Treatment of Pediatric Obesity
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Treatment of Pediatric Obesity

Leonard H. Epstein, PhD; Michelle D. Myers, MA; Hollie A. Raynor, MS, RD; and Brian E. Saelia, MA

ABSTRACT. The primary goal of childhood obesity interventions is regulation of body weight and fat with adequate nutrition for growth and development. Ideally, these interventions are associated with positive changes in the physiologic and psychological sequelae of obesity. To contribute to long-term weight maintenance, interventions should modify eating and exercise behaviors such that new, healthier behaviors develop and replace unhealthy behaviors, thereby allowing healthier behaviors to persist throughout development and into adulthood. This overview of pediatric obesity treatment, using predominantly randomized, controlled studies, highlights important contributions and developments in primarily dietary, activity, and behavior change interventions, and identifies characteristics of successful treatment and maintenance interventions. Potential positive (eg, reduction in blood pressure, serum lipids, and insulin resistance) and negative (eg, development of disordered eating patterns) side effects of treatment also are described. Recommendations for improving implementation of childhood obesity treatments, including application of behavioral choice theory, improving knowledge of response extinction and recovery in regards to behavior relapse, individualization of treatment, and integration of basic science with clinical outcome research, are discussed. Pediatrics 1998;101:554–570; pediatric obesity, treatment, weight maintenance.

ABBRévIATIONS. BMI, body mass index; PSMF, protein-sparing modified fast; HDL, high-density lipoprotein.

There has been a lot of interest in developing effective treatments for obesity, with the overwhelming majority of this research focused on treating adults. A salient characteristic of the adult obesity treatment is that although obese adults can...
lose significant amounts of weight, maintenance of weight loss has proven to be a persistent problem.1-3 There are several more hopeful signs in the treatment of pediatric obesity by using dietary and activity changes. For example, two research groups have shown successful maintenance of treatment effects 5 years4 and 10 years5,6 after initiation of treatment. In direct comparisons of children and adults in families provided similar family-based interventions, preadolescent children responded with greater relative weight loss and better maintenance of weight loss, although there was still considerable relapse.7 Almost one third of the children treated were nonobese after 10 years.7 This is encouraging, but it indicates that a significant amount of work is required to improve long-term maintenance of pediatric obesity treatment.

There are behavioral and biological reasons to be optimistic about treating pediatric obesity. For example, it may be easier to mobilize support through families for obese children than for obese adults; obese children also generally have not had the unhealthy eating or activity patterns as long as obese adults. In addition, treatment of pediatric obesity can take advantage of growth and increases in lean body mass as well as weight change.5,8 Furthermore, instead of shrinking adipose cells, treatment at an early age prevents the development of excess adipose cells.

Despite these potential advantages, many pediatric studies show a decrement in treatment effects over time. The goal of this report is to provide an overview of the treatment and prevention of pediatric obesity, to highlight important contributions and developments in treatment, and to identify characteristics of successful treatment. First, treatment of pediatric obesity is reviewed. Next, the positive and negative side effects of treatment are presented. Third, ideas for improving implementation of pediatric obesity treatment, including new directions and areas for future research, are discussed. This report concludes with a brief summary.

METHODS

The goals for treating childhood obesity are regulating body weight through adequate nutrition for growth and development, thereby preventing interruption of linear growth, minimizing loss of lean body mass, and preventing endocrine disturbances. In addition, ideal treatments should be associated with positive changes in physiologic and psychological sequelae of obesity. Treatments should modify eating and exercise behaviors along with the factors that regulate these behaviors, so that the new, healthier behaviors persist throughout development.

This review is organized according to major components of treating pediatric obesity, including dietary, activity, and behavior change components. In addition, more aggressive approaches, including pharmacologic and surgical interventions, are reviewed. The quality of the study design was considered, with the focus on randomized, controlled studies. In some areas, such as surgery and drug studies, there are limited randomized controlled studies, and we present uncontrolled research in these areas. When studies did not provide sufficient detail to know how the groups were developed (ie, whether subjects were allowed to self-select themselves to groups or whether they could have been placed in groups on the basis of factors that could bias interpretation of treatment and control differences), we erred on the conservative side and considered them not to be randomized studies. (To give sufficient attention to the discussion of new ideas, many details of intervention and supporting studies are not discussed.)

The details of the randomized studies that were reviewed are presented in Tables 1 and 2 for clinical studies and in Tables 3 and 4 for school-based studies. These tables include subject age, group assignment, sample size, sex distribution, dietary components, exercise component, and results. There were several dependent measures used across studies; the most common were changes in percent of overweight, body mass index (BMI), body weight, and percent of body fat. Where available, we have provided the baseline values, end of treatment changes, and end of follow-up changes. To provide a common definition of when treatment ends and follow-up begins, we considered treatment to be continuing as long as subjects were seen at least once per month. The most relevant information is significance in the rate of change among groups over time, but if this information was not available, within-group differences are presented.

Although this review is divided into contributions of diet, activity, and behavior change components, treatment efficacy is derived from integration of the components of treatment. For example, although most treatments include a dietary component, it is generally recognized that nutrition intervention is ineffective as a solitary treatment for pediatric obesity.10 Extracting the contribution of treatment components is complicated further by variations in multiple components of treatment across studies. Different caloric ranges for the diet are in the context of different types of exercise programs and different methods to enhance behavior change.

RESULTS

Dietary Components

Diet therapy for obesity is founded on the hypothesis that obese individuals consume too much energy relative to energy expenditure or they consume an imbalance of macronutrients. Therefore, the general goals of most dietary interventions involve reducing and stabilizing caloric intake, reducing fat intake, and restructuring eating habits to follow more closely current dietary recommendations, resulting in increased nutrient density.

If positive energy balance is attributable to excess intake, then the degree of reduction in caloric intake should relate to treatment success. Amador et al11 demonstrated this by randomizing children to a restricted diet (0.17 MJ/kg of expected body weight for height) versus a less restricted diet (0.25 MJ/kg of expected body weight for height) and found significantly better results after 1 year for the diet with the lower caloric intake. There is very little work on diet composition beyond calories. When obese children of elementary-school age were given 15 g of fiber supplementation combined with a reduced-energy diet for 4 weeks, they demonstrated no significant increases in weight loss or significant decreases in energy intake compared with the results from 4 weeks of the reduced-energy diet alone.12 The caloric level of the diet influences weight loss. There has been no research on the contribution of fat content to treatment success.

