

Obesity prevention interventions in rural children: A systematic review and meta-evaluation

Ishveen Chopra^{1*} and Avijeet Chopra²

¹School of Pharmacy, West Virginia University, Morgantown, WV 26505, USA

²Department of Molecular and Cell Biology, University of Connecticut, Storrs, CT 06269, USA

Abstract

The prevalence of obesity in the United States has increased rapidly over the past few decades and has become a major public health concern. Childhood obesity is a risk factor for the development of several chronic physical and mental health conditions. Studies suggest that children in the rural areas are at a higher risk for obesity. Thus, there is a need to have effective interventions to prevent childhood obesity. The objective of this systematic review and meta-evaluation is to identify existing interventions for prevention of obesity and evaluate quality and applicability of these interventions in different populations. We conducted a systematic search for studies published in electronic databases from 1980 to 2014. Intervention studies with a focus on prevention of obesity in children ages 2-20 years, residing in rural or Appalachian region of the United States were included. The selection process identified 21 eligible studies for inclusion. A majority of the studies used quasi-experimental design (N = 9) and mostly targeted children from the ages of 8-11 years. Outcome measures included attitude and knowledge of healthy lifestyle, change in diet and physical activity, and body mass index. A large variation in meta-evaluation score was obtained (15-29). Overall, studies reported positive changes in healthy behaviors, suggesting the importance and effectiveness of these interventions in the prevention of obesity. These findings provide insight for designing effective future interventions for obesity prevention.

Introduction

The prevalence of obesity among children in the United States has increased rapidly over the past three decades to a point where pediatric obesity is now considered a public health threat [1,2]. According to the 2009-2010 National Health and Nutrition Evaluation Survey results, approximately 17% of children and adolescents (ages 2-19 years) in the U.S. are obese and about 32% are overweight or obese [3]. Further, economic costs of obesity impact the entire nation, with childhood obesity-related medical costs estimated at \$14 billion annually [4]. Childhood obesity has been identified as a risk factor for the development of chronic diseases, including depression, anxiety, hypertension, insulin resistance, dyslipidemia, metabolic syndrome, and type II diabetes [5,6]. This dramatic increase in the rate of obesity is adversely affecting the health of pediatric population. In addition to the physiological complications, psychological issues such as low self-esteem, depression, and social isolation are also highly prevalent in overweight and obese children, resulting in poor quality of life [7].

Previous research suggests that children in rural-dwelling areas are at a disproportionately higher risk for overweight and obesity compared to their peers in urban and suburban settings [8]. In addition, Appalachian areas have the highest prevalence rates of obesity among the rural areas in the U.S [9]. Reasons for these higher rates of obesity in rural and Appalachian children may be related to several factors, including poverty [10,11], inadequate access to healthcare and preventive health, low levels of physical activity [12], poor nutrition practices [12], and lack of supportive environments [11]. For children of these rural areas, obesity education and prevention is of particular importance due to the lack of medical and health-related formal communication.

Childhood obesity is problematic because it is resistant to treatment

once established and increases the likelihood of adult obesity, which is associated with several health risks [13]. Furthermore, cultural, economic and geographical characteristics of Appalachian and rural communities make it challenging to reduce childhood obesity [9]. Thus, prevention is the major focus of public health authorities. One of the goals of Healthy People 2020 is to reduce the proportion of children and adolescents aged 2 to 19 years who are considered obese (Objective NWS-10.4) [14]. This systematic review and meta-evaluation focuses on intervention studies for the prevention of childhood obesity, conducted in rural-dwelling areas.

Methods

Literature search process

A systematic literature search was conducted, for studies published from January 1, 1980 to October 31, 2014, in electronic databases including Academic Search Premiere, CINAHL, ERIC, PubMed, and psychINFO. The search strategy included a combination of keywords related to obesity and interventions such as overweight, obesity, program, prevention, intervention, treatment, rural, and Appalachia.

According to Appalachian Regional Commission, Appalachia consists of the area following the Appalachian Mountains which

Correspondence to: Ishveen Chopra, School of Pharmacy, West Virginia University, 1 Medical Center Drive, Morgantown, WV 26505, USA, Tel: 412-427-5627; **E-mail:** ishveenkc@gmail.com

Key words: appalachia, childhood obesity, intervention, meta-evaluation, prevention of obesity, rural

Received: July 06, 2015; **Accepted:** August 20, 2015; **Published:** August 25, 2015

includes all of West Virginia and portions of 12 other states: Alabama, Georgia, Kentucky, Maryland, Mississippi, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, and Virginia [15]. A large portion of this Appalachian region is rural. According to the U.S. Census Bureau, rural region is considered anything not urban, or a population smaller than 2,500 people [16].

