 See accompanying Commentary by Summerbell, p. 1341

Interventions to Prevent or Treat Obesity in Preschool Children: A Review of Evaluated Programs

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Abstract
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Objective: To identify effective programs to prevent or treat overweight among 2- to <6-year-old children.
Research Methods and Procedures: We searched six databases to identify evaluated intervention programs assessing changes in weight status or body fat and systematically summarized study attributes and outcomes.
Results: Four of the seven studies (two intervention, two prevention) documented significant reductions in weight status or body fat. Among these, three sustained reductions at 1 or 2 years after program initiation, three incorporated a framework/theory, two actively and one passively involved parents, three included multicomponent strategies, and all four monitored behavioral changes. Of the three (prevention) studies that did not show reduction in weight or fat status, all performed assessments between 4 and 9 months after program initiation, and one used a multicomponent strategy. Other significant changes reported were reductions in television viewing, cholesterol, and parental restriction of child feeding.
Discussion: The paucity of studies limits our ability to generalize findings. Among the available studies, multicomponent programs with 1- to 2-year follow-up in clinics or child care settings were successful in their impact on weight; they were likely enhanced by parental involvement. Both treatment programs and two of five prevention programs reduced weight/fat status. Our review highlights the need to evaluate more programs, advocate for use of a framework/behavioral theory and objective behavioral measures, further examine the impact of involving parents and the impact of intervention duration and follow-up time, strengthen prevention programs, and further evaluate successful programs in other settings and among other racial/ethnic groups.

Key words: preschool, children, prevention, interventions, evaluation

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Introduction

The primary focus of public health initiatives is to help people become and remain healthy. Toward this end, there have been significant efforts to reduce the prevalence of obesity, which has increased substantially over the past 3 decades with a negative impact on health. National data indicate that overweight (BMI for sex and age ≥ 95th percentile) among preschool-age children in the United States has increased from 7.2% to 10.3% between the periods 1976 to 1980 and 1999 to 2002 (1,2). Among preschool-age children from low-income families in 30 states, overweight (BMI ≥ 95th percentile) increased from 10.8% in 1989 to 13.7% in 2000, suggesting that it may be a slightly greater problem among children from low-income families (3). Moreover, studies have found strong links between BMI values in childhood and those in adulthood (4,5). Also, major causes of adult mortality, such as coronary heart disease and atherosclerosis, are associated with overweight during childhood (6). Other health conditions associated with overweight in childhood are higher blood pressure (7–9) and serum insulin levels (10,11), adverse lipid levels (12), and orthopedic (13,14) and psychosocial disorders (15).

Many interventions have been directed toward adolescents. However, Hedley et al. (2) found no signs of the prevalence of obesity being reduced among the general population of adolescents. Furthermore, it is disturbing that Sherry et al. (3) documented acceleration in the increase in the prevalence of overweight among low-income children 2 to 5 years old between 1989 to 1994 and 1995 to 2000. This suggests an urgent need to identify successful interventions to prevent overweight among young children so that programs can be implemented before the prevalence of overweight among preschool-age children reaches the levels found among adolescents.

Many approaches are being used to prevent and treat overweight among preschool-age children; however, the effectiveness of many intervention programs has not been evaluated. To increase the efficiency of fund use and the effectiveness of prevention efforts, it is imperative to identify and use successful programs. Although systematic reviews of interventions to prevent or treat overweight among children exist (16,17), there is no systematic review of interventions specific to preschool-age children. However, Summerbell et al. (16) did include three of the studies we identified (18–20) and excluded another (21) in their review of prevention of obesity; Summerbell et al. (17) did not include any studies that we identified in their review of treatment of obesity. The goal of our study was to identify and summarize effective evaluated interventions to prevent or treat obesity among preschool children.

Research Methods and Procedures

Search Strategies

We systematically reviewed Medline, the Cumulative Index of Nursing and Allied Health Literature, PsycINFO (Psychological Abstracts), the Excerpta Medica Data Base, Current Contents, and Chronic Disease Prevention File databases using database-specific keywords relevant to preschool, childhood, interventions, obesity, and obesity prevention. We also conducted a search of Medline, PsycINFO, and Sociological Abstracts with terms related to weight (obesity, BMI, weight change, skinfold, fat, gordo, overweight, weight-for-height percentile, adipose, avoirdupois, corpulent, endomorphic), program (intervention, prevention, program, interference, intercession), and age (preschool, prekindergarten, toddler, bambino, and pediatric). The search included publications from 1966 through March 2005.

Inclusion Criteria

Domestic and international studies of preschool-age children that used physical activity and nutritional strategies in interventions to prevent or treat overweight, were at least 3 months in duration, and had a measured outcome variable of weight status, BMI, or body fat were included. Case reports or series were excluded. Studies were not excluded because of their aim (for example, did not have to include weight change), design, or duration of the intervention or follow-up if ≥3 months, primarily because of the limited number of studies found for review. Seven studies that met these criteria were identified. Five studies reported new interventions developed by the researchers, and two (19,22) were adapted from previously implemented interventions.

Intervention Frameworks or Behavioral Theory Bases for Studies

It is well accepted that use of a grounded behavioral change theory [e.g., social-psychological perspectives relevant to patient-provider interactions (23), social cognitive theory (previously referred to as social learning theory) (23), and behavioral economics theory (BET)[1] (24,25)] will very likely enhance the impact of a health intervention (23,26), and the use of a theoretical approach will provide a framework for developing and carrying out an intervention. Behavioral change theories are still being advanced and developed to better understand the process of behavioral change (27,28). For example, Baranowski (27) proposed intervening on mediating variables that are the effective manipulators of the behavioral changes of interest. To better understand the theoretical basis of the interventions, we reported the intervention framework or behavioral theory used for each of the intervention programs reviewed.

