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Psychosocial Determinants of Childhood and Adolescent Obesity

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The purpose of this article was to identify psychosocial determinants of childhood and adolescent obesity. Some of the determinants were considered non-modifiable such as genetics, sex, age, and race. The risk of developing obesity started early on in life, with high birth weight, rapid growth in infancy, maternal smoking during pregnancy, and lack of breastfeeding indicated as positive predictors. Family food environment and dietary behaviors were considered modifiable determinants and included: consumption of unhealthy foods, portion sizes, snacking, and number of family meals. Physical activity was also considered a protective factor against the development of obesity, with overweight children significantly less active than those who were non-overweight. Recommendations for successful interventions and future research were discussed.

Key words: overweight, physical activity, nutrition, children

Problems of childhood and adolescent overweight and obesity have reached epidemic proportions (Ogden, Flegal, Carroll, & Johnson, 2002). Globally, more than 1 billion people have been classified as overweight and of those at least 30% were obese (World Health Organization, 2003). Overall, 10% of the school-aged children in the world were overweight (Lobstein, Baur, Uauy, & IASO International Obesity Task Force, 2004). Childhood and adolescent overweight and obesity have been considered especially harmful as these persist in later years into adulthood (Serdula et al., 1993; Whitaker, Wright, Pepe, Seidel, & Dietz, 1997). The dangers of being overweight or obese in childhood and adolescence have been well established. The Bogalusa Heart Study conducted in the United States found that by 10 years of

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age, 60% of overweight children had at least one biochemical or clinical cardiovascular risk factor and 25% had more than two (Freedman, Dietz, Srinivasan, & Berenson, 1999).

Childhood and adolescent obesity has been associated with numerous short-term and long- term medical consequences. Examples of short-term effects of obesity included adverse blood lipid profile, altered glucose metabolism, and obstructive sleep apnea: while long term effects included higher risk of hypertension, diabetes, cardiovascular disease, gall bladder disease, and osteoarthritis into adulthood (Whitaker et al., 1997). Childhood and adolescent overweight and obesity have also been linked with psychological consequences such as poor self-image, lowered self-esteem, eating disorders, and poor quality of life (Strauss, 2000).

In the United States, the national health care expenditures related to overweight and obesity in adults were estimated between $98 billion to $129 billion (Institute of Medicine, 2004). Two of the determinant behaviors of obesity, unhealthy dietary habits and sedentary behavior, together have accounted for approximately 300,000 deaths every year (Allison, Fontaine, Manson, Stevens, & VanItallie, 1999). The Surgeon General suggested that obesity was second only to smoking as a preventable cause of death (Satcher, 2002). Therefore, in the *Healthy People 2010* report, the goal for reducing overweight and obesity in children and adolescents was aimed at 5% from the 1988-1994 baseline of 11% (United States Department of Health and Human Services, 2000). Unfortunately, progress towards this objective was not met, as the proportion of adults and children who were overweight or obese increased substantially and this represented one of the biggest challenges for the future initiatives of *Healthy People 2020*. In collaboration to combat this obesity epidemic, the *Surgeon General's Call to Action to Prevent and Decrease Overweight and Obesity* published in 2001 suggested various steps at all levels to help make a substantial impact (Office of the Surgeon General, 2001).

The factors which have contributed to overweight and obesity were considered numerous and complex. Body weight has been shaped by a combination of genetic, metabolic, behavioral, environmental, cultural, and socioeconomic influences. Recent and systematic reviews for determinants of childhood and adolescent obesity were missing. Hence, the purpose of this article was to identify determinants of childhood and adolescent obesity from current literature and present recommendations for interventions and future research.

A comprehensive literature search was conducted using MEDLINE, CINHAL, and SPORTDISCUSS to locate studies on determinants of childhood and adolescent obesity. The following sections summarize the findings from salient studies under several relevant headings: common genetic variants, determinants of weight in first years of life, maternal behaviors, family food environment and dietary behaviors, physical activity and inactivity, and environmental factors. The determinants within each of these headings have been summarized in Table 1.

