PREVENTION OF OVERWEIGHT AND OBESITY in Young Canadian Children

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## Abbreviations

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<th>Abbreviation</th>
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<tr>
<td>AMDR</td>
<td>Acceptable Macronutrient Distribution Range</td>
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<tr>
<td>ADA</td>
<td>American Dietetic Association</td>
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<td>AAP</td>
<td>American Academy of Pediatrics</td>
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<td>BM I</td>
<td>Body Mass Index</td>
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<td>CCHS</td>
<td>Canadian Community Health Survey</td>
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<td>CDC</td>
<td>Centers for Disease Control and Prevention (US)</td>
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<td>DRI s</td>
<td>Dietary Reference Intakes</td>
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<td>FITS</td>
<td>Feeding Infants and Toddlers Study (US)</td>
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<td>HDL</td>
<td>High Density Lipoprotein</td>
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<td>IOM</td>
<td>Institute of Medicine (US)</td>
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<td>IOTF</td>
<td>International Obesity Task Force</td>
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<td>LDL</td>
<td>Low Density Lipoprotein</td>
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<td>NASPE</td>
<td>National Association for Sport and Physical Education</td>
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<td>NEAT</td>
<td>Non-Exercise Activity Thermogenesis</td>
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<td>NHANES</td>
<td>National Health and Nutrition Examination Survey (US)</td>
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<td>OPPS</td>
<td>Obesity Prevention Strategies Plus Parenting Support</td>
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<tr>
<td>PAL</td>
<td>Physical Activity Level</td>
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<tr>
<td>PARF</td>
<td>Population Attributable Risk Factor</td>
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<tr>
<td>PS</td>
<td>Parenting Support</td>
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<tr>
<td>STRIP</td>
<td>Special Turku Coronary Risk Factor Intervention Project</td>
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<tr>
<td>TV</td>
<td>Television</td>
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<tr>
<td>US</td>
<td>United States</td>
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<tr>
<td>USDA</td>
<td>United States Department of Agriculture</td>
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<tr>
<td>WHO</td>
<td>World Health Organization</td>
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<td>WIC</td>
<td>Women, Infants and Children (US)</td>
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Executive Summary

The prevalence of excess weight is increasing among young children in developed and developing countries. In Canada, 15.2% of 2–5 year olds are overweight and 6.3% are obese, according to International Obesity Task Force criteria for overweight and obesity among children. If current trends continue, 46% of school-aged children in the Americas will be overweight or obese by 2010, as the current generation of preschoolers enters school.

Although childhood obesity puts children at significant risk for many health problems, scientists suggest that the greatest health problems will be seen as the present generation of overweight and obese children becomes the next generation of adults. Insofar as childhood obesity persists into adulthood, higher rates of obesity-related disease are predicted to emerge in younger adults, who may require access to specialized healthcare throughout their remaining lifetimes.

The energy and nutrient requirements of young children have been summarized recently by the Institute of Medicine. The appropriateness of energy intake can be assessed based on growth in weight and length according to standardized growth charts. Much less is known regarding the optimal amount of physical activity for children, and there is not a firm evidence base from which to develop guidelines. Canadian survey data for children aged 0–6 years are lacking, and therefore it is not possible to fully characterize the dietary and physical activity patterns of young children, or to assess how changes in these patterns may have contributed to the current epidemic of obesity.

Obesity in early childhood predicts obesity in adulthood, particularly when at least one parent is also obese. Although it is not clear whether early childhood Body Mass Index (BMI) is associated with an increased risk of chronic disease in adulthood, risk factors for chronic disease emerge early in the course of obesity and are known to persist from childhood into adulthood. Beyond adverse effects on the physical health of children, the most immediate consequences of childhood obesity may be in terms of its negative consequences on the social and emotional well-being of children.

