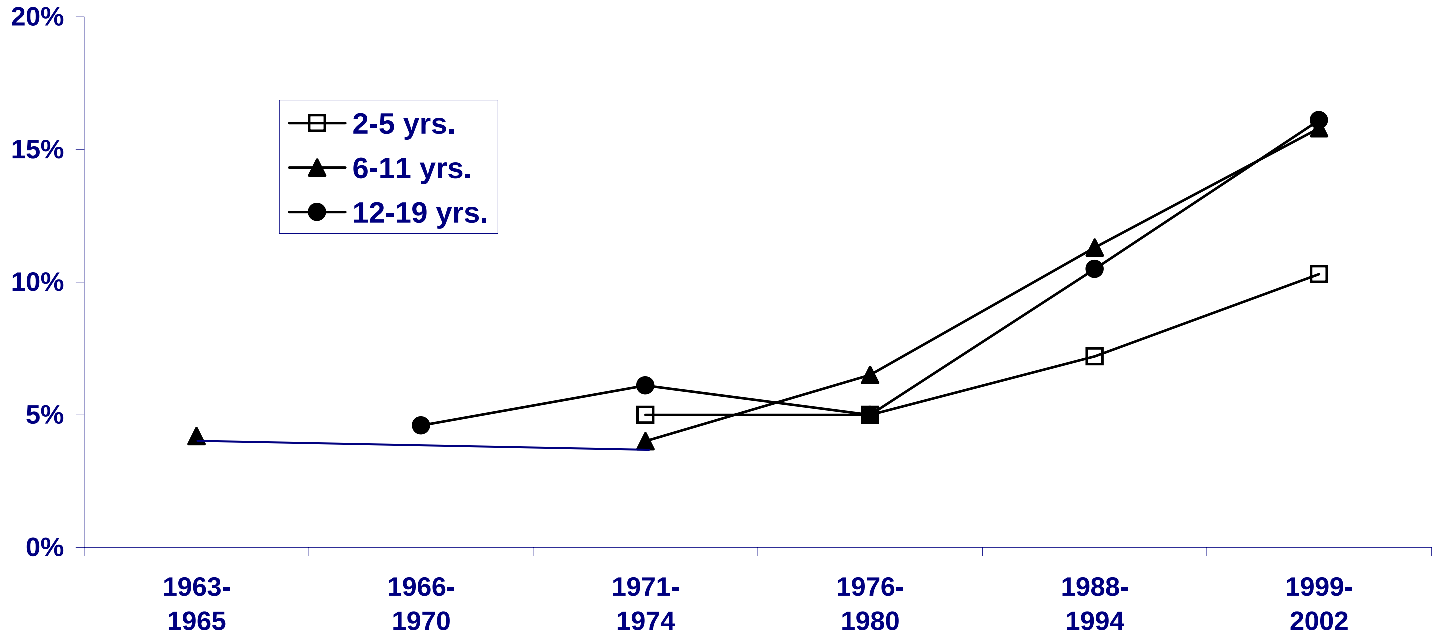
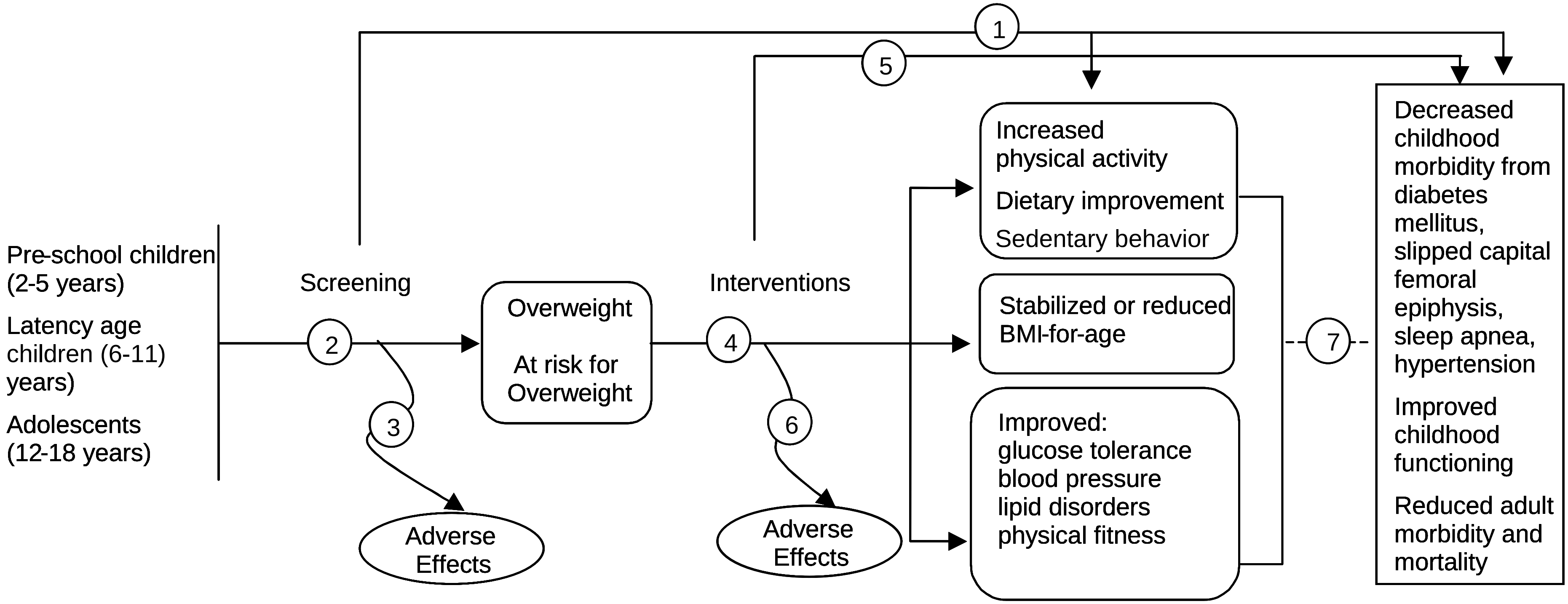
Figure 1. Overweight trends in children and adolescents[45]



Ogden CL, Flegal KM, Carroll MD, Johnson CL. Prevalence and trends in overweight among US children and adolescents, 1999-2000. JAMA 2002; 288(14Oct 9): 1728-1732.

