

Four Generations of Intervention Types to Mitigate Pediatric Obesity: Where Do We Go from Here?

Moria Golan*

Department of Nutrition, Tel-Hai College, Upper Galilee and The Hebrew University of Jerusalem. Shahaf, Community Services for Eating Disorders, Israel

***Corresponding Author:** Moria Golan, Department of Nutrition, Tel-Hai College, Upper Galilee.

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Abstract

Background: The management of pediatric obesity is a main concern in public health.

Objective: Using a review-of-reviews approach, the intervention types are categorized into three generations. Directions are suggested for the next generation of strategies.

Results: The first generation of interventions took a weight-reduction approach via restricted food intake and increased physical activity, usually with suitable psychoeducation. The second generation shifted to a healthy-lifestyle approach, with school-based prevention programs and interventions involving parents and children as agents of change to reduce obesogenic factors. The third generation employed a combination of anti-obesogenic environment policy and parent-only intervention in young children, while later targeting adolescent or adolescent-and-parent interventions. Web-based programs, mobile phone applications, smart games and the like were used to promote healthy lifestyle. Surgeries became safer and were used for adolescents with morbid obesity. Pharmacotherapeutic strategies were not extensively disseminated due to small effect size in the long term and a high rate of side effects.

Conclusion: As we enter the fourth generation, I suggest, in addition to all that is already being done, to focus on enhancing emotion regulation as well as effortful control in the treatment and prevention of pediatric obesity. This direction is explored.

Keywords: *Pediatric Obesity; Treatment; Prevention*

Background

Reducing the incidence and prevalence of pediatric obesity is one of the biggest challenges of pediatric health in the western world [1,2]. Multilevel approaches involving environmental strategies have been employed to achieve control of weight gain and reduction in body mass index (BMI), toward preventing the long-term complications of obesity in childhood and adulthood. In a recent review, Altman and Wilfley [3] concluded that all efficacious treatments consist of multicomponent interventions that include dietary and physical-activity modifications and utilize behavioral strategies. Treatment is optimized if family members are specifically targeted. Research supports the use of multicomponent lifestyle interventions, with family-based treatment and parent-only behavioral treatment being the most widely supported treatment types [3].

Nevertheless, obesity is a lifelong battle for many individuals, and therefore different population groups need different solutions. Some will benefit from prevention programs, some will need episodic treatment and some will need a life-long support group. A stepped care model is frequently offered in parallel to a multicomponent approach, but adherence and motivation issues are well-known barriers [4]. Although epidemiological evidence calls for prevention strategies targeting multiple risk factors continuously from birth to adulthood [5,6], most of the effective interventions are designed for older children [7]. Furthermore, multiple studies have shown “scarring” of specific hypothalamic nuclei involved in energy balance and the reason for the tendency of obesity to persist into adulthood [8]. This calls for interventions, which start as early as possible and provide age-appropriate continuous solutions.

Using a review-of-reviews approach, a search was performed in Medline, PsychINFO, Scopus, Embase, Web of Sciences, ERIC and the Cochrane Library for the terms childhood or pediatric obesity and treatment or intervention or prevention programs, during September 2016.

Three generations of intervention types that have been employed in the past, and until today, in the management of pediatric obesity are categorized. Pharmacotherapy and bariatric approaches will not be discussed here, as they are not part of the conservative/usual treatment. A fourth type of intervention is suggested for the next generation addressing this issue.

