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Guiding Family-Based Obesity Prevention Efforts in Low-Income Children in the United States. Part I: What Determinants Do We Target?

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Abstract

The current study aims to provide a descriptive summary of the current state of empirical evidence for behavioral determinants related to pediatric overweight in low-income children that can be influenced by families. Pubmed and PsychINFO databases were searched for the period of March 2003-April 2006. Data from trend, mechanistic, observational and prevention studies were extracted on participant age and income, and study design and findings. Conclusion statements were formulated with respect to strength of evidence supporting the association of each determinant with overweight. Evidence supported the addition of three new determinants to the existing list of nine: dietary energy density, sleep duration and parenting style. Sufficient evidence from the four types of studies was lacking for food variety, portion size and stress. Combined with other recent reviews, there is current evidence to support a total of 12 family-modified determinants of pediatric overweight. A relative lack of attention on low-income families and children was also noted. This review represents an integral first step in guiding future efforts toward identification of low-income children participating in USDA's food assistance and education programs who are at highest risk for becoming overweight.

Keywords: Obesity, diet, physical activity, sleep, parenting style, child.

Introduction

Pediatric overweight is one of the most pressing child health issues in the United States today, with children in the lowest income brackets at particular risk. The national prevalence of obesity (BMI > 95th percentile) in the last 20 to 30 years has doubled among 2- to 5-year olds and tripled among older children and adolescents (1). Over nine million children over the age of six years in the US are

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classified as severely overweight (BMI = 99th percentile). Approximately 60% of overweight children 5 to 10 years of age already have one cardiovascular disease risk factor, such as elevated blood pressure (2). Low-income populations are disproportionately affected (3, 4) due to risk factors such as limited resources and high food insecurity rates (5). Such trends are a particular concern given that overweight in childhood tends to track into adulthood socioeconomic status (6). Given the association between overweight status and SES (4), the prevalence of negative health outcomes is likely to disproportionately affect children in poverty, making identification and prevention efforts in low-income populations especially critical.

Despite these trends, few assessment tools have currently been developed to aid public health practitioners in determining those children most at risk before behaviors become entrenched and excessive weight gain occurs. However, recent reviews of research point to results that may be useful in guiding the development of such tools. Toward this effort, the present paper summarizes and expands several recent comprehensive reviews of diet and lifestyle determinants of overweight in children in order to identify determinants that hold the most promise for early detection of risk. While there is increasing attention being paid to factors external to the immediate family environment (e.g. media, schools, communities), for the purpose of the current paper, we are particularly interested in those determinants that are in the immediate control of the family. We then extend and expand on these earlier reviews by examining and summarizing the most current research in three primary categories: diet, lifestyle and parenting. Thus, the goal of this descriptive summary of the field is to identify empirically supported determinants of pediatric overweight, with a special interest in studies focusing on low-income children, in order to guide future efforts toward early identification of children who are at the highest risk for becoming overweight.

Diet-Related Determinants

A comprehensive review of studies published in 1992-2003 on dietary determinants of pediatric

overweight (7) was recently conducted by the Center for Weight and Health (CWH) at UC Berkeley. Diet-related topics for all ages, including feeding practices used by parents, were selected based on an extensive review of the etiology of pediatric overweight (8) and input from a panel of experts. Support was found for some determinants for children and some for adults. However, the cumulative evidence was used to derive conclusions based on the rationale that since children and adults live together and since children become adults, different recommendations for children and adults would be neither practical nor applicable. The authors concluded that seven diet-related determinants met the rigorous evidenced-based criteria for content in pediatric primary prevention interventions (7): dietary fat, dietary fiber, fruit/vegetables, calcium/dairy, sweetened beverages, restaurant prepared food, and breakfast. Three additional determinants (energy density, food variety, portion control) had insufficient evidence at the conclusion of the review in 2003. While the review of portion control found a substantial number of mechanistic studies to support large portion size as a determinant of overweight (7), observational and intervention studies were notably lacking and only two studies examined this relationship in children.

Since the publication of that review in 2003, additional work has emerged in the field to warrant reconsideration of these three potential determinants. Thus, further consideration is given in the current paper to subsequent research on these three emerging determinants.

Lifestyle-Related Determinants

A similar review process was undertaken on behalf of the American Dietetic Association with respect to observational studies of physical and sedentary activities as determinants of overweight among youth (9). As a result of this evidence-based review, physical activity and television viewing were identified as the most compelling activity-related determinants of pediatric overweight. Insufficient evidence was found at that time to include sleep duration and psychological stress. Since the time of this review, increasing attention has been paid to sleep as possible determinants of pediatric overweight. For

instance, Americans report that they do not get enough quality sleep time (10) and sleep has been associated with activity-related energy expenditure in children (11) and adolescents (12). Similar associations were found in studies reviewed of young children. In fact, one study found that the odds of becoming obese were nearly three-fold greater among children with <8 hours of sleep in comparison to those who slept 10 or more hours (13). Some studies have also documented that inadequate sleep can cause neuro-cognitive changes as well, contributing to increased sleepiness during the day and a reduction in activity-related energy expenditure (14,15).

