ELSEVIER

Journal of Adolescent Health 46 (2010) 309–323

JOURNAL OF
ADOLESCENT
HEALTH

Review article

A Meta-Analysis of Obesity Interventions Among U.S. Minority Children

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Manuscript received December 31, 2008; manuscript accepted November 16, 2009

Abstract

Purpose: To quantitatively evaluate the efficacy of interventions designed to prevent or treat obesity among U.S. minority children using meta-analytic techniques.
Methods: A total of 40 intervention trials involving 10,725 children aged 6–19 years were examined.
Results: Interventions with more components showed a higher mean effect size than those with fewer components: among 32 controlled trials, $d = .07$ for one-component (n = 6); $d = .08$ for two-component (n = 15); $d = .33$ for three-component (n = 10); and $d = .71$ for four-component (n = 1) interventions. Interventions with parental involvement (n = 22, $d = .21$) and lifestyle interventions (n = 14, $d = .34$) showed a greater mean effect size than those without parental involvement (n = 10, $d = .05$) or lifestyle interventions (n = 18, $d = .04$), despite the fact that their 90% confidence intervals overlapped. Among uncontrolled trials (n = 8), two-component interventions (n = 5) yielded $d = .86$ and three-component interventions (n = 3) yielded $d = .96$.
Conclusions: Evidence indicates that, among U.S. minority children, obesity interventions with three or more components might be more efficacious than those using fewer components. Parental involvement, lifestyle change, culturally-based adaptation, and interactive computer programs seem to show promise in the reduction of obese minority children.

Keywords: Obesity; Meta analysis; Children; Minority; Interventions

In the last two decades, the prevalence of childhood obesity, defined as at or above the 95th percentile of body mass index (BMI) for age and gender [1], has more than doubled among children aged 6–11 years and tripled among adolescents aged 12–19 years [2–4]. There is no evidence that this trend is coming to an end [3]. This is a serious public health concern because obese children and adolescents (hereafter ‘‘children’’) are at an increased risk for various physical, mental, and emotional health problems, including impaired glucose tolerance [5,6], insulin resistance [7], atherosclerosis [8], coronary heart disease in adulthood [9–11], later development of eating disorders [12,13], and low self-esteem [14].

The obesity epidemic disproportionately affects racial/ethnic minority children, who are defined as American Indian, Alaska Native, Asian American, black, African American, Hispanic, Latino, Native Hawaiian, or other Pacific Islander [15]. According to estimates based on the 2001–2002 National Health and Nutrition Examination Survey (NHANES), among children aged 6–19 years, 22.2% (standard error [SE] = 1.1) of Mexican American children and 20.5% (SE = .8) of non-Hispanic blacks (hereafter ‘‘blacks’’) were obese as compared with only 13.6% (SE = 1.1) of non-Hispanic whites (hereafter ‘‘whites’’) [3]. Other studies [2,16,17] also affirm a larger prevalence of obesity among Mexican American and black children compared with white children. These rates of obesity are far from the 2010 national health objective of ≤5% (Healthy People 2010 objective no. 19–3c) [18]. The higher incidence of obesity among minority children is alarming because these racial/ethnic groups have a lower insulin sensitivity than white children [19]. Many researchers [20–59] have conducted reviews of childhood obesity interventions. Of these review studies, results of two meta-analyses [57,58] are renowned because they used a rigorous method to examine the efficacy of childhood obesity intervention strategies. These studies concluded that interventions involving parents and lifestyle changes were efficacious in preventing or

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1054-139X/10/$ – see front matter
doi:10.1016/j.jadohealth.2009.11.202

treating childhood obesity. However, no studies have been published that have reviewed scientific evidence of the efficacy of obesity interventions on U.S. minority children. The purpose of this study was to address that absence by quantitatively evaluating the efficacy of interventions aimed at reducing the percentage of the overweight, *z*-BMI, BMI, or body weight (hereafter ‘‘main outcome measures’’) among minority children. Five research hypotheses were formulated, given the main research question ‘‘What intervention components and strategies would be most efficacious in reducing main outcome measures for multiethnic and minority children?’’ Hypothesis generation was guided by the previous findings [30,36,54,56,57,60–80]. In the face of contradictory findings in the published data, the majority of the findings was the basis for the corresponding hypothesis formulation. Listed below are the five research hypotheses:

(1) It was hypothesized that interventions consisting of three- or more components, including energy expenditure, energy consumption, sedentary behavior reduction, counseling, or medication, would be more efficacious in reducing the main outcome measures than one- or two-component interventions drawn from the same list. A review study [30] showed that diet plus exercise programs produced better weight loss outcomes than diet-only programs. On the basis of the previous finding, an extended proposition has been made on the superiority of the three- or more component programs over the fewer-component programs.
(2) It was hypothesized that interventions involving parents would be more efficacious than those without parental involvement. Parental involvement is defined as a strategy to enhance parental support for children by sending educational materials to parents or by encouraging them to attend intervention sessions [54] rather than having child-only groups. Two meta-analyses [36,54] showed no significant relationship between parental involvement and intervention effects, but a larger number of obesity intervention studies [60–69] and a recent meta-analysis [58] without a focus on minority children found that greater decreases in main outcome measures were observed in interventions that did include parental involvement.
(3) Lifestyle interventions, defined as the incorporation of changes in physical activity and diet into participants’ daily lives [56,70,71], were hypothesized as superior to interventions without that incorporation. Recent meta-analyses [56,57] without consideration of racial/ethnic differences in the efficacy of interventions and other studies [70,72–74] found that lifestyle interventions affected outcome measures more significantly than non-lifestyle interventions.
(4) Culturally-tailored interventions, a set of behavioral change strategies that take into account cultural characteristics, such as attitudes, expectancies, and norms toward a target behavior [75,76], were hypothesized to be more efficacious than those not using such strategies. Several researchers [75,77,78] concur that culturally-tailored interventions would be more efficacious than those absent of cultural factors, though others [79,80] found cultural customization to have no significant effect on interventions.
(5) It was hypothesized that shorter interventions would be more efficacious than those with longer durations because intervention effects are likely to dissipate over time. A review study of obesity interventions [36] affirmed that shorter interventions produced larger effect sizes than those with longer durations.