The first generation of interventions: Weight-reduction orientation

Dieting or other weight-reduction approaches were the state of the art in practices to mitigate obesity from the 1960s to 1980s [9]; they are still common today. Dieting is defined as an intentional effort to create a negative energy balance to lose weight, at least in part through the restriction of energy [10]. In most cases, dieting involves an energy-restricted balanced diet, in association with patient or parent education, behavioral modification, increased physical activity, and reduction in sedentary behaviors that can limit weight gain in many pediatric patients who have mild or moderate obesity. Reductions in total and saturated fat were particularly recommended to adolescents who consumed large quantities of high fat, snacks, and packaged fast foods (french fries, pizza, chips, etc.). Studies in adult subjects demonstrated that lower fat intake is associated with relatively lower body weight, BMI and waist circumference. While similar findings were not confirmed in children, a meta-analysis of available pediatric studies suggested a direct relationship between fat intake and weight gain [11]. Clark [12] examined the responses to treatment methods in 32 reports studying 120 distinct treatment groups. The author concluded that the use of physical activity and exercise (endurance or resistance) is more effective than dieting alone. Structured exercises were shown to be more effective than a general physical activity program. Children and adolescents who are overweight should be encouraged to engage in organized bouts of physical activity to establish a chronic stimulus for a physiological response to the exercise stimulus, rather than relying solely on the establishment of an acute caloric deficit. In the mid-1990s, family-based interventions, rooted in behavior theory and family-system theory, were employed in the management of childhood obesity [10,13]. These combined approaches were aimed at improving children’s health behaviors by improving family interactions and modeling. Family-based interventions included the direct involvement of the target children and one or more family members in the treatment intervention. Typically, a parent, most commonly the mother, participated in the intervention with the target child. The most successful family-based obesity treatment interventions were conducted by Epstein and his colleagues in a clinical setting, using the Stoplight Diet [14].

Kalarchian, *et al.* [15] found family-based behavioral weight control to be effective for severely obese children only in the short term. In a randomized controlled trial with 192 children aged 8 - 12 years whose average BMI percentile for age and sex was 99.18, intervention was associated with significant decreases in percent overweight of children after 6 months (7.58% decrease in percent overweight) compared with the usual care, but differences were not significant at 12 or 18 months. Small but significant improvements in medical outcomes were observed at 6 and 12 months. Children who attended 75% or more of the intervention sessions maintained decreases in percent overweight through 18 months. The clinical significance of such intervention is controversial. Children and families received

psychoeducation as well as tools. However, 7% decrease in percent overweight is clinically significant only if it expresses an overall change in family and individual lifestyle. The long-term results do not provide such evidence.

In their systematic review, Whitlock., *et al.* [16] reported that comprehensive medium- to high-intensity behavioral interventions were the most effective behavioral approach with a 1.9 to 3.3 kg/m² difference favoring intervention groups at 12 months. More limited evidence suggested that these improvements can be maintained for 12 months after the end of treatment and that there is little harm with behavioral interventions. The authors concluded that over the last several years, research on weight management in obese children and adolescents has improved in quality and quantity. Despite important gaps, available research supports at least short-term benefits of comprehensive medium- to high-intensity behavioral interventions in obese children and adolescents. Acknowledging the well-known deterioration in healthy lifestyle consistency and the preference of hedonic eating rather than homeostatic eating patterns, it is not surprising that the clinical significance of such efforts is minimal and thus the pediatric obesity prevalence is not deteriorating.

As adolescents become more autonomous and less motivated by parental influence, family-based treatments may be less appropriate. Thus, weight-reduction programs targeting the individual's behavior are employed. Adolescents with severe obesity, although having health-related impairments in quality of life and barely experiencing any significant reduction in BMI, demonstrated improvements in cardiometabolic, psychological and health-behavior outcomes [17].

In general, highly controlled energy diets are hampered by high dropout rates, losses in lean weight and sometimes, regaining of weight as well as excess weight deposited as a higher percentage of body fat. Significant weight loss produces changes in metabolism and food consumption that hasten the regaining of lost weight, but a history of weight loss diets does not cause weight gain beyond that which would occur in the absence of dieting [10]. Weight loss appears to induce compensatory regulatory responses in the realm of metabolism [18]. More importantly, the long-term effects of highly controlled energy diets on adolescent growth and development and subsequent reproductive function, musculoskeletal development, and intermediary metabolism remain poorly understood. Because of these uncertainties and the difficulties inherent in maintaining caloric restriction, controlled-energy diets cannot be recommended for most children and adolescents with obesity [19].