Common Genetic Variants

Many studies have shown genetic factors to exhibit strong links with obesity, yet the definitive contribution was still unknown. A recent report by the Human Obesity Gene Map consortium counted more than 240 genes that were able to modulate body weight and adiposity through the regulation of food intake, energy expenditure, lipid and glucose metabolism, adipose tissue development, and inflammation processes (Rankinen, Zuberi, & Changnon, 2006). Similarly Herbert et al. (2006) conducted a study to identify common genetic variants associated with elevated Body Mass Index (BMI). They used a dense whole-genome scan of DNA samples from the individuals in the National Heart, Lung, and Blood Institute's Framingham Heart Study. They found a common genetic variant near the *INSIG2* gene associated with obesity.

Table 1
Determinants of Child and Adolescent Obesity

Main determinants	Subheadings of determinants	Relevant studies
Common genetic variants		
	Genes	Rankinen, Zuberi, & Changnon, 2006; Herbert et al., 2006
	Parental BMI	Ness, 2004; Rapp, Schick, Bode, & Weiland, 2005; Reilly et al., 2005
	Sex	Rapp et al., 2005
	Age and height	O'Dea & Wilson, 2006
	Race	Strauss & Pollack, 2001
First years of life		
	Fetal development	Gluckman & Hanson, 2004
	Birth weight	Danielzik, Pust, Landsberg, & Muller, 2005; Kramer et al., 1985; Ness, 2004; Rose & Bodor, 2006
	Growth in infancy	Monteiro & Victoria, 2005; Stettler et al., 2005; Toschke, Beyerlein, & von Kries, 2005
Maternal behaviors		
	Maternal BMI	Harvey et al., 2007
	Smoking during pregnancy	Harvey et al., 2007; Huerta, Bibi, Haviv, Scharf, & Gdalevich, 2006: Ness, 2004; Procter, 2007; Wideroe, Vik, Jacobsen, & Bakketeig, 2003
	Breastfeeding	Arenz, Rucker, Koletzko, &

		Von Kries, 2004; Bergmann et al., 2003; Frye & Heinrich, 2003; Heinig, Nommsen, Peerson, Lonnerdal, & Dewey, 1993; Lande et al., 2003; Ness, 2004; Procter, 2007
Family food environment and dietary behaviors		
	Initial nutritional preferences	Tabacchi, Giammanco, La Guardia, & Giammanco, 2007
	Dietary fat and fat types	Ailhaud & Guesnet, 2004; Blass, 2003; Mace, Shahkhalili, Aprikian, & Stan, 2006
	Consumption of unhealthy foods	Bowman, Gortmaker, Ebbeling, Pereira, & Ludwig, 2004; Ludwig, Peterson, & Gortmaker, 2001; O'Dea & Wilson, 2006
	Portion sizes and snacking	Colapinto, Fitzgerald, Taper, & Veugelers, 2007; Fitzgerald, Taper, & Veugelers, 2007; Huang, Howarth, & Linn, 2004; Procter, 2007
	Family environment	Campbell, Crawford, & Ball, 2006; Colapinto et al., 2007; Gillman et al., 2000; McCaffrey, Rennie, Wallace, & Livingston, 2007; O'Dea & Wilson, 2006; Procter, 2007; Rose & Bodor, 2006; Stanek, Abbott, & Cramer, 1990; Tabacchi et al., 2007
Physical activity and inactivity		
	Physical activity levels	Goran, Reynolds, & Lindquist, 1999; Lioret, Maire, Volatier, & Charles, 2007; Strauss, Rodzilsky, Burack, & Colin,

		2001; Trost, Kerr, Ward, & Pate, 2001; Trost, Sirard, Dowda, Pfeiffer, & Pate**,** 2003
	Screen time	Dietz & Gortmaker, 2001; Lindquist, Reynolds, & Goran, 1999; Rapp et al., 2005; Robinson, 1999; Rose & Bodor, 2006
	Psychological and social correlates	Hampson, Andrews, Peterson, & Duncan, 2007; Sallis, Alcaraz McKenzie, & Hovell, 1999; Strauss et al., 2001; Trost et al., 2001
	Race, gender, and SES	Lindquist et al., 1999; Loriet et al., 2007
	Parental influence	Sallis et al., 1999; Strauss et al., 2001; Trost et al., 2001
Environmental factors		
	Socio-demographic	Lioret et al., 2007; Moreno et al., 2004; Ness, 2004; O'Deas Wilson, 2006; Procter, 2007; Rose & Bodor, 2006; Vieweg, Johnston, O'Lanier, Fernandez, & Pandurangi, 2007

The study was replicated in four additional samples of participants comprising of Western European ancestry and African American descent, and found similar results. As the capabilities of technology have increased, this has been a newly emerging focus in the study of obesity-related factors.