Initial screening identified titles or abstracts related to interventions for childhood obesity. Furthermore, bibliographies of those selected articles were screened for additional studies of relevance. Titles, abstracts or full-texts reviewed were screened against the inclusion criteria described below. Articles that met the inclusion criteria were then subjected to meta-evaluation. The selection criterion is shown in Figure 1.

Study inclusion criteria

The search was limited to studies in English, published in peer-reviewed journals, and those with original research findings for the interventions being evaluated. Studies focusing on interventions in children ages 2-20 years, residing in rural or Appalachian region of the United States were included. Further, most of the studies included assessed school-based interventions. For the purpose of this meta-evaluation, only those studies focusing on preventive interventions were included; interventions with a focus on treatment of obesity were excluded. Furthermore, studies were included if they focused on either promotion of physical activity and/or nutrition along with any other educational interventions. The studies included either used pre-experimental, experimental or quasi-experimental study design. The other requirements for inclusion were use of appropriate statistical techniques and large enough sample size (≥ 30) for meaningful analyses.

Description of meta-evaluation approach

The purpose of this meta-evaluation of intervention studies is to provide a useful evaluation of the overall validity of the research focusing on prevention of childhood obesity. The basic methodological approach for meta-evaluation comprises of a systematic review of research studies using a standardized set of design followed by evaluating studies against a methodological criteria to estimate the relative degree and strength of the internal and external validity of the studies reviewed. In the meta-evaluation approach, a specified number of points are assigned to each study based on the characteristics of each study corresponding to the criteria designed for evaluation. The higher the number of total points, the greater the likelihood of internal and external validity, and therefore the greater the significance of the research findings [17].

The methodological criteria used included the areas of research design, sample size, length of observation period, quality of measurements used, outcome measures considered in the intervention (such as physical activity, dietary intake, health knowledge, body mass index, and sedentary activity), experimental time period, and quality of methodology used (description of setting, population characteristics, theoretical basis, intervention, and statistical analysis). The scoring strategy based on the methodological criteria is listed in Table 1.

Results

Study selection and description

Approximately 2,000 articles were identified for the review process. The selection process resulted in 21 studies eligible for inclusion (Figure 1). The studies included are summarized in Table 2. The table provides

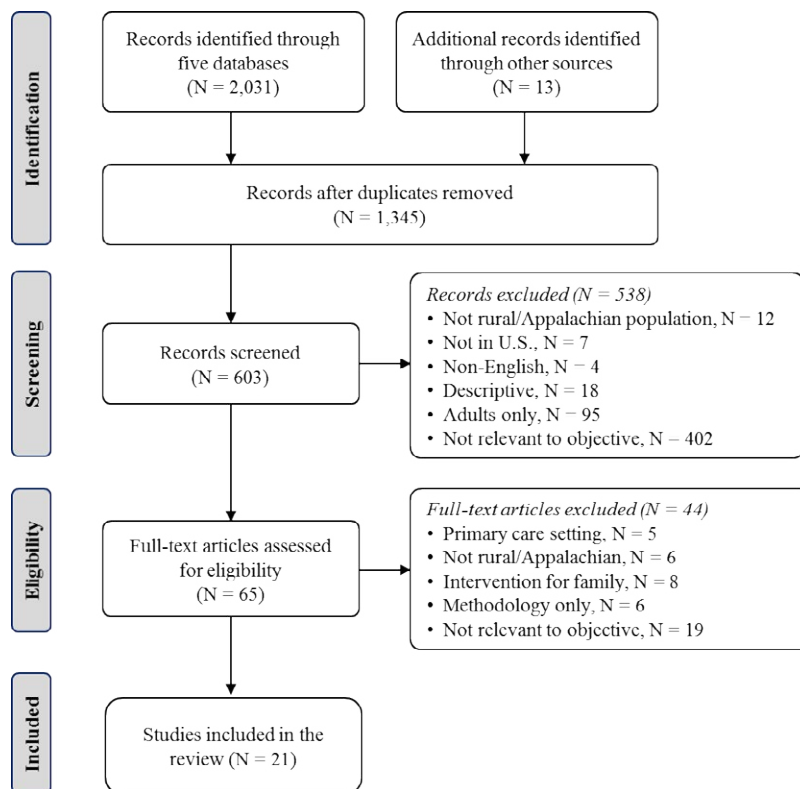


Figure 1. Schematic representation of selection process (PRISMA).

Table 1. Meta-evaluation criteria.