Figure 2. Screening and interventions for overweight in childhood: Analytic framework and Key Questions



Key Questions

Arrow 1: Is there direct evidence that screening (and intervention) for overweight in childhood improves age-appropriate behavioral or physiologic measures, or health outcomes?

Arrow 2: a. What are appropriate standards for overweight in childhood and what is prevalence of overweight based on these?
b. What clinical screening tests for overweight in childhood are reliable and valid in predicting obesity in adulthood?
c. What clinical screening tests for overweight in childhood are reliable and valid in predicting poor health outcomes in adulthood?

Arrow 3: What are the adverse effects of screening, including labeling? Is screening acceptable to patients?

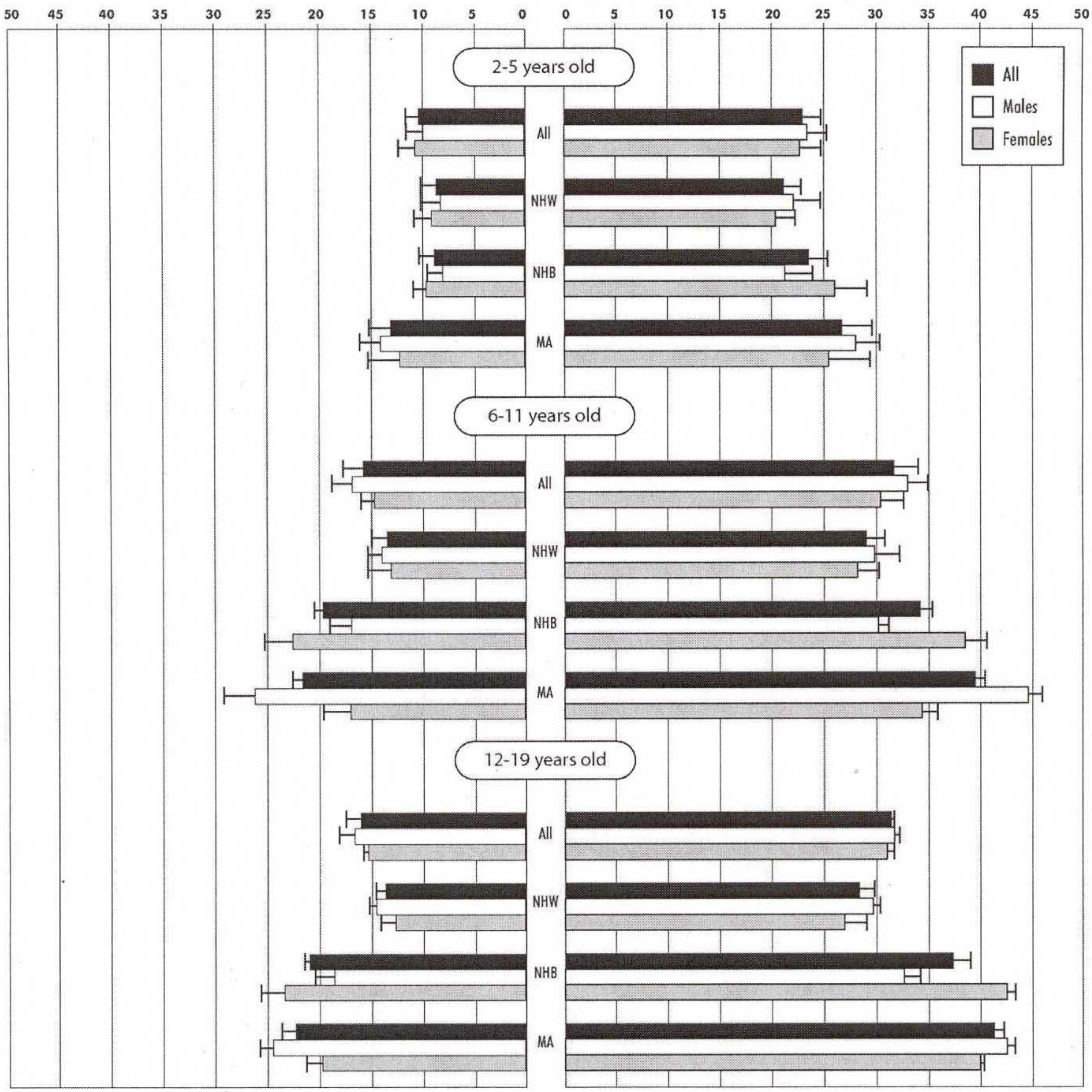
Arrow 4: Do weight control interventions (behavioral counseling, pharmacotherapy, surgery) lead to improved intermediate outcomes, including behavioral, physiologic or weight-related measures?
a. What are common behavioral and health system elements of efficacious interventions?
b. Are there differences in efficacy between patient subgroups?

Arrow 5: Do weight control interventions lead to improved health outcomes, including decreased morbidity, and/or improved functioning (school attendance, self-esteem and other psychosocial indicators)?

Arrow 6: What are the adverse effects of interventions? Are interventions acceptable to patients?