Coding of Studies

Two co-authors independently extracted information on the location, setting, sample size, intervention framework, or behavioral theory used, intervention design and protocol, and results for each study. This information was recorded in a large table template with headings for each of the above categories. These co-authors then compared their tables, resolved discrepancies through discussion and verification of the facts from the original publications of the studies, and created a final table for these variables of interest. This final table formed the basis of the results for this review.

Analysis/Summarization

We looked for both the magnitude of the effect of the interventions on weight status and for patterns for these effects in the context of the framework of the intervention, the age of the participants, the setting, and the duration and follow-up period of the intervention. We stratified the studies into those designed to prevent overweight and those designed to treat overweight. Four of the prevention studies were randomized control trials (RCTs), and one was an assigned group program; both of the treatment studies were pre-/post-test cohort studies. For the RCTs and the assigned group program, we reported the differences in the changes between the intervention and control groups, or, if not

[1] Nonstandard abbreviations: BET, behavioral economics theory; RCT, randomized control trial; CDC, Centers for Disease Control and Prevention; TV, television; TSF, triceps skinfold.

available, we reported the changes observed in each group. The control groups for the RCTs accounted for regression toward the mean; the assigned group program had controls although there was no randomization, so it is not clear how much the controls accounted for regression toward the mean. For the pre-/post-test cohort studies, we reported the change in weight status between baseline and follow-up. Regression toward the mean was not accounted for in either the design or analyses of these pre-/post-test cohort studies.

Indices used to determine weight status varied by study. If available, we reported weight status indices based on the Centers for Disease Control and Prevention (CDC) 2000 growth charts (29) and statistically significant changes in BMI z-score (30).

Only key outcome measures pertinent to changes in weight status were reported. Statistical tests with correspondent p values or 95% confidence intervals were included when available. A p value ≤ 0.05 was considered statistically significant.

Results

Overview

Table 1 summarizes the sample size, setting, location, intervention design and protocol, definition of overweight, and results of the seven identified intervention studies grouped by either prevention or treatment in chronological order of publication. Four studies were from the United States, one was from the United States and Canada, and one each was from Thailand and Singapore. Settings included school, day care/Head Start, clinics, and home. Sample sizes ranged from 17 to 1128, and children's ages ranged from 9 to 70 months. As for intervention frameworks/behavioral theories, four of the seven studies described using one or more of the following as the basis of their study: Social Learning Theory (21,31), self-determination (31), Adelarian parent education model (19), BET (22), Transtheoretical Stages of Change Model (31), Piaget Stage II (21), and High/Scope Active Learning (21). Three studies did not identify any framework or theory as the basis of their intervention (18,20,32). Although change in weight status was our key outcome of interest, researchers may have assessed reductions in other outcomes such as energy intake, parental restriction of child feeding, television (TV) viewing, or serum cholesterol, or increases in physical activity. Four of the seven studies found a significant reduction in weight or body fat status, two found no change, and one demonstrated an increase in weight status among white children, with no change in Latino children and black children.

Study-specific Findings

Obesity Prevention Programs: RCTs. Mo-suwan et al. based their intervention design on their previous research (a retrospective chart review), which showed a relative risk of 2.6 (95% confidence interval, 1.88, 3.65) for obesity among children with low rates of exercise (33); however, they did not include an intervention framework or behavioral theory as a basis for their intervention program. Mo-suwan et al. (18) examined the effect of a school-based aerobic exercise program on overweight indices. Their intervention and evaluation were conducted between June 1995 and February 1996, and five classes from two schools were randomized into an intervention ($n = 145$) or control ($n = 147$) group (Table 1). The exercise program was led by specifically trained personnel and lasted 29.3 weeks in one school and 30 weeks in the second school. A log was kept of each child's participation. This intervention program was provided in addition to the curriculum of 1 h physical activity/wk, which was standard at both schools. The control group received only the routine 1 h physical activity/wk. One of the schools had an optional swim class for 1 h/wk, and analyses accounted for participation in this class in the intervention and control groups. At baseline, both groups were comparable in age, BMI, weight-for-height cubed (ratio of weight in kilograms/height in meters cubed), triceps skinfold (TSF), parental BMI status, family history of obesity, and family income.

Mo-suwan et al. found among girls only that the odds of having an increasing BMI slope was significantly less among the intervention group compared with controls (Table 1). The authors' explanation for the significant difference found only among girls was that girls are more docile than boys, meaning that they may be able to achieve a directed goal more quickly. These authors found a borderline significant reduction in the prevalence of a TSF > 95th percentile at the end of the mean 29.6-week intervention among the intervention group and no change among the control group; however, at baseline, girls in the control group had significantly greater mean TSF values than the intervention girls (Table 1). The authors did not report the effect of this baseline difference.