Points	Meta-evaluation criteria subcomponents
Criterion #1 Research Design (e.g., “Design”)	
5	Randomized pretest and posttest, plus matched control group with multiple replications
4	Equivalent control group design, with pretest and posttest with multiple replications
3	Nonequivalent control group design, with pretest and posttest with multiple replications
2	Subjects as own controls, with pretest and posttest with multiple replications
1	Subjects as own controls, with pretest and posttest with single replication
Criterion #2 Sample size (e.g., “Sample”)	
5	Sample size >1500
4	Sample size from 1000 to 1499
3	Sample size from 500 to 999
2	Sample size from 100 to 499
1	Sample size <100
Criterion #3 Length of observation period (e.g., “Length”)	
5	Observation period >12 months
4	Observation period from 10 to 12 months
3	Observation period from 7 to 9 months
2	Observation period from 4 to 6 months
1	Observation period ≤ 3 months
Criterion #4 Quality of Measurements Used (e.g., “Measurements”)	
5	Self-report with independent objective verification for all measures, with use of standard measures
4	Self-report with independent objective verification for most measures
3	Self-report or independent objective verification for selected measures
2	Self-report only on risk factors and biometric measures
1	Limited consistency in measurement methodology
Criterion #5 Outcome measures considered in the intervention, such as physical activity, dietary intake, health knowledge, body mass index, and sedentary activity (e.g., “Outcomes”)	
5	Number of outcomes evaluated ≥ 5
4	Number of outcomes evaluated = 4
3	Number of outcomes evaluated = 3
2	Number of outcomes evaluated = 2
1	Number of outcomes evaluated = 1
Criterion #6 Experimental time period (e.g., “Recentness”)	
5	Last year of intervention conducted after 2010
4	Last year of intervention conducted from 2006 to 2010
3	Last year of intervention conducted from 2001 to 2005
2	Last year of intervention conducted from 1990 to 2000
1	Last year of intervention conducted prior to 1990
Criterion #7 Quality of methodology used, such as description of setting, population characteristics, theoretical basis, intervention, and statistical analysis (e.g., “Methodology”)	
5	Number of methodology components described in detail = 5
4	Number of methodology components described in detail = 4
3	Number of methodology components described in detail = 3
2	Number of methodology components described in detail = 2
1	Number of methodology components described in detail = 1

Table 2. Summary of interventions for prevention of childhood obesity.

Author/Year	Study design	Population	Region	Intervention	Intervention duration	Theory-based	Outcome measures	Summarized findings
Ling <i>et al.</i> (2014) [29]	Quasi-experimental	K to 5 th graders Age = 6-12 years N = 1,508	Rural KY	School-based healthy lifestyle intervention	5 months	No	Health education (nutrition and physical activity)	Significant increase in percentage of children met physical activity (1% vs. 5%, $P < 0.01$) and nutrition (15% vs. 26%, $P < 0.01$) recommendations after intervention.
Morgan <i>et al.</i> (2014) [30]	Quasi-experimental	4 th graders Age = 9-11 years N = 105	Rural AL	CATCH nutrition curriculum	2.5 months	Social Cognitive Theory	Nutrition education, physical activity, motivation	Significant improvement in nutrition knowledge and healthy food choices ($P < 0.05$) in intervention group.
Smith and Holloman (2014) [37]	Experimental	9 th to 12 th graders Age = 14-20 years N = 186	Rural Appalachia	School-based intervention	1 month	No	Consumption of sugar-sweetened drinks, water consumption	Daily servings of sugar-sweetened beverages significantly decreased (2.32 to 1.32, $P < 0.001$), and water consumption increased by 19% post-intervention.
Struempfer <i>et al.</i> (2014) [38]	Quasi-experimental	3 rd graders N = 2,477	Rural AL	School-based nutrition program	4 months	Experiential Learning Theory	Nutrition	Moderate, but significant increase in food/vegetable consumption in intervention group ($P < 0.01$)
Cohen <i>et al.</i> (2013) [21]	Experimental RCT	1 st to 6 th graders Mean age = 8.65 ± 1.6 years N = 432	Rural communities in CA, KY, MS, SC	CHANGE - community and school-based intervention	12 months	No	Fruits and vegetables intake and other diet	Students enrolled in the intervention consumed significantly more fruits/vegetables and showed a reduction in the average daily dietary glycemic index ($P < 0.05$).
Puma <i>et al.</i> (2013) [33]	Quasi-experimental	2 nd graders N = 363	South-central CO	Integrated Nutrition and Physical Activity Program (INPAP)	3-6 years	Social Cognitive Theory	Nutrition and physical activity knowledge, self-efficacy, attitudes and behaviors, BMI	Long-term effects were observed in nutrition-related knowledge and attitudes, but these effects attenuated over time.
Williamson <i>et al.</i> (2012) [39]	Experimental; Longitudinal, cluster 3-arm RCT	4 th to 6 th graders Mean age = 10.5 years N = 2,060	Rural LA	Environmental School-based prevention program	28 months	No	Percent body fat, BMI, change in behavior	Decreased body fat, but no difference in physical activity in intervention group compared to control group.
Craven <i>et al.</i> (2011) [23]	Quasi-experimental	9 th graders Age = 13-19 years N = 399	Rural Eastern NC	Nutrition Education Intervention	4 months	Social Cognitive Theory	BMI, diet intake	Greater decline in BMI along with fruit/vegetable intake in intervention group.
Greening <i>et al.</i> (2011) [26]	Experimental; RCT cluster by school	Age = 6-10 years N = 450 (Control = 246, Intervention = 204)	Rural MS	TEAM Mississippi Project	8 months	Social Learning Theory	Nutrition, knowledge, health behavior, physical activity, percentage body fat	Significant decline in percent body fat ($P = 0.02$), greater engagement in physical activity ($P = 0.04$), and decline in dietary fat intake ($P < 0.0005$) in intervention group.
Smith <i>et al.</i> (2011) [36]	Pre-experimental	3 rd and 4 th graders who were overweight and obese Age = 8-12 years N = 72	Appalachia	Teen Mentoring Intervention - after-school program	2 months	Theory of Planned behavior	BMI, health behavior, nutritional knowledge, attitude towards healthy eating and physical activity	Significant increase in positive health behavior, i.e. healthy eating ($P = 0.02$), improvement in nutritional knowledge, and improved attitude towards healthy diet ($P = 0.05$). Significant reduction in BMI was also observed ($P = 0.03$).
Hovland <i>et al.</i> (2010) [28]	Quasi-experimental	3 rd graders Age = 6-11 years N = 138	Appalachian OH	Food MASTER curriculum delivered by teachers	9 months	No	Dietary intake	No significant differences in dietary intake.
Canavera <i>et al.</i> (2009) [18]	Pre-experimental	5 th graders Age = 10-12 years N = 122	Rural KY	School-based teacher delivered intervention	3 months; 1 session per week	Social Cognitive Theory	Fruit and vegetable consumption, water consumption, television viewing time, physical activity	Intervention significantly improved consumption of water ($P = 0.022$) and reduced television viewing ($P = 0.022$).