There are a number of general approaches studied to reduce caloric intake and teach better eating habits. One approach is to provide individualized dietary interventions. In a controlled study on exercise, no weight loss was observed for preadolescents who were provided with individualized dietary recommendations for 16 weeks without exercise.15 Another approach is the diabetic exchange system, with a caloric level calculated to produce 1 lb of weight loss...
TABLE 1. Characteristics of Child and Adolescent Obesity Treatment Studies on Clinical Samples

<table>
<thead>
<tr>
<th>Source</th>
<th>Age (y)</th>
<th>Group Assignment</th>
<th>Between-group Variable</th>
<th>N</th>
<th>% Girls</th>
<th>Diet</th>
<th>Exercise</th>
</tr>
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<tbody>
<tr>
<td>Amador et al</td>
<td>10–13</td>
<td>R</td>
<td>1. Restrictive diet</td>
<td>47</td>
<td>47.9</td>
<td>Restricted to 30% of energy requirement</td>
<td>Exercise information (1,2)</td>
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<tr>
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<td>2. Nonrestrictive diet</td>
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<td>(1), nutrition information (1,2)</td>
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<tr>
<td>Aragona et al</td>
<td>5–11</td>
<td>R</td>
<td>1. Response cost +</td>
<td>5</td>
<td>100</td>
<td>Nutrition information (1,2)</td>
<td>Daily exercise instructions and program for parents (1,2)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>reinforcement</td>
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<td></td>
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<td>2. Response cost</td>
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<td>3. Control</td>
<td>5</td>
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<td>Bacon and Lowrey</td>
<td>5–17</td>
<td>R</td>
<td>1. Fenfluramine</td>
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<td>1000–1200 kcal (1,2)</td>
<td>None</td>
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<td>Becque et al</td>
<td>12–13</td>
<td>R</td>
<td>1. Exercise</td>
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<td>58.3</td>
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<td>Minimal exercise information (1,2,3,4)</td>
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<td>Brownell et al</td>
<td>12–16</td>
<td>RS</td>
<td>1. Mother and child seen separately</td>
<td>14</td>
<td>78.6</td>
<td>Nutrition information (1,2,3)</td>
<td>Exercise information (1,2,3)</td>
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<td>2. Mother and child seen together</td>
<td>15</td>
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<td>3. Child seen alone</td>
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<tr>
<td>Coates et al</td>
<td>13–17</td>
<td>RS</td>
<td>1. Daily contact, reinforced for weight</td>
<td>8</td>
<td>68.4</td>
<td>Caloric goals estimated for ↓ 1–2 lb/wk (1,2,3,4)</td>
<td>Minimal exercise information (1,2,3,4)</td>
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<td>2. Weekly contact, reinforced for weight</td>
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<td>3. Daily contact, reinforced for calories</td>
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<td>4. Weekly contact, reinforced for calories</td>
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<tr>
<td>Coates et al</td>
<td>13–17</td>
<td>RS</td>
<td>1. Mother and child seen separately</td>
<td>31</td>
<td>64.5</td>
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<td>Exercise information (1,2)</td>
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<td>Duffy and Spence</td>
<td>7–13</td>
<td>R</td>
<td>1. Cognitive treatment</td>
<td>14</td>
<td>~78.6</td>
<td>Traffic-light diet (1,2)</td>
<td>Lifestyle, aerobic, and calisthenic activity (1,2)</td>
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<td>2. Progressive relaxation</td>
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<td>Epstein et al</td>
<td>6–12</td>
<td>RS</td>
<td>1. Behavior modification</td>
<td>14</td>
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<td>Exercise information (1,2)</td>
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<tr>
<td>Epstein et al</td>
<td>6–12</td>
<td>RS</td>
<td>1. Mother and child targeted</td>
<td>76</td>
<td>69.6</td>
<td>Traffic-light diet limit 1200–1500 kcal (1,2,3)</td>
<td>Exercise information (1,2,3)</td>
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<td>3. Nonspecific target</td>
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<tr>
<td>Epstein et al</td>
<td>8–12</td>
<td>R</td>
<td>1. Aerobic activity + diet</td>
<td>51</td>
<td>~78.4</td>
<td>Traffic-light diet 900–1200 or 1500 kcal (1,2)</td>
<td>Aerobic (1,3) or lifestyle (2,4) activity; isocaloric across groups</td>
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<td>2. Lifestyle activity + diet</td>
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<td>3. Aerobic activity alone</td>
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<td>4. Lifestyle activity alone</td>
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<tr>
<td>Epstein et al</td>
<td>8–12</td>
<td>R</td>
<td>1. Exercise</td>
<td>18</td>
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<td>Traffic-light diet (1,2)</td>
<td>Lifestyle activity (200–400 kcal/day) (1)</td>
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<td>17</td>
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<tr>
<td>Epstein et al</td>
<td>8–12</td>
<td>R</td>
<td>1. Programmed aerobic activity</td>
<td>41</td>
<td>~60.0</td>
<td>Traffic-light diet 1200 kcal (1,2,3)</td>
<td>Aerobic (1), lifestyle (2), or calisthenic (3) activity; isocaloric across groups</td>
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<td>2. Lifestyle activity</td>
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<td>Total</td>
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<td>3. Calisthenics</td>
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<tr>
<td>Epstein et al</td>
<td>8–12</td>
<td>RS</td>
<td>1. Exercise</td>
<td>23</td>
<td>100</td>
<td>Traffic-light diet 900–1200 kcal (1,2)</td>
<td>Supervised exercise, 3-mile walk 3×/wk (1)</td>
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<tr>
<td>Epstein et al</td>
<td>5–8</td>
<td>R</td>
<td>1. Behavior modification</td>
<td>8</td>
<td>100</td>
<td>Traffic-light diet 900–1000 or 1200 kcal (1,2)</td>
<td>Lifestyle activity (1,2)</td>
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<td>2. Education</td>
<td>11</td>
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<tr>
<td>Epstein et al</td>
<td>8–12</td>
<td>R, IV</td>
<td>1. Parent overweight</td>
<td>41</td>
<td>NR</td>
<td>1200 kcal (1,2)</td>
<td>Lifestyle activity (1,2)</td>
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<td>2. Parent normal weight</td>
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<tr>
<td>Epstein et al</td>
<td>8–12</td>
<td>R</td>
<td>1. Mastery criteria</td>
<td>44</td>
<td>~74.4</td>
<td>Traffic-light diet from 900–1000 to 900–1200 kcal (1,2)</td>
<td>Lifestyle activity (1,2)</td>
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<td>2. No mastery criteria (yoked)</td>
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<td>Total</td>
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<tr>
<td>Epstein et al</td>
<td>8–12</td>
<td>R</td>
<td>1. Reinforced for ↑ activity</td>
<td>61</td>
<td>73.0</td>
<td>Traffic-light diet 1000–1200 kcal (1,2,3)</td>
<td>↑ Activity (1), ↓ sedentary (2), or both ↑ activity and ↓ sedentary (3)</td>
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<td>2. Reinforced for ↑ sedentary behavior</td>
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<td>3. Reinforced for both ↑ activity and ↓ sedentary behavior</td>
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<tr>
<td>Figueiroa-Colon et al</td>
<td>7–17</td>
<td>RS?</td>
<td>1. PSMF fast diet</td>
<td>10</td>
<td>57.9</td>
<td>10 Wk of 50% protein, 600–800 kcal (1); 10 wk of hypocaloric balanced diet (800–1000 kcal) (2)</td>
<td>20 Min supervised aerobic activity (10 min @ 70% maximal heart rate); lifestyle activity (Cooper’s aerobic point system) (1,2)</td>
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<td>2. Hypocaloric balanced diet</td>
<td>9</td>
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<tr>
<td>Flodmark et al</td>
<td>10–11</td>
<td>R</td>
<td>1. Family therapy</td>
<td>44</td>
<td>52.3</td>
<td>Nutrition information 1500–1700 kcal, &lt;30% fat kcal (1,2)</td>
<td>Exercise information (1,2)</td>
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<td>2. No family therapy</td>
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per week.\textsuperscript{14-16} In these studies, diet plus exercise programs were associated with better physiologic outcomes than were the no-treatment control groups.