Parenting-Related Determinants

There is increasing interest in the role parents assume in determining early behaviors related to pediatric overweight. Previous reviews of the literature have revealed inconsistent evidence of a relationship between parent-child feeding practices and child weight status (7,16-18). These inconsistent findings may be a result of the tendency to study discrete parent feeding practices rather than to examine parenting style as a context for children's development of diet and lifestyle behaviors.

Parenting researchers have suggested that parenting is composed of both "parenting styles" that reflect the goals, and specific behaviors or "practices" that are used to achieve those goals (19). Thus, while a parenting style describes parent-child interactions across a range of situations, parenting practices are specific to a given situation and may be more or less appropriate depending on that situation. As a result, the success of specific parenting practices depends in part on the parenting style that establishes the context. From this perspective, parenting style may moderate the influence of practices on child outcomes. In the case of child weight, parent-child feeding may be conceptualized as a specific "parenting practice" that may vary across feeding situations. However, the "parenting style" adopted around parents' feeding goals may significantly impact the effects of feeding behaviors. For instance, the style a parent uses when enacting a feeding behavior may influence how successful the parent is in changing the child's eating behavior.

This perspective has proved to be informative in understanding the influence of parenting on children's social and cognitive outcomes. There is overwhelming empirical support for the positive effects of authoritative parenting styles, characterized by reasonable control, high levels of nurturance, appropriate limit-setting and clear communication patterns on children's development (20). In contrast, "authoritarian" styles (i.e. high levels of control, low levels of nurturance and unclear communication patterns) and "permissive" styles (i.e. high levels of nurturance and clear communication patterns but low levels of control) are associated with less positive social and cognitive outcomes for children (21-23). Some evidence for this kind of association in pediatric overweight comes from one study where high levels of parental control over children's food coupled with low levels of support (similar to authoritarian parenting style) was associated with higher caloric intake by children systematically (24). However, to date, this literature on parenting styles has not been included in previous reviews of determinants of childhood overweight. Thus, one aim of the current review will be to examine the latest research evidence of parenting as a determinant of child overweight.

Objectives

The goal for this paper was to augment the recent reviews discussed above, in order to provide a descriptive summary of the current state of the empirical evidence for behavioral determinants related to pediatric overweight that can be influenced by families. Given that low-income children are disproportionately represented in current child overweight estimates (4), particular interest was paid to identifying studies that focused on low-income children. Given that our purpose of this paper is to provide information to guide the development of research-based, behavioral assessment tools, this is not a comprehensive review of the literature. Instead, it is intended to guide research to develop behavioral assessment tools that can be used in pediatric overweight prevention efforts. Toward this end, this paper builds on the evidence contained in the previous reviews summarized above (7, 9) via two objectives:

- update a descriptive review of the literature published from the conclusion of the previous reviews in 2003, investigating specific diet and lifestyle determinants (energy density, food variety, portion size, and sleep) found in earlier reviews not to be conclusively related to pediatric overweight or not to have sufficient evidence at the time to be a priority for review; and
- search parenting style as an additional determinant of interest to account for increasing recognition of the role parenting assumes in the early development of behaviors associated with pediatric overweight.

Methods

Data Sources

Searches were conducted for studies on behavioral determinants that can be influenced by families within the three categories of interest (diet, lifestyle and parenting) for the period of March 2003 (the conclusion of the previous reviews) through April 2006. Pubmed was used as the primary search engine. For parenting, an additional search was conducted within PyschINFO. Studies of four types were sought: secular trends (e.g., changes in a determinant over the time period that obesity rates have dramatically increased); mechanistic studies (e.g., short-term experimental studies relating a determinant to energy intake); observational studies (longitudinal, nationally representative, case-control or other cross-sectional epidemiological studies correlating the determinant to a measure of adiposity); and prevention trials (e.g., interventions on the determinant to modify body weight). In cases where evidence was mixed or indeterminate, expert opinion was sought for input on emerging and not yet published findings in the field.

Inclusion and Exclusion Criteria

Diet

Within the diet category, we reviewed the literature for three determinants previously examined

as part of the review by the Center for Weight and Health (7) and found to be inconclusive: energy density, food variety and portion size. Pubmed search terms used were: '(dietary energy density OR energy density) AND (obesity OR overweight) NOT cancer NOT diabetes'; '(food variety OR dietary food variety OR number of foods OR diet AND variety) AND (obesity OR overweight) NOT cancer NOT diabetes'; 'portion size AND (obesity OR overweight) NOT cancer NOT diabetes'. Overweight treatment studies were excluded given that the focus of this project was overweight prevention, and evidence suggests that treating existing obesity is physiologically different from prevention of the onset of obesity.

Lifestyle

Within the lifestyle category, recent studies focusing on sleep duration were reviewed. Search terms included 'sleep AND (obesity OR overweight) NOT cancer NOT diabetes'.

