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REVIEW

Novel and emerging approaches to combat adolescent obesity

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Abstract: Overweight and obesity continue to be health concerns facing today's adolescent population. Along with metabolic and physical problems associated with obesity, today's obese adolescents also face many psychological issues such as high rates of depression, anxiety, and social discrimination. Obesity is commonly recognized as having many causes, such as genetic, lifestyle and environmental. There are four major modalities for management of overweight and obesity in adolescents: dietary management, increasing physical activity, pharmacological therapy, and bariatric surgery. The purpose of this study was to conduct a review of novel and emerging approaches for preventing and managing adolescent obesity. It was found that while not always the case, theory driven approaches are being better utilized in newer interventions especially by those directed toward prevention. New theories that are being used are the theories of reasoned action, planned behavior, intervention mapping, and social marketing. Schools are found to be the most common place for such interventions, which is appropriate since virtually all children attend some form of private or public school. Limitations found in many studies include the underuse of process evaluations, the low number of studies attempted, environmental or policy changes, and that not all studies used a similar control group for comparison.

Keywords: adolescent overweight, adolescent obesity, interventions

Introduction

In the United States during the past three decades the prevalence of overweight and obesity among school children and adolescents has increased. According to a recent National Health and Nutrition Examination Survey (NHANES) completed in 2006, 16.3% of all children between the ages of 2 to 12 years were found to be obese and 31.9% were overweight.[1] The rates in adolescents between the ages of 12 to 19 years old were even higher, with 17.6% being obese and 34.1% overweight. When stratified further by gender, adolescent males had the highest prevalence of obesity and overweight among all age groups, with 16.8% female and 18.2% male being obese and 33.3% female and 34.9% male being overweight. Disparities also exist across different racial and ethnic groups. Non-Hispanic black (22.9%) adolescents have a higher reported prevalence when compared to non-Hispanic white adolescents (16.0%).[1] Adolescent obesity is not an issue the US faces alone. The World Health Organization (WHO) has called overweight and obesity an 'escalating global epidemic,' which is prevalent in almost all parts of the world (both developed and developing countries), across all age and all socioeconomic groups.[2] In 2003, 23.5% Eastern Mediterranean, 25.5% European and 10.6% of South East Asian children and adolescents were reported either overweight or obese. The authors also noted that these numbers are projected to almost double by 2010.[2]

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In the United States, obesity estimates among adolescents are often based on body mass index (BMI) percentile scores, which the International Obesity Task Force accepts as a valid method for measuring body composition. However, Olds[3] reported secular trends for child and adolescent body fatness as measured by triceps and subscapular skinfold thickness, which may be a better indicator of body composition. Investigators report that child and adolescent body fatness has increased ~0.9% per decade since the 1950's, and in 2003, the average percentage body fatness for child and adolescent boys and girls were 16.2% and 22.2% respectively.[3] It was also noted that among age groups, the largest body fatness increases were those in peripubertal years (10 to14 years old), which is consistent with research finding early childhood obesity promotes early physical maturation and puberty.[4]