Arrow 7: Are improvements in intermediate outcomes associated with improved health outcomes? (Only evaluated if there is no direct evidence for KQ1 or KQ5 and if there is sufficient evidence for KQ4)

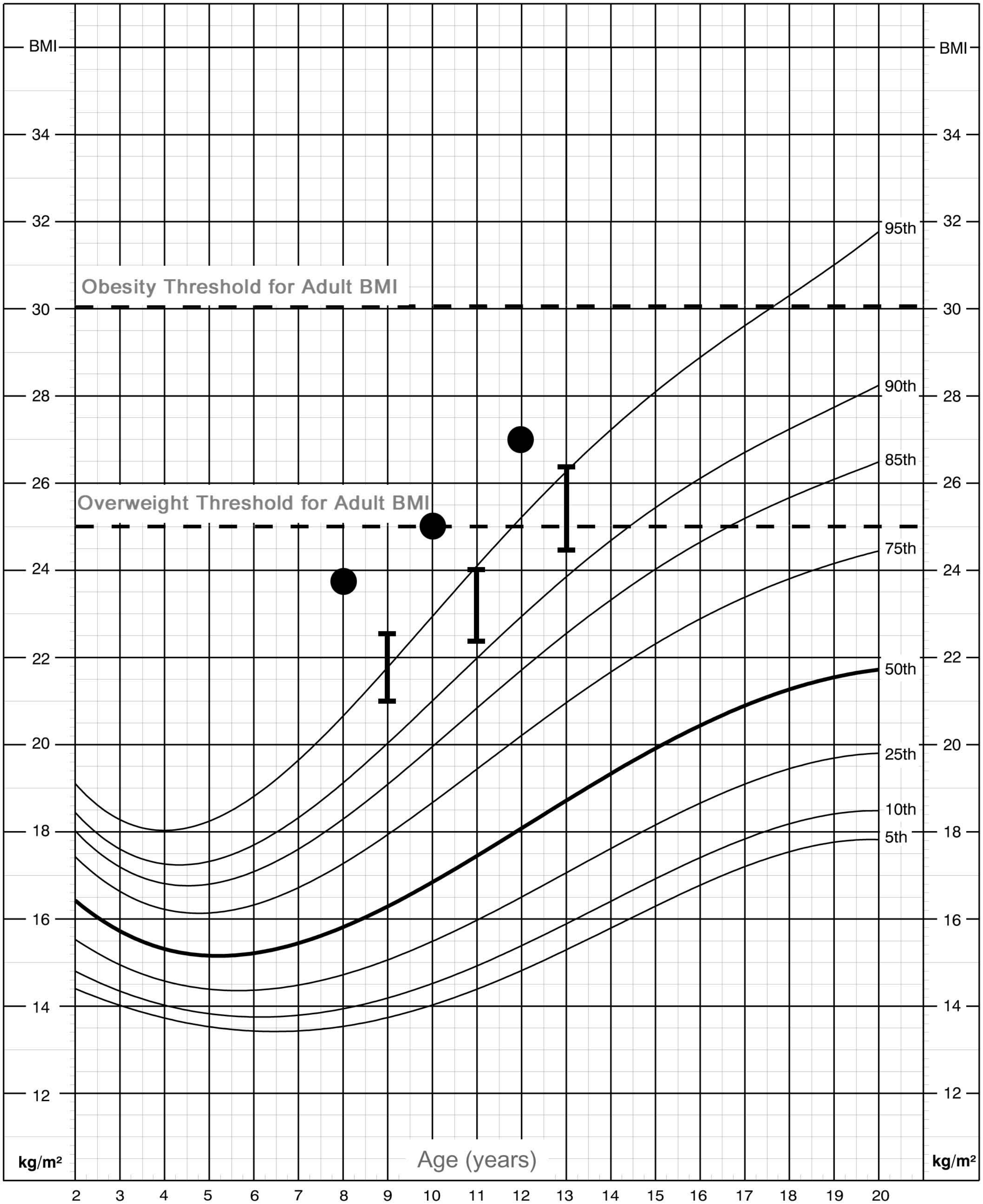
Figure 3. Prevalence of Overweight 1999-2002 % with BMI equal to or greater than 95% with standard error bars[76] | Prevalence of Overweight or at Risk for Overweight 1999-2002 % with BMI equal to or greater than 85% with standard error bars[76]



NHW = Non-Hispanic white; NHB = Non-Hispanic black; MA = Mexican American

Hedley AA, Ogden CL, Johnson CL, Carroll MD, Curtin LR, Flegal KM. Prevalence of overweight and obesity among US children, adolescents, and adults, 1999-2002. JAMA. 2004;291(23):2847-2850.

Figure 4. Modeled effects of behavioral weight loss treatment on BMI for children ages 8 to 13 using CDC Growth Charts: United States. Body mass index-for-age percentiles: Girls, 2 to 20 years.



Published May 30, 2000.
SOURCE: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000).