A third dietary approach is the traffic-light diet, which is used for preschool\textsuperscript{7} and preadolescent\textsuperscript{13,18-30} children. The traffic-light diet is a structured eating plan (900 to 1300 kcal) used to guide participants’ eating patterns to meet age recommendations of the basic four food groups, and now the food pyramid, thereby increasing the nutrient density of the diet. The traffic-light diet groups foods into categories: green foods (go) may be consumed in unlimited quantities; yellow foods (caution) have average nutritional value for the foods within their food group; and red foods (stop) provide less nutrient density per calorie because of high fat or simple carbohydrate content.

Most interventions using the traffic-light diet as part of a comprehensive treatment have produced a significant decrease in obesity\textsuperscript{18-21,23,25-30} in preadolescent children. The traffic-light diet is associated with an improvement in nutrient density for protein, calcium, iron, vitamin A, thiamine, and riboflavin and a decrease in nutrient density for fat in preadolescents.\textsuperscript{18} Significant changes in eating patterns have been reported when comprehensive obesity treatment has been combined with the traffic-light diet.\textsuperscript{29,30} Reductions in “red foods” have been observed after treatment,\textsuperscript{22,30} with significant associations between changes in intake of “red food” and weight loss\textsuperscript{29} or decrease in percent of overweight.\textsuperscript{30} Finally, obese children of elementary-school age who were treated with the traffic-light diet also showed a greater decrease in rated palatability for high-fat/low-sugar, low-fat/high-sugar, and high-fat/high-sugar foods and a greater increase in rated palatability for low-fat/low-sugar foods than did comparable lean children who were not treated.\textsuperscript{31} In addition to short-term effects, long-term obesity changes extending from 5 to 10 years after initiation of treatment have been observed with the traffic-light diet in combination with behavioral, exercise, and familial components.\textsuperscript{3,7,32}
<table>
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<tr>
<th>Source</th>
<th>OW, %*</th>
<th>BMI†</th>
<th>BW, lb*</th>
<th>BF, %*</th>
<th>Rx, mo</th>
<th>OW, %*</th>
<th>BMI†</th>
<th>BW, %*</th>
<th>BF, %*</th>
<th>FU, mo</th>
<th>OW, %*</th>
<th>BMI†</th>
<th>BW, %*</th>
<th>BF, %*</th>
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<td>Amador et al[11]</td>
<td>&gt;97</td>
<td>0–6</td>
<td>1</td>
<td>↓ 18.8§</td>
<td>1</td>
<td>↓ 14.9§</td>
<td>(analyzed by gender)</td>
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<td>Aragona et al[29]</td>
<td>0–3</td>
<td>0–11</td>
<td>OW, BMI, Rx:1,2,3</td>
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<td>Duffy and Epstain et al[20]</td>
<td>0–5</td>
<td>0–8</td>
<td>3</td>
<td>↓ 6.8§</td>
<td>2,6</td>
<td>↓ 7.3§</td>
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</table>

**Table 2:** Outcomes of Childhood Obesity Treatment Studies on Clinical Samples

*SBP = Systolic Blood Pressure, DBP = Diastolic Blood Pressure, BMI = Body Mass Index, OW = Obesity Wave, Rx = Treatment, FU = Follow-up, % = Percent, lb = Pounds, %ile = Percentile.*
The protein-sparing modified fast (PSMF) 33 a more restrictive diet, has been used to treat severe pediatric obesity. The PSMF usually consists of 600 to 900 kcal and 1.5 to 2.5 g of high-biological-quality protein per kilogram of ideal body weight per day, usually provided as lean meat; vitamin and mineral supplementation and consumption of at least 1.5 L of water per day is encouraged. The PSMF is designed to maximize weight loss, preserve mineral balance, and achieve positive nitrogen balance, thereby conserving lean muscle mass in growing individuals. PSMF diets are usually of short duration (4 to 12 weeks), conducted under close medical supervision, and not commonly used with prepubertal children. Figueroa-Colon and coworkers 33 reported an 11.2-kg weight loss in 10 weeks, but at 15 months the decrease in percent of overweight was similar to the decrease in percent of overweight achieved by a less restrictive dietary prescription. 33

These studies show that there are several different approaches to improving food choice and reducing caloric intake in obese children. There are no comparative studies in which other aspects of treatment are held constant as the type of dietary recommendations are varied. The effect of diet depends on the context in which it is presented in treatment; dietary recommendations are complemented by strong components of behavior change to enhance weight control. 20 Very little is known about specific components of dietary recommendations, such as macronutrient content of the diet. Likewise, no studies have concentrated on the pattern of eating in obese children or on the distribution of food in meals and snacks. The degree to which the diet is rigid or flexible or on the distribution of food in meals and snacks.

<table>
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<tr>
<th>Source</th>
<th>OW, *</th>
<th>BMI†</th>
<th>BW, %</th>
<th>BF, %</th>
<th>Rx, mo</th>
<th>OW, %</th>
<th>BMI‡</th>
<th>BW, %</th>
<th>BF, %</th>
<th>FU, mo</th>
<th>OW, %</th>
<th>BMI‡</th>
<th>BW, %</th>
<th>BF, %</th>
<th>Results</th>
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<td>OW,Rx:2&gt;1&gt;2</td>
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</tbody>
</table>

* Baseline.
† Change.
‡ Value significantly different from baseline value (not reported when between-group differences are reported).
OW indicates overweight; BW, body weight; BF, body fat; Rx, treatment period; FU, follow-up period; values with different superscript letters differ significantly from each other. Treatment period was designated as the period when meetings occurred at least monthly (except for the study by Flodmark, when meetings were more sporadic). Values in parentheses were derived for this table from data provided by the authors.
should be studied. If the goal is for children to develop a taste for fruit, should candy be removed from their diet, eaten occasionally, or eaten whenever requested? There is very little research studying the effects of dietary change on food preference, which may be very important if long-term compliance is desired. Finally, research on food choice and preference has not kept up with the rapid changes in the foods available to children, and the influence of sugar and fat replacements should be studied with regard to the health of the children as well as their use in facilitating long-term dietary change.

### Exercise

Exercise treatments are designed to increase energy expenditure to produce or increase negative energy balance. In most obesity treatments, the major impact on energy balance occurs through decreasing caloric intake, but increasing the caloric expenditure of obese children may accelerate weight loss and potentiate maintenance of weight changes. However, exercise should be combined with dietary intervention. For example, extra physical activity had no significant effects on weight in the absence of dietary intervention.

Several studies have included diet and aerobic exercise. Hills and Parker found differences in skinfold changes but not in weight in preadolescent children provided weekly supervised exercise sessions plus a three- or four-time per week home aerobic activity program versus diet alone. Rocchini and colleagues explored the benefits of aerobic activity designed to maintain heart rate between 60% and 80% of maximal exercise heart rate for 40 to 60 minutes in 20-week interventions. In both studies, both diet and diet plus exercise were equal for weight and body fat changes.