Harvey-Berino and Rourke (34) reported that they based their pilot study on the Adelarian parent education model, which focuses on the primacy of parental influence on child behavior. They studied whether exposing mothers to parenting support skills applied to obesity prevention (encouraging discussion of eating and exercise) vs. exposing mothers only to parenting support skills applied generally would reduce the prevalence of obesity in Native-American children. Their parental support program for both the control and intervention groups was based on the work of Mullis (34) and emphasized the child's psychological and behavioral goals, logical and natural consequences, mutual respect, and encouragement techniques for use in parenting. The parental support program for the intervention group had a structure identical to that for the controls; however, it also emphasized how to apply these parenting skills to the de-

Table 1. Evaluated interventions to prevent or treat obesity in preschool children

Authors	Sample/setting/location	Intervention	Obesity definition	Results
Prevention programs				
Randomized controlled trials				
Mo-suwan et al. (18)	Final, 292 children (414 possible, 25% no parental consent, 4% other)	Randomization, classes within kindergartens	Overweight ≥ 95th percentile TSF for age and sex	•No significant BMI change (mean ± SD): I, 16.25 ± 2.35 to 15.76 ± 2.46 vs. C, 16.36 ± 2.22 to 15.94 ± 2.26
	4.5 ± 0.4 Years old (SD)	Duration, 29.6 weeks; remuneration, none reported		•Obesity (>95th percentile TSF) decreased from 12.2% to 8.8% (I) (p = 0.058) vs. from 11.7% to 9.7% (C) (p = 0.179)
	58% Male	C, 1 h/wk physical education		•Among girls,* I less likely than C to have an increasing BMI slope (odds ratio, 0.32; 95% CI, 0.18, 0.56)
	Race/ethnicity not described Two private kindergartens, comparable curricula Thailand	I, 1 h/wk physical education plus 15-minute walk before class and 20-minute aerobic dance 3 times/wk		•No significant changes were found in weight/height^3, TSF, BMI slope for boys, and slopes of weight/height^3 or TSF
Harvey-Berino and Rourke (19)	Final, 40 mother/child pairs (43 pairs recruited, 7% lost to follow-up)	Randomization, volunteer subjects (pilot study)	Overweight, ≥95th percentile weight for height	•Child mean weight for height z scores (I) decreased 0.27 ± 1.1 (SD) vs. increased 0.31 ± 1.1 (SD), p = 0.06 (C)
	9 to 36 Months old	Duration, 16 weeks; remuneration, mothers given $25 gift certificate for completion		•Prevalence of obesity decreased from 15% (n = 3) of children to 5% (n = 1) of children (I) but increased from 25% (n = 5) of children to 30% (n = 6) of children (C), p = not significant

Table 1. Continued

Authors	Sample/setting/location	Intervention	Obesity definition	Results
	Sex not available	C, parental support (active parenting curriculum†) (no eating or exercise behavior) only ~1 h/wk		•Child mean energy intake (kilocalories per kilogram per day) decreased 39.2 (±89.4) (I) vs. increased 6.8 (±55.4) (C), p = 0.06
	Native American	I, parental support plus extra maternal training in child feeding and exercise, ~1 h/wk		•I mothers had a greater decrease in restriction of child feeding by the end of the intervention than C mothers, $p < 0.05$
	In-home program Northern New York and Canada			•No significant differences between I and C in changes in children's fat intake or physical activity or in maternal weight, BMI, energy or fat intake, or physical activity
Dennison et al. (20)	Final, 163 children (222 enrolled); subject change: moved/dropped, left (59%), new enrollees (38%) pre-TV sessions; for TV, n = 176, loss to follow-up (7%)	Randomization, 16 sites	Overweight not defined but adiposity measured by TSF and BMI	•Between fall 2000 and spring 2001, BMI z score change per year (mean ± SE) was 0.19 ± 0.21 (I) vs. 0.37 ± 0.21 (C), p = 0.54
	2.5 to 5.5 Years old	Duration, 39 weeks; remuneration, none reported		•Overall TV watching reduced by (mean) 3.1 h/wk (I) vs. increased by 1.6 h/wk (C), p = 0.02

Table 1. Continued

Authors	Sample/setting/location	Intervention	Obesity definition	Results
	49% Male	C, Health and safety instruction program, 1/mo		•Viewing TV <2 h/d decreased from 33% to 18% (I) vs. increased from 41% to 47% (C), $p = 0.046$
	95% White Preschool and day care facilities Upstate NY	I, interactive sessions 1 h/wk to reduce TV watching (seven of 39 sessions) and promote healthy eating and physical activity (32 of 39 sessions) (30 minutes of music activities, 10 minutes for snack, and 20 minutes of interactive education)		•Changes per year in child weight, height, and TSF were not significantly different between I and C
Fitzgibbon et al. (31)	Final, 362, 14 weeks; 289, 1 year; 300, 2 years (409 enrolled; loss to follow-up: 1 year, 29.3%; 2 years, 26.7%)	Randomization of school pairs (paired on class size)	Overweight, BMI ≥ 85th percentile for age and sex, but only BMI value and z score change were used for outcome	•At Year 1 follow-up, change (mean ± SE) in adjusted‡ model BMI z score was −0.08 (0.05) (I) vs. 0.16 (0.05) (C), $p = 0.006$
	Age, intervention, 48.6 ± 7.6 months; control, 50.8 ± 6.4 months	Duration, intervention, 14 weeks with 1- and 2-year follow-up, remuneration, $5.00 grocery coupon to parent for completion of each weekly homework		•At Year 2 follow-up, change (mean ± SE) in adjusted‡ model BMI z score was 0.00 (0.04) (I) vs. 0.17 (0.04) (C), $p = 0.015$
	50% Male			•At Year 1 follow-up only, I had lower percentage of calories from saturated fat than C, 11.6% vs. 12.8%, respectively: difference, −1.15; 95% CI, −1.74, −0.56