Methods

Search strategy

The search consisted of seven online databases: MEDLINE, Academic Search Premier, Educational Resource Information Center (ERIC), Health Source Nursing/Academic Edition, PsycARTICLES, CINAHL Plus with Full Text, and SPORTDiscus. The search terms used were ‘‘minority or black or African American or American Indian or Mexican American or Hispanic or Latino or Asian American,’’ ‘‘child or adolescent or youth,’’ ‘‘obesity or overweight,’’ in combination with ‘‘intervention or trial’’ and various suffixes. All of the search key words were entered at the same time. In addition to using reference lists from retrieved articles, manual searches for other eligible reports were conducted at a health science library. The search aimed to identify studies that met the following inclusion criteria: (1) the study must include U.S. minority children aged 6–19 years; (2) the study must be an intervention designed to affect weight loss with main outcome measures, such as percentage overweight, *z*-BMI, BMI, or body weight; (3) at least 20% of the study sample must be from a racial minority (the rationale for the 20% is shown at the end of this paragraph); (4) an intervention group must have at least 20 subjects; and (5) the study was published in peer-reviewed English-language journals between January 1980 and July 2007, as the prevalence of obesity was relatively stable until about 1980 [81]. According to U.S. Census Bureau data, as of July 1, 2004 (2004 being the median year of the 40 reviewed interventions), whites made up 80% of the total population (236,057,761 of 293,655,404), leaving 20% as racial minorities. Thus, to ensure the racial minority population was represented in the sample, one of the inclusion criteria declared that a minimum of 20% of the sample must be racial minorities. However, when a sample included Hispanic/Latino participants, a cut-off of 33% was used because non-Hispanic/Latino whites were 67% of the total population in 2004 (197,840,821 of 293,655,404).

Exclusion criteria

Studies not meeting inclusion criteria were excluded. For example, studies not including U.S. minority children were excluded. Authors of studies lacking information on participants' race/ethnicity, changes in main outcome measures, or intervention component details were contacted to acquire such information. The two studies in which the authors did not have access to the race/ethnicity data and the one study in which the authors did not want to provide information on changes in body weight were excluded. Studies not adopting the control group were included in the review, but were given less importance than those using the control group in interpretations. Inclusion/exclusion, review, and quality grading of the studies retained for this meta-analysis were performed independently by two investigators. Any disagreement between those investigators was resolved through a discussion that led to a consensus.

Statistical analysis

Cohen's *d* [82] for each effect of the intervention studies that used both an intervention and a control group was computed by dividing differences in main outcome measure changes (i.e., percentage overweight, *z*-BMI, BMI, or body weight) between the two groups by the average baseline standard deviation of those two groups. Cohen's *d* for studies not using a control group was calculated by dividing main outcome measure changes by the pooled standard deviation. When the pooled standard deviation was unavailable, the baseline standard deviation became the denominator. Positive effect sizes indicate favorable changes compared to either the control group or the mean at the baseline. Because Cohen's *d* is based on noncentral distributions that reflect effects of independent variables when the null hypothesis is false, noncentral 90% confidence intervals (CIs) were computed [83]. The upper CI limit was computed by dividing the noncentrality parameter (δ), corresponding to observing a sample t ratio less than the obtained central *t* ratio 5% of the time, by the square root of the sample size. Likewise, the lower CI limit was computed by dividing the noncentrality parameter, corresponding to observing a sample t ratio greater than the obtained central t ratio 5% of the time, by the square root of the sample size. The noncentrality parameter (δ) related to each effect size was computed using SAS macro.

Selection of outcome measures to compute effect sizes

Although most reviewed studies reported multiple outcome measures, a few studies, particularly old ones, reported only body weight. When it was the only outcome measure, body weight was used to calculate effect sizes. In the following order of priority, the other three outcome measures were used to compute effect sizes: percentage overweight, *z*-BMI, and BMI. It is important to note that applying those three outcome measures is more appropriate than using body weight because they adjust for changes in study participants' height, which affects weight [57].

Results

The on-line library database search initially produced 1,544 hits, and a search through a reference lists review yielded 4 additional studies. Of the total, 40 studies [84–123] were selected in the present meta-analysis. Figure 1 illustrates the study selection process by means of a flowchart.

Brief descriptions of the selected studies are provided in Table 1 The quality of each study was rated on a modified set of Russell and Gregory's criteria for methodological soundness [124] (see Table 2). The quality score ranges from 0-5, 5 being the highest. A total of 21 studies received the highest rating of 5, eight a rating of 4, six a rating of 3, and five studies a rating of 2. A total of 10,725 children aged 6–19 years were covered in this meta-analysis, and the total number of minority children was 6,602, accounting for 62% of the overall sample. Of the 40 studies, 12 were minority-only studies. Although slightly more than half of the studies (n = 26) targeted both males and females, 13 targeted females only and one targeted only males. Attrition rates varied from 0 % to 55%, with an average attrition rate of 17.5%. The minimum and maximum intervention periods were 5 weeks and 3 years, respectively, with a median period of 6 months. Of the 40 selected studies, 16 studies were clinic-based, 12 school-based, seven community-based, and five family-based. In terms of research designs, there were 31 randomized controlled trials, one non-randomized controlled trial, seven one-group pre- and post-trials, and one quasi-experimental design. Two studies [103,107] provided information on interventions and weight changes elsewhere [125,126]. Thus, additional articles were retrieved to identify missing information.

In terms of intervention components, six used one-component interventions, 20 used two-component interventions, 13 used three-component interventions, and one used a four-component intervention (see Table 3). Although three-quarters of two-component (15 of 20) and all three-component interventions (13 of 13) involved parents in the treatment of their children, only two one-component interventions included parental involvement. In terms of lifestyle interventions, about half of two-component (11 of 20) and slightly more than half of three-component interventions (9 of 13) included the lifestyle change strategy. Although no one-component interventions considered study participants' cultural characteristics, approximately one-quarter of two-component (6 of 20) and about half of three-component interventions (7 of 13) were culturally tailored. The effect size ranged from –.93 to 3.28. The median and mean effect sizes were .16 and .30, respectively. An effect size near or above .50 was shown among seven controlled trials. Although the effect sizes of two studies were > 2.00, caution is warranted in the interpretation of those findings because of a lack of a control group. Those two studies received the lowest quality score of 2 among all the 40 studies reviewed.