### Table 3

<table>
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<tr>
<th>Source</th>
<th>Age (y)</th>
<th>Group Assignment</th>
<th>Between-group variable</th>
<th>N</th>
<th>% Girls</th>
<th>Diet</th>
<th>Exercise</th>
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<td>None reported</td>
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<tr>
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<td>7th, 8th grades</td>
<td>Rsch</td>
<td>1. Treatment 2. Control</td>
<td>119</td>
<td>NR</td>
<td>Nutrition information (1)</td>
<td>Supervised aerobic activity (1)</td>
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<tr>
<td>Christakis et al</td>
<td>13–14</td>
<td>RSclass</td>
<td>1. Treatment 2. Control</td>
<td>55</td>
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<td>Nutrition information (1)</td>
<td>Extra exercises + basketball league (1)</td>
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<tr>
<td>Figueroa-Colon et al</td>
<td>9–13</td>
<td>Rsch</td>
<td>1. Treatment 2. Control</td>
<td>12</td>
<td>42.1</td>
<td>10 Wk of 50% protein</td>
<td>45 Min, 5×/wk (25 min @ 75% maximal heart rate) (1)</td>
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<tr>
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<td>Rclass</td>
<td>1. Behavior modification 2. Education</td>
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<td>RS</td>
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<td>30</td>
<td>54.5</td>
<td>Food exchange (1)</td>
<td>Supervised aerobic activity (1)</td>
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</tbody>
</table>

* N indicates number of subjects entering treatment (per group if available); EO, subjects ranked according to overweight, even/odd assignment to group; Rsch, schools were randomly assigned; NR, not reported; RSclass, classes were stratified on key variables and then randomly assigned; Rclass, classes within schools were randomly assigned; RS, subjects were stratified on key variables and then randomly assigned.

### Table 4

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<th>Source</th>
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<th>BMI*</th>
<th>BW, lb*</th>
<th>Rx, mo</th>
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<th>BMI†</th>
<th>BW, lb†</th>
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<td>Botvin et al</td>
<td>≥20</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>0–6</td>
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</table>

* Baseline.
† Change.
‡ Value significantly different from baseline value (not reported when between-group differences are reported).
OW indicates overweight; BW, body weight; Rx, treatment period; NR, not reported; values with different superscript letters differ significantly from each other.
body fat changes, although the diet plus exercise groups showed better improvements in other physiologic parameters. Epstein and colleagues demonstrated a significant effect of exercise implemented initially in a structured camp setting beyond that of diet from baseline to 6 months, with a significant difference between the groups maintained at 12 months.25

Another type of exercise program that has been studied is lifestyle exercise, which attempts to increase energy expenditure in regular daily activity as well as during periods of exercise. Lifestyle exercise was shown to be superior to isocaloric programmed aerobic exercise after 17 months of observation, with the addition of the traffic-light diet showing no additional effect on percent of overweight.19 In a follow-up study, diet plus lifestyle exercise were significantly more effective than diet plus aerobic exercise at 2 years,26 but both exercise programs were superior to diet plus calisthenic control at 10 years of observation (−19.7% and −10.9% vs +12.2%).6 However, in one study, lifestyle exercise was not found to have additional effects beyond diet over 1-year28 and 10-year4 intervals.

The effects of exercise can add to dietary interventions to enhance weight loss and improve long-term maintenance. Preliminary data suggest that less structured, more flexible lifestyle exercise may be superior to more structured and higher intensity aerobic exercise for weight control.6 As with diet, the effect of an exercise program varies as a function of the other components of treatment. There are many unanswered questions about the best exercise approach. Are reliable differences observed as a function of exercise intensity, or is the volume of expenditure most important? Do specific types of exercise have reliable effects on appetite or dietary compliance? Can the new American College of Sports Medicine/Centers for Disease Control and Prevention guidelines for moderate activity change38 be used in childhood obesity treatment? Should exercise be presented in structured ways, as in team sports or group activities, or should children be taught more general principles for increasing activity? Are there important age and developmental differences in coordination or motor learning that would provide recommendations for different exercise interventions?

Surgical Treatments

In an uncontrolled study, jejunoileal bypass surgery was used to treat 11 adolescents who were at least 100% over their ideal body weight. At 10-year follow-up, they had maintained a weight loss ranging from 45 to 90 kg.39 However, a significant number of complications were encountered by all participants, including encephalopathy, nephrolithiasis, cholelithiasis, renal cortical nephropathy, hypoprothrombinemia, systemic fatty acid deficiency, and many other nutritional deficiencies. Three of the 11 adolescents had complications from the bypass that were severe enough that surgery to reverse the operation was necessary. Thus, although this surgery did produce a large amount of weight loss that was maintained over 10 years, the side effects of the procedure were extremely costly, and the investigators did not recommend additional use of this operation for adolescents.39

Drug Treatments

With the surge of interest in the use of pharmacotherapy to treat adult obesity, the suggestion has been made that the use of anorectic pharmacologic agents, specifically protocols that include fenfluramine, should be evaluated for treatment of pediatric obesity.40 One controlled study did not find significant decreases in weight or body fat when fenfluramine was combined with diet intervention.41 A more recent study found that treating adolescent obesity with an energy-restricted diet and d-fenfluramine produced significant decreases in BMI from baseline, but these differences were not significantly different than the control treatment of diet and placebo.42 These studies do not provide confidence in the efficacy of current pharmacologic interventions for pediatric obesity.

Behavior Change in Pediatric Obesity Treatment

Given the complexity of behavior change and the difficulty in adherence to treatment protocols, an understanding of factors that influence behavior change is needed. The importance of including behavior therapy in the treatment of childhood obesity was demonstrated by Epstein and colleagues.20 They reported that the addition of the behavioral techniques of contingency contracting, self-monitoring of caloric intake and weight, praise, and stimulus control to nutrition education significantly improved reduction in percent of overweight compared with nutrition education alone over a 5-month period (−17.5% vs −6.4%). Other investigators have reported the superiority of behavioral treatment versus no-treatment controls.43-45 However, in some school-based programs that have targeted the child alone, behavior modification has neither been necessary for treatment gains46 nor provided treatment gains beyond that of education.47

In an additional test of the role of behavior therapy in obesity treatment, families who have received intense behavioral intervention might be expected to do better than families who receive less behavioral treatment. Israel and colleagues48 found that at 1-year follow-up, children whose parents had participated in a short course in general behavior management had significantly better weight control than children in an intervention that focused only on weight reduction. Families that master behavior change also might be expected to do better in treatment than families provided the same intervention without mastery. Epstein and colleagues49 found that children in the mastery group had significantly better treatment outcome than did children in the non-mastery group at 12 months. At 24 months, children in the mastery condition had larger changes in percent of overweight than did nonmastery control children (−15.4% vs −10.6%), but the results were no longer significantly different.

Behavior therapy is designed to teach new behaviors, and thus research showing differences in learn-
ing as a function of the interval between teaching periods may be relevant to scheduling treatment sessions. Senedia and Spence\textsuperscript{22} assessed the effects of rapid (eight sessions in 4 weeks) or gradual (eight sessions over 15 weeks) behavioral treatment versus a nonspecific control condition and a wait-list control group. At 26-week follow-up, the gradual behavioral group had more significant weight change than did the rapid group, who had more weight change than did the nonspecific control group.