Parenting

Consistent with our aim to identify aspects of parenting styles rather than discrete parenting practices, search terms included '(parenting style' OR 'parenting' OR 'parent-child interaction)' AND (obesity OR overweight) NOT cancer NOT diabetes'.

Data Extraction and Synthesis

For all studies, data was extracted for: study type, age of target audience, socioeconomic status of family, strength of study conclusion. Data were then organized by determinant and reviewed. Based on the reviews, a conclusion statement for each determinant was formulated with respect to the strength of the evidence supporting its association with overweight.

Results

Diet-Related Determinants of Overweight

Energy density. Five newly identified short-term experimental studies reported a positive association between energy density of a food, meal or day's intake and energy intake (25-29). However, results were mixed from five recently published observational studies, three with adults (30-32), and two with children (33, 34). One study found a positive

association between energy density and self-reported BMI in a nationally representative sample of adults (31), and one study found mixed results depending on how energy density was computed (30). The other three studies found no association between the variables of interest. A possible explanation for the variant findings may be the use of different methods for calculating energy density.

Despite the fact that the predominance of mechanistic evidence supported the hypothesis that energy density is related to increased energy intake, the state of the other evidence prohibited firm conclusions from being drawn. The current search revealed an absence of prevention trials evaluating the impact of energy density on adiposity, and a limited number and inconclusive findings from observational studies evaluating the association between dietary energy density and adiposity. Due to the mixed evidence, expert opinion was sought (35). Based on the evidence and expert opinion, it was concluded that energy density is a determinant of pediatric overweight that can be influenced by families.

Variety of foods. Several newly published studies on food variety were reviewed. In one that included a nationally representative study of preschool-age children, a positive association was observed between total energy intake and variety of food consumed (calculated as the number of different foods consumed over 24 hours among the 10 most commonly consumed food types – milk, bread, soft drinks, cereal, juice, cookies, french fries, bananas, peanut butter and macaroni with cheese); however, the relation of food variety with body size was not reported (36). Three new observational studies, two with Chinese adults and one with Spanish children, were identified that examined food variety in relation to a measure of adiposity. In the study by Sea and colleagues (37), eating a greater variety of snack foods was positively associated with all measures of adiposity, while the varieties of grain and meat consumed were inversely related to adiposity. In the study by Yao and colleagues (32), the number of different ingredients in home-prepared dishes was positively related to body fatness. In the third observational study (38) no relation was observed between food variety (as assessed on the basis of the number of different foods consumed more than once a month) and adiposity in 6- to 7-year-old children.

On the whole, these studies provided an inconsistent picture of the relation of food variety to adiposity. The types of foods rather than simply the number of different foods may be an important factor to consider (32). However, more refined definitions of food variety have not yet been employed sufficiently to draw clear conclusions about the relationship between food variety and pediatric overweight. For this reason and with confirmation by expert opinion (35), it was concluded that sufficient evidence does not exist to include food variety as a determinant of pediatric overweight that can be influenced by families.

Portion size. All of the mechanistic studies we reviewed that examined the response between portion size and food/energy intake found that increased portion size was related to increased energy intake (26-28,36, 39-43). Of these studies, three were with children (34,36,39). None of the short-term mechanistic studies we reviewed found significant differences by body weight in food or energy intake in response to variations in portion size. However, in these studies sample sizes were relatively small (all <100 and generally <50), limiting the power to detect such differences. Energy density was simultaneously examined in several of these mechanistic studies (26-28). In most cases, increased portion size resulted in increased energy intake regardless of the energy density of the food provided. The one exception was the study by Rolls et al (28) in which a low-energy dense first course salad resulted in a lower energy intake than eating no salad prior to the meal. Further, a larger portion of a low-energy dense salad had a greater effect in reducing subsequent meal intake than a smaller portion size of the same low energy dense salad. These findings highlight the need for further investigation of the interrelationships between energy density and portion size on energy intake and risk of overweight.

Two new observational studies (34,36) were identified. One study involved a nationally representative sample of children from the same 1994-1996, 1998 CSFII dataset as the only previously identified observational study (which found a positive association between portion size and adiposity in infants (44)). In that study, portion size of the top 10 most commonly consumed foods was positively related to energy intake among 2- to 5-year-old

children, corroborating the findings of shorter-term mechanistic studies that increased portion size of common foods results in increased energy intake over the long term as well. In the other study (34), meal portion size (but not snack portion size) was positively related to BMI percentile among 12- to 19-year-olds and among 6- to 9-year-old boys. The relationship was not significant for 3- to 5-year old children and 6- to 9-year-old girls. One merit of these two observational studies is that they involved nationally representative samples; however a major limitation is that they relied upon parent- or self-reported values of weight and height for children (45).

While recent mechanistic studies add to the evidence that large portion size is a risk factor for overeating, the lack of observational and prevention intervention studies and reliance on self-report make it difficult to provide a conclusive statement with respect to portion size as a determinant of overweight. For this reason and with confirmation by expert opinion (46), it was concluded that sufficient evidence does not exist to include portion size as a determinant of pediatric overweight that can be influenced by families.