Numerous studies have indicated additional genetically-related determinants. For instance, the presence of one or both overweight parents represented a higher risk of obesity in their children (Ness, 2004; Rapp, Schick, Bode, & Weiland, 2005; Reilly et al., 2005). Another genetically-related factor was sex, with a predisposition in females to be overweight, independent of age (Rapp et al., 2005). O'Dea and Wilson (2006) found that age and height were positively associated with BMI. Race also seemed to determine some differences in weight status. For example, Black and Hispanic populations had a higher risk of obesity compared to White populations (Strauss & Pollack, 2001). Although, it was noted that other determinants might play larger predictors and further research was necessary. Allison, Matz, Pietrobelli, Zannolli, and Faith (2001) addressed the variance explained by these genes and suggested that

about 10% of the population may become overweight in an ideal environment and another 10% would remain of normal weight even in an "obesogenic" environment. An obesogenic environment has been defined as "the sum of influences that the surroundings, opportunities, or conditions of life have on promoting obesity in individuals or populations" (Moreno et al., 2004, p.16). The remaining 80% possessed so-called "thrifty" genes, which have evolved to help us deal with periods of famine and feast, but have not yet adapted to the modern environment, which may predispose individuals to obesity.

Determinants of Weight in First Years of Life

Gluckman and Hanson (2004) indicated the risk of developing obesity starts very early in life, even as early as fetal development. Furthering this idea, Gluckman and Hanson explained that the fetus selects appropriate homeostatic responses in relation to the information obtained in utero. This so-called "predictive adaptive response" was determined by the postnatal environment that was expected and the real one that was encountered. For example, if the fetus expected a nutritionally poor postnatal environment, development would reflect that. This idea emphasized that it was the difference between the nutrition of prenatal and postnatal environments that determined the pathological risk rather than the absolute level of nutrition.

Kramer et al. (1985) conducted a study to evaluate potential determinants of weight and adiposity in the first year of life. The study found that birth weight, sex, age at introduction of solids, and duration of breastfeeding were all significant predictors of weight at 12 months. Continuing on this research, high birth weight was indicated as a positive predictor of overweight status in other studies (Danielzik, Pust, Landsberg, & Muller, 2005; Ness, 2004; Rose & Bodor, 2006). The relationship between growth in infancy and weight gain in later childhood, adolescence, or adulthood had also been well established. Monteiro and Victoria (2005) conducted a review of such studies and concluded that 13 out of 16 studies found early rapid growth to be associated with overweight or obesity later in life. Stettler et al. (2005) studied the effect of weight gain in the first week of life on adult obesity, where they followed a group of formula-fed participants who had been measured seven times during infancy through age 20 to 32 years. Stettler et al. found that weight gain during the first week of life was a crucial determinant for development of obesity later in life. Likewise, Toschke, Beyerlein, and von Kries (2005) utilized classification and regression trees (CART) analysis to identify the most powerful set of combined predictors for childhood overweight at school entry. High weight gain in the first two years of life was found to be the best predictor for overweight at school entry.

Maternal Behaviors

A study by Harvey et al. (2007) examined maternal influences on neonatal body composition using assessment of fat and lean body mass by dual x-ray absorptiometry within two weeks of birth. The study found that bigger maternal size, higher parity, smoking history, women who walked slower, and women who had greater fat stores were important determinants of greater fat in neonatal body composition.

Maternal smoking during pregnancy. Maternal smoking during pregnancy has also been associated with an increased risk of childhood obesity (Ness, 2004). A dose-dependent relationship between the number of cigarettes smoked during pregnancy and the extent of childhood overweight or obesity was found, after accounting for potential confounders including social class, maternal weight, and birth weight (Procter, 2007). There was no association with smoking after pregnancy, suggesting that it was the intrauterine exposure that was fundamental to the increased risk of obesity.