The second generation of interventions: Healthy lifestyle orientation

The second generation of interventions shifted from the dieting approach to a healthy-lifestyle orientation. This orientation, rooted in the early 1990s, focused on the development of interventions and policies that would reduce the obesogenic load in the individual's ecological niche. Comprehensive behavioral interventions, including changes in diet, physical activity and lifestyles of individual patients or families were commonly used, and generally considered primary modes of treatment [20,21]. Epstein., *et al.* [22] suggested that the family-based interventions (based on a family systems approach) focus on healthy food choices within an energy-restricted diet as a useful family-based weight-control program. In their study, 14 children aged 8 - 12 years at > 85th BMI percentile were randomly assigned to a 24-month family-based behavioral treatment that targeted increased fruit and vegetables and low-fat dairy, as compared to a group with reduced intake of high-energy-dense foods. Children in the increased healthy food group showed a greater reduction in BMI z-score (zBMI) than children in the reduced high-energy-dense food group at 12-month (-0.30 zBMI units vs. -0.15 zBMI units, P = 0.01) and 24-month (-0.36 zBMI units vs. -0.13 zBMI units, P = 0.04) follow-ups. Children in the reduced high-energy-dense food group showed larger sustained reductions in high-energy-dense foods (P < 0.05). Although statistically significant differences between groups a reduction of less than half zBMI is not clinically significant, if it does not accompany with a long-lasting change in eating habits). It is acceptable, that even a stable weight in a growing child with obesity is considered an improvement improvement, as long as there is improvement in health status and it is a long lasting change due to major life style improvement – such evidences are not provided herby. In concordance, two meta-analyses summarizing the findings of > 60 randomized controlled trials with > 5,500 children reported that combined

behavioral lifestyle interventions are more effective in reducing obesity in children than standard care or self-help at 6 months and 12 months after onset of the intervention [23,24]. Nevertheless, both acknowledge the high probability of reporting bias as well as limited methodological features that protect their results from bias, thus overestimate the treatment effect and can only yield weak inferences. A repeated weakness of the reported trials is their limited duration, hence do not provide evidence for long-term outcome.

Berge and Everts [25] published a meta-analysis of 20 studies performed between 2000 and 2009. They reported that most of the studies had a moderate to large effect size for change in the target child's BMI (BMI percentile, zBMI, percent overweight) after participating in a family-based intervention. Long-term change varied by study, but most studies produced a sustainable change in the child's BMI, albeit with smaller effect sizes. Reinehr [26] reviewed all randomized controlled trials and meta-analyses dealing with lifestyle interventions in children with overweight or obesity, as well as studies with > 200 obese children and/or a follow-up period of > 5 years between 1990 and April 2013. Results showed that the only proven effective diet advice was a reduction in the intake of sugar-sweetened drinks. Increased physical activity, although not associated with weight loss, has many benefits for cardiovascular health, while decreasing sedentary behavior reduces BMI, particularly in preschool children, and children with overweight rather than obesity. The author stated that the lack of effectiveness of lifestyle interventions in childhood obesity is because most children with overweight or obesity and their families do not want to participate in lifestyle interventions and due to the high dropout rate in such programs [27].

In clinical practice, the degree of weight loss with lifestyle intervention was only moderate-reducing mean BMI by -1 to -2 kg/m², and the long-term success rate (a decrease in BMI SD score of < 0.25) at 2 years was < 10% [26].

Peirson, *et al.* [28] performed a meta-analysis assessing 31 randomized trial studies of primary care-relevant behavioral (diet, exercise, lifestyle) and pharmacological (orlistat) interventions for treating overweight and obesity in children and youth aged 2–18 years. Both behavioral and pharmacological interventions showed a significant effect on BMI or zBMI in favor of treatment (behavioral: standardized mean difference [SMD] -0.54, 95% confidence interval [CI] 0.73 to 0.36; orlistat plus behavioral: SMD -0.43, 95% CI 0.60 to 0.25). Studies reported no significant difference between groups in the likelihood of reduced prevalence of overweight or overweight and obesity. The authors concluded that low- to moderate-quality evidence suggests that behavioral treatments are associated with an intermediate effect in terms of reduced BMI or zBMI compared to the small effect shown by combined pharmacological and behavioral interventions. To conclude, although the three intervention components of diet, physical activity, and behavioral change were delivered in a way that challenges and empowers parents' practices, reviews showed moderate to large effect sizes for effectiveness of family-based interventions to enhance healthy lifestyle in reducing child weight. Nevertheless, the long-term maintenance of the achievements remains unclear as well as the issue of low attendance rates. Thus, these approaches are not enough in addressing the epidemic of childhood obesity.