There are four major modalities for the management of overweight and obesity in adolescents: dietary management, increasing physical activity, pharmacological therapy, and bariatric surgery.[5–8] Dietary management consists of restricting total caloric intake so there is a mild negative energy balance, restricting the intake of calorie-dense foods such as those containing saturated fats and added sugars, eliminating sugar sweetened beverages, and avoiding an unbalanced diet. This also allows children's height to 'catch up' with their weight. For increasing physical activity first sedentary behaviors such as watching TV, surfing the Internet and playing video games are reduced then age-specific exercise is added with gradually increasing intensity, frequency, and duration. It is recommended that overweight and obese adolescents engage in at least 60 minutes of physical activity everyday, and in some cases, may need to engage in more than 60 minutes everyday.[5] In pharmacological therapy there are two drugs that are approved by the Food and Drug Administration in the United States.[7] These are orlistat and sibutramine. Pharmacological intervention is recommended only if severe physical (such as sleep apnea or orthopedic problems) or psychological co-morbidities are present. Orlistat blocks absorption of fat in the intestines by decreasing action of lipase and as a result creates a negative energy balance. The main adverse effects associated with its use are malabsorption of fat soluble vitamins and oily stools. Sibutramine promotes satiety and increases energy expenditure by inhibiting reuptake of noradrenaline and serotonin. It also causes anorexia. Side effects of sibutramine include palpitations, high blood pressure, and headaches. Tziomalos and colleagues,[9] in a recent review of studies using sibutramine, note that it is a useful drug for decreasing body weight and improving cardiometabolic risk factors. The last modality is bariatric surgery, which is only recommended for adolescents in extreme circumstances. Only obese adolescents with a BMI of over 40 kg/m^2 or more and who have associated complications such as diabetes or sleep apnea are considered for bariatric surgery.[7] There are four types of procedures in bariatric surgery: laparoscopic gastric banding, vertical banded gastroplasty, Roux-en-Y gastric bypass, and duodenal switch and biliopancreatic diversion.[5] It is against this backdrop that this article summarizes the causes and consequences of adolescent obesity and focuses on reviewing newer interventions for preventing and managing adolescent obesity.

Causes and trends of adolescent obesity

The pathophysiology of adolescent obesity has been described using three perspectives: homeostatic, epidemiological, and pathological.[10] However, it is commonly accepted that the overlying cause of overweight in adolescence is an imbalance of energy status whereby more calories are consumed than expended.[10] The underlying cause for this imbalance has been debated; how much can be associated from either nature or nurture. Genetic variations have been shown to predispose some individuals for developing overweight and obesity more easily than others. Specifically, children born with a low birth weight have been noted to be at greater risk for developing obesity. It is hypothesized this is partly due to prenatal stress experienced by the fetus causing genetic alterations and resulting in impairments in insulin secretion and sensitivity. Polymorphisms in the GAD2 gene has also been associated with adult morbid obesity.[11] While this may support genetics being a causal factor for the development of obesity, it is also important to recognize that parents not only give their children a genetic make-up, but also construct the home environment in which their children are raised.[12] Foods made available in the household and eating habits learned from the parent or caregiver may better allow these genetic predispositions to be expressed.[13]

Elements of the home environment have been noted to influence adolescents' dietary habits, which potentially contribute to the development of obesity. Adolescents are more likely to eat foods they observe their parents, and friends consume.[14] The availability and accessibility of foods within the home have been noted to impact dietary intake and food preference among adolescents. Since parents keep foods in the home they typically prefer to eat, their children will have repeated exposures to these foods, which will likely influence and shape their preferences. This may lead

to increased adiposity if children are constantly exposed to energy-dense, and nutrient-poor foods.[15] Further problems can ensue when parents teach their children to label foods as 'good' or 'bad'. By limiting or withholding 'bad' foods as a punishment, adolescents are more likely to become fixated and consume these foods when given the opportunity. It can also be confusing for them when foods are categorized as such, given the social context for which they are commonly placed. For instance positive life events, such as birthday parties and holiday celebrations, are often celebrated with 'bad' foods such as cake and ice-cream.[12]

Adolescents participate in less physical activity in both at home and school, consequently they engage in more screen time, including watching television, and playing computer and video games.[16] It is of concern that the food industry is the largest buyer of television advertising and television is the largest single source of media about food.[17] Food companies that sell energy-dense, nutrient-poor foods and beverages, and spend large amounts of money to aggressively advertise to adolescents in an attempt to build brand awareness, recognition, preference, and loyalty for their products. Adolescents can also be considered vulnerable recipients of marketing campaigns, since they can be easily persuaded by the emotional ties that are associated with advertisements. Namely, advertisements that concern their appearance, self-identity, belonging, and sexuality.[17]