Table 1. Continued

Authors	Sample/setting/location	Intervention	Obesity definition	Results
	89.5% Black, 6.6% Latino	C, 20-minute general health (no diet or physical activity) curriculum 1 time/wk. Relevant weekly parental newsletter		•No significant difference in change in BMI or BMI *z* score postintervention (14 weeks); no significant change in physical activity or TV viewing at 14 weeks, 1 year, or 2 years
	Head Start programs Chicago, IL	I, 20-minute healthy eating or exercise lesson with activity, plus 20-minute aerobic physical activity 3 times/wk, relevant weekly parental newsletter with parental homework assignment		
Assigned intervention/ control trial				
Williams et al. (21)	Final, 745 children (787 enrolled; lost to follow-up for anthropometry, 5.3%)	Assignment: I, six sites that could modify food service randomized to nutrition education (Healthy Start) and food service (FS/NU) or food service and safety curriculum (FS/S) but aggregated for analyses because there was no difference in effect on outcome measures; three sites (C) that could not modify food service were used as control sites and given safety education curricula	Overweight not used for outcome. Change in BMI values and weight for height (pounds per inch) assessed	•Among whites, weight to height ratio increased 0.053 (I) vs. 0.018 (C); mean difference, 0.034 pounds/inch; 95% CI, 0.023, 0.045

Table 1. Continued

Authors	Sample/setting/location	Intervention	Obesity definition	Results
	Age, FS/NU, 48.3 ± 6.9 months; FS/S only, 47.9 ± 6.4 months; controls, 49.3 ± 6.1 months 51.3% Male	Duration, school year (months not specified), remuneration, none		•Relative risk of total serum cholesterol (milligrams per deciliter) ≥ 170 in I vs. C was 0.69; 95% CI, 0.57, 0.85 •Prevalence of total serum cholesterol ≥ 170 mg/dL decreased 9.7% (I) vs. increased 3.8% (C)
	42.6% Black 31.6% Latino 22.9% White Head Start programs Upstate New York	C, safety, accident prevention, and general health (no nutrition) education curriculum, time per week not specified		•Change in BMI was not a significant predictor of change in total serum cholesterol •No significant changes in weight-to-height ratio found for blacks or Hispanics
		I, modified school food service to include heart-healthy menus, time per week not specified. Group parent meetings (health themes) three to four times during school year		
Treatment programs: pre-/post-test cohort studies				
Epstein et al. (22)	Final, 17 obese children (recruitment not specified, lost to follow-up not reported)	Duration, intervention weekly for 10 weeks then monthly for 10 months; evaluation follow-up at 10 weeks, 2 months, 6 months, 1 year, and 2 years, renumeration, none	Degree of overweight measured as percentage above ideal weight norms for age, sex, height (43)	•Mean weight percentage greater than ideal weight for height, age, sex (*p* values for comparison with baseline):

Table 1. Continued

Authors	Sample/setting/location	Intervention	Obesity definition	Results		
				Month	**Mean (±SD)**	***p*-value**
	14 to 70 Months old					
	35% Male	Intervention: 10 weekly visits followed by 10 monthly visits; parent and child instructed separately on diet, exercise, and behavioral principles; goals set and followed up; directed traffic light diet and physical activity		Baseline	42.1 (±18.8)	
				12	24.0 (±18.4)	<0.01
				24	27.8 (±21.1)	<0.01
	Race/ethnicity not described Clinic-based Pittsburgh, PA			•Mean (±SD) energy intake (kcal) decreased from 1457.2 (±452.2) to 1024.9 (±191.1) after 10 weeks ($p < 0.01$) •No significant changes in height for age percentile, suggesting appropriate growth		
Ray et al. (32)	Final, 957 obese children (1128 enrolled, 15.2% lost to follow- up)	Duration, 1-, 2-, 5-, 8-month counseling sessions (78.7% completion) plus follow- up measurements at 1-year, renumeration, none reported	Obese ≥ 2 SD (97.7th percentile) above mean weight-for-height-for-age standards for recruitment. For analyses, obese ≥120% normal weight-for-height-for-age	•Distribution of obesity at baseline and at 1 year follow-up (all statistically significant)		

Table 1. Continued

Authors	Sample/setting/location	Intervention	Results			
	36 to 60 Months old			**Pre (%)**	**Post (%)**	***p*-value**
	50% Male 46% Chinese 45% Malay 8% Indian 1% Other Government primary health clinics Singapore	Intervention: severe obesity [≥160% normal weight-for height-for-age (WH)] referred to dietitian (6.1%). Moderate [140% to 159% WH] and mild [120% to 139% WH] given family counseling on nutrition, physical activity, and growth monitoring by preplanned sessions by nurses. Goals set and followed up	Not obese	0.0	20.2	<0.05
			Mild	64.4	50.7	<0.05
			Moderate	29.3	23.2	<0.05
			Severe	6.3	5.9	<0.05
				•At 1 year follow-up, the percentage improvement in baseline obesity status among Indian (47.2%), Chinese (44.4%), and Malay (35.0%) children, $p < 0.05$		

SD, standard deviation; C, control; I, intervention; SE, standard error.
* Adjusted for baseline BMI of group, sex, and interaction between sex and exercise.
† Includes child psychological and behavioral goals, logical and natural consequences, mutual respect, and encouragement techniques.
‡ Adjusted for baseline age quartile, baseline value of BMI, and Head Start site.

velopment of appropriate eating and exercise behaviors in their children. A trained indigenous peer educator conducted this pilot program in the home of each mother/child pair (Table 1). A convenience sample of mother/child pairs was recruited through media advertisements, day care programs, and clinics for the Special Supplemental Nutrition Program for Women, Infants, and Children. The pairs were randomized to the intervention or control group. Behavior changes for diet from baseline and completion of intervention were based on mothers' keeping 3-day food records; physical activity changes were based on data from accelerometers worn during the periods the 3-day food records were kept. After 16 weeks, Harvey-Berino and Rourke documented borderline significant differences between intervention and control groups in weight status and in energy intake (Table 1). Also, maternal restriction of child feeding was reduced more in the intervention group than in the control group ($p < 0.05$).