Interventions with more components showed a higher mean effect size than those with fewer components. Among

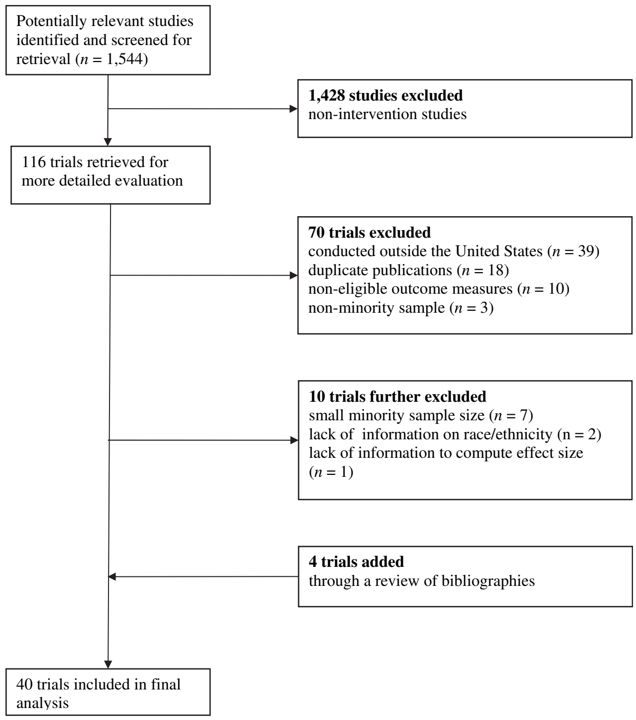

Figure 1. Study selection process.

controlled trials (n = 32), one-component interventions (n = 6) showed *d* = .07 (90% CI = –.16-.43); two-component interventions (n = 15) *d* = .08 (90% CI = –.08-.55); three-component interventions (n = 10) *d* = .33 (90% CI = –.02-.67); and a four-component intervention (n = 1) *d* = .71 (90% CI = .58-.85). Interventions with parental involvement (n = 22, *d* = .21, 90% CI = –.05-.65) and lifestyle interventions (n = 14, *d* = .34, 90% CI = .00-.68) showed a higher mean effect size than those without parental involvement (n = 10, *d* = .05, 90% CI = –.06-.41) and those without lifestyle interventions (n = 18, *d* = .04, 90% CI = –.10-.49), though their CIs overlapped. Culturally tailored interventions (n = 12) showed *d* = .25 (90% CI = –.12-.63), whereas interventions that did not include such a strategy (n = 20) showed *d* = .12 (90% CI = –.02-.55). Among uncontrolled trials, two-component interventions (n = 5) yielded *d* = .86 (90% CI = .55-1.18) and three-component interventions (n = 3) yielded *d* = .96 (90% CI = .33-1.57).

One-component intervention

Of the 40 selected studies, six used only one intervention component, such as physical activity, nutrition, sedentary behavior reduction, or counseling. None of the six studies were culturally tailored and only one [96], the Healthy Habits study, used both the parental involvement and lifestyle change strategies. Except in the Healthy Habits study (*d* = .32), the effect size varied from –.08 to .11 (mean: .07), which indicated limited effects of single-component interventions on reducing main outcome measures.

Two-component intervention

A total of 20 studies, including five uncontrolled trials used two intervention components. Of these 20, 18 used physical activity and nutrition, and two used physical activity and sedentary behavior reduction. With the exception of the five uncontrolled trials, the two-component interventions produced almost the same mean effect size (*d* = .08) as that of one-component interventions.

Yin et al. [86] and Stice et al. [90] conducted school-based interventions that focused on increasing energy expenditure and decreasing energy consumption. Their interventions produced unfavorable results (i.e., increases in BMI post-test). More recent studies [115,118], similar to the two aforementioned studies, yielded weak effects on reducing *z*-BMI. However, in a more well-designed study [82] that included both lifestyle interventions and parental involvement, substantial decreases were observed in weight and BMI (*d* = .49). A unique component of that study was that parent-children contracts were used to reinforce physical activity and diet goals. The Pathways study, another similar yet longer study (36 months) that produced at least eight publications [127–133] deserves mention [104]. In that culturally-tailored intervention, a total of 1,704 American Indian children, grades 3–5, from 41 schools in three states participated. Although significantly greater reductions in total fat and saturated fat content of school lunches were achieved in the intervention schools compared to the control schools, the Pathways study led to a very small effect size (*d* = .08). This might be due to the study participants being from low-risk populations, a low fidelity of delivery, or the non-use of lifestyle change interventions.

Other culturally-tailored, school-based interventions [116,119] were conducted for a 6-month duration among Mexican American children. The studies included parent-training sessions on preparing healthy Mexican foods and physical activity sessions to encourage children to develop daily activity skills that could remain beyond the interventions' end. Although intervention group children in the two studies showed *z*-BMI and BMI reductions, control group children experienced *z*-BMI and BMI increases. Another culturally-tailored study, the Memphis Girls Health Enrichment Multisite Studies (GEMS), succeeded in reducing BMI among girls in the intervention group, yielding the greatest effect size (*d* = .51) among the reviewed two-component trials [93]. All participants were black and the intervention elements included culturally-tailored physical activity sessions (e.g., hip-hop aerobics and dance with parents), nutrition sessions (e.g., making healthier fast food choices), and focus on healthy family lifestyle (e.g., washing cars and walking after dinner with parents). It is noteworthy that other studies that included only black girls [105,123] and that used passive internet interventions experienced an increase in BMI post-test or a weak effect on reducing BMI. This might be due to the lack of lifestyle change strategies, a passive internet health education web site, and low