Sleeping patterns have also been reported as a risk factor for overweight among adolescents. Cross sectional studies suggest that children and adolescents who sleep less, go to sleep later in the night, and awake earlier in the morning are more likely to be overweight, compared to those with adequate sleep.[18] This may be the result of a disruption of appetite and metabolism induced by a hormone imbalance. Less sleep has been shown to cause a reduction of leptin and an increase in ghrelin production, hormones associated with hunger and appetite.[18]

Many dietary trends have been associated with the development of child and adolescent obesity. Recent data indicate that more children are skipping breakfast than in previous years. It has been reported that among preadolescence (aged 12 and 13 years) 42% skip breakfast throughout the week.[19] Skipping breakfast has been found to associated with overweight and obesity in adolescents.[20,21] While breakfast consumption has decreased among adolescents, snacking also appears to have increased. It is estimated that adolescents now consume one-fourth to one-third of their daily caloric intake in the form of snack foods. Of concern, snack foods tend to be higher in fat and energy density, and frequent snacking has been associated with higher intakes of fat, sugar, and calories. The most commonly consumed snack foods among adolescents include: potato chips, candy, and cookies.[22]

Eating away from home has also increased in recent years, which has been positively associated with the intake of dietary fat, and negatively associated with the intake of fruit, vegetable, and dairy groups.[23] Several studies have shown that high fat intake has been associated with an increase in adiposity.[12,22] Fat is highly palatable, yet energy dense, making it relatively easy to consume large amounts with smaller portions. Diets high in fatty foods have been noted to be low in fruits, vegetables, complex carbohydrates, and micronutrients.[12] Low consumption of fruits and vegetables have been associated with poor diet quality, and is considered one of the most common risk factors for the development of chronic diseases.[22]

Currently adolescents do not consume the recommended amounts of fruits and vegetables. In a recent report using data from NHANES 1999–2003, it was found that 45.4% of adolescents did not consume the recommended amount of fruits and 52.4% did not consume the recommended amount of vegetables.[24] These percentages can also be misleading, if you take into account the significant contributors for which make up fruit and vegetable consumption. French fries were noted as the largest contributor to vegetable intake and 100% fruit juice was noted as the largest contributor to fruit intake.[24]

One of the most widely cited dietary behaviors for the development of child and adolescent obesity is the consumption of added sugars, and more specifically those found in soft drinks. Older adolescents report drinking more carbonated beverages, fruit drinks and citrus fruits than younger children. In a study among US adolescents, it was demonstrated that sugar sweetened beverage consumption was independently, positively associated with fasting blood glucose levels, systolic blood pressure, waist circumference, and BMI (for age and sex), and negatively associated with high-density lipoprotein (HDL) cholesterol.[25]

Role of depression in adolescent obesity

As reported in the recent *American Heart Association Childhood Obesity Research Summit Report* it has been consistently reported that overweight children and adolescents experience greater psychological distress such as high rates of depression, low self-esteem, social marginalization, and negative body image, compared to their normal weight peers.[10,16] This may stem from higher social discrimination

overweight adolescents experience from family members, peers, and even teachers.[4] Examples of misconceptions that are commonly placed on obese youth, that may reinforce a negative body image, include personal traits such as laziness, selfishness, and lower intelligence.[16] Adolescence is also a time when individuals have heightened sensitivity about their perceived body image. In a cross-sectional study using adolescents, while only 8.8% of the sample was measured as obese, 12.7% self-reported themselves as 'fat'.[26] Obesity rates were also higher among males, however, females were more likely to consider themselves fat.