Dennison et al. (20) based their intervention design on the fact that one risk factor well-documented for overweight among older children is TV viewing (35–38), yet the impact of reducing TV viewing on weight status has not been examined among young children. Using this rationale, plus their concern about healthy eating and physical activity patterns of preschool children, they developed a comprehensive 39-week program for young children called "Brocodile, the Crocodile" (20). However, they did not report use of any framework or theory as the basis for their intervention. They reported on the change in TV viewing from fall 2000 to spring 2001 and the change in weight status from fall 2000 through spring 2001 only among those who participated in the TV viewing sessions of the intervention program. The change in TV viewing was based on parental recalls of their child's TV viewing/video games/surfing internet in the previous week at both the beginning and at the end of the monitoring period. The sample included children in eight intervention and eight control preschool and day care facilities (Table 1). At all intervention sites, the same two interventionists, an early childhood teacher and a music teacher, provided 1-hour weekly sessions promoting healthy eating; seven of these sessions (the focus of this analysis) were devoted (during the fall of 2000) to reducing TV viewing, whereas the control group received monthly instruction sessions on different health and safety topics. All children were weighed and measured using standardized protocol at baseline (fall 2000), winter 2000, and post-intervention (spring 2001) (29,39,40). Questionnaires given to parents in September 2000 and spring 2001 provided baseline and follow-up information on their child's time spent watching TV/video games on average and during the past week, eating behaviors during TV viewing, and whether they had a TV in their bedroom. The two groups were comparable for TV/video viewing time at baseline. Parents were asked to keep a 1-week diary of their child's TV viewing habits during December 2000 to increase their awareness of their child's media-viewing habits. Materials were sent home with the children as an impetus to involve the parents. One goal was for the children to not watch TV for a week at home; parents were given a weekly calendar with stickers to daily reward their children for not watching TV.

Dennison et al. examined both proximal (behavior change) and distal (anthropometric) outcomes. After controlling for sex, age, and pre-intervention media use, they found that the intervention group reduced TV viewing, whereas the control group increased TV viewing (Table 1). Dennison et al. found a significant association between children and parents in the frequency of snacking while watching TV ($p < 0.001$) at baseline, suggesting a possible influence of one on the other. No statistically significant differences in BMI change were found between the intervention and control groups.

Fitzgibbon et al. developed a dietary and physical activity intervention to reduce weight status using input from educators, pediatricians, nutritionists, exercise physiologists, community health advocates, experts in minority health, and focus groups (31). They reported that their intervention was based on Social Learning Theory, Self-Determination, and the Transtheoretical Stages of Change Model (41). Their sample was composed of preschoolers from 12 Head Start programs; the 12 sites were paired on the basis of size and then randomly assigned to an intervention or control group (Table 1). Children in the six intervention schools participated in a healthy eating and exercise intervention, whereas children in the control schools were given a general health concepts education. At baseline and at the follow-up visits, trained data collectors interviewed parents as to the frequency and intensity of their child's physical activity and the hours per day that their child watched TV. Additionally, at baseline and follow-up visits, single 24-hour dietary recalls were obtained from parents for their child by a dietitian; 48% and 100% of the 1- and 2-year follow-ups, respectively, were obtained by phone. Although there were no differences at the end of the 14-week program, at the 1- and 2-year follow-up assessments, BMI z-scores of the intervention group showed a statistically significantly greater reduction (Year 1) or less gain (Year 2) than those of the control group (Table 1). Additionally, although the intervention and control groups had similar percentages of calories from saturated fat at baseline, at 1-year follow-up, the intervention group had a significantly lower percentage of calories from saturated fat than the control group. The intervention group was significantly younger, exercised less, and included more black children than the control group. Age and baseline BMI were adjusted for, but whether or how these other differences affected their findings is not reported.

Obesity Prevention Programs: Assigned Intervention and Control Trials. Williams et al. examined how a change in the school food service aimed at reducing saturated fat intake, without compromising energy intake or nutrient content of the available diet, modified serum cholesterol and weight status (21). They based their intervention on the Piaget Stage 2 Model, Social Learning Theory, and High/Scope Active Learning (21). The study included nine Head Start programs. There were initially three groups of study: a control group with a safety education curriculum but without food service modification, an intervention group with food service modification plus a child/family nutrition education program, and an intervention group with food service modification plus a safety curriculum (Table 1). Behavioral changes regarding participation either in the school meals program or in the take-home activities that were included in this program were not measured. At the end of the intervention, data from the two intervention groups indicated that the nutrition education and safety curricula accounted for little change in the six modified food service groups, so these sites were aggregated into one intervention group for analyses.

Among white children, there was a statistically significant difference in the change in weight-to-height ratio between the intervention and control groups; no differences in changes were noted for black or Latino children (Table 1). Researchers also documented a statistically significant difference between the intervention and control groups with respect to mean change in total serum cholesterol and the prevalence of total cholesterol $\geq$ 170 mg/dL; however, no baseline comparisons were available (Table 1). Of note in this study, the two intervention categories (three programs each) had a longer follow-up than the control programs (5.8, 6.6, and 4.8 months, respectively), and the intervention programs had more black, white, slightly younger, and smaller children than the control programs. These potential confounders were adjusted for in their generalized linear modeling.