Table 1
Descriptive data of studies selected in this meta-analysis

Study	Total N	Proportion of minority N (%)	Sex	Age	Dropout rate (%)	Length of treatment (mon)	Study design	Setting
Ebbeling et al [84]	103	66 (64)	M and F	13–18	0	6.25	RCT	School
Jelalian et al [85]	76	16 (21)	M and F	13–16	18.0	4	RCT	Community
Yin et al [86]	601	415 (69)	M and F	8.7[a]	8.0	8	RCT	School
Resnicow et al [87]	147	147 (100)	F	12–16	16.0	6	RCT	Community
Pate et al [88]	2744	1,345 (49)	F	14[a]	24.0	12	RCT	School
Williamson et al [89]	50	50 (100)	F	11–15	12.0	6	RCT	Community
Stice et al [90]	188	69 (37)	F	14–19	2.1	3	RCT	School
Chanoine et al [91]	533	128 (24)	M and F	12–16	35.6	12	RCT	Clinical
Kirk et al [92]	177	63 (36)	M and F	5–19	55.0	5	PPT	Clinical
Beech et al [93]	60	60 (100)	F	8–10	0	3	RCT	Family
Neumark-Sztainer et al [94]	201	116 (58)	F	15.4[a]	5.5	4	RCT	School
Berkowitz et al [95]	82	37 (46)	M and F	13–17	14.6	12	RCT	Clinical
Saelens et al [96]	44	13 (29)	M and F	12–16	27.2	4	RCT	Clinical
Sothern et al [97]	63	15 (24)	M and F	7–17	37.5	5	PPT	Clinical
Eliakim et al [98]	44	35 (80)	M	15–17	13.6	1.25	RCT	School
Suskind et al [99]	50	29 (58)	M and F	7–17	20.0	2.5	QET	Clinical
Robinson [100]	198	50 (25)	M and F	8.9[a]	3.0	6	RCT	School
Sothern et al [101]	73	19 (26)	M and F	7–17	23.0	12	PPT	Clinical
Goran and Reynolds [102]	207	120 (58)	M and F	9–11	0	2	RCT	School
McDuffie et al [103]	20	10 (50)	M and F	12–17	25.0	6	PPT	Clinical
Caballero et al [104]	1,704	1,704 (100)	M and F	7.6[a]	20.9	36	RCT	School
Baranowski et al [105]	35	35 (100)	F	8.3[a]	11.4	3	RCT	Family
Levine et al [106]	24	6 (25)	M and F	8–12	33.3	3	PPT	Family
Gutin et al [107]	76	41 (54)	M and F	7–11	11.3	4	RCT	Community
Sothern et al [108]	56	12 (21)	M and F	13–17	39.8	12	PPT	Clinical
Dreimane et al [109]	264	243 (92)	M and F	8–17	51.1	3	PPT	Clinical
Berkowitz et al [110]	498	216 (44)	M and F	12–16	27.5	12	RCT	Clinical
Williamson et al [111]	57	57 (100)	F	11–15	30.0	24	RCT	Clinical
Budd et al [112]	79	34 (43)	M and F	13–17	10.1	6	RCT	Clinical
Savoye et al [113]	174	110 (64)	M and F	8–16	31.6	12	RCT	Clinical
Williams et al [114]	38	30 (79)	F	11–16	15.8	3	RCT	Clinical
Economos et al [115]	1,178	658 (56)	M and F	7.6[a]	30.6	8	NRCT	Community
Johnston et al [116]	60	60 (100)	M and F	10–14	5.0	6	RCT	School
Wilfley et al [117]	150	44 (29)	M and F	7–12	6.7	4	RCT	Clinical
Rodearmel et al [118]	218	96 (44)	M and F	7–14	15.6	6	RCT	Community
Fullerton et al [119]	80	80 (100)	M and F	12[a]	3.6	6	RCT	School
Barbeau et al [120]	201	201 (100)	F	8–12	0	10	RCT	School
Robinson [121]	61	61 (100)	F	8–10	1.6	3	RCT	Family
Story [122]	54	54 (100)	F	9–10	1.9	3	RCT	Community
White et al [123]	57	57 (100)	F	11–15	12.3	6	RCT	Family

RCT = randomized controlled trial; PPT = pre- and post-trial; QET = quasi-experimental trial; NRCT = non- randomized controlled trial.
[a] Mean age.

Table 2
Quality assessment of reviewed studies

Study	1. Research question clear/adequately substantiated?	2. Design appropriate for research question?	3. Appropriate sampling method?	4. Data collected and managed systematically?	5. Data analyzed appropriately?	Quality score
Ebbeling et al [84]	No	Yes	Yes	Yes	Yes	4
Jelalian et al [85]	Yes	Yes	Yes	Yes	Yes	5
Yin et al [86]	Yes	Yes	Yes	Yes	Yes	5
Resnicow et al [87]	Yes	Yes	Yes	Yes	Yes	5
Pate et al [88]	Yes	Yes	Yes	Yes	Yes	5
Williamson et al [89]	No	No	Yes	Yes	Yes	3
Stice et al [90]	Yes	Yes	Yes	Yes	Yes	5
Chanoine et al [91]	Yes	Yes	Yes	Yes	Yes	5
Kirk et al [92]	Yes	Yes	No	Yes	Yes	4
Beech et al [93]	Yes	No	Yes	Yes	Yes	4
Neumark-Sztainer et al [94]	Yes	Yes	Yes	Yes	Yes	5
Berkowitz et al [95]	Yes	Yes	Yes	Yes	Yes	5
Saelens et al [96]	Yes	Yes	No	Yes	Yes	4
Sothern et al [97]	No	No	No	Yes	Yes	2
Eliakim et al [98]	Yes	Yes	No	Yes	Yes	4
Suskind et al [99]	No	No	Yes	Yes	No	2
Robinson (1999) [100]	Yes	Yes	Yes	Yes	Yes	5
Sothern et al [101]	No	No	Yes	Yes	Yes	3
Goran and Reynolds (2005) [102]	No	No	Yes	Yes	Yes	3
McDuffie et al [103]	No	No	No	Yes	Yes	2
Caballero et al [104]	Yes	Yes	Yes	Yes	Yes	5
Baranowski et al [105]	Yes	Yes	No	Yes	Yes	4
Levine et al [106]	No	No	No	Yes	Yes	2
Gutin et al [107]	Yes	Yes	Yes	Yes	Yes	5
Sothern et al [108]	No	No	No	Yes	Yes	2
Dreimane et al [109]	Yes	No	Yes	Yes	No	3
Berkowitz et al [110]	No	No	Yes	Yes	Yes	3
Williamson et al [111]	Yes	Yes	Yes	Yes	Yes	5
Budd et al [112]	Yes	Yes	Yes	Yes	Yes	5
Savoye et al [113]	Yes	Yes	Yes	Yes	Yes	5
Williams et al [114]	Yes	Yes	No	Yes	Yes	4
Economos et al [115]	Yes	No	Yes	Yes	Yes	4
Johnston et al [116]	Yes	Yes	Yes	Yes	Yes	5
Wilfley et al [117]	Yes	Yes	Yes	Yes	Yes	5
Rodearmel et al [118]	No	No	Yes	Yes	Yes	3
Fullerton et al [119]	Yes	Yes	Yes	Yes	Yes	5
Barbeau et al [120]	Yes	Yes	Yes	Yes	Yes	5
Robinson [121]	Yes	Yes	Yes	Yes	Yes	5
Story [122]	Yes	Yes	Yes	Yes	Yes	5
White et al [123]	Yes	Yes	Yes	Yes	Yes	5