The third generation of interventions: Anti-obesogenic environmental policies and Parenting practices

Following a dramatic increase in the prevalence of obesity in the late 1990s and beginning of the new millennium, an understanding emerged of the need to employ a combination of anti-obesogenic environmental policies. The first step involved public health effort to restrict the adverse marketing of sugary product to children as well as taxing some of the obesogenic food products. This policy have to be expanded and strengthened to protect older children from increasingly sophisticated marketing of sedentary activities and energy-dense, nutrient-poor foods and beverages [29]. To meet this challenge, the governance of food supply and food markets should be improved and commercial activities subordinated to protect and promote children's health.

To further combat the obesogenic environment at home, focus was oriented toward educating parents as the main agents of change to improve their skills, practices and family functioning in order to be able to promote healthy lifestyle. However, the next advance in the field was the suggestion to omit the children from the intervention.

As the pioneer developer and author of this approach, I suggested omitting the child from the direct intervention to overcome the child's resistance to change, as well as to avoid positioning him or her in the identified patient role [30]. This approach was further supported by Sung-Chan., *et al.* [31], who reviewed 15 randomized controlled trials and reported that behavioral approaches to family-based healthy-lifestyle intervention consistently achieved better outcomes than the other three types (behavioral approach plus parent education, family therapy, and family therapy plus family-based psychoeducation). Although many programs today employ parents-only intervention, it more often serves as a preferred setting for discussing nutritional issues, rather than as an opportunity to focus on parenting skills and enhance parents' practices in endorsing anti-obesogenic environment and healthy lifestyle—a huge challenge in western society. Nevertheless, some programs that focused on parenting practices [32] reported changes in zBMI scores from baseline (-0.23, 95% CI: -0.42 to -0.03, $P = 0.027$) at the 2-year follow-up and 42% of the children had a clinically significant reduction in zBMI. Significant improvements were seen in children's quality of life and eating habits in the home, while there were sustained reductions in unhealthy foods and sedentary behavior. Fruit and vegetable consumption and parent's mental health were not significantly different at the 2-year follow-up. Costs of the program were much less than that of programs targeting the child and parent in the intervention. Recently, Loveman., *et al.* [33] reviewed 20 randomized controlled trials, including 3,057 participants in a parent-only intervention, for childhood overweight or obesity in children aged 5 to 11 years. Results suggested that overall, in trials comparing parent-only interventions with parent-child interventions, there were no substantial differences in BMI measures at either the post-intervention follow-up or the longest follow-up period. The parent-only interventions were found to be better at improving children's weight than the waiting list controls. West., *et al.* [34] reported data from the Parenting Scale, which is a validated measure of parental discipline. Parenting Scale scores were 2.7 (SD 0.7) in the parent-only group and 3.4 (SD 0.5) in the waiting list control group ($P < 0.0125$) in favor of the parent-only intervention. In looking at the longest follow-up periods of the included trials, Loveman., *et al.* [33] did not find firm evidence of an advantage or disadvantage of parent-only interventions when compared with either parent and child interventions. However, the quality of the evidence was low, mainly because there were only a few trials per measurement or the number of included children was small. Most studies did not find or report changes in parenting skills, family functioning or parent-child relationships, although there were the foci of these types of programs; there were neither measured nor reported adverse emotional effects when programs targeted the child directly. Thus, this type of intervention merely assessed the main targeted areas beyond weight status. Moreover, all those that work in the field of recruiting parents for interventions report on huge difficulties to achieve consistence attendance at sessions, a major mediator of the outcome in such programs [26].

Current challenges in the management of childhood obesity

A few challenges emerge from this review. From a clinical perspective, many interventions have achieved meaningful reductions in child's obesogenic status and behavior at list statistically. Nevertheless, its long-term clinical impact is questionable. Moreover, within the individual trials, there is considerable heterogeneity in terms of duration of the interventions and their respective follow-ups, and in targeting specific parenting practices and assessing them. To date, studies have not adequately addressed how or which family components (family dynamics, family functioning, communication style, restricting habits, lack of boundaries, etc.) can potentially mediate treatment effects, and what the focus of the intervention content should be with respect to parenting practices. Moreover, most of these studies have not assessed or reported the emotional effects of targeting children and parents compared to the parents-only approach. Some of these programs target only the parents with healthy-lifestyle objectives but still approach the overweight child directly by offering physical activity classes in parallel which, in my view, misses the idea of omitting the child from the healthy-lifestyle intervention, as the child is still targeted with the 'tune' of weight reduction [35]. Thus, it is difficult to establish whether any particular intervention type is more likely to lead to effective and successful outcomes and less adverse effects.