Obesity Treatment Programs: Pre-/Post-test Cohort Studies. Epstein et al. sought to determine whether their family-based program, grounded essentially on Epstein et al.'s BET (24,25), which was effective for pre-adolescents, could be adapted to effectively control overweight in younger children (22). Their program focuses on weight loss by reducing calorie intake while providing adequate nutrition to support growth and by increasing physical activity through walking. The nutrition portion of the study was an adapted version of Epstein's traffic light diet (42). In addition, there was a pre-intervention training of mothers to use food models and verbal feedback to keep complete food records for their children. The food records were used to establish calorie limits, and foods from the basic four food groups were recommended as nutritious choices. Behavior changes in eating were discussed during the counseling sessions and were assessed by parents using star charts to note avoidance of the red (stop) foods in the traffic light diet. Children whose weight status became <10% overweight based on their ideal weight norms specific to their age, sex, and height (43) were given a weight maintenance dietary program.

The physical activity portion of the intervention included the parent and child initially walking 0.25 miles 6 d/wk; this was increased by 0.25 miles every 2 weeks until a maximum of 1 mile/d was reached. In addition, parents with children younger than 3 years were given the option of one walk or several smaller walks throughout the day to complete the required walking. Behavior management techniques included contracting, modeling, and social reinforcement with immediate parental feedback to their children such as the positive reinforcement with star charts. These star charts rewarded the child for walking the distance required in the exercise component of the program daily.

Epstein et al. (22) found that the mean percentage overweight in excess of ideal body weight-for-height for age and sex decreased significantly from baseline to 6, 12, and 24 months after baseline measurements (Table 1). Their results also documented a substantial and statistically significant reduction in energy intake after 10 weeks of treatment (Table 1). There was no reduction in height-for-age percentile during the 2-year follow-up, suggesting no compromise in growth.

Ray et al. (32), in their intervention program, used professionally administered goals and assessment (similar to a management/consulting approach) for obese children in conjunction with their families to prevent and control obesity in preschool children; however, they did not base their intervention on any framework or theory. Their 1-year program was developed for the primary health care setting in response to the increasing prevalence of obesity among children in Singapore. The Ministry of Health, Food, and Nutrition Department in Singapore trained 30 nursing staff and doctors. They obtained their sample from children attending 17 Singapore primary health care clinics. These children were from low- to medium-income families and had a weight-for-height value greater than two standard deviations above the normal weight-for-height (44–46) (Table 1). Children with a physician-diagnosed medical secondary cause of obesity were excluded.

For this intervention, a specially trained staff nurse counseled the mildly or moderately obese children. The severely overweight children were referred to a dietitian for counseling until they reduced their weight sufficiently to be classified as moderately overweight, after which they and their families were included in the counseling program. The counseling program focused on education and behavioral changes with respect to diet and exercise patterns of the child and family. During each counseling session, the nurse discussed information on diet, exercise, height and weight patterns, energy balance, and nutritional guidelines with the family and child. Behavior changes were based on parental reports of food intake and exercise patterns and were used only for the counseling sessions. Initial counseling took place within 1 month of diagnosis; follow-up sessions were held after 1, 4, and 7 months. At the end of the 1-year follow-up, Ray et al. (32) found statistically significant reductions in all categories of obesity, and 20.2% of their initially obese participants became non-obese ($p < 0.05$) (Table 1).

Discussion

Overview

Our search yielded only seven interventions to prevent or treat overweight or to enhance the nutritional status of 9- to 70-month-old children that measured weight status to evaluate impact. Of these seven studies, two of the five prevention studies (18,31) and both treatment studies (22,32) reported a statistically significant reduction in weight status or body fat, and one other prevention study (19) reported a reduction that approached significance.

The heterogeneity of frameworks/theories, strategies, and outcome measures used made it difficult to identify any single strategy of intervention that was more effective than others. Among the four studies (18,22,31,32) that documented a significant reduction in weight status or body fat, two (one prevention, one treatment) based their interventions on frameworks or theories (22,31), three (one prevention, two treatment) used some form of nutrition education or diet component (22,31,32), all four (two prevention, two treatment) included either guidance for or directed physical activity programs, and one (prevention) gave remuneration (31). However, the three prevention studies that did not report significant reductions in weight or fat status used similar approaches; two used frameworks or theories, all had a diet component (19–21), and one included directed physical activity (20). Of potential relevance, though, two of these latter studies that did not impact weight had other specific aims, to reduce TV viewing time (20) or lower cholesterol (21).

The literature cites similar challenges in identifying effective interventions to prevent or treat overweight among school-age children. Although there are more studies available for school-age children and adolescents, reviews of that literature revealed heterogeneity with respect to study design and the theoretical models used, thereby making comparisons difficult (16,47,48). In our review of preschool interventions, of the five that were multicomponent (physical activity and diet), three resulted in reductions in BMI. The American Dietetic Association found that 32 of the 34 multicomponent (components varied) interventions among school-age children were effective in reducing adiposity (47). Interestingly, Summerbell et al. (16) found that interventions that included both nutrition and physical activity components may have changed behaviors related to those but did not significantly improve BMI, whereas interventions that focused on only one of these strategies did show a positive impact on BMI. Additionally, the Task Force on Community Preventive Services (48) found an insufficient number of studies of adequate quality in design to support recommending school-based interventions to prevent and control overweight among school-age children.