Drummond <i>et al.</i> (2009) [24]	Pre-experimental	K to 12 th graders N = 1,876 (approx.)	Rural AZ	Steps to a Healthier Arizona - childcare setting	3 years; 7 workshops across 9 months	Community Change Model	Nutrition, physical activity	Significant increase in median total number of best practices from 36 to 44 ($P = 0.0003$). Significant increase in nutrition best practices from 25 to 30 ($P = 0.0003$).
Schetzina <i>et al.</i> (2009, 2011) [34, 35]	Pre-experimental	Age = 7-10 years N = 114	Rural Appalachia	Winning with Wellness - school-based approach	18 months; 6 workshops	Coordinated School Health Model	BMI, physical activity, nutrition	Children were more active at school after program implementation, followed healthy food habits ($P < 0.0001$).
Muth <i>et al.</i> (2008) [31]	Experimental; RCT cluster by classrooms	4 th graders N = 75 (Control = 37, Intervention = 38)	Rural NC	IMPACT - integrated in-classroom curriculum	3 months	Social Cognitive Theory	Dietary intake	Significant increase in daily fruit/vegetable intake, calcium-rich foods, and grain intake ($P < 0.05$) in intervention group as well as Increase in diet knowledge ($P = 0.01$).
Gombosi <i>et al.</i> (2007) [25]	Pre-experimental	K to 8 th graders Age = 5-14 years N = 4,241 (approx.)	Rural PA	Fit for Life - health education curriculum	5 years (1999 - 2004; during school year)	No	BMI, health education	Overall increase in overweight and obesity of children, indicating inadequate health education.
Cason <i>et al.</i> (2006) [20]	Quasi-experimental	4 th graders Age = 9-11 years N = 130	Rural SC	Jump Into Foods and Fitness (JIFF) curriculum	5 months	No	Health knowledge and behavior (diet and physical activity)	Significant improvement in health-related behavior after the completion of intervention program. ($P < 0.005$).
Carrel <i>et al.</i> (2005) [19]	Experimental; RCT	Children with BMI > 95 th percentile for age Mean age = 12 ± 0.5 years N = 53	Rural WI	School-based fitness program	9 months	No	BMI, percentage body fat, cardiovascular fitness	Significantly greater loss of body fat, greater increase in cardiovascular fitness, and greater improvement in fasting insulin level ($P < 0.05$).
Cottrell <i>et al.</i> (2005) [22]	Experimental; RCT cluster by school	Kindergarten Age = 4-6 years N = 50 (Control = 26, Intervention = 24)	WV	CARDIAC-Kinder Care	1 month	No	Physical activity, child diet	Significantly greater consumption of fruits/vegetables and fewer sweets among children in intervention group ($P < 0.05$).
Harrell <i>et al.</i> (2005) [27]	Quasi-experimental	5 th graders Mean age = 11.9 ± 0.06 years N = 205	Rural MS	Cardiovascular health in children - school-wide program	4 months	No	Fruit and vegetable intake, health knowledge	Significant increase in health knowledge ($P < 0.0001$), increase in vegetable consumption ($P < 0.05$), and decrease in sugar-sweetened drinks ($P < 0.05$) in intervention group.
Pate <i>et al.</i> (2003) [32]	Quasi-experimental	5 th graders Mean age = 10.8 ± 0.7 years N = 436	Rural SC	Community-based after-school program	18 months	No	Physical activity	No significant differences in physical activity.

brief description of the target population, intervention, duration of intervention, theoretical framework, outcome measures, and relevant findings [18-39].