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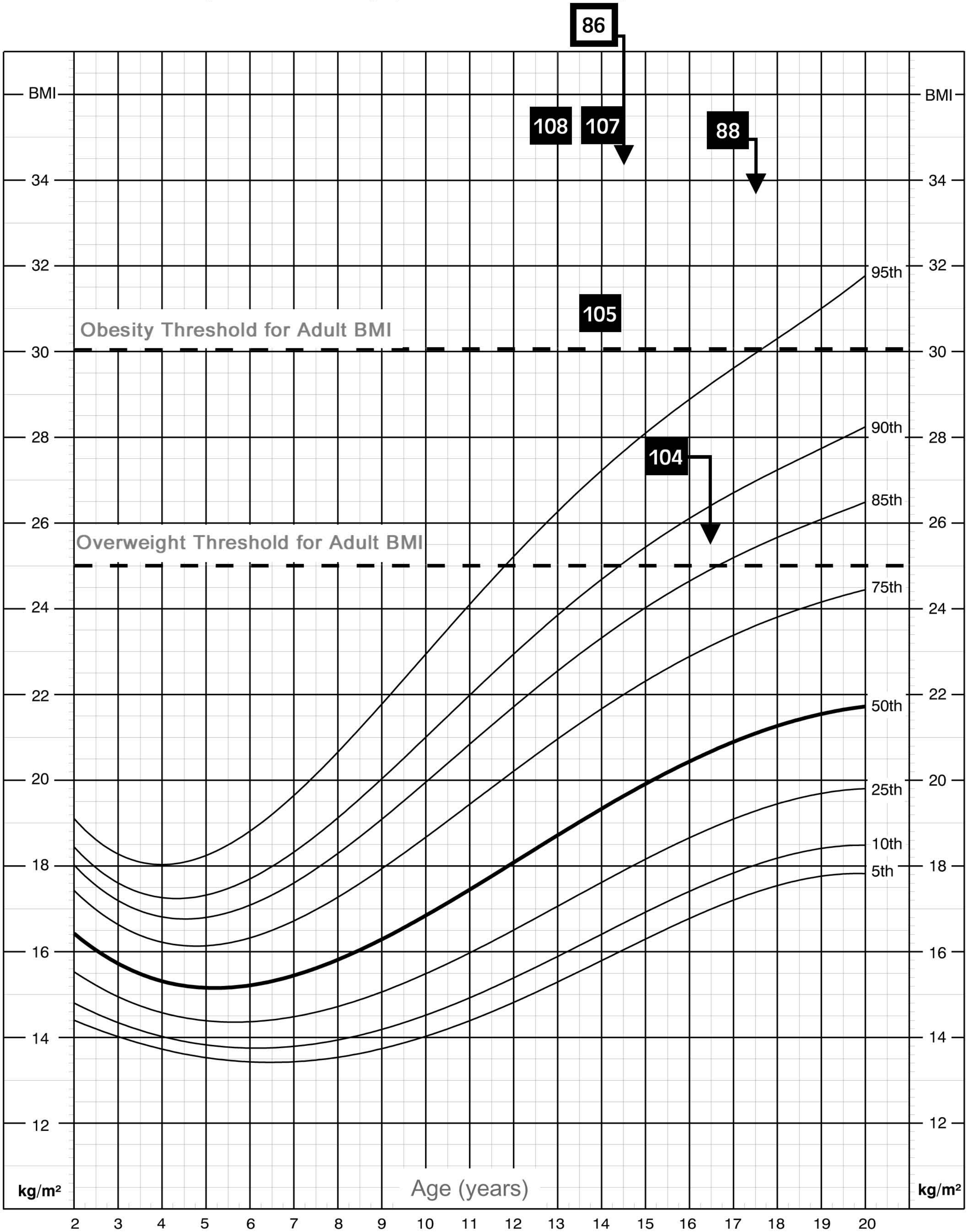
Figure 5. Effects of behavioral weight loss treatment on BMI for adolesdents using CDC Growth Charts: United States. Body mass index-for-age percentiles: Girls, 2 to 20 years.



Published May 30, 2000.

SOURCE: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000).

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Figure 5. Boxes represent mean BMI at entry for each behavioral counseling intervention trial. The white box indicates a study of behavioral counseling plus sibutramine. Numbers inside boxes identify studies in the reference list. Arrows indicate the mean change in BMI at study follow-up six months or later. No arrow indicates that the mean BMI for the treatment group did not change significantly.

Table 1. Overweight and obesity associated health conditions in children and adolescents

Health Condition	Population Source (Number)	Age/Race-ethnicity/gender	Level of Overweight	Prevalence %	Reference cited in source bibliography
Diabetes Mellitus					
Diabetes Mellitus Type II	Community N=2066	PIMA NA* -ages 15-19 yrs girls boys -ages 10-14 yrs girls boys		 5.31 3.78 2.88 1.4	Dabelea, 1998[23]
	Community N = 142	Navajo NA -ages 12-19		1.41	Lobstein, 2004[4]
	NHANES III N=2867	NHW, NHB, MA adolescents -aged 12-19		.04 (includes Type I DM as well)	
Diabetes Mellitus Type II	Obesity clinic (n=55)	Multi-ethnic boys and girls ages 4-10 years	BMI > for age & sex (95%ile)	0	Sinha, 2002[24]
	Obesity clinic (n=112)	Multi-ethnic boys and girls ages 11-18 yrs	BMI >95%ile	4 (all were NHB or H)	
Asthma					
Parental report of doctor diagnosed asthma in child	NHANES III Subset of children with family history of parental asthma N=625	Ages 10 –16 years, multiethnic girls and boys	BMI $\geq$ 85 BMI < 85	31 14.5	Rodriguez, 2002[15]
Sleep apnea (SA)					
Sleep-associated abnormal breathing tests	Obese children referred for history of sleep disordered breathing N=32	Ages 2.7 – 13.8 years, multi-ethnic boys and girls	Mean IBW = 196 $\pm$ 45%	40-90	Silvestri, 1993[17]

Table 1. Overweight and obesity associated health conditions in children and adolescents

Health Condition	**Population Source (Number)**	**Age/Race-ethnicity/gender**	**Level of Overweight**	**Prevalence %**	**Reference cited in source bibliography**
1 or more abnormal polysomnography test Severely abnormal tests (severe SA)	Obesity clinic N=222	Children and adolescents ages 3 – 20 years	"Severe obesity" - >150% IBW, mean = 208% IBW	6.8 (calc) 1 (calc)	Mallory, 1989[18]
1 or more abnormal polysomnography test Severely abnormal test (severe SA)	Obesity clinic patients with history of sleep disordered breathing N=41			32 5	
Nonalcoholic fatty liver disease					Tominaga, 1995[19]
Steatosis by US	General pediatric N=810	Japanese school boys and girls ages 4 – 12 years	Population sample	3	
Steatosis by US Steatosis and elevated transaminases (presumptive NASH)	Obesity clinic N=72	Italian boys and girls ages 4.5-15.9 years	Obese > 120% IBW	53 Of these, 32% had elevated transaminases (calc)	Franzese, 1997[20]
Steatosis by US Steatosis and elevated transaminases (presumptive NASH)	Obesity clinic N=84	Chinese children, mean age 12	BMI > 95th percentile for age and sex	77 24	Chan, 2004[21]
Slipped capital femoral epiphysis				3.4 per 100,000 children (50-70% are "obese")	Kelsey, 1973[16]

*The highest risk population in the world (Dabelea D. Endo and Metab clinic 1999)
Calc: calculated number

Childhood morbidities discussed in reviews without reporting prevalence: Binge-eating disorders, low self-esteem.