Furthermore, randomized controlled trials, which are often conducted with highly select populations in academic settings, have focused on time- and resource-intensive models, approaches that are often difficult to implement and sustain, particularly in primary care. Moreover, there is a gap between the science-based programs for the management of childhood obesity and those that are provided by

practitioners to families and children in public clinics [36]. Consequently, conclusions on effectiveness cannot necessarily be generalized to all groups in the population.

In accordance with known biological adaptations to weight loss, introducing time-limited weight-management interventions and still identifying ways of maintaining intervention results over the long term is a challenge [28]. Program facilitators have reported that recruitment and retention of families in programs is a barrier for long-term intervention and change. Maximova, *et al.* [37] reported that two-thirds of parents were in lower stages of engagement in making healthy changes to their lifestyle habits, changes that could potentially serve to model and reinforce healthy habits for children. Given the high degree to which parents are included in their children's care, this low level of engagement may be contributing to program attrition. Skelton and Beech [38] suggested that there is some evidence that treatment is not meeting families' expectations (content of the program, help with insurance coverage or cost and engaging the child) or schedule (schedule of clinic visits, missed school and work). Rather than blame the program or the families, efforts should evaluate the interface between the two to determine why a program successfully reaches one family whereas others do not return, even for a second visit. Behavioral therapies that overcome barriers of time and schedule, such as home visits or internet-based video meetings, may provide a new arena for treatment. Customized and tailored approaches may not only prove successful with those at high risk of dropout, but could improve overall treatment outcomes. In addition, the staff might benefit from ongoing supervision and advanced skills in motivational interviewing, steps that are currently employed only in a few trials [39].

From a research perspective, the evidence supporting the clinical superiority of one particular approach is currently limited due to low trial quality. Some of the trials have had a high risk of bias since they assess individual studies rather than assess precisions, directness and applicability. Moreover, many suffer from loss of follow-up. Furthermore, the heterogeneous interventions and comparators, and the high rates of non-completion and lack of evidence for several important outcomes, such as change in parenting practices, are a problem.

Future studies are expected to improve the robustness of the analyses by type of comparator, large sample size that permits subgroup analysis by intervention component and the setting. Trial reports should provide adequate details about the interventions so that they can be replicated by others, mainly differentiating between program content and program setting, which often overlap.

Emotion regulation, resilience and self-control: suggested foci for the fourth generation of interventions

Today, emotion regulation, resilience and self-control are leading areas of research in psychology [40,41]. Stress combined with ineffective emotion regulation leads to increased adiposity via abnormal cortisol patterns, emotional eating, sedentary lifestyle, reduced physical activity, and increased sleep problems [42]. Eating and binge-eating may serve as ways to escape painful feelings or avoid feeling at all. Dieting and restrictions may serve to induce numbness, suppressing difficult memories and decisions before they even surface into consciousness. All of these behaviors serve to unhealthfully suppress the proper recognition, regulation and expression of emotional states.

In contrast, effective regulation of emotions decreases unhealthy obesity-related behavior and enhances protective psychological factors such as self-esteem and self-efficacy, which boost health [43]. Shonkoff and Phillips [44] define self-regulation as a child's ability to gain control of bodily functions, manage powerful emotions, and maintain focus and attention. The growth of self-regulation is a cornerstone of early childhood development and is visible in all areas of behavior. When caring for an infant or toddler, parents and caregivers act as extensions of or supports for the child's internal regulation ability. Later on, teachers and other authority figures can induce the attainment and practice of self-regulation strategies by providing developmentally appropriate environments, demands, regularity, novelty, and interactions [43]. Tan and Holub [45] reported that children who self-regulate while eating and children who show high global self-regulation abilities, such as inhibitory control, are less likely to be overweight than children who do not show the same capacities