Study characteristics

Studies were carried out in rural regions of 13 different states, with most of them conducted in Kentucky [18,21,29], Mississippi [21,26,27], and South Carolina [20,21,32] (N = 3 each). Studies included in this review were conducted either in a school-based or child care setting. Most of the studies were published after 2008 (N = 14) [18,21,23,24,26,28,30,33-39]. Further, a majority of the studies used quasi-experimental design (N = 9) [20,23,27-30,32,33,38]; study design in which a control group is used, however, the design doesn't account for randomization, followed by randomized control trials (N = 7) [19,21,22,26,31,37,39]. For the studies utilizing randomized control design, randomization occurred at the individual, school or classroom level.

The sample size for these intervention studies ranged from 50 to

4,241. Five studies had an adequate sample size of greater than 500 [24,25,29,38,39] and only two studies had a small sample size of less than 100 [31,36].

Population characteristics

Children from ages 4-20 years (kindergarten through 12th grade) were targeted for intervention, with most of the children in the age group of 8-11 years (N = 15). Consistently, most of the students were in 3rd to 5th grade (N=15). Sex distribution of the participants was included in all of the studies reported in this review. At-risk participants, *i.e.* those who were overweight or obese, were specifically targeted for intervention in only two studies [19,36].

Theoretical framework

Ten intervention studies used theoretical framework for design of the program and implementation [18,23,24,26,30,31,33-36,38]. Among these studies, five of the interventions were based on Social Cognitive Theory [18,23,30,31,33]. Studies that utilized theoretical framework

either used quasi-experimental or pre-experimental design (N = 4 each).

Intervention evaluation

Twenty interventions were school-based and one was conducted in a child care setting [24]. Intervention programs ranged in duration from 1 month to 6 years. Many of the programs in school setting implemented intervention as a part of the school curriculum and teaching staff helped in the implementation of program. Interestingly, one of the studies had teen mentors for program implementation [36]. The programs utilized educational, behavioral, environmental, and social strategies with the focus being either improving knowledge of health behavior or improving health behavior. The health behaviors targeted included fruit and vegetable consumption, consumption of sugar-sweetened beverages, water, type of dietary foods, and physical activity. Almost all of the studies, included in this review, indicated a significant improvement in knowledge or health behavior. Interestingly, one of the studies indicated that improvement in health knowledge faded away over a period of time.

Meta-evaluation of intervention studies

The results of meta-evaluation are shown in Table 3. Overall total score for the studies ranged from 15-29. A majority of studies had a total score above 20 [21-26,28,29,31,33-36,38,39], with only six studies having higher total score equal to or greater than 25 [21,26,33-35,38,39]. Studies with better study design, large sample size, longer observation period, standard measurement methods, higher number

of outcomes, and comprehensive methodology scored higher for the corresponding criterion (Table 1). The points obtained by each study varied corresponding to each criterion.

Discussion

The prevalence of obesity among children in the U.S. has increased rapidly over the past several decades, becoming a leading nationwide concern. The estimates for childhood obesity in rural-dwelling areas exceed the averages by as much as double, with Appalachian areas having the highest prevalence rates among the rural areas of the U.S. [1,2,9]. Further, current strategies for preventing childhood obesity have not shown promising results in rural Appalachia [9].

School-based interventions provide opportunities for researchers and program planners to target larger population of children efficiently and effectively. With existing resources already available in schools, interventions can be conducted for a longer duration of time. Further, children spend a majority of time in school and thus, successful school-based programs can be integrated into the curriculum. Improving attitude and knowledge regarding diet and physical activity can help children implement positive health behaviors in their everyday life. Content of the program and adequate training of teachers and staff can result in implementation of successful obesity prevention interventions. Further, existing evidence-based guidelines can be used as the foundation for developing, implementing, and evaluating obesity prevention interventions.

This meta-evaluation study provides insight into the quality of

Table 3. Summary of meta-evaluation scores.