Obesity-promoting dietary behaviours such as low meal frequency, low intakes of vegetables and fruit, fibre, and milk products, and high intakes of fat, saturated fat, sugar-sweetened beverages, and high sugar/high fat snacks are evident in young children. Limited evidence suggests that dietary interventions in young children may improve some aspects of diet quality, health and body weight status. The relationship between physical activity levels and obesity in young children is not clear, and therefore the optimal amount and nature of physical activity for obesity prevention has not been defined. Young children may self-regulate energy expenditure better than older children such that compensatory activity occurs as required to maintain energy balance. A link between time spent watching television and obesity has been documented in preschool-aged children, although this association is not conclusive. Short sleep duration among young children increases the risk of childhood obesity in a dose-dependent manner. Although interventions which target the eating, activity and sleep patterns of young children are limited, results suggest that these types of interventions may be efficacious. Additional research is needed in this area, and future studies should focus on parents and caregivers as agents of change.
Early life experiences may induce permanent changes in physiologic function that program the long-term regulation of energy balance. Fetal conditions including maternal dietary and physical activity patterns, maternal weight status, gestational diabetes, and smoking may adversely impact postnatal obesity risk. Postnatal experiences relevant to obesity risk include extremes of birth weight, breast and bottle feeding, the timing of introduction of solid foods, and upward centile crossing. Given that obesity may be programmed in utero and during early infancy, preventive measures should be initiated in utero and continue throughout early childhood.

The influence of parents and caregivers on the weight status and lifestyle behaviours of young children is substantial. Parental obesity is the primary predictor of obesity among young children, and also predicts obesity in adulthood. Parental involvement and role modeling is essential for the success of obesity prevention programs among young children. Young children depend upon their parents for the provision of food, and therefore children’s dietary behaviours are primarily shaped by their parents. Authoritative parenting styles characterized by parental acceptance and a firm parenting style may promote healthy lifestyle behaviours in children. Parents should avoid exerting excessive control over children’s intake by pressuring them to eat more of certain foods or by restricting others. Food should not be used as a reward, or to manage children’s negative moods. The role of parents is to offer a variety of nutritious food options in a supportive eating context, and to allow children to decide what and how much to eat of the foods that are offered. It is not clear whether parents need to be active for their children to become active; however, parental encouragement can foster active lifestyles in and outside the home.

Physicians are ideally placed to identify children who may be at risk of obesity; however, opportunities for early intervention are frequently missed. Physicians should follow recommendations to calculate and plot BMI for all children. Obesity prevention should be initiated in utero and continue throughout early childhood in all children. Other health professionals should also play an active role in obesity prevention strategies. In this way, physicians and allied health professionals may play a significant role in curbing the rise in overweight and obesity among children and adults.

Obesity prevention is a community responsibility that is best addressed using multi-level, multi-sectoral public health strategies. A comprehensive ecological approach to obesity prevention combines strategies that focus on changing individual behaviours, with strategies that change the environment in which individual behaviours occur. Government and non-government agencies can cooperate to develop and implement policies and programs. Policy makers should consider policy suggestions in the literature, and should look to the successes of other nations in formulating future policies and programs. The Canadian Government should institute a formal, large-scale surveillance program for obesity. In reality, all children may be at risk of obesity, and can benefit from interventions to encourage physical activity and a healthy diet. A comprehensive public health approach that targets all children in all age groups may therefore be the most efficacious means of preventing childhood obesity.
I. Background and Context of Obesity in Young Children

For the purposes of this review, the term “infant” will be used to describe children from birth through 12 months of age, “toddlers” will refer to children 12 to 36 months of age, and “preschoolers” to children 3 to 6 years of age.

A. Defining overweight and obesity in young children

It is important to establish an internationally acceptable, standardized definition of overweight and obesity for young children to ensure that prevention and treatment are correctly directed; however, a standardized definition does not currently exist. Within the general population, the appropriateness of body weight is most commonly assessed via anthropometry, ideally by evaluating percentage body fat (Cole et al., 2000). Although it provides the best estimate of health risk for individuals, percentage body fat measurement is impractical for widespread epidemiological monitoring (Cole et al., 2000). Weight for height, body mass index (BMI=kg/m²), and waist circumference are alternative, practical means of estimating adiposity using anthropometry; however, the last is not currently recommended in children as there are insufficient reference data and no standardized measurement protocols (Katzmarzyk et al., 2007).