Aragona et al\textsuperscript{50} compared the effects of response cost (loss of monetary deposit contingent on meeting attendance, self-monitoring, and child weight-loss criteria) with or without reinforcement versus a no-treatment control group in a small sample of 5- to 11-year-old children. At follow-up, no treatment effect was found, although reinforcement appeared to add a slight benefit for the group in terms of less weight regain. The goals targeted for reinforcement also can influence outcome. Coates and coworkers\textsuperscript{53} contrasted groups in which changes in caloric intake or weight were targeted and reinforced according to meeting daily or weekly goals. At 10 months, the best results were obtained for adolescents reinforced for weight change on a daily basis.

Obesity has been considered a disorder of self-control, and two studies evaluated whether self-management treatment would enhance child weight control. In both studies, children were provided comprehensive behavioral family-based programs; neither the study by Epstein and colleagues\textsuperscript{6,52} nor the study of Israel and colleagues\textsuperscript{53} observed significant effects of child self-control training.

Research on obesity treatment in children and adolescents has tested the influence of including multiple family members. In a long-term study, Epstein and colleagues\textsuperscript{29} explored the influence of selection of targeting parents and children by randomizing families to one of three groups for behavior change: 1) nonspecific target, 2) child target, and 3) child and parent target. At posttreatment and 2-year follow-up, children in all groups demonstrated similar changes in percent of overweight; however, at 10-year follow-up, the parent–child group had significantly better changes in weight status than did the nonspecific control, with the child-only group in between. Despite the intuitive nature of the conclusion that including parents in treatment improves treatment outcome, a number of studies have not found that targeting parents adds to treatment effects in preadolescent\textsuperscript{34} and adolescent\textsuperscript{55} samples.

If both parent and child are treated, the structure of the treatment sessions may be important. Two studies explored the effect of parent participation in adolescent weight change by randomizing families into one of three groups: 1) child-alone group, 2) child and mother treated together, and 3) child and mother treated in separate groups. At 1-year follow-up of a white sample,\textsuperscript{36} children in the child–mother separate group decreased their percent of overweight significantly more than did children in either the child–mother together or the child-alone groups, which did not differ (−20.5% vs −5.5% and −6.0%, respectively). However, no differences were observed in black children by similar methods after 10 months.\textsuperscript{57}

Mendonca and Brehm\textsuperscript{58} evaluated the role of perception of choice in therapeutic outcome of behavioral obesity treatment. Children who perceived that they chose the type of treatment reduced in percent of overweight more than did children in the no-choice control at 12 weeks. No treatment effect was found at 9 months, but the small sample size and attrition precluded meaningful interpretation at this time point.

On the basis of behavioral choice theory,\textsuperscript{59} Epstein and colleagues\textsuperscript{21} evaluated the influence of treatments in which children are targeted and reinforced for greater activity, less sedentary behavior, or a combined group. The children reinforced for reducing sedentary behavior showed a significantly greater decrease in percent of overweight compared with the children reinforced for increased activity, with the combined group in between; at 1-year follow-up, the group reinforced for less sedentary behavior maintained their weight loss, whereas the combined group had gained weight and become equivalent to the group reinforced for activity.

Graves and colleagues\textsuperscript{23} found that problem-solving, a component of many behavioral treatments, is necessary for successful treatment, because families provided behavioral treatments with parental problem-solving had significantly better outcomes at 8-month follow-up than families not provided training in problem-solving. However, Duffy and Spence\textsuperscript{30} found no additional benefit of cognitive therapy techniques such as targeting monitoring of negative thoughts, restructuring of maladaptive thoughts, problem-solving, and self-reinforcement in addition to behavioral techniques for 7- to 10-year-old and 10- to 13-year-old children at 8-month follow-up.

Finally, one study assessed the effects of family therapy on treatment of obesity in 10- and 11-year-old children.\textsuperscript{24} At the end of 14 months, neither group showed decreases in obesity, but children in the family therapy group had significantly smaller increases in BMI than did children in the conventional dietary counseling group. This difference disappeared 1 year later.

The use of behavior change methods in treatment is critical to long-term success of obesity treatment, and interventions for behavior change act in concert with the diet and exercise components to determine outcome. Some preliminary observations on behavior change can be made. The research suggests that effects are enhanced for programs that include behavior therapy,\textsuperscript{20} with outcome related to intensity of treatment.\textsuperscript{68} Furthermore, parental involvement can be an important part of child obesity treatment.\textsuperscript{30,36} However, there are many unanswered questions about how treatment should be implemented. How important is general parent training, or should the parent training be specific to eating and activity change? How are different parent training programs adapted to the age of the child, because different programs are needed for preschoolers, preadolescents, and adolescents?\textsuperscript{26} What do we know about
parent motivation to help children change their dietary or physical activity practices? What is the role of specific components of parent training, including parent use of goal-setting, parent problem-solving, and parent application of rewards for attained changes? How many sessions are optimal, and how should the meetings be scheduled? Because parenting approaches need to change as the child grows older, should regular booster sessions be scheduled to train parents in developmentally appropriate methods? What is the best combination of parent modeling and parent support of desired behavior to produce long-term stable improvement in food choice and activity choice? Can school-based education teach skills needed for obesity treatment and prevention, and can school and community programs be linked to clinical activities to reinforce treatment efforts?

Side Effects of Treatment
Positive Physiologic Side Effects of Treatment

Besides the overtly obvious goal of a decrease in percent of overweight or overfat, treatment goals for pediatric obesity should include improvement in other physiologic parameters such as blood pressure, serum lipids, and insulin resistance. Research has found that after treatments that produce significant decreases in body fat, percent of overweight, or weight, adolescents demonstrated significant decreases in systolic and diastolic blood pressures. A change in serum lipids also has been documented as a positive outcome in the comprehensive treatment of pediatric obesity. For children, significant reductions in fasting serum cholesterol and triglycerides and significant increases in high-density lipoprotein (HDL) serum cholesterol have been found after comprehensive treatment, with serum HDL levels remaining significantly higher than baseline levels at 5-year follow-up. Epstein et al reported that at 5-year follow-up, changes in relative weight and fitness were significantly associated with change in HDL levels. Sasaki and colleagues found that a long-term aerobic exercise program, which resulted in significant decreases in body fat in children, resulted in significant increases in HDL concentrations. In addition, dietary treatments have been associated with significant reductions in fasting serum cholesterol and triglycerides and low-density lipoproteins.

Other improvements in the metabolic profile of obese children and adolescents have been documented after treatment. Investigators have reported decreases in fasting serum insulin levels after comprehensive treatment for obese children and adolescents. At 5-year follow-up, insulin levels were not significantly different from levels at baseline, but occurrence of hyperinsulinemia had decreased, and a significant negative correlation was found between serum insulin levels at the end of treatment and a decrease in relative weight over the follow-up. Hoffman and coworkers reported significant increases in mean insulin sensitivity when obese children treated with an energy-reduced diet showed significant reductions in body weight, but Gutin and colleagues found no significant changes in fasting insulin after weight change.

Psychological Benefits of Weight Reduction

Obese children seeking treatment often experience psychological comorbidity, and obesity treatment may improve their psychological status. There has been considerable research on self-esteem and psychopathology in obese children. There has been some debate about whether psychological problems cause obesity or are caused by obesity and whether the prevalence of psychological problems is greater in obese than in nonobese children and adolescents.