Author, Year	Design	Sample	Length	Measurements	Outcomes	Recentness	Methodology	Total
Ling <i>et al.</i> 2014 [29]	3	5	2	4	2	4	5	25
Morgan <i>et al.</i> 2014 [30]	3	2	1	3	2	5	4	20
Smith and Holloman, 2014 [37]	2	2	1	1	1	5	3	15
Struempfer <i>et al.</i> 2014 [38]	3	5	2	5	1	5	5	26
Cohen <i>et al.</i> 2009 [21]	5	2	5	4	1	4	5	26
Puma <i>et al.</i> 2013 [33]	3	2	5	4	4	5	3	26
Williamson <i>et al.</i> 2012 [39]	5	5	5	2	2	5	5	29
Craven <i>et al.</i> 2011 [23]	3	3	2	5	3	4	5	25
Greening <i>et al.</i> 2011 [26]	5	3	3	4	3	4	5	27
Smith <i>et al.</i> 2011 [36]	5	2	1	5	3	4	4	24
Hovland <i>et al.</i> 2010 [28]	3	2	3	5	2	4	5	24
Canavera <i>et al.</i> 2009 [18]	2	2	1	3	3	4	4	19
Drummond <i>et al.</i> 2009 [24]	1	5	5	2	2	4	3	22
Schetzina <i>et al.</i> 2009, 2011 [34, 35]	2	2	5	4	4	4	5	26
Muth <i>et al.</i> 2008 [31]	5	1	1	4	2	4	5	22
Gombosi <i>et al.</i> 2007 [25]	1	2	5	4	2	3	4	21
Cason <i>et al.</i> 2006 [20]	3	2	3	2	2	3	3	18
Carrel <i>et al.</i> 2005 [19]	5	1	3	3	1	3	3	19
Cottrell <i>et al.</i> 2005 [22]	5	1	2	4	3	3	5	23
Harrell <i>et al.</i> 2005 [27]	3	2	2	4	2	3	4	20
Pate <i>et al.</i> 2003 [32]	3	2	4	3	1	3	4	20

Scores were assigned based on criteria specified in Table 1.

existing school-based intervention study evaluated on the selected criteria for evaluation. The studies included in this meta-evaluation varied in terms of design, sample size, observation period, outcomes considered, measurements, methodology, and recentness of the study. All of these criteria discussed here are helpful in evaluating an intervention for its replicability and applicability to other populations.

The studies selected for meta-evaluation used different study designs-experimental, pre-experimental, and quasi-experimental. The experimental studies obtained more points for their design, followed by quasi-experimental study design, suggesting robustness of these studies in terms of their design. For interventions focusing on preventive strategies, the purpose was to design an intervention strategy which is effective in the population being tested as well as generalizable to other populations. Thus, both experimental and quasi-experimental designs seem to be appropriate for the interventions focusing on prevention.

A large sample size is more representative of a population and limits the effect of outliers or extreme observations. Most of the studies included had sample size less than 500, which is adequate for statistical analyses, but not for generalization. However, sample sizes above 1000 are more feasible and large sample sizes were used by only three studies with either experimental or quasi-experimental design. Studies with large sample size are warranted for to evaluate generalizability of these interventions. Overall, lowest points were assigned for sample size for most of the studies.

Regarding observation period, most of the studies scored lower points, *i.e.*, they had a shorter observation period, either ≤ 3 months, 4-6 months or 7-9 months. All the studies included focused on change in behavior, *i.e.* nutrition and/or physical activity, as one of the primary outcome. Furthermore, it is also important to assess the duration for which individuals retain the change in behavior. Thus, longer duration of observation period is more effective at assessing post-intervention change in the outcome. Most of the pre-experimental studies had longer observation period compared to experimental or quasi-experimental studies.

Almost all of the studies used self-reported standard measures; a few studies provided objective verification for all the measures used. This suggests that the interventions were assessed with appropriate measurement of outcomes and can be used effectively and reliably. Experimental studies had higher points for quality of measurement followed by pre-experimental studies.

Physical activity and dietary intake are the most important outcomes that are often assessed for obesity interventions. A majority of studies evaluated both change in physical activity and dietary intake as a primary outcome. All of the intervention studies showed positive change in these outcomes, which suggests that these interventions were effective in promoting change in behavior. In addition, some of the interventions were theory-based, whereas others did not use any theory for designing intervention. Theory enhances understanding of complex situations and is important for identifying the range of factors that might modify the situation. Furthermore, theory provides a basis for evaluating elements of a program and further improvement of existing programs.

All the studies provided comprehensive description of the methodology, including description of setting, population characteristics, intervention, and statistical analyses. Furthermore, all intervention studies reviewed were conducted after 2001, with most of them being very recent (*i.e.*, after 2008). The more recent the

study, the more relevant it is because these studies tend to use newer prevention strategies and technologies. With time, there are changes in demographics, socioeconomic status, lifestyle, etc., which warrants newer interventions. Since the studies are recent, the interventions assessed can be used in other populations-children and adolescents for prevention of obesity.