for self-regulation. Self-regulation in eating and inhibitory control were positively correlated: $r = 0.54$. Self-regulation in eating predicted parents' use of restrictive feeding practices above and beyond, children's inhibitory control and parents' concerns about their children's weight ($P < 0.01$). Thus, parents are advised to use less restrictive feeding practices, because restriction can compromise self-regulatory abilities. In contrast to this view, Lowe [9] suggested that exaggerated claims about the dangers of dieting (or more generally, restricting food intake) work against the goal of creating unwarranted fears of abstention and temperance in eating habits. The contradiction between these two approaches may be addressed by advances in the content of preventive and therapeutic programs focusing on the development of self-regulation and inhibitory control so that individuals can resist and counteract the influences of western society's stressors as well as its temptations. Such programs may also address the need of links over time in age-appropriate interventions, which continue in spiral mode from age group to age group, differing in the way they are delivered and the game/activity design, while targeting the same outcome (improved self-regulation and self-control).

Accumulating evidence indicates an inverse relationship between BMI and neurocognitive performance, linking maladaptive eating behaviors with reduced cognitive functioning, particularly attention and executive function [46]. Compared with healthy-weight children, obese children showed greater difficulty with delayed gratification and inhibition of food incentives or cues only [47,48]. Moreover, compared with lean adolescents, obese adolescents were likely to have greater anticipation of food rewards (in the gustatory cortex and somatosensory brain regions) but experience less actual reward, possibly owing to decreased neural activation in the dorsal striatum (reward-processing brain region), thus increasing the likelihood of overeating and weight gain [49]. Executive-function deficits have often been proposed as underlying core deficits in impulse control [50]. Liang, *et al.*'s review [46] showed that in 22 out of 30 studies, evidence supported a relationship between obesity and deficits in the areas of executive functioning, 7 out of 10 studies showed deficits in attention, 2 out of 2 studies showed deficits in visuospatial skills, and 17 out of 20 studies showed deficits in motor skills.

Since the effort to curb and reverse obesity involves a battle between numerous obesogenic influences in the environment on one hand, and people's ability to resist and counteract these influences on the other, I suggest, in addition to all that is already being done, that prevention and intervention focus on enhanced self-regulation of emotion as well as effortful control. Neurocognitive deficits that impact obesity and obesity-related behaviors may be targeted in preventive and therapeutic programs. Some evidence suggests that executive-function training for obese children can improve working memory and inhibition and can help with maintenance of weight loss [51]. Since participation in exercise programs may improve neurocognitive functioning, increasing their availability through schools should be mandatory.

Future advances in this field should improve parents' skills in developing better emotion-regulation practices for their children as well as inhibitory control to address the overt responsiveness to rewards as well as other neurocognitive deficits. Novel mechanisms to improve children's emotion-regulation skills and inhibitory control such as using smart games and other new developments in science and technology should be encouraged. The flourishing of 'cognitive neuroscience' has led to new insights into the role of biology and the brain in play and toy preferences. Today, there are a variety of applications and technologies for improving executive function in children [52]. Digital games and gamification mechanics applied in leisure contexts can be used by parents and their child together and thus can bring high pay-offs. An online training can be implemented in a population-oriented prevention intervention and make a real change in the life of a large number of targeted population. Change may be achieved by promoting positive communication between parents and child, engaging parents in the enhancement of children's self-regulation as well as overall executive functioning, provide training in delay gratifications (for both parent and child) and improve their maladaptive behavior. Today the evidences for such programs are weak and their application in the field of childhood obesity is scarce and should be further developed and assessed.

Conclusions

To combat childhood obesity and change the individual energy balance in the context of unavoidable obesogenic environment, we need states, communities, schools, and parents help to make the healthy choice the easy choice for children, teens, and their families. At the same time, there is an urgent need for development of novel strategies that assist individuals to cope with the hedonic system, which overrides the homeostatic and other energy-balance protectors. Such intervention and strategies should be the focus of the coming efforts to address self-regulation and effortful-control issues. Age-appropriate tools should be employed in spiral modality, providing link over time and over various age-needs. The new emerging technology should provide platforms that enable parents to play with their kids and integrate quality time with self-regulation and self-control training.

Conflict of Interest Statement

No conflict of interest was declared.

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