Table 2: Overweight and obesity associated risk factors in children and adolescents

Risk Factor	Population Source	Age/Race-ethnicity/gender	Level of Overweight (percentile of BMI for age and sex if given)	Prevalence %	Reference cited in source bibliography
Impaired glucose tolerance					
Impaired glucose tolerance	Obesity clinic (N=55)	Multi-ethnic boys and girls ages 4-10 years	> 95	25	Sinha, 2002[24]
	Obesity clinic (N=112)	Multi-ethnic boys and girls ages 11-18 yrs	> 95	21	Sinha, 2002[24]
Hyperinsulinemia					
(Insulin levels above the 95%ile)	Bogalusa Heart Study	Black and white boys and girls aged 5-10 years	< 95 95-97 > 97	≤ 4 10 27	Freedman, 2002[25]
Metabolic syndrome					
Hypertension, hypertriglyceridemia, low HDL cholesterol, hyperinsulinemia)	NHANES	Adolescent boys and girls aged 12-19 years	< 85 85-95 ≥ 95	0.1 6.8 28.7	Cook, 2003[26]
With at least three of: SBP or DBP > 95%ile, triglycerides > 95%ile, 2 hr. GTT > 140 mg/dl, BMI z score ≥ 2.0 (97%ile), HDL cholesterol < 5%ile	Obese sample (N=439)	41% white, 31% black, 27% Hispanic. Ages 4-20 years	-z-score 2-2.5 -z-score>2.5	38.7 49.7 overall (39 in blacks)	Weiss, 2004[27]
Hypertension					
Hypertension	Population based	Multiethnic boys and girls, ages 5-11	Obese	Up to 30	Figueroa-Colon, 1997[29]
Hypertension	Muscatine Heart Study (>6600)	5-18 years	Community distribution	1 (60% of these had relative wt >120%)	Dietz, 1998[28]
Increased systolic blood pressure measures >95%ile	Bogalusa Heart Study	Black and white boys and girls aged 5-10 years	<95 95-97 >97	2-7 12 22	Freedman, 2002[25]
Increased diastolic blood pressure >95%ile	Bogalusa Heart Study	Black and white boys and girls aged 5-10 years	<95 95-97 >97	2-7 9 14	Freedman, 2002[25]

Table 2: Overweight and obesity associated risk factors in children and adolescents (continued)

Risk Factor	Population Source	Age/Race-ethnicity/gender	Level of Overweight	Prevalence	Reference cited in source bibliography
Dyslipidemia					
LDL cholesterol > 130 mg/dl	Bogalusa Heart Study	Black and white boys and girls ages 5-10 years	< 85 85-94 95-97 > 97	8-10 across all percentiles 18 12 23	Freedman, 2002[25]
HDL cholesterol < 35 mg/dl	Bogalusa Heart Study	Black and white boys and girls ages 5-10 years	< 85 85-94 95-97 > 97	5-8 & non-linear 8 7 18	Freedman, 2002[25]
TG levels > 130 mg/dl	Bogalusa Heart Study	Black and white boys and girls ages 5-10 years	< 85 85-94 95-97 > 97	2-6 10 10 21	Freedman, 2002[25]

Risk factors discussed in reviews without reporting prevalence: Menstrual disorders, polycystic ovarian syndrome, early maturation (girls), late maturation (boys)

Table 3. Effect of age and race on the correlation of childhood with young adult BMI

Effect of age on the correlation of childhood with young adult BMI

Reference	Population	Childhood Age, Years	Males	Females
Guo 1994[55]	100% White (n=555)	3	.18	.22
Lauer 1989[62]	100% White (n=109 observations)	7 to 8	.57	.45
Lauer 1989[62]	100% White (n=603 observations)	9 to 10	.63	.61
Clarke 1993[63]	100% White (n=1286 observations)	9 to 10	.61	.59
Lauer 1989[62]	100% White (n=1018 observations)	11 to 12	.67	.65
Guo 1994[55]	100% White (n=555)	13	.5	.65
Lauer 1989[62]	100% White (n=1041 observations)	13 to 14	.64	.68
Clarke 1993[63]	100% White (n=1104 observations)	13 to 14	.7	.7
Lauer 1989[62]	100% White (n=615 observations)	17 to 18	.74	.73
Clarke 1993[63]	100% White (n=631 observations)	17 to 18	.81	.72

Effect of race on the correlation of childhood with young adult BMI

Reference	Population	Childhood Age, Years	Males	Females
Hulman 1998[51]	100% Black (n=137)	13	.37	
Wattigney 1995[52]	100% Black (n=147)	13 to 17	.69	.72
Wattigney 1995[52]	100% White (n=327)	13 to 17	.63	.48
Freedman 2004[50]	67% White (n=2212)	14 to 17	.76	.73

Table 4. Probability of adult obesity (BMI ≥30) based on childhood BMI percentile measures at various ages

Study ID	Overweight Measure in Childhood, BMI percentile	Child's Age when Measured	Adult's Age when Measured	Probability of adult overweight (Male & Female combined)	Probability of adult overweight (Males)	Probability of adult overweight (Females)
Gortmaker, 1993[66] (n=10,039) 80% White, 14% Black, 6% Hispanic 51% Female	> 95	16-24	23-31	--	.77*	.66*
Freedman, 2001[57] (n=2617) 67% White, 32% Black, 57% Female	< 50	5-17	18-37	.07	--	--
Freedman, 2001[57] (as above)	85-94	5-17	18-37	.51	--	--
Freedman, 2001[57] (as above)	≥ 95	5-17	18-37	.77	--	--
Guo, 2002[58] (n=347) 100% White, 52% female	≥ 75	3	35	--	.1	.14
	≥ 85			--	.1	.17
	≥95				.2	.24
Guo, 2002[58] (as above)	≥ 75	8	35	--.	.1	.16
	≥ 85				.1	.23
	≥ 95				.2	.46
Guo, 2002[58] (as above)	≥ 75	13	35	--.	.2	.16
	≥ 85				.2	.27
	≥ 95				.5	.64
Guo, 2002[58] (as above)	≥ 75	18	35	--	.2	.15
	≥ 85				.3	.26
	≥ 95				.8	.68

* In this study adult overweight was defined as >95%ile on NHANES.