In a study examining the relationship of depression and obesity among adolescents in grades 7–12, those with the highest BMI's were found to have the highest rate of depression.[27] After a 1-year follow up, sustained elevated BMI's were again positively associated with higher depression rates. In another cross-sectional study obese female adolescents (as compared with nonobese female adolescents (n = 5201) were: 1.63 × less likely to associate with friends, 1.79 × more likely to report hopelessness, 1.49 × more likely to report serious emotional problems, and 1.73 × likely to report a suicide attempt, within the past week.[2] Depressed adolescents are also commonly placed on antipsychotic medications such as risperidone, olanzapine or clozepine. A common side effect for such mediations is the inducement of insulin resistance, which may increase weight gain and risk of developing metabolic syndrome.[28]

Long-term psychosocial effects in adolescent obesity

Overweight adolescents have been noted to be more socially isolated and have fewer friends when compared with their normal weight peers. Lower social support has also been negatively associated with women's waist-to-hip ratio and central adiposity.[29] In one study reviewed by Midei and Matthews it was shown that low levels of social support predicted waist circumference over a 5-year period, when controlling for baseline waist circumference.[29] Adolescent males also feel the pressure of adiposity. In another study reviewed by Midei and Matthews with adolescent and young adult men, a negative association between social support and waist-to-hip (WHR) was reported over a 3-year period.[29] Another cross-sectional study with 15- and 16-year-old adolescents reported higher expressive anger in overweight boys, but not girls.[29]

A longitudinal study by Merten and colleagues[30] looked at gender and racial differences in obese adolescents as they reached young adulthood. They found that in adolescent obese females there was lower status attainment and higher rates of depression when compared to normal weight counterparts. In the case of obese adolescent males negative psychosocial outcomes were not found in early adulthood. Likewise no significant differences for psychosocial outcomes between races were found by this study.

It has also been reported that overweight adolescents tend to engage in harmful health behaviors to either lose weight or cope with stress. While the 2005 Youth Behavior Risk Survey (YRBS) reported that only 1% of adolescents engage in unhealthy dietary practices (ie, food restricting, purging, using laxatives/diuretics), it is important to note that these behaviors increase with age and are more common with overweight adolescents than normal weight adolescents.[28] Female adolescents may also be more vulnerable than males for such behaviors. In another study, researchers reported 18% of overweight females engaged in unhealthy dietary behaviors such as taking diet pills, laxatives/diuretics, and vomiting.[28] Smoking is another health behavior that is generally positively associated with depression. In a cross-sectional study with 2,051 adolescents, investigators found weight concerns and dieting were an important factor for girls, in the dyadic relationship between smoking and depression.[31] A positive association has also been demonstrated with obesity and several lifetime psychiatric disorders (ie, depression, social phobia), lifetime mood or anxiety disorder, and suicidal ideation and attempts.[32]

Bullying is another issue that faces obese and overweight adolescents. Data from a report using longitudinal data suggested that weight status and bullying were generally predictive of one another.[10] In other studies, it has been noted that weight-based teasing is negatively associated with outcomes such as usage of unhealthy weight control methods, decreased body satisfaction and self-concept, and depressive symptoms.[10] In turn, higher body dissatisfaction has also been noted to be associated with higher depression and anxiety scores.

Preventative and management strategies

Schools are the most common setting for preventative interventions for reducing adolescent obesity. Sharma[33] published a review of preventative interventions for obesity undertaken in schools among children and adolescents in 2006. These interventions were conducted with general population and not just overweight or obese individuals and were thus preventative in nature. The review identified 11 such interventions published between the years 1999 and 2004. Most of these preventative interventions targeted both physical activity and

nutrition behaviors. However there were some interventions that focused on only one dimension such as restricting drinking of carbonated drinks or television watching or increasing physical education time in the school. The majority of the interventions were based on some behavioral theory and the most popular theory was social cognitive theory. However, very few interventions measured and documented changes in behavioral constructs of the theory they used. The majority of the interventions were longer than six months while brief interventions were also utilized. Some interventions used out of school activities and involvement of parents. Both these approaches were found to be beneficial. The majority of the interventions focused on individual level behavior change approaches and few addressed broader policy and environmental level changes. The majority of the interventions utilized existing teachers for implementation of the interventions. Only a few interventions documented the degree of fidelity in implementation of the planned interventions. On the whole the review showed that the interventions resulted in modest changes in behaviors and had mixed results with indicators of obesity such as BMI, triceps skinfold thickness and waist circumference.