Lifestyle-Related Determinants of Overweight

Sleep duration. The review of the mechanistic studies on sleep found that the mechanism underlying the association between sleep and weight gain has not been clearly established. However, evidence reviewed with adults and adolescents suggests that there may be hormonal links between regulation of the sleep/wake cycle and hunger and appetite, particularly for high calorie and high sugar foods (47-49). Moreover, some studies have documented that inadequate sleep can cause neuro-cognitive changes as well, contributing to increased sleepiness during the day and a reduction in activity-related energy expenditure (14,15,50). Self-reported fatigue has been related to increased BMI among adults (51). In summary, these studies suggest that a lack of adequate sleep at night may contribute to an increase in energy intake and a decrease in energy for physical activity during the day.

Several observational studies among adults, both with longitudinal (52) and cross-sectional (53) designs, reported that short sleep duration was related

to increased obesity. Insomnia has also been related to obesity in adults (54). Similar associations were found in studies reviewed of young children. For instance, increased sleep duration in young children was found to be associated with concurrent (11,55-58) and later (59-61) overweight. In fact, one study found that the odds of being obese were nearly three-fold greater among children with <8 hours of sleep in comparison to those who slept 10 or more hours (57). In another study the odds of overweight or obesity was over three-fold greater among children with 8-10 hours of sleep in comparison to longer sleepers (56). In most of these studies, the relation of sleep duration and adiposity remained significant after adjustment for a variety of potential confounders such as gender, parental obesity, physical activity, and other lifestyle factors. Only one study identified, this a case-control study involving a relatively small number of children (n=29), reported no difference in sleep duration by weight status (62). Sleep apnea, a known consequence of obesity, may explain some of these findings. However, the fact that longitudinal studies support that short sleep duration precedes the obesity suggests that sleep duration may play a distinct role in obesity development.

Due to the substantial observational and mechanistic evidence supporting a relation between sleep duration and overweight among children as well as adults and adolescents, it was concluded that the evidence supports sleep duration as a determinant of pediatric obesity that can be influenced by the family.

Parenting-Related Determinants of Overweight

Parenting styles. Search results for the parenting category revealed five papers investigating the relation of parenting styles to aspects of children's nutrition and adiposity. In the first study, parenting styles were investigated in conjunction with feeding styles, in order to measure parenting styles in the context of nutrition and food among low-income African American and Hispanic parents (63). Parents who were more authoritative in their general parenting were also more authoritative when feeding their children. Similarly, authoritarian parenting was associated with authoritarian feeding practices (higher restriction and pressure regarding food); while

permissive parenting was linked with permissive feeding practices (positive interactions around food but low control). This study also demonstrated an association between feeding styles and child weight. Parents who were classified as permissive or indulgent in their feeding styles had children with the highest BMI. However, there were no statistically significant differences between the BMI of children with authoritative parents and those with authoritarian parents.

In another report by this research group (64), parenting styles in the context of nutrition and food were associated with children's eating behaviors. Specifically, children with authoritarian parents (low warmth, high control) ate fewer vegetables than children of authoritative parents (high warmth, appropriate control), even after controlling for child gender and BMI, as well as for parent ethnicity and education. Children with authoritative parents also consumed more dairy than did other children.

Results from two other studies examined general parenting styles, rather than parenting styles in the context of child diet. In the first study, parenting styles failed to predict child weight (24). The dependent measure in this study, however, was dichotomous (weight for age over or under the 85th percentile), reducing power to detect significant findings, particularly considering the relatively small sample size of 150 children. On the other hand, a prospective longitudinal study that also employed a more strict dichotomous measure of child weight (over or under 95th percentile) on a large sample of nearly 900 children from 10 sites around the United States, found support for an association between parenting styles and childhood overweight (65). Children with authoritarian parents had the highest rates of childhood overweight and were significantly more likely to be overweight than children with authoritative parents. Children with permissive or neglectful parents were also significantly more likely to be overweight than children with authoritative parents. Similarly, a study of Mexican school children revealed that children with permissive parents were more likely to be overweight (over the 95th percentile) than were other children (66).

While the research in this area is relatively new and clear evidence for a link between parenting styles and childhood overweight has not yet been

conclusively documented, there is overwhelming evidence from the child development literature pointing to the importance of parenting styles and the quality of parent-child interactions for a wide variety of children's developmental outcomes (20). Together with the findings from the few studies discussed here and in consultation with expert opinion (46), evidence supporting the importance of parenting styles in other disciplines lends support for its importance as a determinant of pediatric overweight that can be influenced by families.

Conclusive determinants. Based on a preponderance of evidence and expert opinion from previous reviews of the literature (7, 9), and from the current expanded review, we conclude that 12 determinants are presently supported as determinants of pediatric overweight that can be influenced by families. Table 1 summarizes the findings for all identified determinants across the reviews.