A study conducted by Wideroe, Vik, Jacobsen, and Bakketeig (2003) followed 482 women throughout pregnancy and their children from birth to five years, to collect data on maternal smoking, diet, socio-economic determinants, breastfeeding, and anthropometric measures. It was found that after adjusting for maternal diet, breastfeeding, maternal obesity, and socio-economic status, mothers who smoked during pregnancy had increased risk of overweight children at 5 years of age. The study concluded that maternal smoking was a potential risk factor for childhood obesity. Similarly, another study examined the effects of parental education and smoking on the risk of overweight while controlling for age, sex, and immigration status (Huerta, Bibi, Haviv, Scharf, & Gdalevich, 2006). Parental smoking was found to be an independent risk factor for overweight and obesity.

Breastfeeding. There was conflicting evidence regarding the relationship between breastfeeding and childhood obesity. It has been shown that there was a reduction in the risk of obesity with longer duration of breastfeeding in a few studies (Frye & Heinrich, 2003; Ness, 2004). A longitudinal birth cohort study by Bergmann et al. (2003) examined whether breastfeeding was protective against overweight and obesity at 6 years of age. The study found that at 3 months the bottle-fed group had higher BMI than the breastfed group. This trend continued at 6 months of age and in the 4^{th}, 5^{th}, and 6^{th} years. A systematic review conducted by Arenz, Rucker, Koletzko, and Von Kries (2004) found that breastfeeding had a protective effect, albeit small, against subsequent childhood obesity. Confounding variables such as maternal BMI, diabetes, and smoking during pregnancy, as well as birth weight, family dietary choices, and SES, should also be taken into consideration when studying the effects of breastfeeding.

Breastfed babies grew faster during the first 3 months of life, slower until 1 year, and reached the same weight during the 2^{nd} year of life. On the contrary, children fed with formula doubled their birth weight earlier than those who were breastfed, and weight increase was relatively faster than height increase (Lande et al., 2003). Several mechanisms have been proposed to explain the protective effect of breastfeeding. One was related to the timing of weaning, as solid foods tended to increase the energy density of the diet, which could lead to excess energy intake and consequent weight gain. Secondly, the amount of protein in the diet tended to increase with bottle-feeding and early weaning, which may reduce the age of adiposity rebound and increase the risk of subsequent obesity (Heinig, Nommsen, Peerson, Lonnerdal, & Dewey, 1993; Procter, 2007). Thirdly, considering dietary habits, children who were breastfed for the first year of life had a lower intake of sugared soft drinks and added sugars, meat, and fish, and a higher intake of water, vitamins, minerals, and fiber (Heinig et al., 1993).

Family Food Environment and Dietary Behaviors

Having an obese parent has been identified as a risk factor in childhood and adolescent overweight and obesity. Some of this risk has been attributed to shared family experiences related to food preferences, eating patterns, and habits (McCaffrey, Rennie, Wallace, & Livingston, 2007). Tabacchi, Giammanco, La Guardia, and Giammanco (2007) speculated that at the beginning of life, nutritional intake was controlled by innate biological systems and internal signals, which then determined initial preferences. However, these can later be modified by the learning processes, which lead to the formation of attitudes and beliefs about food and nutrition. These attitudes and beliefs tended to be carried into adulthood. Nonetheless, during the first years of life, much of these nutritional preferences were influenced by parents. Each member of the family acts as a role model for the child, with their behavior reinforcing and supporting the development of diet and activity behaviors.

Dietary fat and fat types. Mace, Shahkhalili, Aprikian, and Stan (2006) concluded that the role of dietary fat and fat types consumed by mothers during gestation and the children in infancy as determinants of childhood obesity has not been studied well. Based on rodent studies, they purported that maternal high fat feeding during pregnancy and lactation resulted in adiposity in childhood. They hypothesized that polyunsaturated fatty-acid-enriched diets in mothers and children caused obesity during childhood, and suggested further longitudinal population-based studies to substantiate their hypothesis.

Blass (2003) explained that there is a release of opioids in the brain as a result of ingesting fat flavors or sweet tastes, indicating palatability of the food becomes a major contributing factor to obesity. Ailhaud and Guesnet (2004) presented evidence from invitro, in vivo, and epidemiological studies that polyunsaturated fatty acids of omega-6 series were promoters of adipogenesis. The role of dietary fat and fat types had not been studied enough in humans to determine causality.