In another metaanalysis[34] that included 57 randomized controlled trials (RCTs) of physical activity and nutrition interventions between 1985 and 2003 it was found that these interventions had modest or mixed impact. From the 57 RCTs only four studies showed significant outcomes in the areas of: increasing physical activity, decreasing physical inactivity, and improving nutrition. The interventions from all four studies with significant outcomes were either implicitly or explicitly based on social cognitive theory. For interventions without significant outcomes, limitations pertained to their methodology, program design, implementation, and evaluation. Methodological limitations were: inadequate sample size, and evaluation staff not being blinded to outcome assessments creating the potential for bias. Limitations in program design and implementation were: lack of monitoring of program integrity, theoretical basis not being described or used to explain results, and the training program for implementation personnel not being described. Limitations for the evaluation of interventions were: inadequate sub-analyses, unclear relationship of dose effect for programming, and inappropriate data analyses.

Since the publication of these review articles other primary preventative interventions have also been published. These are summarized in Table 1.

From these interventions it is clear that some of the new theories that are being used are; the theory of reasoned action, the theory of planned behavior, intervention mapping, and social marketing theory. While a majority of the interventions have used standard curricular approach some of the new approaches that some of the interventions have used are influencing policy, including garden based activities, and providing students with free fruits and vegetables. Experimental and quasi experimental designs have been used in evaluation of these interventions. Most of the interventions have focused on influencing physical activity and nutrition behaviors. While a number of interventions have been greater than six months in duration some of the interventions have been brief and even been successful. Process evaluations have been done by some but not all interventions.

With regard to management strategies for combating overweight and obesity in adolescents also number of interventions have been developed. These interventions are different from preventive interventions as these are directed toward overweight and obese adolescents with an intention to reduce weight. As mentioned earlier there are four major modalities for management of overweight and obesity in adolescents: dietary management, increasing physical activity, pharmacological therapy, and bariatric surgery Kelly and Melnyk[44] conducted a systematic review of interventions for managing adolescent obesity conducted between 1980 and December 2007. They identified 17 RCTs that had been undertaken during this period. They found that about half of these interventions had physical activity as a component of the intervention. Most of the interventions required participants to meet on a weekly basis. Thirteen interventions had a parental component. The majority of the interventions used weight as BMI or BMI percentile as the outcome indicator while some studies used weight, relative weight, percentage overweight or percentage body fat. Some of the limitations of the studies were; not including outcome measures for all program components, lack of an equivalent comparison group in nine studies, small sample sizes (eight studies had sample size less than 50), high attrition rates (>20% in seven studies), use of convenience sampling which limited generalizability, and lack of theoretical framework in majority of the studies.

Since the publication of this review article other interventions for management of overweight and obesity in adolescents have also been published. These are summarized in Table 2. It is evident from Table 2 that a majority of the interventions have not used any behavioral theory to guide the behavior change necessary in such interventions. They have also not tracked the behavioral theory based constructs from before to after the intervention. Of the six interventions, two have been in schools, two in hospitals, and one each in

Table 1 Summary of recent preventative interventions in adolescents to combat obesity