Discussion

To guide the development of behavioral assessment tools in pediatric prevention efforts, we augmented previous reviews to provide a descriptive summary of the current state of empirical evidence related to behavioral determinants of pediatric overweight that can be influenced by families. The previous reviews and current augmentation lead us to identify 12 determinants (see table 1) that should be considered in future studies toward developing behavioral assessment tools aimed at identifying children at highest risk for child overweight. These determinants warrant further study for related behaviors in a next step toward developing needed assessment tools for practitioners to use with children. While we were particularly interested in the evidence for low-income populations, there was a surprising lack of studies focusing on this vulnerable population. Moreover, for some determinants, we found a paucity of studies focusing on young children. Thus, conclusions were made based on the available data on adults in middle to high income ranges in order to move the agenda forward with the use of evidence we have to date.

Table 1. Determinants of pediatric overweight by category, hypothesized effect and status of evidence

Category	Determinant	Reference for Review	Hypothesized Effect	Status of Evidence
Diet	Dietary fat	a	Direct	✓✓✓
	Protein	a	Uncertain	✓✓
	Dietary fiber	a	Inverse	✓✓✓
	Fruit/vegetables	a	Inverse	✓✓✓
	Fruit juice	a	Direct	✓
	Calcium/dairy	a	Inverse	✓✓✓
	Sweetened beverages	a	Direct	✓✓✓
	Reduced fat food products	a	Uncertain	✓
	Restaurant prepared foods	a	Direct	✓✓✓
	Breakfast	a	Direct	✓✓✓
	Energy density	a, c	Direct	✓ ¹
	Portion size	a, c	Direct	✓
	Variety of foods	a, c	Direct	✓
	Eating frequency	a	Uncertain	✓
	Snacking	a	Direct	✓
Food insecurity	a	Direct	✓	
Lifestyle	Physical activity	b	Inverse	✓✓✓
	Sleep duration	c	Inverse	✓✓✓
	Television viewing	b	Direct	✓✓✓
	Sports participation	b	Inverse	✓✓
	Video game playing	b	Direct	✓✓
Parenting	Parenting styles	c	n/a ²	✓ ¹
	Concern about child's weight	a	Direct	✓
	Dietary restraint/inhibition	a	Direct	✓
	Encouragement/pressure to eat	a	Direct	✓
	Family functioning	a	n/a ²	✓
	Parental control of feeding	a	Direct	✓
	Restricting highly palatable foods	a	Direct	✓
Using food as a reward	a	Direct	✓	

¹Included as a determinant of interest on the basis of expert opinion rather than the conclusiveness of the evidence as a determinant of adiposity.

²No hypothesized effect is included in the table because the effect is not expected to be linear.

References:

a, Woodward-Lopez G, Ritchie LD, Gerstein D, Crawford PB. Obesity: Developmental and Dietary Influences. Boca Raton, FL: CRC Press. 2006.

b, American Dietetic Association. Factors associated with Childhood Overweight. www.adaevidencelibrary.com.

c, Review for 2003 – 2006 provided by this paper.

✓✓✓ indicates persuasive evidence (secular trend data, mechanistic studies, observational studies, prevention trials);

✓✓, suggestive evidence with more research recommended;

✓, limited or equivocal evidence with more research being essential.

We recognize that the empirical evidence for parenting styles and energy density was less conclusive than for the other determinants retained for

identification of related behaviors. This may be due more to the relatively recent nature of the work. However, in consultation with experts in these fields,

we retained both determinants. Specific to parenting styles, there are few empirical studies examining the relation of parenting styles to pediatric overweight. Although there are many more studies that examine child-feeding practices of parents in relation to child overweight, there are considerable inconsistencies in measurement across these studies. Moreover, feeding practices are dependent on the specific content and context of the parent-child interaction and may be appropriate during certain circumstances but inappropriate during others. It would not be reasonable to expect a linear relationship between specific feeding practices and child weight.

Parenting styles, however, are multi-dimensional and independent of specific context. It is important that future work in this area draw from methodologies in other disciplines that have established consistent results for relations between authoritative parenting styles (i.e., a combination of high warmth, appropriate control, and coherent communication) and positive child outcomes (20). Finally, only one investigation was found examining the longitudinal effects of parenting styles in the early years on weight during school age or adolescence (65). More such studies are needed in order to fully understand the role of parenting in children's weight.

The current study adds to earlier reviews of the literature to identify the most likely determinants of overweight in children. For example, Sherry (67) reviewed the literature for six strategies emphasized by the CDC for intervention programs: promoting breastfeeding, promoting physical activity, reducing TV/video viewing, increasing fruit and vegetable consumption, reducing sugar-sweetened drink consumption, and reducing portion sizes. Although not a comprehensive review, Sherry's findings agree with ours for physical activity, TV viewing, fruit and vegetables, and sweetened beverages. Likewise, Parsons et al (68) conducted a comprehensive review of childhood predictors of adult obesity through 1998. Unlike our findings, the authors found little evidence to suggest a relationship between any childhood dietary determinants and adult weight. However, only studies with longitudinal designs were included. The current study adds to this literature by also considering the extent to which the determinants reviewed can be influenced by families. This is an important consideration given that prevention of

pediatric overweight takes place in the context of the family environment.