Table 5. Randomized controlled trials addressing overweight in children and adolescents

Study Reference	N Randomized Country	Age % Male % non-white	Baseline measure of overweight	Intervention characteristics*: Components Comprehensive? Parent participation? Group vs. Indiv.	Intervention characteristics*: Time period # of Sessions Session length Total contact time (min)
Berkowitz 2003[86]	82 adolescents USA	13-17 33% 45%	BMI 37.8 kg/m^2 (3.8); BMI z-score: 2.4 (0.2)	BM,D,E yes yes G	6 mo (phase I) 19 (phase I) NR NR
Duffy 1993[87]	29 children Australia	7-13 21% NR, Australian	48.4% overweight	BM,D,E yes yes NR	8 wk 8 90 in 720 min
Ebbeling 2003[88]	16 adolescents USA	13-21 31% 19%	BMI 34.9 kg/m^2 (reduced glycemic group); 37.1 kg/m^2 (reduced fat diet group)	BM,D No No NR	12 mo 14 NR NR
Epstein 1985[89]	41 families USA	8-12 40% NR	48% overweight	BM,D,E yes yes NR	12 mo 18 NR NR
Epstein 1985[90]	23 children USA	8-12 0% NR	48 % overweight	BM,D,E yes yes NR	12 mo NR NR NR
Epstein 1985[91]	24 children USA	5-8 0% NR	39-42% overweight	BM,D,E yes yes G, unclear if I	12 mo unclear, approx 26 NR
Epstein 1994[92]	44 families USA	8-12 26% NR	59.6% over the 50th%ile for BMI	BM,D,E yes yes unclear	1 yr 32 NR NR
Epstein 1995[93]	61 families USA	8-12 27% 4%	51.8% overweight	BM,D,E yes yes I + G	6 mo 18 NR NR
Epstein 2000[94]	90 families USA	8-12 32% NR	62% overweight	BM,D,E yes yes I + G	6 mo 20 45-60 min 900-1200 min

Intervention characteristics: BM=behavior modification; D = special diet; E = exercise program; G = group; I = individual;
Other outcomes: B = behavioral ; P = physiological; H = childhood health outcomes; A = adverse effects

Table 5. Randomized controlled trials addressing overweight in children and adolescents

Study Reference	Group	Units of measure	Study duration	Outcome at latest follow-up time	P value for comparisons between groups**	Other outcomes	USPSTF Quality Grade
Berkowitz 2003[86]	Sibutramine Placebo	change in BMI (% change from entry BMI)	6 months	-8.5% -4.0%	p = 0.001	P, A	Good
Duffy 1993[87]	BT + cognitive self- BT + relaxation placebo	% overweight change	6 months	-8.9% -9.2%	n.s.	B	Fair-to-Poor
Ebbeling 2003[88]	Reduced glycemic load Reduced fat diet	absolute change in BMI	12 months	-1.2 kg/m2 0.6 kg/m^2	p < 0.05	B, P	Fair
Epstein 1985[89]	Lifestyle PA Aerobic PA Low-intensity calisthenics PA	% overweight change	24 months	-18.0% -6.8% -7.2%	<0.05, lifestyle PA vs. Aerobic PA; <0.05, lifestyle PA vs. calisthenics	B, P	Fair
Epstein 1985[90]	Diet + PA Diet alone	% overweight change	12 months	-25.4% -18.7%	n.s.	B, P	Fair
Epstein 1985[91]	BT Education only	% overweight change	12 months	-26.3% -11.2%	< 0.05	B	Fair
Epstein 1994[92]	Mastery criteria & contingent reinforcement Comparison group	% overweight change	24 months	-15.4% -10.6%	n.s.	B	Fair
Epstein 1995[93]	Combined Decreased SB Increased PA	% overweight change	12 months	-8.7% -10.3% -18.7%	p < 0.05, combined vs. increased PA	B, P	Fair
Epstein 2000[94]	Decreased SB high dose Decrease SB low dose PA high dose PA low dose	% overweight change	24 months	-14.3% -11.6% -13.2% -12.4%	n.s.	B, P	Fair

Intervention characteristics: BM=behavior modification; D = special diet; E = exercise program; G = group; I = individual;
Other outcomes: B = behavioral ; P = physiological; H = childhood health outcomes; A = adverse effects

Table 5. Randomized controlled trials addressing overweight in children and adolescents

Study Reference	N Randomized Country	Age % Male % non-white	Baseline measure of overweight	Intervention characteristics*: Components Comprehensive? Parent participation? Group vs. Indiv.	Intervention characteristics*: Time period # of Sessions Session length Total contact time (min)
Epstein 2000[95]/ Epstein 2001[96]	67 children USA	NR, mean (sd) 10.3 (1.1) yrs 48% 4%	BMI 27.4 kg/m^2 (3.2)	BM,D,E yes yes I + G	6 mo 18 45-60 min 810-1080 min
Epstein 2001[96]	67 families USA	8-12 52% NR	60.2% overweight (compared to the 50%ile BMI for age and sex); BMI 27.4 kg/m^2 (3.6 kg/m^2)	BM, D,E yes yes I + G	6 mo 20 30 min 600 min
Flodmark 1993[97]	44 children (plus 50 matched controls) Sweden	10-11 48% NR (Swedish)	24.7 kg/m^2 (family therapy group); 25.5 kg/m^2 (conventional treatment group); 25.1 kg/m^2 (control group)	D,E no yes I	14-18 mo 5 + 6 family therapy sessions NR NR
Golan 1998[98]	60 children Israel	6-11 38% NR (Israeli)	39.1%overweight (conventional group); 39.6% (parents agents of change group)	BM,D,E yes no* G+I	1 yr 30 60 min 1800 min
Graves 1988[99]	40 children USA	6-12 NR NR	52%-56% overweight	BM,D,E yes yes G	8 wk 8 60 min 480 min