Schools can promote a sense of community and support for children. Further, schools can also involve parents or families in childhood obesity prevention programs, which can further influence a child's behavior. Few studies demonstrated success of after school-based programs. These programs can involve parents or families in the intervention. In addition, programs that use teen or peer mentoring might provide inexpensive and effective strategies for motivating children for a healthier lifestyle. Children often look up to their peers often look up others in their community and are motivated to adopt healthy lifestyle behaviors. This strategy is specifically beneficial in rural areas, where there is a lack of formal health education programs. Another important aspect is duration of these intervention programs. A school-based setting offers opportunities for longer duration of these interventions. Having a program integrated into curriculum and providing health-related knowledge over a period of time may help children adopt these healthier habits and retain it in their life.

The search strategy included only published literature; this may have excluded some of the effective interventions. Further, we included interventions targeting rural and Appalachian children. Studies with no clear specification of interventions in rural population were, thus, excluded. Despite these limitations, this review provides insights into the existing interventions for prevention of obesity. Further, this review examines the quality and applicability of interventions.

Conclusion

The meta-evaluation of the intervention studies provided a meaningful evaluation of the quality of the research focusing on interventions for prevention of obesity in rural-dwelling children. Overall, studies reported positive change in behavior regarding physical activity and dietary intake, suggesting the importance and effectiveness of these interventions in prevention of obesity. Further, the variation in scores suggests wide range of quality and rigor in the design and implementation of these interventions.

References

1. (2014) Centers for Disease Control and Prevention. Overweight and obesity: childhood obesity facts.
2. Reilly JJ (2006) Obesity in childhood and adolescence: evidence based clinical and public health perspectives. *Postgrad Med J* 82: 429-437. [[Crossref](#)]
3. Ogden CL, Carroll MD, Kit BK, Flegal KM (2012) Prevalence of obesity and trends in body mass index among US children and adolescents, 1999-2010. *JAMA* 307: 483-490. [[Crossref](#)]
4. (2009) Robert Wood Johnson Foundation. Facts about childhood obesity.
5. (2012) Centers for Disease Control and Prevention. Overweight and obesity: basics about childhood obesity. Centers for Disease Control and Prevention.
6. Washington RL (2008) Metabolic syndrome – No longer an adult only disease. *The Journal of Pediatrics* 152: A1.
7. Daniels SR (2005) Regulation of body mass and management of childhood overweight. *Pediatr Blood Cancer* 44: 589-594. [[Crossref](#)]
8. Patterson PD, Moore CG, Probst JC, Shinogle JA (2004) Obesity and physical inactivity in rural America. *J Rural Health* 20: 151-159. [[Crossref](#)]
9. (2010) Robert Wood Johnson Foundation. F as in fat: How obesity policies are failing in America, Washington, DC: Trust for America's Health.