National growth charts do not exist to monitor weight for height in Canadian children. Health professional bodies recommend that the reference growth charts for children developed by the Centers for Disease Control and Prevention (CDC) in the United States (US) be used to assess and monitor the growth of Canadian children (Dietitians of Canada, 2004). The CDC curves can be used to describe existing growth patterns of children in comparison to the growth reference of US children from 1963 to 1994 (Dietitians of Canada, 2004). More recent growth data were not included in the CDC reference to avoid an upward shift due to the increasing prevalence of obesity among American children (Dietitians of Canada, 2004). Recently, the World Health Organization (WHO, 2006) released new child growth standards that depict how young children should grow under optimal environmental conditions. These international growth standards depict healthy growth, and suggest a model to try to achieve (Dietitians of Canada, 2004; WHO, 2006).

The BMI is readily calculated from measured height and weight, and is the most common means of defining what constitutes a healthy body weight for both adults and children (Katzmarzyk et al., 2007). BMI and its associated health risks change substantially with age, however, and therefore the BMI classification system is different for children and adults (Cole et al., 2000). BMI in children is associated with other measures of body fatness, and is predictive of adverse health later in life (Katzmarzyk et al., 2007). A high BMI during childhood is not, however, associated with a high incidence of morbidity or mortality, and it is therefore difficult to quantify levels of excessive fatness in children (Fox, 2004a). Two major approaches have been developed to identify children with excessive body weights on the basis of BMI (Katzmarzyk et al., 2007). The growth charts developed by the CDC use the 85th and 95th percentiles of BMI to identify children “at risk of overweight” and “overweight”, respectively (CDC 2000). This approach assumes that the reference population constitutes an “ideal” population, and categorizes individuals based on arbitrary cut-off points (Lobstein et al., 2004). The second approach, endorsed by the International Obesity Task Force (IOTF), links childhood BMI cut-off points with adult overweight (BMI=25 kg/m²) and obesity (BMI=30 kg/m²) thresholds (Cole et al.,...
These thresholds are more internationally acceptable because they are based on data from six nations (not including Canada), even though they reflect the relationship between BMI and health risks in adulthood rather than during childhood (Katzmarzyk et al., 2007). Neither scheme is ideal, as little data are available to assess the sensitivity and specificity of the BMI thresholds across a range of ages and maturational status (Katzmarzyk et al., 2007). Studies have shown that the two methods yield approximately similar results, with greater discrepancies among young children (Flegal et al., 2001). In general, the IOTF reference yields a more conservative view of the prevalence of overweight and obesity than the CDC reference (Lobstein et al., 2004). Future studies should attempt to define child BMI cut-offs that relate to health risks in childhood (Lobstein et al., 2004).

The Canadian clinical practice guidelines on the management and prevention of obesity in adults and children (Katzmarzyk et al., 2007), and Canadian health professional bodies (Dietitians of Canada, 2004) recommend that Canada use the CDC BMI charts to monitor the BMI of children aged 2 years or older. In Canada, the 85th and 95th percentiles are used to classify children as “overweight” or “obese”, respectively (Katzmarzyk et al., 2007). Weight-for-height growth charts are used to monitor the growth of children under the age of 2, as BMI charts do not exist for infants. The IOTF reference cut-offs are recommended for obesity surveillance in research settings (Katzmarzyk et al., 2007).

B. The problem of overweight and obesity among young children

Canadian rates of overweight and obesity among young children
The Canadian Community Health Survey (CCHS; Shields, 2004) recently provided objective evidence of the alarming rise in overweight and obesity among Canadian children. Whereas obesity was rarely observed among children and adolescents 30 years ago, it is now evident among all age groups (Shields, 2004). Between 1978-79 and 2004, the overall prevalence of overweight among 2–17 year olds increased from 12% to 18%, while the prevalence of obesity jumped from 3% to 8% (Shields, 2004). The rate of overweight among the subgroup of children aged 2–5 years was slightly lower at 15.2%, while 6.3% were obese (Shields, 2004). The combined rate of 21.5% remains unchanged since 1978-79 (Shields, 2004). The most significant increases in overweight may have occurred during the 1990s, when an additional 1% of Canadian children became overweight every year (Lobstein et al., 2004). Overall these data indicate that more than a quarter, or approximately 1.6 million Canadian children and youth, are overweight or obese (Shields, 2004).