Intervention characteristics: BM=behavior modification; D = special diet; E = exercise program; G = group; I = individual;
Other outcomes: B = behavioral ; P = physiological; H = childhood health outcomes; A = adverse effects

Table 5. Randomized controlled trials addressing overweight in children and adolescents

Study Reference	Group	Units of measure	Study duration	Outcome at latest follow-up time	P value for comparisons between groups**	Other outcomes	USPSTF Quality Grade
Epstein 2000[95]/ Epstein 2001[96]	PS to parent and child	change in BMI z-score	24 months	-0.5	$p < 0.05$, PS to parent and child vs. no PS; $p < 0.05$, PS to parent and child vs. PS to child only	H, A	Fair
	PS to child only			-0.9			
	No PS			-1.1			
Epstein 2001[96]	Increased PA	change in absolute BMI (statistical comparisons done on percent overweight change)	12 months	girls: -0.27 kg/m^2; boys: -0.65 kg/m^2	$p < 0.01$, interaction of group by sex; $p < 0.001$, boys in combined group vs. girls in combined group $p < 0.05$, boys in combined group vs. girls in increased PA group	none	Fair
	Combined increased PA + decreased SB			girls: 1.0 kg/m^2; boys: -1.76 kg/m^2			
Flodmark 1993[97]	Family therapy	change in BMI (kg/m2)	26 - 30 months	1.1 kg/m^2	$p < 0.05$, family therapy vs. untreated controls	P	Fair
	Conventional treatment			1.6 kg/m^2			
	Matched controls - untreated			2.8 kg/m^2			
Golan 1998[98]	Conventional: children responsible for own wt loss	% overweight change	12 months	-8.1%	$p < 0.05$	none	Fair
	Parents exclusive agents of			-14.7%			
Graves 1988[99]	BT + parent PS	% overweight change	6 months	-24.5%	$p < 0.05$, PS vs BT only; $p < 0.05$, PS vs. instruction only	B	Fair
	BT only			-10.2%			
	Instruction only			-9.5%			

Intervention characteristics: BM=behavior modification; D = special diet; E = exercise program; G = group; I = individual;
Other outcomes: B = behavioral ; P = physiological; H = childhood health outcomes; A = adverse effects

Table 5. Randomized controlled trials addressing overweight in children and adolescents

Study Reference	N Randomized Country	Age % Male % non-white	Baseline measure of overweight	Intervention characteristics*: Components Comprehensive? Parent participation? Group vs. Indiv.	Intervention characteristics*: Time period # of Sessions Session length Total contact time (min)
Israel 1985[100]	33 children USA	8-12 30% NR	45.88% overweight (parent training group); 53.13% (BT only); 56.02% (controls)	BM,D,E yes yes G	12 mo 17 same +2-60 min sessions >930 min
Israel 1994[101]	36 families USA	8-13 NR NR	48.1% overweight (enhanced child involvement group); 46.0% (standard treatment group)	BM,D,E yes yes G	26 wk 17 90 min 1530 min
Kang 2002[103] **/Gutin 2002**[102]	80 adolescents USA	13-16 33% 69%	40.7% body fat (white boys); 45.8% body fat (white girls); 43.9% body fat (black boys); 45.2% body fat (black girls)	BM,E no no G	8 mo 160 60 min for LSE, variable for PA NR
Mellin 1987[104]	66 adolescents USA	12-18 21% 22%	30-37% overweight	BM,D,E yes yes G	14 wk 16 90 min 1440 min
Saelens 2002[105]	44 adolescents USA	12-16 59% 30%	BMI 30.7kg/m^2 (3.1)	BM,D,E yes no I	4 mo 13 10-20 min for TC, NR for visit NR, >200 min

Intervention characteristics: BM=behavior modification; D = special diet; E = exercise program; G = group; I = individual;
Other outcomes: B = behavioral ; P = physiological; H = childhood health outcomes; A = adverse effects

Table 5. Randomized controlled trials addressing overweight in children and adolescents

Study Reference	Group	Units of measure	Study duration	Outcome at latest follow-up time	P value for comparisons between groups**	Other outcomes	USPSTF Quality Grade
Israel 1985[100]	BT + parent training in child management	% overweight change	12 months	-10.2%	p < 0.001 per NHS review	B	Fair-to-Poor
	BT only			-1.3%			
	Wait list controls			NR			
Israel 1994[101]	Enhanced child involvement	% overweight change	36 months	-4.8%	n.s.	none	Fair-to-Poor
	Standard treatment (parents primarily responsible)			6.4%			
Kang 2002[103] **/Gutin 2002**[102]	LSE + high intensity PA	change in % body fat	8 months	-2.9%	n.s.	B, P	Fair-to-Poor
	LSE + moderate PA			-1.4%			
	LSE			-0.1%			
Mellin 1987[104]	SHAPEDOWN group (Cognitive, behavioral, affective	% overweight change	15 months	-9.9%	Between group comparison NR (15 months vs. baseline: p < 0.01, SHAPEDOWN ; n.s., control group)	B, H	Fair
	No treatment controls			-0.1%			
Saelens 2002[105]	Healthy habits intervention	% overweight change & change in BMI (statistical analyses on BMI z-scores)	7 months	-2.4%, 0.1 kg/m2	n.s.	B, A	Good
	Typical care			4.1%, 1.4 kg/m2			

Intervention characteristics: BM=behavior modification; D = special diet; E = exercise program; G = group; I = individual;
Other outcomes: B = behavioral ; P = physiological; H = childhood health outcomes; A = adverse effects