	Study/Grade/Age/Year of publication	Theory	Design and sample	Intervention	Duration	Salient findings
1.	*Fit for Life*[35] K–8th grade 5–14 year olds 2007	No known theory	Quasi-experimental n = 4, 241 ± 200	5 components: (1) school-based education with American Heart Association's Heart power kits; (2) virtual reality wellness club that used booklets to track physical activity and nutrition choices; (3) point source program for county residents to make healthy food choices at restaurants; (4) occupational health initiative for parents and grandparents that included fairs and screenings; (5) community activity that included working with health agencies	4 years	No significant change in overweight or obesity rates Changes in behaviors and their antecedents not studied
2.	*Policy-based School Intervention*[36] 4th–6th grade Mean age 11.3 years 2008	Social marketing and other theories	Experimental with random assignment at group level (n = 1,349)	Five components: (1) self-assessment by using CDC School Health Index; (2) 50 hours of nutrition education per student per school year using *Planet Health* and *Know your Body* curricula; (3) nutrition policy for foods sold; (4) social marketing of healthy food products; (5) family outreach through home and school association meetings, report card nights, parent education, and weekly nutrition workshops.	2 years	50% reduction in the incidence of overweight After 2 years only 7.5% children in the intervention group were overweight as compared to 14.9% in the control group and this difference was statistically significant
3.	*Nutrition in the Garden*[37] 6th grade 10–13 year olds 2007	No known theory	Quasi-experimental (n = 99 for three groups)	Food recall workbooks were used that included age appropriate instructions and portion size illustrations 12 week nutrition education curriculum that combined nutrition with horticulture Hands-on garden-based activities that included maintaining a garden	12 weeks	Students in garden-based nutrition group increased their fruit and vegetable consumption ($P < 0.001$) than other two groups Significant increase in vitamin A, C, and fiber ($P < 0.05$)
4.	*Dutch Obesity Intervention in Teenagers*[38] 6th grade 12–14 year olds 2009	Intervention Mapping	Experimental with random assignment at school level (n = 632 in 10 intervention schools; 476 in 8 control schools)	Individual component consisting of 11 lessons in courses of biology and physical education Environmental component consisting of asking schools to offer additional physical education classes and changes in school cafeteria	20 months	At 20 months biceps skinfold thickness among girls decreased (0.07 mm; 95% CI: 1.3, 0.04 mm) At 20 months sum of 4 skinfolds among girls was lower (2.0; 95% CI: 3.9, 0.1 mm) At 20 months skinfold thickness of triceps (0.7 mm; 95% CI: 1.2, 0.1 mm), biceps (0.4 mm; 95% CI: 0.8, 0.1 mm) and subscapular (0.5 mm; 95% CI: 1.0, 0.1 mm) decreased for boys

5.	*School–based Obesity Prevention Program*[39] 6th–8th grade 12–15 year olds 2008	No known theory	Only formative evaluation done (n = 78)	16 sessions during physical education classes Topics for discussion included reviewing food labels, portion size, food pyramid, and healthy food decision making. Each session also included 20–30 min of physical activity that comprised of moving and games	16 classroom sessions	Formative evaluation revealed that small group settings was successful Lack of parental involvement was a limitation
6.	*Choice, Control, and Change*[40] 7th grade 11–13 year olds 2007	Theory of planned behavior	Pre-test post-test design (n = 278)	24 lessons taught by science teachers over a period of 7–8 weeks Curriculum met some national science standards in biology and science 5 units: getting right amount of energy, making healthy food and activity choices, importance of healthy food and activity choices, impact of environment, and skills of a competent mover and eater	8 weeks	Significant decrease in sedentary activities Significant increase in frequency of fruit and vegetable intake Decrease in frequency of sweetened beverages, packaged snacks, eating at fast food restaurants and ate and drank smaller portions
7.	*Present and Prevent*[41] Middle school Mean age 14.5 years 2008	Evaluation based on theory of reasoned action	Experimental with random assignment at group level (n = 880; 551 in experimental and 329 in delayed treatment group)	A commercially available Power Point program consisting of two 30 min slides Topics included: health problems associated with obesity, causes of obesity, importance of preventing obesity, body image, benefits of healthy weight, healthful food choices, reading food labels, portion control, changing unhealthy habits, how to increase physical activity, and overcoming barriers	1 week	Significant improvement in knowledge scores between pretest and post-test for experimental group ($P < 0.01$) No effect on attitudes Significant improvement in friends subjective norm between pretest and post-test for experimental group ($P < 0.01$) Significant improvements in behavioral intention for eating fried foods, sweets, looking at food labels, and limiting TV watching between pretest and post-test for experimental group ($P < 0.01$)
8.	*Michigan Model (MM) Nutrition Curriculum*[42] Middle school Mean age 12.5 years 2008	No known theory	Quasi-experimental (n = 576; experimental = 407; control = 169)	8 lessons: (1) five food groups; (2) health benefits of each food group; (3) selling points for each food group; (4) food labels; (5) advertising claims; (6) healthy body image; (7) surviving fast food; (8) nutrition at school	1 month	Significant increase in nutrition knowledge at post test for intervention group Significant improvement in eating behaviors and efficacy expectations for intervention group Intervention group was more likely to eat fruits and vegetables
9.	*USDA Fresh Fruit and Vegetable Program (FFVP)*[43] 4th–9th grade 9–14 year olds 2008	No known theory	Quasi-experimental (n = 1,127; 784 in intervention; 343 in control)	Provision of free fresh fruit or vegetable daily	2 academic years	Intervention students when compared to control were more willing to try fruits (24.8% vs 12.8%, $P < 0.01$) and vegetables (25.1% vs 18.4%, $P = 0.01$) at school