Compared to the combined overweight/obesity rate of 26.3% among 2- to 17-year-old white children, Aboriginal children living off reserve had a much higher rate of overweight and obesity at 41.3%, while Canadian children of Southeast/East Asian descent had a lower rate of 17.7% (Shields, 2004). The rate of overweight/obesity among black children or children of “other” ethnic origins in Canada was not different from the rate among white children (Shields, 2004). The prevalence of obesity appears to increase with age among Canadian boys, while Canadian girls’ rates remain relatively stable regardless of age (Shields, 2004).

Global rates of overweight and obesity among young children
The global burden of overweight and obesity among children is significant; however, it is difficult to understand and characterize the nature of the problem on an international level due to...
the lack of comparable nationally representative data, the use of varying criteria to define overweight and obesity, and other factors (Lobstein et al., 2004). Nevertheless, the available data indicate that the prevalence of excess weight is increasing among children in developed and developing countries, albeit at different speeds and in different patterns (Lobstein et al., 2004). Developed nations in the Americas and Europe, for example, have a much higher prevalence and rate of increase in overweight and obesity compared to developing nations in Africa and Asia (Lobstein et al., 2004). Indeed, the problem of overweight and obesity among young children may be the most pronounced in the US, where estimates suggest that 27% of 2- to 5-year-old boys, and 25% of 2- to 5-year-old girls are overweight or obese (Ogden et al., 2006). Few data are available among younger children in the rest of the world; however, a comprehensive study in 1995 reported that the prevalence of obesity among children under 5 in developing countries was 3.3%. However, this average reflects a wide range in obesity rates from less than 1% in Vietnam, to over 9% in Algeria (de Onis and Blossner, 2000).

The reader is encouraged to consult reviews by Lobstein and colleagues (2004) and Wang and Lobstein (2006) for additional discussion of these worldwide trends.

Economic causes and consequences of overweight and obesity
Economics and obesity are inextricably linked at multiple levels, and the prevalence of obesity varies according to the economic context of the region in question (Wang and Lobstein, 2006). In industrialized nations children in lower income families are more vulnerable to obesity, while higher income groups are more susceptible in developing nations (Lobstein et al., 2004). Overall, poorer nations have a much lower prevalence of childhood obesity, and socioeconomic development leads to higher obesity rates (Wang and Lobstein, 2006).

Conversely, whereas economic factors play an important role in the development of obesity, obesity has significant economic consequences for affected regions. The economic costs of obesity can be divided into three categories: direct costs, indirect costs, and intangible costs (Lobstein et al., 2004). Direct costs of obesity refer to healthcare costs, and are estimated to account for 2%–7% of health care spending in developed nations (Wang et al., 2004). In 2001, the total direct costs associated with all obesity in Canada were 1.6 billion dollars (Katzmarzyk and Janssen, 2004). The proportion of these costs attributable to childhood obesity is not known; however, Wang and Dietz (2002) estimate that US health care spending for childhood obesity in the late 1990s was 127 million dollars, amounting to 1.7% of annual hospital costs.

It is difficult to ascertain the total indirect costs of childhood obesity, because the contributions that children make to national economies are variable and difficult to determine (Lobstein et al., 2004). Relevant cost factors may include time off for parents caring for sick children, time off school, additional costs to the education system for special equipment and teaching, unemployment due to early onset obesity, premature death, and others (Lobstein et al., 2004).