Consumption of unhealthy foods. A high consumption of unhealthy foods, including fast food and sweetened beverages were found to be contributors to obesity. When children consumed fast food, their energy and fat intake were more likely to be higher, and the fruit and vegetable intake lower, than the recommended servings (Bowman, Gortmaker, Ebbeling, Pereira, & Ludwig, 2004). Those who ate fast food consumed an average of 770 kJ/day more than those who did not. In theory, this could result in a weight gain of 2.7 kg/year in a child who regularly consumed fast food. Also, an increase in sweetened beverages and/or soft drinks led to an increase in energy intake. Ludwig, Peterson, and Gortmaker (2001) found that the consumption of soft drinks was positively associated with obesity in children over 19 months. O'Dea and Wilson (2006) contributed that nutritional quality of breakfast and food varieties were negatively associated with child and adolescent BMI.

***Portion sizes and snacking*.** As the incidence of overweight and obesity has escalated, a corresponding increase in the portion size of foods served in restaurants and fast food establishments has occurred. Huang, Howarth, and Linn (2004) reported that portion size was positively associated with BMI percentile in boys aged 6-11 years and in adolescents aged 12-19 years, but not in 3-5 year olds. In children, satiety cues may start to be overridden by environmental cues, including pressure from parents to "clean up their plate," enabling the preference for larger portions (Fitzgerald, Taper, & Veugelers, 2007). However, the evidence of portion-size effects on energy intake in children is limited, with limited or no studies examining familial patterns of energy density, intake, and portion size.

Colapinto, Fitzgerald, Taper, and Veugelers (2007) found that children who ate dinner in front of the television more than once per week were more likely to choose large portions. Also, those children who ate at a fast food restaurant more than once per week chose larger portions of French fries and potato chips, and conversely smaller portions of vegetables.

Snacking has also been noted as a risk factor for obesity. Individuals have become less inclined to eat three meals a day, creating more frequent, irregular intervals of eating. Snacking has been associated with more energy-dense foods and more total food consumed, which contributes to the positive energy balance known to lead to weight gain (Procter, 2007).

Family environment. Family environment was probably one of the most important factors that influenced most of the food choices and eating behaviors of children. Parents influenced food behaviors of their own children through availability and accessibility of food, meal structure, food socialization practices, their own body weight, socioeconomic status, cultural beliefs, food preferences, family structure, and attitudes toward their children (Tabacchi

et al., 2007). Rose and Bodor (2006) examined the association between food insecurity and overweight status in young children. Food insecurity was measured by the 18-item U.S. Department of Agriculture Household Food Security Scale. They found that household food insecurity was not associated with higher prevalence of overweight among young schoolchildren.

Parents who reported less healthful eating habits were more likely to have children who chose smaller portions of cooked vegetables and larger portions of potato chips (Colapinto et al., 2007). Stanek, Abbott, and Cramer (1990) found that the family environmental factors associated with a better dietary quality were asking for the child's cooperation in preparing food at the table, giving small portions when introducing a new food, incorporating discussion into meal time, making the child try new foods (a few bites), allowing the child to make decisions about the type of food eaten, and giving positive feedback when the child eats healthy foods.

Campbell, Crawford, and Ball (2006) examined the relative importance of predictors in family food environment on child's dietary behaviors such as perceptions of adequacy of the child's diet, modeling of eating, child feeding strategies (of pressure, restriction, and monitoring), food availability, confidence in cooking, cost of and preference for fruits and vegetables, mealtime interruptions, and television viewing. They assessed total energy intake per day, vegetable consumption, savory snack foods consumption, high-energy (no dairy) food consumption, and sweet snack consumption in 560 children along with their primary care provider (92% mothers, 8% fathers). It was found that "pressure to eat" was significantly associated with an increase in predicted energy intake. Likewise, high-cost and low-preference of fruits and vegetables, as a barrier to consumption, was associated with increase in predicted energy intake. Increased television viewing also was associated with higher energy intake and lower vegetable consumption. On the other hand, for mealtime interruptions, energy intake decreased. More positive parental perceptions of the adequacy of children's diet and of confidence in cooking were significantly and negatively associated with vegetable consumption. Parental modeling was significantly and positively associated with vegetable consumption. Parental perception of dietary adequacy, pressure to eat, and high-cost of and low-preference for fruits and vegetables were significant predictors for savory snack food consumption. Parental perception of dietary adequacy, pressure to eat, and television viewing were positively associated with sweet snack consumption. Therefore, it was concluded that there were several factors in the family food environment that should be considered as important predictors leading to dietary behaviors that may promote obesity. O'Dea and Wilson (2006) assessed nutritional and socio-cognitive factors associated with BMI in children and adolescents. It was found that nutritional knowledge and dietary self-efficacy were positively associated with BMI.