Next Steps

Unique from these previous studies, the current review considers multiple lines of evidence ranging from secular trend data to observational cross-sectional and longitudinal studies to prevention interventions. While more robust evidence is certainly needed on which to base interventions to prevent excess weight gain in children, designing assessment tools aimed at early identification based on the preponderance of evidence currently available is warranted given the health costs of failing to prevent the escalating rates of obesity among low-income children. Toward this aim, we have examined the behaviors associated with each of the 12 determinants of pediatric overweight from the current review in identifying children at risk for overweight (69). However, for such efforts to be optimally effective in low-income children who suffer a disproportionate prevalence of pediatric obesity in (3, 4), studies specifically focusing on factors associated with pediatric obesity in this population are needed.

Acknowledgments

Funding for this study was provided by a Core Issue Grant from the University of California Division of Agriculture and Nature Resources and the Food Stamp Nutrition Education Program.

References

1. Freedman DS, Khan LK, Serdula MK, Ogden CL, Dietz WH. Racial and ethnic differences in secular trends for childhood BMI, weight, and height. *Obesity* 2006;14:301-6.
2. Freedman DS, Dietz WH, Srinivasan SR, Berenson GS. The relation of overweight to cardiovascular risk factors among children and adolescents: The Bogalusa Heart Study. *Pediatr* 1999;103:1175-82.
3. Molarius A, Seidell JC, Sans S, Tuomilehto J, Kuulasmaa K. Educational level, relative body weight, and changes in their association over 10

- years: An international perspective from the WHO, MONICA project. *Am J Public Health* 2000;91:1260-8.
4. Zhang Q, Wang Y. Trends in the association between obesity and socioeconomic status in US adults: 1971 to 2000. *Obes Res* 2004;12:1622-32.
 5. Townsend MS, Love B, Achterberg C, Murphy S. Food insecurity is positively related to overweight in women. *J Nutr* 2001;131:1738-45.
 6. Whitaker RC, Wright JA, Pepe MS, Seidel KD, Dietz WH. Predicting obesity in young adulthood from childhood and parental obesity. *N Engl J Med* 1997;997:869-73.
 7. Woodward-Lopez G, Ritchie L, Gerstein DE, Crawford PD. *Obesity: Dietary and Developmental Influences*. Boca Raton: CRC Press, 2006.
 8. Ritchie L, Ivey S, Masch M, Woodward-Lopez G, Ikeda J, Crawford P. *Pediatric overweight: A review of the literature*. Center for Weight and Health, University of California, Berkeley; 2001 [cited 2006 March]; Available from: http://cnr.berkeley.edu/cwh/PDFs/Full_COPI_secure.pdf.
 9. American Dietetic Association. *Evidence Analysis Library. Factors associated with childhood overweight - physical activity and inactivity*. [cited 2006 March]; Available from: <http://www.adaevidencelibrary.com>.
 10. *Sleep in America*. National Sleep Foundation; 2005 [cited 2006 March]; Available from: www.sleepfoundation.org/_content/hottopics/2005_summary_of_findings.pdf.
 11. von Kries R, Toschke AM, Wurmser H, Sauerwald T, Koletzko B. Reduced risk for overweight and obesity in 5- and 6-y-old children by duration of sleep: A cross-sectional study. *Int J Obes Relat Metab Disord* 2002;26:710-6.
 12. Gupta NK, Mueller WH, Chan W, Meininger JC. Is obesity associated with poor sleep quality in adolescents? *Am J Hum Biol* 2002;2002:762-8.
 13. Sekine M, Yamagami T, Handa K, Saito T, Nanri S, Kawaminami K, et al. A dose-response relationship between short sleeping hours and childhood obesity: Results of the Toyama Cohort Study. *Child Care Health Dev* 2002;28:163-70.
 14. Liu X, Uchiyama M, Okawa M, Kurita H. Prevalence and correlates of self-reported sleep problems among Chinese adolescents. *Sleep* 2000;23:27-34.
 15. Vorona RD, Winn MP, Babineau TW, Eng BP, Feldman HR, Ware JC. Overweight and obese patients in a primary care population report less sleep than patients with a normal body mass index. *Arch Intern Med* 2005;165:25-30.
 16. Birch LL, Fisher JO. Development of eating behaviors among children and adolescents. *Pediatr* 1998;101(3):539-49.
 17. Ritchie L, Welk G, Styne D, Gerstein DE, Crawford PB. Family environment and pediatric overweight: What is a parent to do? *J Am Diet Assoc* 2005;105:70-9.
 18. Faith MS, Scanlon KS, Birch LL, Francis LA, Sherry B. Parent-child feeding strategies and their relationships to child eating and weight status. *Obes Res* 2004(1711-1722).
 19. Darling N, Steinberg L. Parenting style as context: An integrative model. *Psychol Bull* 1993;113:487-96.
 20. Teti DM, Candelaria MA. Parenting competence. In: Bornstein MH, editor. *Handbook of parenting*. 2nd ed. Mahwah, NJ: Lawrence Erlbaum, 2002:149-80.
 21. Baumrind D. The development of instrumental competence through socialization. In: Pick AD, ed. *Minnesota symposium on child psychology*. Minneapolis, MN: Univ Minnesota Press, 1973:3-46.
 22. Lamborn SD, Mounts NS, Steinberg L, Dornbusch SM. Patterns of competence and adjustment from authoritative, authoritarian, indulgent and neglectful families. *Child Dev* 1991;62:1049-65.
 23. Steinberg L, Lamborn SD, Darling N, Mounts NS, Dornbusch SM. Over-time changes in adjustment and competence among adolescents from authoritative, authoritarian and neglectful families. *Child Dev* 1994;65:754-70.
 24. Drucker RR, Hammer LD, Agras WS, Bryson S. Can mothers influence their child's eating behavior? *J Dev Behav Pediatr* 2005;20(2):88-92.
 25. Darmon N, Briand A, Drewnowski A. Energy-dense diets are associated with lower diet costs: A community study of French adults. *Public Health Nutr* 2004;7:21-7.