Most of the research in this area has targeted self-esteem. Although self-esteem may change during some interventions, this change is not consistently associated with decreases in percent of overweight. For example, in school-based interventions designed for prepubertal children, increases in self-esteem occurred in the absence of weight change, and equivalent improvements in self-esteem were demonstrated for both experimental and control groups. Wadden and colleagues found significant increases in self-esteem and decreases in depression in black girls; however, consistent with other studies, no relationship was found between self-esteem or depression and changes in weight. Furthermore, studies of adolescents have demonstrated equivalent increases in self-esteem for both treatment and control groups as well as no increase in self-esteem during treatment. Research to date suggests that improvement in self-esteem in obese children in treatment may be better accounted for by nonspecific treatment effects than by improvement in weight status.

Parent and child psychological problems may influence treatment outcome. Epstein and colleagues demonstrated that parental distress had negative effects on child weight loss during the treatment phase, which were mediated by their child’s level of anxiety and depression. At 2-year follow-up, parental distress affected child weight change through effects on the child’s social problems; children who had greater social problems had less successful treatment. Obesity treatment also may influence child psychological changes. We are in the process of collecting follow-up psychosocial data on obese children treated in a 16-week, family-based behavioral treatment program. Preliminary analyses show an improvement in child behavior checklist values at 1 year, with the greatest decrease shown for social problems. Significant reductions also have been observed for anxiety and depression, withdrawn behavior, attention problems, and somatic complaints. The broad-band internalizing and total-problems scales also have shown significant improvements. More importantly, the improvement in weight status from baseline to 1-year assessment is associated with improvement in psychosocial functioning, with significant positive correlations between weight loss and social problems, somatic complaints, and total problems.
Negative Physiologic Effects of Treatment

With any dietary intervention that reduces energy and consequential macro- and micronutrient intake during a period of growth, there is the potential of impairing linear growth. Growth failure has been reported in the overzealous treatment of hypercholesterolemia in children because of inadequate energy, fat, and micronutrient intake, and investigators have reported significant reductions in height velocity during interventions with obese children. Amador et al. found that more restrictive energy intakes (0.17 instead of 0.25 MJ/kg) prescribed to children in the early stages of puberty produced significantly less height gain in the children during a 6-month treatment; there was no significant difference in height gain between the two groups from baseline to 12-month measures. Also, increases in lean body mass were lower in the more restricted energy group than in the less restricted energy intake group, both after treatment and from baseline to 12-month measures. Positive growth velocity z scores in children also have been documented after the children were treated for obesity.

However, these changes in growth velocity must be interpreted within the context that obese children experience an earlier growth spurt than their non-obese counterparts; thus, obese children may naturally undergo a deceleration in height velocity later in development. This hypothesis reconciles the data that children with earlier growth spurts are not taller in development. In our long-term, 10-year follow-up studies, we have not found that the more successful children show less growth, and height percentiles showed the expected decrease over 10 years, so that children came to resemble their same-sex parent in height. Multiple-regression analysis found that child percent of overweight change made no contribution to predicting height change, and that child sex, age, baseline height, percent of overweight, midparent height, and height change from baseline to 5 years accounted for 95% of the variance in growth that occurred from baseline to 5-year follow-up.

Eating Disorders

Dietary restriction that can be part of weight-control programs is a defining characteristic of both anorexia and bulimia nervosa. A number of studies have found caloric restriction to precede binge-eating. For example, in one study, 75% of bulimic patients interviewed reported that the inability to maintain a low-carbohydrate diet immediately preceded bulimic symptoms. More importantly, prospective studies of adolescent girls suggest that dietary restriction predate bulimic symptoms, with one study reporting that adolescent girls who were dieting had an eightfold increased risk for being diagnosed with an eating disorder compared with non-dieters.

However, few of the obesity treatments described above assessed the prevalence of disordered eating after obesity intervention, which would require significant long-term follow-up. Only Epstein and colleagues report the prevalence of eating disorders in 158 individuals who had been treated for obesity. At the 10-year follow-up, 4% of the subjects (all female) reported having been treated for eating disorders, which compares favorably with population prevalence rates ≤9% in studies that used self-reported diagnoses and prevalence rates ≤5% in studies that diagnosed eating disorders by means of structured interviews. Given that obese adults presenting for obesity treatment have higher rates of eating disorders than do community samples of obese adults, it would not have been surprising to have found even higher rates of eating disorders than those in community samples of children. Thus, moderate caloric restriction in a structured behavioral intervention may not carry the increased risk for development of disordered eating found by more drastic caloric restriction. Clearly, more work is needed in this area; however, it would be worthwhile to determine whether appropriate education and skills training during development in obese pediatric patients might prevent eating disorders as well as to understand what characteristics of treatment, if any, are associated with developing eating disorders.

DISCUSSION

Improving Implementation of Pediatric Obesity Treatment

Substantial progress has been made in the development of treatments for childhood and adolescent obesity. However, most pediatric obesity interventions are marked by small changes in relative weight or adiposity and substantial relapse, although there is some evidence for long-term efficacy. It is premature to assume that there are standardized treatments that are efficacious, and research is needed to improve treatment outcome and maintenance of treatment effects. There are many new developments in diet, exercise, and behavior change that should be incorporated into treating childhood obesity; however, for brevity, we focus here on behavior change. Additional new findings in eating and exercise behaviors that can inform treatment development are described by both Birch and Fisher and Kohl and Hobbs.

First, given the central role of behavior therapy in the treatment of child and adolescent obesity, a thorough understanding of behavioral principles and their use is a necessary component of successful weight control programs. It is possible that interventions that claim to have a behavioral component may be misusing behavioral techniques or misapplying behavioral principles. Stunkard notes that behavior therapy for obesity was and sometime still is seen as a set of tools to micromanage within-meal eating behaviors such as the rate of eating and bite size. However, there is little empirical evidence that these behaviors are associated with weight status or that changes in these behaviors correlate with weight loss. Behavior therapy for obesity has expanded considerably from these roots and demands a current knowledge of the factors that influence energy balance behaviors as well as an awareness of behavioral
principles and their application to changing activity and eating habits if long-term maintenance is to be achieved.

More comprehensive assessments of the process of behavior change are needed. There are few studies that provide measures of compliance to treatment outcome, and these studies may be compromised by the well-documented problems that have been noted in self-reporting of dietary and activity changes. If behavior change strategies are to be effective, it is critical to ensure that people are in fact implementing these programs as planned and are demonstrating mastery of new skills. The mediators of behavior change are assumed to be changes in eating and activity. However, as Baranowski and colleagues have pointed out for community health interventions, the link between the hypothesized mediators and health outcomes is weak. The same could be said for obesity treatment, and one solution may be studies that focus on modifying the proposed mediators instead of assuming that changes in the mediators will influence outcome. Until eating and activity patterns can be modified reliably, investigators must rely on weak treatments to attempt modification of behaviors that are quite resistant to change. Research also is needed to assess the short- and long-term effects of exercise and diet interventions on regulation of food intake, body composition, fat distribution, energy metabolism, and substrate use. In the long term, it is more cost-effective to focus on development of methods that modify the proposed mediators of change reliably and test for changes in proposed mediators rigorously than to ignore mediators and focus only on weight loss.