The number of family meals individuals incurred was associated with a healthy diet, including lower consumption of saturated and trans fats, fried foods, and soda. One reason cited may be due to a reduction in the number of ready-made dinners consumed (Gillman et al., 2000). According to Procter (2007), the lack of family meal times implied fewer social controls on eating and opportunities provided for positive role modeling.

Physical Activity and Inactivity

Associations between eating patterns and the risk of obesity cannot be viewed in isolation, and interactions between food consumption and other relevant lifestyle behaviors need to be considered. Goran, Reynolds, and Lindquist (1999) concluded that physical activity protects individuals from development of obesity by increasing energy expenditure and increasing resting metabolic rate. The United States Department of Health and Human Services (2007) recommended for children to engage in at least 60 min of moderate to vigorous physical

activity, which was developmentally appropriate, enjoyable, and involved a variety of activities on most, preferably all days of the week.

Accuracy of physical activity levels has been difficult to gauge in children and adolescents. However, the existing data has shown that today's youth were insufficiently physically active. One study found that 10-16 year olds only engaged in vigorous activity 12.6 mins per day (Stanford University, 2007). Strauss, Rodzilsky, Burack, and Colin (2001) studied psychosocial correlates of physical activity in children and found that children spent 75.5% of the day being inactive. Children watched TV, sat on a computer, or did homework, for a mean of 5.2 ± 1.8 hrs, while the children spent only 1.4% of the day (12.6 ± 12.2 min) engaged in vigorous physical activity. The study concluded that physical inactivity was an important contributing factor in the maintenance of childhood obesity.

Trost, Sirard, Dowda, Pfeiffer, and Pate (2003) compared the physical activity levels of overweight and non-overweight 3 to 5 year old preschoolers. Physical activity was measured by direct observation using the observation system for recording activity in schools (OSRAP) and real time accelerometry. It was found that overweight boys were significantly less active than those who were non-overweight. However, no significant differences were found between overweight and non-overweight girls. A similar cross-sectional study (Trost, Kerr, Ward, & Pate, 2001) compared the physical activity and its determinants in a sample of obese and non-obese middle school children. It was found that obese children had significantly lower daily accumulations of total moderate and vigorous physical activity and lower 5, 10, and 20 min bouts of moderate to vigorous physical activity.

Lioret, Maire, Volatier, and Charles (2007) found in a sample where 15.2% of the children were overweight (of whom 3.5% were obese), those children who engaged in leisure-time physical activity were significantly less likely to be overweight than children who performed no leisure-time physical activity. Likewise, the level of sedentary behavior was positively correlated with overweight at any age, but more so in ages 6-14 years. In addition, obese children reported involvement in significantly fewer community organizations promoting physical activity.

Screen time. The amount of time children and adolescents watched television, played video games, and used the computer, has increased by over an hour during the past five years, from about 7.5 hr to 8.5 hr a day (Laningham-Foster et al., 2006; Stanford University, 2007). Consequently, it has been reported that duration of television watching for more than two hours per day was positively associated with overweight in children (Rapp et al., 2005; Robinson, 1999; Rose & Bodor, 2006). Similarly, a prospective study by Dietz and Gortmaker (2001) showed a strong positive dose-response relationship between time watching television and prevalence of overweight; after adjusting for potential confounders including baseline maternal overweight, previous overweight, family structure, ethnicity, SES, and maternal and child aptitude test scores. Lindquist, Reynolds, and Goran (1999) found higher television viewing in children from single-parent homes. The effect of television viewing on obesity has been described as being widespread through a variety of factors including contribution to a decrease in physical activity levels, potential for an increase in energy intake while snacking during viewing, reduction of resting metabolic rate, and influences on food choices due to advertisements for unhealthy foods (Procter, 2007).