26. Devitt AA, Mattes RD. Effects of food unit size and energy density on intake in humans. *Appetite* 2004;42:213-20.
27. Kral TV, Roe LS, Rolls BJ. Combined effects of energy density and portion size on energy intake in women. *Am J Clin Nutr* 2004;79:962-8.
28. Rolls BJ, Roe LS, Meengs JS. Salad and satiety: Energy density and portion size of a first-course salad affect energy intake at lunch. *J Am Diet Assoc* 2004;104:1570-6.
29. Ledikwe JH, Blanck HM, Khan LK, Serdula MK, Seymour JD, Tohill BC, et al. Dietary energy density determined by eight calculation methods in a nationally representative United States population. *J Nutr* 2005;135:273-8.
30. Kant AK, Graubard BI. Energy density of diets reported by American adults: Association with food group intake, nutrient intake, and body weight. *Int J Obes Relat Metab Disord* 2005;29:950-6.
31. Ledikwe JH, Blanck HM, Kettel-Khan L, Serdula MK, Seymour J, Tohill BC, et al. Eating patterns and weight status associated with a low-energy-dense diet in US adults. *Obes Res* 2004;12:A211.
32. Yao M, McCrory MA, Ma G, Tucker KL, Gao S, Fuss P, et al. Relative influence of diet and physical activity on body composition in urban Chinese adults. *Am J Clin Nutr* 2003;77:1409-16.
33. Alexy U, Sicheert-Hellert W, Kersting M, Schultze-Pawlitschko V. Pattern of long-term fat intake and BMI during childhood and adolescence: Results of the DONALD Study. *Int J Obes Relat Metab Disord* 2004;28:1203-39.
34. Huang TT, Howarth NC, Lin BH, Roberts SB, McCrory MA. Energy intake and meal portions: Associations with BMI percentile in U.S. children. *Obes Res* 2004;12:1875-85.
35. Drewnowski A. Director of the Nutritional Sciences Program and Professor of Epidemiology and Medicine at the University of Washington and Director of the Center for Public Health and Nutrition and the Exploratory Center for Obesity Research. Seattle, WA.
36. McConahy KL, Smiciklas-Wright H, Mitchell DC, Picciano MF. Portion size of common foods predicts energy intake among preschool-aged children. *J Am Diet Assoc* 2004;104:975-9.
37. Sea MM, Woo J, Tong PC, Chow CC, Chan JC. Associations between food variety and body fatness in Hong Kong Chinese adults. *J Am Coll Nutr* 2004;23:404-13.
38. Royo-Bordonada MA, Ortega H, Martin-Moreno JM, Lasuncion MA, Garces C, Gil A, et al. Greater dietary variety is associated with better biochemical nutritional status in Spanish children: The Four Provinces Study. *Nutr Metab Cardiovasc Dis* 2003;3:357-64.
39. Orlet Fisher J, Rolls BJ, Birch LL. Children's bite size and intake of an entree are greater with large portions than with age-appropriate or self-selected portions. *Am J Clin Nutr* 2003;77:1164-70.
40. Rolls BJ, Roe LS, Meengs JS, Wall DE. Increasing the portion size of a sandwich increases energy intake. *J Am Diet Assoc* 2004;104:367-72.
41. Rolls BJ, Roe LS, Kral TV, Meengs JS, Wall DE. Increasing the portion size of a packaged snack increases energy intake in men and women. *Appetite* 2004;42:63-9.
42. Wansick B, Painter JE, North J. Bottomless bowls: Why visual cues of portion size may influence intake. *Obes Res* 2005;13(93-100).
43. Diliberti N, Bordi PL, Conklin MT, Roe LS, Rolls BJ. Increased portion size leads to increased energy intake in a restaurant meal. *Obes Res* 2004;12(562-568).
44. McConahy KL, Smiciklas-Wright H, Birch LL, Mitchell DC, Picciano MF. Food portions are positively related to energy intake and body weight in early childhood. *J Pediatr* 2002;140:340-7.
45. Townsend MS, Melgar-Quinonez H, Pearson J, Hudes M, Crawford P. Errors in reporting children's heights and weights. *FASEB J* 2004;18:A901.
46. Orlet Fisher J. Assistant Professor of Pediatrics at Baylor College of Medicine. Houston, TX.
47. Mullington JM, Chan JL, Van Dongen HP, Szuba MP, Samaras J, J. PN, et al. Sleep loss reduces diurnal rhythm amplitude of leptin in healthy men. *J Neuroendocrinol* 2003;15:851-4.
48. Spiegel K, Tasali E, Penev P, Van Cauter E. Brief communication: Sleep curtailment in healthy young men is associated with decreased leptin