log-on rates (i.e., overall log-on rates of 48% in the Baylor GEMS Study [105]).

Effect sizes of the five uncontrolled trials [97,99,101,108,109] ranged from .32 to 3.28 except one [109] (*d* = .05 for the 8-week program and *d* = .12 for the 12-week program). The Committed to Kids studies [97,99,101,108], a four-phase multidisciplinary weight reduction program including lifestyle change approaches and parental involvement, succeeded in reducing main outcome measures. One study [108] conducted among 56 children (21% Black) yielded a 4.10 kg/m^2 reduction in BMI in 1 year and the greatest effect size (*d* = 3.28) in this meta-analysis. This might be primarily because of the fact that children attended weekly two-hour sessions with their parents for 1 year, and parents were involved in all aspects of those weekly sessions. Despite the successful results, the interpretation of them warranted caution for the following reasons: none of the four Committed to Kids studies [97,99,101,108] used a control group, and two [97,108] of them suffered high dropout rates (i.e., 37.5% and 39.8%). Thus, extraneous confounders might have accounted for part of the findings [134]. Also, as with almost all the uncontrolled interventions, the participants of the studies were obese rather than normal-weight children, lending themselves to statistical regression bias [134]. Unsurprisingly, these uncontrolled studies received the lowest quality scores.

Three-component intervention

A total of 13 studies, including three uncontrolled trials, used three intervention components. Of the 13 studies, five used physical activity, nutrition, and sedentary behavior reduction; four used physical activity, nutrition, and counseling; three used physical activity, nutrition, and medication; and one used nutrition, counseling, and medication. Controlled three-component interventions (n = 10) produced a mean effect size of *d* = .33.

Go Girls, a study limited to black girls, used a culturally-tailored intervention, with parents encouraged to attend every other session [87]. In that study, the intervention group experienced a .80 kg/m^2 reduction in BMI (*d* = .18). A total of 54 black girls participated in a similar, yet better- designed three-month study adapted from the Minnesota GEMS [122]. The Minnesota GEMS paralleled the Stanford GEMS, in that, interventionists of the same race/ethnicity as the participants conducted the intervention. Like the Go Girls study, the Minnesota GEMS was culturally tailored, but it used more parental involvement. Parents were asked to select one nutrition and physical activity goal and engage in physical activity with their children, instead of watching TV. Trained black staff members contacted parents for encouragement and to check on the progress. The Minnesota GEMS produced a larger effect size (*d* = .48) than the Go Girls study.

Another analogous study [117] was conducted among multiethnic children. Children received either behavioral skills maintenance (BSM), emphasizing self-regulation behaviors and relapse prevention strategies, or social facilitation maintenance (SFM), which focused on promoting social support for healthy behaviors. Children developed plans for permanent lifestyle change strategies with their parents in this study. Parents were taught how to select healthy foods consistent with cultural preference and were encouraged to attend treatment sessions. BSM and SFM not only yielded a .27 reduction in *z*-BMI, but also produced medium effect sizes (*d* = .45 and .46). Yale Bright Bodies Weight Management Program [113], a similar project with a longer intervention period of 12 months and a larger sample size (N = 174), yielded a greater BMI reduction and effect size (1.70 kg/m^2, *d* = .50) than the Go Girls, the Minnesota GEMS, and the BSM/SFM studies. The Yale intervention was tailored to inner-city minority children, asking them to select an activity to engage in regularly, in addition to encouraging them to set nutrition and physical activity goals with their parents.

A few studies [95,103,112] demonstrated that pharmacotherapy coupled with a comprehensive behavioral program could produce increased BMI loss among minority children. A study with whites and blacks [112], a double-blind, randomized clinical trial of behavioral and pharmacologic weight loss, examined the effect of the weight-loss medication sibutramine on 79 girls (43% black). The intervention group received sibutramine and family-based behavioral weight-loss sessions, whereas the control group received a placebo and those same sessions. Parents attended sessions designed to reinforce their children's behavioral change. White and black girls in the intervention groups experienced 3.80 kg/m^2 (*d* = .63) and 3.20 kg/m^2 (*d* = .33) BMI reductions, respectively, which were the two highest BMI reductions among all the reviewed controlled trials. An interesting strategy used by this study was that parents were encouraged to praise their children for adhering to the weight-loss program. A similar, yet longer, study [95] using 82 children (42% black) also produced a medium effect size (*d* = .50).

Four-component intervention

Of the 40 selected studies, only one [110] used four intervention components—physical activity, nutrition, counseling, and medication—which produced the greatest effect size (*d* = .71) among all the reviewed controlled trials. Berkowitz et al [110] conducted a 1-year, randomized, double-blind, and placebo-controlled trial among 498 children (44% non-white). Although both intervention and control groups received a behavioral therapy program focusing on lifestyle changes, only the intervention group took sibutramine whereas the control group had placebos. The intervention group showed a 3.10 BMI kg/m^2 reduction (*d* = .71). The lifestyle change strategies, based on participants' needs and aimed at not only increasing energy expenditure in children's lifestyles, but also decreasing energy consumption, may factor into the highest effect size among the controlled trials.