The intangible costs of childhood obesity may be virtually impossible to estimate, but may be more personally relevant for the obese child (Lobstein et al., 2004). These costs can range from the cost of commercial weight loss programs, to a lower self-esteem and the resulting impact on school performance and employment prospects (Lobstein et al., 2004).
Adverse health effects of overweight and obesity among children

Obesity in infancy persists through the preschool years (Mei et al., 2003), and children who become obese before the age of 6 are likely to be obese later in childhood (Quattrin et al., 2005). Childhood obesity is also an independent risk factor for adult overweight or obesity (Felton et al., 1998; Whitaker et al., 1998b), with obese children having at least a 25%–50% increased risk of being obese as adults (Guo et al., 2000). The age of onset and severity of childhood overweight is related to its persistence into adulthood (Wen et al., 2007), and the magnitude of the correlation between childhood and adult BMI increases with age (Baker et al., 2007). Early childhood BMI is moderately correlated with adult adiposity (Freedman et al., 2005), and overweight 2- to 5-year-old children are more than four times as likely to become overweight as adults (Freedman et al., 2005).

Long-term prospective studies have demonstrated eight diseases to be definitively associated with obesity: coronary artery disease, stroke, hypertension, colon cancer, postmenopausal breast cancer, type 2 diabetes, gall bladder disease, and osteoarthritis (Katzmarzyk and Janssen, 2004). Although clinical evidence of disease is often absent in children, traditional and non-traditional risk factors emerge early in the course of obesity and establish a pervasive environment for the development of premature health problems including pulmonary, orthopaedic, gastroenterologic, neurologic, cardiovascular, and endocrine conditions (Lobstein et al., 2004; Dietz, 1998; Visser et al., 2001; Kelly et al., 2004; Balagopal et al., 2005; Monzavi et al., 2006). Overweight children are more likely than non-overweight children to exhibit risk factors for chronic disease such as hyperlipidemia, low HDL cholesterol, hypertension, and hyperinsulinemia (Morrison et al., 1999a, Morrison et al., 1999b, Freedman et al., 1999, Chu et al., 1998; Csabi et al., 2000). Obese children may exhibit multiple risk factors for disease, particularly if they have been obese for a longer period of time (Csabi et al., 2000). Risk factors for chronic disease have been observed in children as young as 5 years of age (Young-Hyman and Schlundt, 2001), and may persist from childhood into adulthood (Lobstein et al., 2004).

Risk factors are distinct from clinical disease, and until recently overt disease was rare among children (Lobstein et al., 2004). The physical consequences of childhood obesity are, however, increasingly leading to overt disease in childhood (Lobstein et al., 2004). Previously seen only in adults, type 2 diabetes has emerged among children as a direct consequence of rising obesity rates (Lobstein et al., 2004), and has been observed in children as young as 4 years of age (Fagot-Campagna et al., 2000). Diabetes among children increases the risk of early adulthood macro- and microvascular complications (Lobstein et al., 2004; Ebbeling and Ludwig, 2001). The metabolic syndrome is also apparent among children and adolescents, and worsens with increasing obesity regardless of age, sex or pubertal status (Csabi et al., 2000; Weiss et al., 2004). The majority of obesity-related adverse health consequences do not affect children, however, and usually manifest at older ages (Wang et al., 2007). Adults who were obese as children may have an elevated risk for subsequent morbidity and mortality, independent of their adult weight (Baker et al., 2007; Must et al., 1992; Gunnell et al., 1998; Styne, 2001); however, it is not clear whether this relationship holds true for obesity during early childhood (Lawlor and Leon, 2005; Taylor et al., 2005). The adult BMI level remains the most important correlate of chronic disease risk (Freedman et al., 2005). The development of chronic disease may therefore be a long process that originates in childhood (Csabi et al., 2000).
Beyond its adverse effects on the physical health of children, the most immediate consequences of childhood obesity may be in terms of adverse social and psychological health (Lobstein et al., 2004). Many of the negative psychosocial consequences of adult obesity are well known (Kushner and Foster, 2000; Sullivan et al., 1993; Doll et al., 2000); however, the effects of pediatric obesity on emotional and social well-being are not well characterized (Friedlander et al., 2003). Peer rejection, decreased self-esteem, body dissatisfaction and a desire to lose weight, depression and attempted suicide, unhealthy eating behaviours, and many other factors have all been studied with respect to their relationship to childhood obesity, with conflicting results (Lobstein et al., 2004). Furthermore, although health-related quality of life is assumed to be lower among obese children, it is not clear whether it is a cause or a consequence of obesity, and should be taken into account (Lobstein et al., 2004). Balagopal (2006) has suggested that the adverse psychological and mental consequences of obesity may exacerbate its negative physical consequences, accelerating the progression to diabetes and/or cardiovascular disease in obese children. The psychosocial complications of overweight and obesity among infants and toddlers have not been studied.