Behavioral Economic Research

An example of using advances in behavior theory to inform treatment development is application of behavioral choice theory. Behavioral choice theory provides a conceptual and methodologic framework for understanding behavioral choice. One important choice for obese children is whether to be active or sedentary. In general, obese children choose to be sedentary when they are given the option of engaging in physical or sedentary activity, because they have a more negative perception of physical activity and find physical activity less reinforcing than sedentary activity relative to their nonobese peers. Highly reinforcing sedentary activities compete with physical activity and decrease children's levels of physical activity. Behavioral choice theory suggests that one way to increase physical activity is to increase the relative reinforcing value of physical activity relative to sedentary activity, either by increasing the reinforcing value of physical activity or by decreasing the reinforcing value of sedentary activity. This reframing of physical activity as a choice between physical and sedentary activity requires consideration of sedentary activity when interventions to increase physical activity are being designed. This is particularly important in obese populations, because participation in sedentary activity has been found to be cross-sectionally and longitudinally related to childhood and adult obesity.

Both laboratory research and clinical outcome research show that positively reinforcing reductions in high-preference sedentary activities increases the physical activity of obese children to a magnitude similar to that obtained by positively reinforcing increases in physical activity. In clinical research, no benefits have been observed for targeting the combination of reduced sedentary behavior and increased activity. Children who are reinforced for decreasing time spent in some of their high-preference sedentary activities reallocate time from these behaviors to engage in both lower preference sedentary activities and physical activity.

One advantage of reinforcing reductions in sedentary activity to increase physical activity is the greater choice and control afforded by this contingency compared with contingencies that reinforce increases directly in physical activity. Maintaining choice and control is important in establishing reinforcing value and enhancing these variables may minimize the sense of deprivation associated with reducing common sedentary behaviors. Deprivation is a powerful way to increase the reinforcing value of an activity or other commodity, and interventions that minimize the sense of deprivation are likely to have more long-term behavior change and decreased likelihood of relapse.

Children reinforced for decreasing sedentary activities choose to replace these activities with physical activity or nontargeted sedentary activities, thus maintaining their control over the choice between physical and sedentary activity. Additional support for the need to maintain children's choice and control about activity choice comes from examination of various techniques to decrease sedentary behavior. There is some evidence that different strategies for reducing sedentary activity have different effects on physical activity. In a laboratory study that compared the effects of positive reinforcement, punishment, and restriction to reduce sedentary activity, each strategy was found to be equally effective in reducing time spent in the targeted sedentary activities. However, children reinforced for decreasing sedentary activity were more physically active than a noncontingent control group, whereas children who had their targeted sedentary activities removed from their environment (restriction) did not engage in significantly more physical activity than the noncontingent control group. Children in the restriction group increased their liking for the targeted sedentary activities, whereas children reinforced for decreases in the targeted sedentary activities decreased their liking for these activities over time.

Reinforcing a reduction in access to sedentary behaviors that compete with being active represents one method for modifying the environment that may lead to obesity. When obesity is being treated, the role of environmental and stimulus control of active behavior should be considered at multiple levels. At the individual level, families may want to increase the cues and opportunities to be active and reduce cues to be sedentary. It is obvious that the larger environment also influences eating and activity. Weather may influence activity, as may having safe
places to play. Children who live in an environment where they can walk or bicycle to school may expend many more calories than children who are driven or bused to school. Access to after-school and weekend active play or sports teams also can enhance activity levels.

Memory Research

Another research area that has considerable relevance for obesity treatment is learning and memory research designed to understand response extinction and recovery. One of the most common and least understood aspects of obesity treatment is relapse, a ubiquitous occurrence in obesity treatment. Most therapists assume that extinction of a behavior or replacement of an unwanted behavior with a new behavior removes a response from the subject’s repertoire. The appearance of relapse therefore implies that the treatment was ineffective.

Bouton and colleagues have begun to understand processes that account for recovery of response after extinction. In a series of animal studies, Bouton has explored the influence of stimulus cues presented when a response is learned (context of the learning) on extinction of that response. Bouton and colleagues112 have demonstrated that context influences recovery of a response that is not reinforced and that has been reduced in frequency. Many treatment approaches attempt to replace a response with a new response pattern by counterconditioning. If the same context is present when both behaviors are learned, spontaneous recovery of the initial response is expected, which demonstrates that learning the new response pattern does not destroy the initial learning.115 If the new behavior is learned in a different context from the initial behavior, presenting the context for the more adaptive behavior will retard relapse to the initial set of behaviors.114 Furthermore, the context during extinction appears to be more important than the context for initial learning. What is learned during response extinction includes memories of being reinforced for a response during learning as well as memories of not being reinforced for the response when treatment occurs. The response observed depends on which memory is retrieved.115

This model has many clinical implications for treatments that attempt to influence weight status by development of positive behaviors (eg, exercise) and extinction of problematic behaviors (eg, overconsumption of high-fat foods). Ignoring problematic behaviors or reinforcing competing behaviors does not destroy the original reinforcement associations that maintained the problematic behavior.116 Changing contingencies for the child’s behavior has added an association to the child’s memory and behavioral repertoire (ie, candy request–no candy) rather than replaced the original association (ie, candy request–candy).

Context and memory may be very important processes for long-term behavioral regulation. Treatments designed to make permanent changes in behavior must take into account that acquired associations may not disappear completely from the repertoire of associations that produce behavior. Relapse prevention, such as expanding the contexts in which extinction conditioning takes place or training children to become aware of extinction cues, may help increase the maintenance of treatment gains for overweight children.

Individualization of Treatment

Treating obesity as a homogeneous condition, with all participants receiving a common intervention, might contribute to the mixed treatment outcomes that are reported. Research has identified many etiologic factors of obesity, including genetic, metabolic, biochemical, environmental, psychological, and physiologic variables.117,118 However, at the individual level, it is probably rare for all of these factors to be involved in development and maintenance of obesity; consequently, the etiology and maintenance of obesity can be very different from one individual to another. Conceptualization of obesity in this way suggests that interventions need to be heterogeneous and individualized; treatments included in interventions should depend on factors that are believed to be involved with development and maintenance of obesity for that individual.117–120 Research is needed to identify which treatment components are successful with different etiologic and maintenance factors of obesity.

Excess intake could be attributable to individual differences in food craving or satiety. The most commonly craved foods in obese individuals are chocolate, cakes, cookies, ice cream, and other desserts,121 which are composed predominantly of simple carbohydrates and fat. Drewnowski121 suggests that food cravings for fat and sugar may involve endogenous opioid peptides; animal research has linked fat and sucrose intake to the endogenous opioid system, indicating a potential mechanism for food cravings. If the mechanism for food cravings can be identified, treatment would involve identifying the critical dimension of the food (eg, nutrient, sensory cue, etc) that is the source of the craving and substituting more appropriate foods that also contain the critical dimension necessary to evoke the neurochemical system linked with the food craving.