Table 5. Randomized controlled trials addressing overweight in children and adolescents

Study Reference	N Randomized Country	Age % Male % non-white	Baseline measure of overweight	Intervention characteristics*: Components Comprehensive? Parent participation? Group vs. Indiv.	Intervention characteristics*: Time period # of Sessions Session length Total contact time (min)
Senediak 1985[106]	45 children USA	6-13 approximately 66% NR	37.22% overweight	BM,D,E yes yes G	4 wk 8 90 min 720 min
Wadden 1990[107]	47 girls USA	12-16 0% 100% black	95.1 kg; BMI 35.6 kg/m^2	BM,D,E yes yes G	10 mo 22 60 min (first 16 sessions), others NR >960 min
White, 2003[108]**/ Williamson unpublished data**	57 adolescents USA	11-15 0% 100%	BMI 36.34 kg/m^2; 98.3 BMI %ile	BM,D,E yes yes I	6 mo 4 + weekly website logins NR NR

*for most intensive intervention which is listed first

Intervention characteristics: BM=behavior modification; D = special diet; E = exercise program; G = group; I = individual;
Other outcomes: B = behavioral ; P = physiological; H = childhood health outcomes; A = adverse effects

Table 5. Randomized controlled trials addressing overweight in children and adolescents

Study Reference	Group	Units of measure	Study duration	Outcome at latest follow-up time	P value for comparisons between groups**	Other outcomes	USPSTF Quality Grade
Senediak 1985[106]	Rapid schedule BT	% overweight change	6 months	-14.7%	p < 0.05, rapid and gradual schedule BT groups combined vs. non-specific controls; (comparison of rapid vs. gradual schedule BT groups n.s.)	B	Fair-to-Poor
	Gradually decreasing schedule BT			-18.3%			
	Non-specific treatment controls			-10.9%			
	Wait list controls			NR			
Wadden 1990[107]	Mother and child together	change in weight	6 months	1.7 kg	n.s.	P, H	Fair-to-Poor
	Child alone			3.0 kg			
	Mother and child separate			3.5 kg			
White, 2003[108]**/ Williamson unpublished data**	Behavioral	change in % body fat; change in BMI	6 months	-1.12%; -0.19 kg/m2	p < 0.05 (% body fat); P < 0.05 (change in BMI)	B	Good
	Education only			0.43%; 0.65 kg/m2			

**if multiple comparisons, then presented only if p < 0.05

Intervention characteristics: BM=behavior modification; D = special diet; E = exercise program; G = group; I = individual;
Other outcomes: B = behavioral ; P = physiological; H = childhood health outcomes; A = adverse effects

Table 6. Summary of evidence quality for key questions addressing childhood and adolescent overweight

Key Question		Study Hierarchy	Overall USPSTF Quality
1.	Screening	-	Poor.
2a.	Prevalence	II-2	Good, but lacking for specific non-White racial/ethnic subgroups.
2b,c.	Screening tests as a risk factor	II-2	Fair. Data for BMI as a risk factor for adult overweight from childhood overweight are the most valid but are very limited for non-Whites. Data for BMI as a risk factor for adult morbidities generally do not control for confounding by adult BMI.
3.	Screening harms	-	Poor. Due to lack of screening studies, possible harms can only be inferred from other sources.
4,5.	BCI Interventions	I	Fair-to-poor. Data are limited by very small samples, non-comparable interventions & not using intent-to-treat analyses. Little reporting of intermediate outcomes—including risk factor changes, or changes in health outcomes. Poor generalizability due to specialist interventions not widely available and addressing mostly 8-12 yrs. No data in 2-5. Few trials include non-Whites.
4,5.	Pharmacology with BCI	I	Fair. One good quality trial in adolescents.
4,5.	Surgery	-	Poor.
6.	Intervention harms	I, II-2	Fair-to-Poor. Very limited reporting of harms for BCI interventions.

Appendix 1: USPSTF Hierarchy of research design and quality rating criteria[35]

Hierarchy of Research Design

- I Properly conducted randomized controlled trial (RCT)
- II-1: Well-designed controlled trial without randomization
- II-2: Well-designed cohort or case-control analytic study
- II-3: Multiple time series with or without the intervention; dramatic results from uncontrolled experiments
- III: Opinions of respected authorities, based on clinical experience; descriptive studies or case reports; reports of expert committees

Design-Specific Criteria and Quality Category Definitions

Systematic Reviews

Criteria:
- Comprehensiveness of sources considered/search strategy used
- Standard appraisal of included studies
- Validity of conclusions
- Recency and relevance are especially important for systematic reviews

Case-Control Studies

Criteria:
- Accurate ascertainment of cases
- Nonbiased selection of cases/controls with exclusion criteria applied equally to both
- Response rate
- Diagnostic testing procedures applied equally to each group
- Measurement of exposure accurate and applied equally to each group
- Measurement of exposure accurate and applied equally to each group
- Appropriate attention to potential confounding variables

Randomized Controlled Trials and Cohort Studies

Criteria:
- Initial assembly of comparable groups
    - -for RCTs: adequate randomization, including first concealment and whether potential confounders were distributed equally among groups
    - -for cohort studies: consideration of potential confounders with either restriction or measurement for adjustment in the analysis; consideration of inception cohorts
- Maintenance of comparable groups (includes attrition, cross-overs, adherence, contamination)
- Important differential loss to follow-up or overall high loss to follow-up
- Measurements: equal, reliable, and valid (includes masking of outcome assessment)
- Clear definition of the interventions
- All important outcomes considered

Diagnostic Accuracy Studies

Criteria:
- Screening test relevant, available for primacy care, adequately described
- Study uses a credible reference standard, performed regardless of test results

Appendix 1: USPSTF Hierarchy of research design and quality rating criteria (Continued)

- Reference standard interpreted independently of screening test
- Handles indeterminate result in a reasonable manner
- Spectrum of patients included in study
- Sample size
- Administration of reliable screening test