Abbreviations: n, number; CI, confidence interval; CDC, Disease control and prevention; K, kindergarten.

Table 2 Summary of recent interventions to reduce weight in overweight and obese adolescents

	Study/Age/Setting/Year of publication	Theory	Design and sample	Intervention	Duration	Salient findings
1.	*Sensible treatment of obesity in rural youth (STORY)*[45,46] 8–14 years Cooperative Extension Service Office 2008	No known theory	Three arm randomized controlled trial: (1) behavioral family-based, (2) behavioral parent-only, (3) wait-list control group (n = 93)	Delivered by Family and Consumer Sciences agent, postdoctoral psychologist, and graduate students in psychology For both intervention conditions weekly 90 min. sessions × 8 weeks then biweekly × 8 weeks Modified version of Stoplight Diet Setting dietary goals by families Increased physical activity gauged by pedometers and goal setting	10 months	At 4 months children in parent-only group had a significant decrease in BMI as compared to control (MD 0.127, 95% CI: 0.027, 0.226) while there no difference in family-based group with control At 10 months both parent-only (MD 0.115; 95% CI: 0.003, 0.220) and family-based groups (MD 0.136; 95% CI 0.018, 0.254) had decreases in BMI compared to control
2.	*Weight-loss E-learning Program*[47] 12–14 years School 2008	Positive reinforcement	Pre-test post-test (n = 37)	Two domains: information domain and interactive domain Information domain had five components: general, nutrition, exercise, pharmacy, and other Interactive domain used an active server page Regular 45 min classes, exercise twice a week for 40 min. and individual counseling sessions 20–30 min twice/thrice a semester	14 weeks	Significant decrease in BMI ($P < 0.05$), waist circumference ($P < 0.05$), and triceps skinfold thickness ($P < 0.001$) Improvements in three physical fitness tests Improvements in weight loss knowledge scores, body image scores, self-esteem scores, and weight loss self-efficacy scores
3.	*Swiss inpatient program*[48] 12–15 years Hospital 2008	No known theory	Pre-test post-test (n = 130)	Nutritional: Nutritionist performed a qualitative and quantitative analysis of child's food intake; children received balanced low calorie diet Physical activity: 60–90 minute session supervised by exercise therapists Behavior modification: Modify eating and exercise behaviors	8 weeks	Significant decreases in BMI, weight, body fat, % body fat, fat free mass
4.	*Telemedicine support program*[49] Mean age 13.7 years Hospital followed by telemedicine 2008	No known theory	Pre-test post-test (n = 140)	Phase I: 4–6 week hospitalization and given a STTP Phase II: Telemedicine program by Internet and mobile phone. Participants filled information about weight etc and physician gave feedback	12 months	In phase I the body weight decreased from 82.4 kg to 76.0 kg ($P < 0.001$) The acceptance of phase II telemedicine program was 93% at 6 months and 46% at 12 months BMI at admission was 30.5 kg/m^2 and at 12 months was 27.7 kg/m^2 ($P < 0.05$)