Table 3
Comparison of body mass index changes and effect sizes

Study	Parent involvement	Focus on lifestyle change	Culturally tailored	Intervention	Body mass index			
					Base-line	Post-test	Δ	Effect size[a] (90% CI)
One-component intervention with control group								
Ebbeling et al [84]	No	No	No	I: Decreasing sugar-sweetened beverage consumption	25.70	25.77	+0.07	.02[b] (–.30, .34)
				C: No treatment	24.90	25.11	+.21	
Pate et al [88]	No	No	No	I: Physical education activities and environmental changes that support PA	59.76[c]	62.38	+2.62	–.01[b,d] (.00, .06)
				C: No treatment	60.30[c]	62.74	+2.44	
Saelens et al [96]	Yes	Yes	No	I: Tailored lifestyle change counseling	62.00[e]	59.80	–2.20	.32[b] (–.21, .84)
				C: Non-tailored lifestyle change counseling	62.30[e]	66.20	+3.90	
Eliakim et al [98]	No	No	No	I: Running, aerobic dance, competitive sports, and weight-lifting	61.00[c]	61.80	+0.80	–.08[b,d] (.00, .52)
				C: No treatment	66.20[c]	66.80	+.60	
Robinson [100]	Yes	No	No	I: Classroom curriculum to reduce TV, videotape, and video game use	18.38	18.67	+.29	.11[b] (–.13, .35)
				C: No treatment	18.10	18.81	+.71	
Gutin et al [107]	No	No	No	I: Stationary cycling and playing games (basketball and dodge ball)	57.50[c]	58.60	+1.10	.05[b] (–.34, .44)
				C: No treatment	56.90[c]	58.90	+2.00	
Two-component intervention with control group								
Jelalian et al [85]	Yes	Yes	No	I: Changing lifestyle in PA + diet with peer-enhanced adventure therapy (increasing self-confidence)	85.75[c]	80.14	–5.31	.49[f] (.10, .88)
				I: Changing lifestyle in PA + diet with (aerobics and brisk walking)	86.44[c]	83.24	–3.20	.23[f] (–.14, .60)
				C: No treatment	NA	NA	NA	
Yin et al [86]	No	No	No	I: PA (basketball and stretching) + healthy snack	19.40	19.50	+.07	.04[b] (–.13, .21)
				C: No treatment	19.30	19.60	+.30	
Stice et al [90]	No	Yes	No	I: Changing lifestyle in exercise + changing lifestyle in diet	22.82	22.88	+0.06	.03[b] (–.21, .27)
				C: No treatment	23.79	23.99	+.20	
Beech et al [93]	Yes	Yes	Yes	I: Memphis GEMS intervention targeting children (changing lifestyle in PA + diet)	25.50	24.30	–1.20	.51[b] (–.01, 1.02)
				I: Memphis GEMS intervention targeting parent (changing lifestyle in PA + diet)	23.00	24.30	+1.30	.14[b] (–.37, .65)
				C: Self-esteem decline prevention treatment	22.60	24.70	+2.10	
Neumark-Sztainer et al [94]	Yes	Yes	No	I: Changing lifestyle in PA + diet	27.60	26.64	–0.96	.26[b] (.01, .51)
				C: Information on PA and healthy eating	25.90	26.65	+.75	
Goran and Reynolds [102]	No	No	No	I: CD-ROM intervention (increasing PA + decreasing sedentary behavior) among boys	19.30	19.50	+.20	–.22[b,d] (.00, .65)
				C: No treatment among boys	19.90	19.30	–.60	
				I: CD-ROM intervention (increasing PA + decreasing sedentary behavior) among girls	19.30	19.50	+.20	–.14[b,d] (.00, .51)
				C: No treatment among girls	19.90	19.60	–.30	

Caballero et al [104]	Yes	No	Yes	I: Increasing PA + reducing fat in school lunches	18.80	21.90	+3.10	.08[b] (.00, .16)
				C: No treatment	18.80	22.20	+3.40	
Baranowski et al [105]	Yes	No	No	I: Summer camp (PA and pep rally) and Baylor GEMS intervention (games targeted at increasing PA and FJV intake) + weekly internet intervention (links to PA and diet)	21.10	24.60	+3.50	–.93[b,d] (.37, 1.50)
				C: Summer camp intervention + monthly internet intervention	26.30	24.10	–2.20	
Economos et al [115]	Yes	No	No	I: PA + diet among boys	0.92[g]	0.88	–.04	.03[b] (–.14, .20)
				C: No treatment among boys	0.78[g]	0.77	–.01	
				I: PA + diet among girls	0.78[g]	0.75	–.03	.02[b] (–.15, .19)
				C: No treatment among girls	0.62[g]	0.60	.00	
Johnston et al [116]	Yes	Yes	Yes	I: Changing lifestyle in PA + diet	25.40	24.41	–.99	.41[b] (.03, .79)
				C: Information on weight loss	26.70	27.78	+1.08	
Rodearmel et al [118]	No	Yes	No	I: Changing lifestyle in PA + changing lifestyle in diet	1.76[g]	1.69	–.07	.06[b] (–.17, .29)
				C: No treatment	1.68[g]	1.64	–.04	
Fullerton et al [119]	Yes	No	Yes	I: PA and nutrition classes	1.83[g]	1.70	-0.13	0.40[b] (0.14, 0.66)
				C: No treatment	1.74[g]	1.78	+0.04	
Barbeau et al [120]	No	No	No	I: PA (basket ball and stretching) + healthy snack	20.90	21.60	+.70	.11[b] (–.10, .32)
				C: No treatment	20.90	22.20	+1.30	
Robinson [121]	Yes	No	Yes	I: Stanford GEMS intervention (dance classes + reducing TV viewing)	20.95	21.45	+.50	.04[b] (–.40, .48)
				C: Information on health education	21.57	22.28	+.71	
White et al [123]	Yes	No	Yes	I: Internet intervention (increasing PA + setting goals for eating)	35.31	35.07	–.24	.12[b] (–.32, .56)
				C: Information on PA and nutrition	37.34	38.05	+.71	
Three-component intervention with control group								
Resnicow et al [87]	Yes	No	Yes	I: Increasing PA + decreasing fat intake + decreasing sedentary behavior	32.50	31.70	–.80	.18[b] (–.14, .50)
				C: Information on benefits of PA	33.20	33.60	+.40	
Williamson et al [89]	Yes	No	Yes	I: Internet intervention (increasing PA + food monitoring and goal setting for nutrient intake + counseling)	35.31	35.12	–.19	.11[b] (–.33, .55)
				C: Information on health	37.34	37.99	+.65	
Chanoine et al [91]	Yes	Yes	No	I: Changing lifestyle in diet + counseling + medication (orlistat)	35.70	35.15	–.55	.21[b] (.09, .33)
				C: Changing lifestyle in diet + counseling + medication (placebo)	35.40	35.71	+.31	
Berkowitz et al [95]	Yes	Yes	No	I: Changing lifestyle in PA + diet + medication (sibutramine)	2.40[g]	2.20	–.20	.50[b] (.11, .88)
				C: Changing lifestyle in PA + diet + medication (placebo)	2.50[g]	2.40	–.10	
Williamson et al [111]	Yes	Yes	Yes	I: Internet intervention (changing lifestyle in PA + diet + counseling)	36.40	37.13	+.73	.06[b] (–.25, .37)
				C: Information on health education	36.40	37.60	+1.20	