Use of Intervention Framework/Behavioral Theory as Basis for Interventions

The interventions reviewed used a variety of frameworks/theories and strategies to prevent or treat overweight. The only theory used by more than one study was the Social Learning Theory (21,31). Interestingly, in this review, four of the seven studies based their intervention on a framework or theory, and only two of these four studies documented reductions in weight status. The other two studies based on theories found either a close-to-significant reduction in weight status (19) or reduced cholesterol levels (21). Of the studies that did not base their interventions on a framework or theory, two may have achieved weight loss because they either used a classroom program of physical activity with good compliance (18), or the treatment program had individual child/parent counseling sessions that monitored behavioral changes in diet and exercise (32). The other study (20) focused on reducing TV viewing at home through daycare-based programs that included developing alternative activities to TV viewing at home; however, the use of these specific alternatives was not reported, so we do not know whether they would have the potential to reduce weight status. Additionally, of the four studies that based their intervention on a framework or theory, one involved changing only parental behaviors (19), and the other three focused on both the child and the parent (21,22,31). However, there was no mention as to whether the cognitive models used were applied in a manner that was developmentally appropriate for the children's age (27). Baranowski (27) points out that this is necessary to capture the true variance of the behavior of interest. As previously mentioned, there is evidence that basing interventions on a framework or theory is likely to enhance program outcome (23), so we would advocate for the use of these to develop interventions.

Strategies Used

Of the seven interventions reviewed, five used both nutritional/diet- and physical activity-focused strategies. Among the four studies that achieved significant weight loss among the participants, three used some form of nutrition education or diet component (22,31,32) (one treatment, two prevention), all four (18,22,31,32) (two prevention, two treatment) included either guidance for or a directed physical activity program, and one (prevention) gave remuneration (31). Moreover, the three prevention interventions that did not report significant reductions in weight status used similar approaches; all had a diet component (19–21), but only one included directed physical activity (20), and one provided remuneration (19).

Behavioral outcomes of these interventions were based primarily on parental reports; four studies used objective measures, but three studies either did not monitor behavior changes or used techniques that were more subjective, which could have biased parental reporting. Three prevention studies and one treatment study tried to make these measures objective. Mo-suwan et al. (18) logged participation in the physical activity program, Harvey-Berino and Rourke (19) used 3-day food records to measure diet change and accelerometers to assess physical activity changes between baseline and the end of the program, and Fitzgibbon et al. (31) used 24-hour parental dietary recalls to assess changes in diet. Dennison et al. (20) used parental recall of their child's TV viewing time for the past week and stickers on calendars to monitor children not watching TV for a whole day during their "TV Turn Off" week; however, they did not report monitoring of diet or physical activity changes associated with this intervention. Additionally, in this study, it was difficult to delineate the effect of the reduction in TV viewing sessions of their intervention from the other sessions that emphasized healthy eating. Williams et al. (21) did not report monitoring of any behavior changes, including participation in the school meal program that was the basis of their intervention. Epstein et al. (22), in their treatment study, used parental recordings on star charts of their child's avoidance of "stop" foods and meeting goals for physical activity; the other treatment study (32) did not give details of techniques used to monitor behavior changes but reported that they used these for goal setting for the subsequent visit. Both of the treatment studies actively incorporated monitoring of behavior changes and used these to guide the subsequent setting of goals, which may have enabled these studies to be successful in demonstrating weight loss of the overweight children.

Clearly, the age range of the children at baseline, 9 to 70 months, included in these studies indicates a range in child development abilities (49). Both the nutrition/healthy eating and the physical activity components of these interventions needed to be tailored to age-specific abilities. None of the studies addressed this issue directly, but, in regard to physical activity, among the prevention studies, Mo-suwan et al. (18), Dennison et al. (20), and Fitzgibbon et al. (31) appeared to have activities in line with the American Academy of Pediatric milestones (49). Harvey-Berino and Rourke (19) included developmental stages in lesson topics for both their intervention and control groups, and Williams et al. (21) did not include a physical activity component. As for the treatment studies, Epstein et al. (22) appeared to have reasonable physical activity goals for their participants as they adjusted walking distance and time for age, but Ray et al. (30) did not describe the physical activities that were promoted. The healthy eating/nutrition components of these interventions were not described adequately to determine their appropriateness for the children's age.

Role of Parents in Interventions

Researchers used either the child exclusively or a family or parent focus as the entrée to implement the different strategies. Among the four interventions that reported a reduction in weight or body fat status, the two treatment studies (22,32) actively involved the parents in education and activities, which included goal setting and follow-up; for the two prevention studies, one passively involved parents by sending materials home weekly (31), and the other involved only the children (18). As for the three prevention studies that did not demonstrate a weight change, one used parents as the agents of change (19), two sent home to parents educational materials that included parent activities (20,21), and one included educational group meetings for parents three or four times during the school year (21).

Our finding that two of the four programs that successfully reduced weight or fat status actively included the parents and another sent materials home to parents on a weekly basis suggests that more work is needed to examine how active parental involvement needs to be in intervention programs for young children. Epstein et al. (50) showed that when parents were included in the counseling plan, there was a better reduction in weight status after 10 years of follow-up than in the child-targeted group. Golan et al. (51) also found that, in a clinical study of parent-only or child-only interventions for treatment of obesity in children, both the parents and the children reduced their weight status; this program awarded parents' behavioral changes that could help them promote, as role models, healthier eating, and increased physical activity among their children. Dietz and Robinson (52) also advocated parental involvement. They recommended that parents be the ones to institute their four proposed strategies for controlling weight status, which include controlling the environment, monitoring behavior, setting goals, and rewarding successful changes in behavior (52). This approach supports change that could lead to increasing competence among family members to develop and reach goals and to monitor their own efforts toward functional independence to promote healthy weight loss and maintenance.