Psychological and social correlates. Sallis, Alcaraz, McKenzie, and Hovell (1999) examined psychological and social correlates of physical activity in childhood. They found that psychological variables explained changes in physical activity slightly more for boys than for

girls. It was also found that obese children had significantly lower self-efficacy for physical activity (Strauss et al., 2001; Trost et al., 2001).

Strauss et al. (2001) also indicated that social influence scores were correlated with the amount of time spent in vigorous physical activity. Hampson, Andrews, Peterson, and Duncan (2007) conducted a study that addressed children's social images and physical activity. Most past research has related social images to unhealthy behaviors, but more recently social images have been related to health-protective behaviors, such as exercise and healthy eating. Hampson et al. examined the influence of children's early social images of other children who engaged in physical activity on their own subsequent physical activity behaviors, and related these trajectories of physical activity to subsequent levels of obesity. A cohort-sequential design was employed, in which five grade cohorts (N = 1,075) were assessed annually over 4 years, until they were in the 5th through 8th grades. Conclusions made were that children's social images of exercise in early childhood influenced their subsequent activity level, and should be targeted in obesity prevention interventions.

Race, gender, and socioeconomic status. Lindquist et al. (1999) examined sociocultural determinants of physical activity in a cross-sectional sample of African American and Caucasian children 6.5 to 13 years of age. Sociocultural and physiological predictors in the study included gender, ethnicity (African American & Caucasian), age, single parent home, pubertal development (Tanner stage I to V), and social class (Hollingshead four factor index). After controlling for social class and single versus dual parent family background, few ethnic differences existed. Lioret et al. (2007) also examined how physical activity and sedentary behavior were associated with socioeconomic status and overweight. They found overweight and sedentary behavior were inversely related to socioeconomic status in children over 6 years of age. The study indicated the multi-dimensional aspect of physical activity and the influence of these sociocultural factors.

Physical activity and parental influence. Parental influence explained changes in physical activity in boys more so than girls (Sallis et al., 1999). Physical activity levels of parents have shown to be a significant predictor of physical activity in children. Trost et al. (2001) found children who were obese had a less physically active father or local guardian. Parents also influenced participation in physical activity in terms of support. The frequency of parents transporting children to activity locations explained significant proportion of variance for both girls and boys' physical activity levels (Strauss et al., 2001).

Environmental Factors

The importance of the environment in controlling obesity was acknowledged by the World Health Organization (2003), who stated that major social and environmental changes to make healthier choices more accessible and preferable are required to prevent obesity. The importance of environmental factors has gained increasing momentum. The environment discussed includes various factors: food commercialism, technology, as well as urban and socioeconomic development. All of these were considered to be contributors in the creation of obesogenic environments that are nurturing over-eating and inactive lifestyles (Maziak, Ward, & Stockton, 2008). The fact that the rise in childhood obesity has been so rapid suggests that these environmental factors had more of an impact than genetic influences, which would take longer to pass between generations (Procter, 2007).

***Socio-demographic determinants*.** Income, education, and occupation have been widely used measures of socio-economic status. Public schools in Chesterfield County, Virginia measured BMI among students in kindergarten, 3rd, 7th, and 10th grades, providing a database to

explore the relationship between BMI and SES (Vieweg, Johnston, O'Lanier, Fernandez, & Pandurangi, 2007). They found a robust relationship between increased BMI (for sex and age) and low SES, suggesting that low SES may be a risk factor for childhood and adolescent obesity. As the size of the high-risk group increased, so did the strength of the relation with low SES. Low income was considered to be a positive predictor of overweight status (Lioret et al., 2007; O'Deas & Wilson, 2006; Rose & Bodor, 2006).

Moreno et al. (2004) examined micro-environmental and socio-demographic determinants of childhood obesity. The study found size of municipality, year of examination, gender, type of school, and province were all significant determinants of childhood overweight in children and adolescents. The study found that in Spain, overweight and obesity were higher in rural areas compared to urban areas and the main inverse determinant of overweight was maternal education level. The Avon Longitudinal Study of Parents and Children (ASLPC) (Ness, 2004) in the United Kingdom followed the children of 14,000 women prospectively. Again, it was found that maternal education had an inverse association with childhood obesity and showed a three-fold increase in the least educated group. These indicators have been related to socioeconomic status.