(Continued)

Table 3
Comparison of body mass index changes and effect sizes (*Continued*)

Study	Parent involvement	Focus on lifestyle change	Culturally tailored	Intervention	Body mass index			
					Base-line	Post-test	Δ	Effect size[a] (90% CI)
Budd et al [112]	Yes	No	No	I: Aerobic exercise and walking + decreasing fat intake + medication (sibutramine) among Whites	37.40	33.60	–3.80	.63[b] (.27, .98)
				C: Aerobic exercise and walking +decreasing fat intake + medication (placebo) among Whites	37.40	35.63	–1.77	
				I: Aerobic exercise and walking + decreasing fat intake + medication (sibutramine) among Blacks	38.50	35.30	–3.20	.33[b] (–.07, .73)
				C: Aerobic exercise and walking + decreasing fat intake + medication (placebo) among Blacks	38.50	36.77	–1.73	
Savoye et al [113]	Yes	Yes	Yes	I: Aerobics and basketball + changing lifestyle in diet + decreasing sedentary behavior	35.80	34.10	–1.70	.50[b] (.25, .75)
				C: PA and diet counseling	36.20	37.80	+1.60	
Williams et al [114]	Yes	No	Yes	I: Walking + restricted snack program + counseling	33.20	32.15	–1.05	.01[b] (–.41, .42)
				C: Walking + free snack program + counseling	31.70	30.70	–1.00	
Wilfley et al [117]	Yes	Yes	Yes	I: Behavioral skill maintenance (changing lifestyle in PA + diet + decreasing sedentary behavior) supporting weight maintenance	2.17[g]	1.90	–.27	.45[b] (.11, .78)
				I: Social facilitation maintenance changing lifestyle in PA + diet + decreasing sedentary behavior) promoting social support of weight control	2.26[g]	1.99	–.27	.46[b] (.11, .81)
				C: No treatment	2.17[g]	2.04	–.13	
Story (2003) [122]	Yes	Yes	Yes	I: Minnesota GEMS intervention (changing lifestyle in PA + diet + decreasing sedentary behavior	21.90	21.70	–.20	.48[b] (.01, .94)
				C: Non-PA and nutrition program (arts, crafts)	19.50	21.50	+2.00	
Four-component intervention								
Berkowitz et al [110]	No	Yes	No	I: Changing lifestyle in PA + changing lifestyle in diet + counseling + medication (sibutramine)	36.10	33.00	–3.10	.71[b] (.58, .85)
				C: Changing lifestyle in PA + changing lifestyle in diet + counseling + medication (placebo)	35.90	35.60	–.30	
Two-component intervention without control group								
Sothern et al [97]	Yes	Yes	No	I: Changing lifestyle in PA + diet	32.70	28.40	–4.30	.63[h] (.27, .99)
Suskind et al [99]	Yes	Yes	No	I: Changing lifestyle in PA + diet	84.80[c]	75.80	–9.00	.32[f] (–.08, .72)
Sothern et al [101]	Yes	Yes	No	I: Changing lifestyle in PA + diet	32.90	28.00	–4.90	.78[h] (.49, 1.07)
Sothern et al [108]	Yes	Yes	No	I: Increasing PA + changing lifestyle in diet + counseling	32.30	28.20	–4.10	3.28[h] (2.86, 3.69)
Dreimane et al [109]	Yes	Yes	No	I: Changing lifestyle in PA + changing lifestyle in diet for 8 wk	2.33[g]	2.31	–.02	.05[f] (–.12, .22)
				I: Changing lifestyle in PA + changing lifestyle in diet for 12 wk	2.38[g]	2.34	–.04	.12[f] (–.13, .37)

Three-component intervention without control group								
Kirk et al [92]	Yes	Yes	No	I: Increasing PA + changing lifestyle in diet + counseling	35.60	33.90	−1.70	.19[f] (.02, .37)
McDuffie et al [103]	Yes	Yes	No	I: Changing lifestyle in PA + diet + medication (orlistat) among Whites	36.20	33.20	−3.00	2.50[h] (1.47, 3.48)
				I: Changing lifestyle in PA + diet + medication (orlistat) among Blacks	50.30	49.20	−1.10	.85[h] (.07, 1.61)
Levine et al [106]	Yes	Yes	No	I: Increasing PA + changing lifestyle in diet + decreasing sedentary behavior	34.50	32.80	−1.70	.31[h] (−.23, .84)

CI = noncentral confidence interval; I = intervention group; C = control group; PA = physical activity; NA = not available; FJV = fruit, 100% fruit juice, and vegetables.
[a] Cohen's *d*.
[b] Formula used is (mean change for intervention – mean change for control)/((SD at baseline for intervention and control)/2)
[c] Body weight was used to calculate effect size because BMI was not available.
[d] Negative sign indicates unfavorable changes in the intervention group compared to the control group, i.e., higher weight gains in the intervention group than in the control group.
[e] Percentage overweight was used to calculate effect size.
[f] Formula used is (mean at baseline – mean at posttest)/(SD at baseline).
[g] BMI z-score was used to calculate effect size.
[h] Formula used is (mean at baseline – mean at posttest)/(pooled SD).