- levels, elevated ghrelin levels, and increased hunger and appetite. *Ann Intern Med* 2004;141:846-50.
49. Taheri S, Lin L, Austin D, Young T, Mignot E. Short sleep duration is associated with reduced leptin, elevated ghrelin, and increased body mass index. *PLoS Med* 2004;1:210-7.
50. Chen MY, Wang EK, Jeng YJ. Adequate sleep among adolescents is positively associated with health status and health-related behaviors. *BMC Public Health* 2006;6:59.
51. Resnick HE, Carter EA, Aloia M, Phillips B. Cross-sectional relationship of reported fatigue to obesity, diet, and physical activity: Results from the third national health and nutrition examination survey. *J Clin Sleep Med* 2006;2:163-9.
52. Hasler B, Buysse DJ, Klaghofer R, Gamma A, Ajdacic V, Eich D, et al. The association between short sleep duration and obesity in young adults: A 13-year prospective study. *Sleep* 2004;27:661-6.
53. Vioque J, Torres A, Quiles J. Time spent watching television, sleep duration and obesity in adults living in Valencia, Spain. *Int J Obes Relat Metab Disord* 2000;24:1683-8.
54. Janson C, Lindberg E, Gislason T, Elmasry A, Boman G. Insomnia in men: A 10-year prospective population based study. *Sleep* 2001;24:425-30.
55. Hui II, Nelson EAS, Yu LM, Li AM, Fok TI. Risk factors for childhood overweight in 6- to 7-year-old Hong Kong children. *Int J Obes* 2003;7:1411-8.
56. Chaput JP, Brunet M, Tremblay A. Relationship between short sleeping hours and childhood overweight/obesity: Results from the Quebec en Forme Project. *Int J Obes* 2006;30:1080-5.
57. Sekine M, Yamagami T, Hamanishi S, Handa K, Saito T, Nanri S, et al. Parental obesity, lifestyle factors and obesity in preschool children: Results of the Toyama Birth Cohort study. *J Epidemiol* 2002;12:33-9.
58. Yu CW, Sung RY, So R, Lam K, Nelson EAS, Li AM, et al. Energy expenditure and physical activity of obese children: Cross-sectional study. *Hong Kong Med J* 2002;8:313-7.
59. Reilly JJ, Armstrong J, Dorosty AR, Emmett PM, Ness A, Rogers I, et al. Early life risk factors for obesity in childhood: Cohort study. *BMJ* 2005;330(7504):1357.
60. Agras WS, Hammer LD, McNicholas F, Kraemer HC. Risk factors for childhood overweight: A prospective study from birth to 9.5 years. *J Pediatrics* 2004;145:20-5.
61. Sugimori H, Yoshida K, Izuno T, Miyakawa M, Suka M, Sekine M, et al. Analysis of factors that influence body mass index from ages 3 to 6 years: A study based on the Toyama cohort study. *Pediatrics Int* 2004;46(302-310).
62. Maffei C, Zaffanello M, Pinelli L, Schutz Y. Total energy expenditure and patterns of activity in 8-10-year-old obese and nonobese children. *J Pediatr Gastroenterol Nutr* 1996;23:256-61.
63. Hughes SO, Power TG, Orlet Fisher J, Mueller S, Nicklas TA. Revisiting a neglected construct: Parenting styles in a child-feeding context. *Appetite* 2005;44:83-92.
64. Patrick H, Nicklas TA, Hughes SO, Morales M. The benefits of authoritative feeding style: Caregiver feeding styles and children's food consumption patterns. *Appetite* 2005;44:243-9.
65. Rhee KE, Lumeng JC, Appugliese DP, Kaciroti N, Bradley RH. Parenting styles and overweight status in first grade. *Pediatr* 2006;117:2047-54.
66. Brewis A. Bicultural aspects of obesity in young Mexican school children. *Am J Hum Biol* 2003;15:446-60.
67. Sherry B. Food behaviors and other strategies to prevent and treat pediatric overweight. *Int J Obesity* 2005;29:116-26.
68. Parsons TJ, Power C, Logan S, Summerbell CD. Childhood predictors of adult obesity: A systematic Review. *Int J Obes Relat Metab Disord* 1999;23:1-107.
69. Townsend MS, Young T, Ontai L, Ritchie L, Williams ST. Developing an assessment tool for obesity prevention in low-income children: Part 2-What behaviors do we measure? *Int J Child Adolescent Health* 2009;2 (1): xxx.