10. Horodynski MA, Hoerr S, Coleman G (2004) Nutrition education aimed at toddlers: a pilot program for rural, low-income families. *Fam Community Health* 27: 103-113. [[Crossref](#)]
11. Wood D (2003) Effect of child and family poverty on child health in the United States. *Pediatrics* 112: 707-711. [[Crossref](#)]
12. Lutfiyya MN, Lipsky MS, Wisdom-Behounek J, Inpanbutr-Martinkus M (2007) Is rural residency a risk factor for overweight and obesity for U.S. children? *Obesity (Silver Spring)* 15: 2348-2356. [[Crossref](#)]
13. (2013) Effective Health Care Program. Childhood obesity prevention programs: Comparative effectiveness review and meta-analysis.
14. (2014) Office of Disease Prevention and Health Promotion. Healthy People 2020.
15. (2014) Appalachian Regional Commission. The Appalachian Region.
16. Health Resources and Services Administration. Defining the rural population.
17. Chapman LS; American Journal of Health Promotion Inc (2005) Meta-evaluation of worksite health promotion economic return studies: 2005 update. *Am J Health Promot* 19: 1-11. [[Crossref](#)]
18. Canavera M, Sharma M, Murnan J (2008) Development and pilot testing a social cognitive theory-based intervention to prevent childhood obesity among elementary students in rural Kentucky. *Int Q Community Health Educ* 29: 57-70. [[Crossref](#)]
19. Carrel AL, Clark RR, Peterson SE, Nemeth BA, Sullivan J, et al. (2005) Improvement of fitness, body composition, and insulin sensitivity in overweight children in a school-based exercise program: a randomized, controlled study. *Arch Pediatr Adolesc Med* 159: 963-968. [[Crossref](#)]
20. Cason KLL, B.N. (2006) Educational Intervention Improves 4th-Grade Schoolchildren's Nutrition and Physical Activity Knowledge and Behaviors. *Top Clin Nutr* 21: 234-240.
21. Cohen JF, Kraak VI, Choumenkovitch SF, Hyatt RR, Economos CD (2014) The CHANGE study: a healthy-lifestyles intervention to improve rural children's diet quality. *J Acad Nutr Diet* 114: 48-53. [[Crossref](#)]
22. Cottrell L, Spangler-Murphy E, Minor V, Downes A, Nicholson P, et al. (2005) A kindergarten cardiovascular risk surveillance study: CARDIAC-Kinder. *Am J Health Behav* 29: 595-606. [[Crossref](#)]
23. Craven KW, Moore JB, Swart AS, et al. (2011) School-based nutrition education intervention: effect on achieving a healthy weight among overweight ninth-grade students. *J Public Health Manag Pract* 17: 141-146. [[Crossref](#)]
24. Drummond RL, Staten LK, Sanford MR, et al. (2009) A pebble in the pond: the ripple effect of an obesity prevention intervention targeting the child care environment. *Health Promot Pract* 10: 156S-167S. [[Crossref](#)]
25. Gombosi RL, Olasin RM, Bittle JL (2007) Tioga County Fit for Life: a primary obesity prevention project. *Clin Pediatr (Phila)* 46: 592-600. [[Crossref](#)]
26. Greening L, Harrell KT, Low AK, Fielder CE (2011) Efficacy of a school-based childhood obesity intervention program in a rural southern community: TEAM Mississippi Project. *Obesity (Silver Spring)* 19: 1213-1219. [[Crossref](#)]
27. Harrell TK, Davy BM, Stewart JL, et al. (2005) Effectiveness of a school-based intervention to increase health knowledge of cardiovascular disease risk factors among rural Mississippi middle school children. *South Med J* 98: 1173-1180. [[Crossref](#)]
28. Hovland JA, McLeod SM, Duffrin MW, Johanson G, Berryman DE (2010) School-based screening of the dietary intakes of third graders in rural Appalachian Ohio. *J Sch Health* 80: 536-543. [[Crossref](#)]
29. Ling J, King KM, Speck BJ, Kim S, Wu D (2014) Preliminary assessment of a school-based healthy lifestyle intervention among rural elementary school children. *J Sch Health* 84: 247-255. [[Crossref](#)]
30. Morgan AZ, Ulrich P, Simmons KP, et al. (2014) Effectiveness of a multi-faceted, school-based health intervention program with 4th graders in Alabama. *Children and Youth Services Review* 37: 46-54.
31. Muth ND, Chatterjee A, Williams D, Cross A, Flower K (2008) Making an IMPACT: effect of a school-based pilot intervention. *N C Med J* 69: 432-440. [[Crossref](#)]
32. Pate RR, Saunders RP, Ward DS, Felton G, Trost SG, et al. (2003) Evaluation of a community-based intervention to promote physical activity in youth: lessons from Active Winners. *Am J Health Promot* 17: 171-182. [[Crossref](#)]
33. Puma J, Romaniello C, Crane L, Scarbro S, Belansky E, et al. (2013) Long-term student outcomes of the Integrated Nutrition and Physical Activity Program. *J Nutr Educ Behav* 45: 635-642. [[Crossref](#)]
34. Schetzina KE, Dalton WT 3rd, Lowe EF, Azzazy N, VonWerssowetz KM, et al. (2009) A coordinated school health approach to obesity prevention among Appalachian youth: the Winning with Wellness Pilot Project. *Fam Community Health* 32: 271-285. [[Crossref](#)]
35. Schetzina KE, Dalton WT, 3rd, Pfortmiller DT, et al. (2011) The Winning with Wellness pilot project: rural Appalachian elementary student physical activity and eating behaviors and program implementation 4 years later. *Fam Community Health* 34: 154-162. [[Crossref](#)]
36. Smith LHI (2011) Piloting the use of teen mentors to promote a healthy diet and physical activity among children in Appalachia. *J Spec Pediatr Nurs* 16: 16-26. [[Crossref](#)]
37. Smith LH, Holloman C (2014) Piloting "sodabriety": a school-based intervention to impact sugar-sweetened beverage consumption in rural Appalachian high schools. *J Sch Health* 84: 177-184. [[Crossref](#)]
38. Struempfer BJ, Parmer SM, Mastropietro LM, et al. (2014) Changes in fruit and vegetable consumption of third-grade students in body quest: food of the warrior, a 17-class childhood obesity prevention program. *J Nutr Educ Behav* 46: 286-292. [[Crossref](#)]
39. Williamson DA, Champagne CM, Harsha DW, Han H, Martin CK, et al. (2012) Effect of an environmental school-based obesity prevention program on changes in body fat and body weight: a randomized trial. *Obesity (Silver Spring)* 20: 1653-1661. [[Crossref](#)]