The increased prevalence of obesity in children from more deprived socioeconomic backgrounds could be due to a multitude of factors including: dietary differences; lack of safe play areas for the children; lack of opportunity or means to participate in extracurricular physical activities; and lack of accessible, affordable, healthy foods (Procter, 2007).

Discussion

The purpose of this article was to review studies that discussed determinants of overweight and obesity in childhood and adolescence. It was found that some of the determinants were considered non-modifiable such as genetics, sex, age, and race. Research recently found common genetic variants associated with obesity. Future research needs to confirm these findings and locate any other such genetic markers. This would enable identification of high-risk individuals and lead to more concerted preventive programs for those people. However, most of the population is more likely affected by the influences of surroundings, opportunities, or conditions predisposing individuals to obesity.

The risk of developing obesity started early on in life. High birth weights as well as rapid growth in infancy were indicated as positive predictors of overweight and obesity later on in life. Maternal influences on neonatal body composition have been considered important in determining future plausibility of childhood and adolescent obesity. One modifiable maternal behavior was smoking during pregnancy. Mothers who smoked during pregnancy had increased risk of overweight children. Educational programs can be designed for pregnant mothers, as well as for women in the reproductive age group, for smoking prevention and cessation. Additionally, breastfeeding was considered a protective factor against overweight and obesity. Effective antenatal and post-natal educational programs that promote breastfeeding can be helpful in attaining normal weight and improved dietary habits into infancy.

The importance of family food environment and dietary behaviors was directly related to risk of child and adolescent obesity. Family members become role models for the child, with their eating patterns and habits, shared family experiences, and food preferences supporting the future development of their children. Consumption of unhealthy foods, large portion sizes, an abundance of snacking, and a decreased number of family meals have all been associated with a greater incidence of obesity. Educational programs that advocate family mealtimes, reduction of

portion sizes and promote consumption of healthier foods, such as fruits and vegetables, must be designed. These educational programs must target the child, as well as the family, to have an impact on such behaviors.

Physical activity was also considered a protective factor against the development of obesity. In general, overweight children were significantly less active than those who were non-overweight. Also obese children had significantly lower self-efficacy for physical activity than their non-obese counterparts. Self-efficacy for physical activity can be modified through educational programs. Examples of strategies, which could be used in building self-efficacy, include breaking down the complex behavior into practical and doable small steps, using a demonstration from credible role models, using persuasion and reassurance, and reducing stress. Children also are influenced early on by their social images of exercise. Therefore, this should be targeted in obesity prevention interventions as well. Again, parental influence is important, and should be incorporated into all educational attempts. Related directly to physical activity, it was demonstrated that duration of television watching was positively associated with overweight in children. Interventions designed to reduce screen time have shown promising results and must be utilized by future interventions.

Environmental factors have taken on continued importance in the prevention and control of obesity. This review did not focus on environmental components such as food commercialism, technology, or development of particular infrastructures. However, these are important when looking at the big-picture of determinants which could make an impact. Yet, the realizations of individual environmental concerns such as socioeconomic influence need to be considered when designing obesity-related interventions. Issues such as lack of safe play areas, opportunity or means to participate in physical activity, as well as lack of healthy and affordable foods are critical components to the success of behavior change.

Conclusion

Tackling childhood and adolescent obesity is critical to improving and sustaining the health of the United States. The role obesity has played in contributing to increased morbidity and mortality throughout the world has been profound. In order to make an impact on the obesity epidemic, there must be a clear understanding of its etiology, regardless of the abundance of determinants which have been studied. As this review pointed out, some of these determinants are non-modifiable, including genetics. Yet the focus should be on those determinants which are considered modifiable (specific maternal behaviors, nutrition and physical activity behaviors, and parental influences) as they make up the majority of predictors established. It is imperative to establish which of the predictors are most responsive to change. Additionally, if trends are found to be more prevalent among some groups of children and adolescents, it may be beneficial to designate resources appropriately to those groups. Developing far-reaching, population-level interventions and public health policies to prevent childhood obesity is critical. This will necessitate a multifaceted approach, which involves a collaboration of all levels of society.

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