Barkeling and colleagues122 observed that obese children ate lunch significantly faster and did not decelerate their eating toward the end of the meal as much as do children of normal weight. Because deceleration of food intake toward the end of a meal is considered to be a sign of satiation, this lack of deceleration might indicate a deficient satiation signal or an impaired behavioral response to satiation signals.122 For obese children who show impaired satiation responses, interventions that focus on strengthening satiation signals through conditioning satiation to orosensory cues or strengthening behavioral responses to satiation signals by training individuals to focus on internal cues (learning to identify when hungry or full and to show appropriate behavioral responses such as beginning or terminating eating) might be appropriate.123,124

Interventions designed to promote attending to internal cues are consistent with a nondieting approach that has been proposed as an alternative to
current treatment paradigms, which usually emphasize some amount of energy restriction combined with increased activity. If subjects could reliably attend to internal cues that would help them match energy intake to energy requirements for a healthy body weight, there might be a reduction in restrained eating and preoccupation with food as a result of perceived food deprivation. Training in food regulation would reduce the parent's perceived need to control the child's intake, which Johnson and Birch have found to interfere with a child's ability to self-regulate energy intake. In this paradigm, parental responsibilities might be different than in a usual weight-control program. Parents would be responsible for providing nutritious and pleasing foods at predictable and comfortable times during the day. Children would be allowed to choose from the available foods; they would also choose how much to eat, so that they can respond to their internal signals of hunger, appetite, and satiety.

Another important factor that may introduce heterogeneity to treatment effects are racial and ethnic factors. Although we are not aware of any research that has contrasted treatment response of different ethnic groups in the same study, investigators from one research group have shown a different pattern of response to a common treatment in white and black teenagers. Obese black and white girls differ in body composition, and resting energy expenditure is different in obese black and white women. These physiologic differences, in addition to the increased prevalence of obesity in the black community, suggest that additional information is needed to understand etiologic differences as well as differences in the response to treatment in different racial and ethnic populations.

If there is heterogeneity in causes for obesity and factors that maintain the obese state, providing a standard group intervention, as is currently usually done, would be sufficient only for those individuals who receive the appropriate intervention by chance. With better assessment techniques, more homogeneous groupings of obese children and adolescents can be achieved, with interventions targeted appropriately to these groups.

**Obesity and Comorbid Conditions**

As reviewed by Dietz, obesity is associated with a variety of comorbid medical conditions, including some that are critical in disease development, such as hypertension, hyperlipidemia, and insulin resistance. Treatment of obesity in these cases should be useful in preventing morbidity and mortality associated with obesity and comorbid diseases. However, there is a series of less prevalent conditions that are associated with morbidity and mortality during childhood and adolescence that may require more aggressive treatment, such as pseudotumor cerebri and sleep apnea.

There is no research designed specifically to study obesity in association with comorbid conditions. Research in these areas is needed to evaluate whether these children are responsive to the same interventions as children without these often medically serious conditions. If these children do not respond to the common dietary, activity, and behavior change components of treatment, more aggressive treatments may be justified.

If individual difference variables such as the degree of obesity or comorbid medical or psychiatric conditions influence treatment outcome, it may be worthwhile to consider a graded approach to treatment. Children or adolescents who are more obese or have comorbid conditions that require immediate treatment may require more aggressive treatment, such as pharmacotherapy or PSMF. In these cases, it is important to monitor the comorbid condition carefully and evaluate whether changes in obesity in fact do result in changes in comorbid status. If weight control does not reduce comorbid problems, then other interventions in addition to weight control must be considered.

One unique aspect of treating children with comorbid medical problems may be motivation for treatment. Most treatment outcome research that was reviewed used subjects who were motivated to participate in an obesity treatment study. However, many obese youth in treatment because of a comorbid condition may not be motivated to participate, or if they are motivated, their parents may not be motivated to take part in treatment. It may be important to be able to assess motivation for change, taking advantage of concepts in the stages of change model. If it is determined that there is not sufficient motivation for behavior change, motivational interviewing may be a useful technique for enhancing motivation to lose weight.

**Integrate Basic and Clinical Research**

Advances in basic science should be integrated into treatment development. Rapid increases in our knowledge of the genetic and molecular basis for obesity provide a stimulus for development of new pharmacologic approaches to obesity treatment. Understanding the influence of genes on eating behavior and obesity also is important for understanding the complementary role of the environment in obesity as well as for identifying specific etiologic factors that may lead to some individuals being at high risk. For example, identifying the genetic basis for behavioral phenotypes, such as impairments in satiety, may be important in developing more focused treatments that target specific behaviors instead of the usual broad-based group methods for treatment.

As reviewed by Birch and Fisher and Kohl and Hobbs, basic behavioral sciences also are providing new insights into processes that may influence eating and exercise behavior. It is important for childhood obesity researchers to be familiar with new developments in child development, learning, and psychology, to name just a few areas that can make important contributions to treatment development. The basic behavioral sciences often are ignored by clinical researchers; consequently, new developments that can inform better behavior change strategies are not incorporated into treatment programs. The pharmaceutics industry takes rapid advantage of new genetic and metabolic findings for drug de-
development and testing, but there is no industry that uses behavioral scientists to read basic behavioral science and neuroscience for treatment development. This responsibility falls to the individual investigator or investigative team to translate basic science into clinical interventions.

Investigators focusing on pharmacologic interventions generally do not reduce attempts to find new pharmacologic treatments when current treatments are not effective. Rather, the search for new drugs goes on, and often the next generation of drug treatment provides better results. Hopefully, we will see the same type of progress made with behavioral and psychosocial interventions for obesity, and investigators will persist in developing more powerful treatments.

CONCLUSIONS

Future Directions

This review provides an overview of contemporary research in treating childhood obesity. The focus is on clinical interventions, although some school-based treatments are discussed. There are many opportunities for treatment development outside the clinic setting—in school-based and community-based programs—although initial research on school-based programs has not been particularly promising. In addition, prevention of obesity, instead of treatment of the problem after it has developed, may be important to public health. There is very little research available on prevention, and prevention approaches are needed at the population level as well as in targeted high-risk populations. Although progress has been made in treating obese children, research is needed that makes contact with developments in nutrition, exercise, and behavioral science to improve long-term weight regulation, maximizing the positive benefits of weight regulation and minimizing the negative side effects of treating obese children.

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Childhood Obesity: Future Directions and Research Priorities

James O. Hill, PhD*, and Frederick L. Trowbridge, MD‡

ABSTRACT. The threat of obesity is greater than ever for US children and adolescents. All indications are that the current generation of children will grow into the most obese generation of adults in US history. Furthermore, there is every expectation that the next generation of children is likely to be fatter and less fit than the current generation. Despite the recognition of the severe health and psychosocial damage done by childhood obesity, it remains low on the public agenda of important issues facing policy makers. Perhaps this is because the most serious health effects of obesity in today’s children will not be seen for several decades. Action must be taken now to stem the epidemic of childhood obesity. This action will require a prioritization of research into the etiology, treatment, and prevention of childhood obesity. It is unlikely that sufficient resources for such research will be available from public and private sources until the issue of childhood obesity is moved higher on the public agenda.

From the *Department of Pediatrics, University of Colorado Health Sciences Center, Denver, Colorado; and ‡Nutrition and Health Promotion Program, International Life Sciences Institute (ILSI), Atlanta, Georgia.

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Leonard H. Epstein, Michelle D. Myers, Hollie A. Raynor and Brian E. Saelens

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