5.	*Exercise training program*[50] 13–14 years School 2008	No known theory	Randomized controlled trial with two groups: exercise (n = 12) and control (n = 12)	Both groups participated in 2 sessions of 40 minute physical education per session per week The exercise group participated in additional 2 sessions per week of 45–60 minutes per session of exercise training for 12 weeks	12 weeks	Significant improvements occurred in exercise group for body mass index, lean muscle mass, fitness, and other indicators Body weight increased in the control group
6.	*Intervention in overweight Latino adolescents*[51] Mean age 15.5 years Lifestyle lab. 2009	No known theory	Randomized control trial with three groups: nutrition, nutrition plus strength training, and control (n = 54)	Nutrition only: 1 nutrition class per week × 16 weeks; goals to decrease added sugar consumption and increase fiber Nutrition plus strength training: Added strength training twice per week × 16 weeks Outpatient visit in which measures were taken 7–14 days later inpatient admission	16 weeks	There were no significant differences in sugar or fiber intake across the three intervention groups From the total 55% reduced sugar intake and 59% increased fiber intake

Abbreviations: n, number; CI, confidence interval; BMI, body mass index; STTP, structured treatment and teaching program; MD, mean difference.

extension office and lifestyle laboratory. In terms of design three have been randomized controlled trials and three have used less robust pre-test post-test designs. The sample size has generally been small (n = 24–140). Most of the interventions have focused on nutrition and exercise as chosen strategies for reducing weight while one has focused on only exercise. The duration of the interventions has ranged from 8 weeks to 12 months. Both short and long term interventions have demonstrated reduction in weight. Five of the six interventions have shown positive results in terms of weight reduction.

Conclusions

All over the world the rates of overweight and obesity in adolescents are increasing. In the United States 17.6% adolescents are obese and 34.1% are overweight. The primary cause of overweight in adolescence is due to an imbalance of energy status whereby more calories are consumed than expended. Factors that contribute to this imbalance are genetics, dietary habits, sedentary lifestyle, greater screen time (television watching, computer usage, video games), media messaging and advertisements about food, sleeping patterns, breakfast skipping, consumption of high energy snack foods, consumption of high fatty foods, low consumption of fruits and vegetables, and consumption of added sugars especially those found in soft drinks. There are several long term psychosocial effects of adolescent overweight and obesity such as becoming more socially isolated, having fewer friends, having higher expressive anger, having lower status attainment in adulthood, having higher rates of depression, engaging in harmful behaviors, and having higher rates of psychiatric diagnoses.

As adolescent obesity and overweight continue to increase, the need for novel approaches for prevention and management are greatly needed. From this report, it appears that while not all studies have utilized theory-based approaches, the trend toward using theory is growing especially in those directed toward prevention. Interventions directed toward managing obesity need to do a better job in utilizing behavioral theories. Some of the new theories that are being used are; the theory of reasoned action, the theory of planned behavior, intervention mapping, and social marketing theory. In the past social cognitive theory was more popular.[30] Growing use of newer behavioral theories will improve the quality of interventions. It is less likely that brief interventions will impact weight status; however, these interventions do have the potential to influence important mediating variables that drive behavior change. Given that theory-driven approaches are important

and needed, evaluations should focus on measuring changes in the constructs of behavioral theories that mediate behavior change. Schools were also found to be the most common place for intervention by both types of interventions (prevention and management). This appears appropriate, since virtually all children attend some form or private or public school.

There are also limitations to these interventions. Not all studies employed the use of a process evaluation, to measure program fidelity. This is especially important in larger studies that implement programming across different schools, using different teachers or implementers. Policy and environment changes are also still uncommon in these interventions. It is unclear why this does not occur. Future studies that attempt such changes are recommended to document key challenges and barriers they are faced with, and what actions they took or foresee taking to overcome such barriers. Lack of an appropriate control group was also noted, however, this may be difficult to overcome since it is conceivable that it would be difficult to find schools willing to participate in studies as control schools, or schools that receive no intervention.

Disclosures

The authors report no conflicts of interest in this work.

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