Discussion and Conclusion

Previous research [2,3,16,17] has shown continuing racial/ethnic disparity in the prevalence of childhood obesity. However, no study has reviewed obesity interventions among U.S. minority children. The current review provides the first systematic analysis that focused on the efficacy of obesity interventions among U.S. multiethnic and minority children. Six conclusions could be drawn from this review. First, as hypothesized, interventions addressing three or more components, such as physical activity, nutrition, sedentary behavior reduction, and counseling, are more efficacious than those that use fewer components. Among controlled trials, the mean effect size for three- or four-component interventions greatly exceeded that of one- or two-component interventions. Second, interventions with parental involvement seem more efficacious in assisting minority children's loss of main outcome measures than those interventions without such a strategy. This result is in line with the previous findings [58,60–69]. Thus, future obesity interventions for minority children may benefit from targeting both, the children and the parents rather than children alone. Third, lifestyle interventions emphasizing an integration of desired changes in physical activity and diet into the participants' daily routines seem to achieve more success than non-lifestyle interventions. The mean effect size for lifestyle interventions was higher than that of nonlifestyle interventions, although the CIs overlapped. This is consistent with the findings of a recent meta-analysis [57]. Fourth, culturally-tailored interventions appear to be more efficacious than those where culture is not incorporated, affirming previous findings [75–77]. Fifth, contrary to the hypothesis, no evidence was found that interventions with shorter durations would be more efficacious than those with longer durations. Finally, interactive computer programs that provide participants with individualized feedback on physical activity and eating behaviors and give motivational encouragement for healthful changes may be more efficacious than passive computer-based interventions without such strategies. This finding was affirmed by other studies with an adult population [135–138]. For example, an internet weight-loss program [135] for white and non-white adults showed that participants in the interactive group not only experienced a greater weight reduction than the control group, but also successfully maintained the weight loss. However, given that the participants of the studies were adults, more research is needed in the area of internet obesity interventions to test that finding among minority children [139].

The effects of intervention settings and durations deserve mention as well. As reported earlier, no evidence was found that interventions with shorter durations would necessarily be more efficacious than those with longer durations. The number of intervention components influenced the effect size more than duration. In terms of intervention settings, clinic-based controlled trials yielded a higher effect size (d = .35) than school-based controlled trials (d = .08).

However, it should be noted that the majority of school-based controlled trials used only one or two components, whereas all the clinic-based controlled trials except one study used three or more components. Moreover, all the clinic-based interventions recruited overweight or obese children, which is conducive to yielding higher effect sizes because of the statistical regression effect. Examined together, these findings illustrate the importance of addressing multiple components affecting obesity risk factors among minority children.

Limitations of this meta-analysis should be acknowledged too. Of the 40 studies included in this review, 28 had non-minority participants. Among those 28, no study, except one [112], reported racial/ethnic differences in main outcome measures, though it did use a multiethnic sample with more than 20% of it from minority populations. Given the lack of studies reporting racial/ethnic differences, this review study might not reflect all the racial/ethnic differences with regard to efficacy of obesity interventions among minority children. Also, given the racial/ethnic disparity in the prevalence of childhood obesity, it is important for future obesity prevention or treatment programs to report racial/ethnic differences in main outcome measures. It is also vital for researchers to report the standard deviation or CIs of main outcome measures, allowing researchers to compute effect sizes for different interventions to determine which intervention components and strategies are the most efficacious for which racial/ethnic groups. Different recruitment methods in different settings is an additional limitation that may have affected the efficacy of each intervention. Of the 12 school-based interventions, only three showed a decrease in z-BMI or BMI. Overall, they were less efficacious than the clinic-based, community-based, or family-based interventions. Children in schools are less likely to recognize their own possible weight problem [21] or may be less interested in participating in the interventions than children who attend weight-management clinics [97,113] or children who are recruited through radio advertisements [112], advertisements [117], or announcements in local newspapers and notices [85]. In addition, all of the 16 clinical interventions were obesity treatment programs designed to reduce main outcome measures for children from high-risk populations (most being obese), whereas only two school-based interventions, four community-based interventions, and two family-based interventions were such treatment programs. The other school, community, and family-based interventions were obesity prevention trials designed to prevent weight gain for children with normal weight. Thus, part of the differential intervention effects observed in clinical studies could be attributed to the statistical regression effect, in line with the finding of a previous review study [33], which found that interventions treating heavier children yielded larger weight losses. Finally, heterogeneity in the intervention periods of the selected studies could confound the findings of this review study. It is difficult to avoid such heterogeneity in review studies.

Summary and Implications

Evidence shows that obesity interventions using three or more components are more efficacious than those that address less, illustrating the importance of applying multiple components to affect obesity risk factors among minority children. Intervention strategies, such as involving parents, changing lifestyles by integrating desired physical activity, and diet changes into participants' daily routines, considering cultural characteristics, and using interactive computer programs, may be efficacious in preventing or treating obesity among minority children. It is recommended that future obesity preventions or interventions targeting minority children incorporate these strategies into multicomponent programs combining the promotion of healthy physical activity and dietary habits. In the real world, adopting multi-component interventions could be very challenging because of limited and precious resources that could be wasted on inefficacious single-component interventions. Most school-based interventions addressed only one or two components, leading to small effect sizes. Although securing enough resources for even one program would be challenging, this meta-analysis clearly indicates that obesity interventions targeting minority children need to address multiple components to be efficacious.

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