Other Documented Changes in Health Status

The three prevention studies that did not demonstrate a reduction in weight or body fat status did document significant changes likely to improve health status. The Dennison et al. study (20) showed a significant reduction in hours per week that the children watched TV. Gortmaker et al. (37)

documented a strong dose-response association between hours of TV watched per day and overweight status among adolescents, and Dennison et al. (38) and Ma et al. (53) documented the same association for preschool children. In addition, reducing sedentary behavior (including TV viewing) has been shown to decrease energy intake (54) and increase fruit and vegetable intake (55). In their intervention, Williams et al. (21) documented a reduction in serum cholesterol levels, which at high levels are associated with cardiovascular disease in children (56). Additionally, Harvey-Berino and Rourke (19) found a reduction in maternal restriction of child feeding, which may be associated with overweight in children (57).

Duration and Follow-up Period

In the seven studies, follow-up periods varied from 16 weeks to 2 years. By definition, we would expect proximal measures to change more quickly than distal measures. We consider behavior changes such as reducing TV viewing to be proximal measures, whereas we categorize anthropometric measures as distal measures. The four studies that demonstrated changes in weight or body fat status had follow-up periods of 7.5 months to 2 years. Impressively, in their in-home program, Harvey-Berino and Rourke (19) found a close-to-significant reduction in weight-for-height *z*-score after only 16 weeks of intervention among 9- to 36-month-old children. In contrast, Dennison et al. (20) found no significant change in weight status at the 1-year follow-up. Future interventions need to examine the impact of both intervention duration and follow-up time on weight loss and maintenance.

Intervention Settings

Our review demonstrated success in a variety of locations. In-home, day care, Head Start, preschool, and clinic settings all were shown to be options for implementing effective interventions. However, because each intervention was implemented in one type of setting and may have included only one racial or ethnic group, future studies need to examine the effectiveness of these programs implemented in different intervention settings for different income and racial/ethnic groups. Income data were not available in some of the studies we reviewed, so we were unable to examine this issue.

Strengths and Challenges

The seven intervention studies reviewed have several strengths. Four of the seven were randomized controlled trials, and four had sample sizes >200. In addition, a variety of racial/ethnic groups were studied, including white, black, Latino, and Native-American children. In the United States, 2- to 5-year-old white and black children have a similar elevated prevalence of overweight—8.6% and 8.9%, respectively; however, an estimated 13.1% of Mexican-American preschoolers are overweight (2). Hispanic and Native-American children are of particular concern; data from low-income children in the United States suggest an even higher prevalence of overweight among Hispanics (19.4%) and Native Americans (18.0%) compared with whites (12.3%) and blacks (12.0%) (58). Other strengths include the use of a variety of social means to include the family, such as increasing parenting skills and educating the parent and the child.

The interventions reviewed also present us with some challenges, which weaken the clarity of recommendations from this review. The heterogeneous nature of the settings, methodologies, intervention strategies, definitions of obesity, and outcome measures makes comparisons among these studies difficult. The lack of use of a framework or theory as the basis of the interventions in three studies was noted. Parental reporting of behavioral changes during these studies could have biased the study results; however, four studies used more objective measures such as diet records or accelerometers to assess changes. Some of the studies did not monitor behavior changes or lack thereof; reporting of these might have helped clarify why studies did or did not demonstrate a reduction in weight status. Finally, none of these evaluated interventions included a cost-effectiveness component. As with the reviews of interventions to prevent overweight among school-age children mentioned above (16,47), our review also found a lack of evidence as to what was the most effective component, duration, and intensity of the intervention.

Conclusions and Implications

All of the studies reviewed were actively trying to reduce BMI, weight-for-height, or body fat through behavior change. As such, the studies reviewed met Smiciklas-Wright and D'Augelli's call for "programs which involve individuals in a careful, active change of problematic health-related behaviors" (59) by using several types of social strategies for their interventions. Among the studies here, the variables exhibiting significant change were weight status, energy intake or percentage of calories from saturated fat, TV viewing time, maternal restriction of child feeding, and serum cholesterol. These studies provide a strong base to further develop effective interventions. Clearly, more interventions need to be implemented and evaluated. A first step would be to evaluate the effectiveness of the preceding interventions among other racial/ethnic groups and in other settings.

Our finding that five of the seven interventions reviewed used multicomponent strategies, and the interventions used a variety of settings and frequently included parents as agents of change, could be considered a model coincident with the Institute of Medicine's recommendation that because obesity has a variety of causes, a multicomponent intervention program, focusing on more than one strategy, using a variety of settings, and involving parents and other adults such as teachers, is likely to be more effective in preventing overweight (60).

It seems prudent to recommend that interventions for children include parents and other adult models (e.g., teachers) rather than children alone. Standardizing the definition of obesity and categorization of outcome measures would greatly facilitate comparison of studies. Longer follow-up periods of at least 1 or 2 years to assess change in weight status may increase the likelihood of adequately evaluating program impact and sustainability of the program's impact. In conclusion, there are great opportunities for further work in developing and evaluating intervention programs to prevent or treat overweight among preschool children.

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