Change in landscape
The increased prevalence of obesity is widely regarded as an epidemic that threatens to ruin the physical and economic health of North America. If current upward trends continue linearly, the proportion of overweight and obese school-aged children in the Americas will grow to more than 46% by 2010, as the current generation of preschoolers enters school (Wang and Lobstein, 2006). Smaller, but significant, proportions of school-aged children will be overweight and obese in other nations, including 41% of children in the Eastern Mediterranean region, 38% in Europe, 27% in the Western Pacific region, and 22% in South East Asia (Wang and Lobstein, 2006). Overall, one in seven children in the Americas will be obese, as will one in ten children in the Eastern Mediterranean and Europe (Wang and Lobstein, 2006).

Although childhood obesity puts children at significant risk for many health problems, scientists suggest that the greatest health problems will be seen as the present generation of overweight and obese children becomes the next generation of adults (Lobstein et al., 2004). Up to 33% of adult obesity may have its origins in childhood obesity (Power et al., 1997a; Serdula et al., 1993). Insofar as childhood obesity persists into adulthood, higher rates of obesity-related disease are predicted to emerge in younger adults, who may require access to specialized healthcare throughout their remaining lifetimes (Lobstein et al., 2004). The consequences will be evident in rapid escalation of healthcare spending, significant losses to society, and a greater health burden for individuals (Lobstein et al., 2004). The projected impact of childhood obesity on the prevalence of chronic disease carries significant implications for the sustainability of [Canada’s] healthcare system (Flynn et al., 2006). Investments in childhood obesity prevention programs are likely to be quantitatively small compared to the accumulated costs associated with treating and managing obese individuals.

These projections of greater childhood obesity may be tempered by recent evidence demonstrating that for the first time in 25 years, adult obesity rates in the US did not increase between 2003 and 2004 and between 2005 and 2006 (National Center for Health Statistics, 2007). The reasons for this plateau are not known; however, they may portend a similar leveling off in
the pediatric population, although this is speculation. It is not known whether obesity rates in Canada have plateaued, or whether they continue to increase.

C. Lifestyle-associated behaviours of young children

Optimal diets for young children

The Dietary Reference Intakes (DRIs) are a comprehensive set of reference values for nutrient intakes for healthy North Americans (Institute of Medicine [IOM], 2002). Determined from the best available scientific data, the DRIs prescribe recommended intakes for energy, macronutrients, and micronutrients for individuals in all age and gender groups. Whereas previous guidelines emphasized the prevention of disorders caused by short-term nutrient deficiencies, the DRIs emphasize the importance of early nutrition for long-term health and the prevention of chronic disease (Morgan, 2005). Children whose diets contain recommended levels of nutrients as specified in the DRI reports are likely to have a reduced risk of diet-related adverse health outcomes (IOM, 2002).

The appropriateness of energy intake in children can be assessed based on growth in weight and length at a rate that is consistent with positive health outcomes during infancy and later in life (Uauy et al., 2006). For infants and children, the total energy requirement is the sum of the total energy expenditure plus the energy stored as growth (Uauy et al., 2006). Total energy expenditure represents the sum of basal metabolism, the thermic effect of feeding, thermoregulation, and physical activity (Uauy et al., 2006). The IOM (2002) has developed prediction equations for total energy expenditure for each age and gender group. A single equation based only on weight was found to predict total energy expenditure among children 0–2 years of age, to which an additional allowance for growth was added (IOM, 2002). Separate equations were developed for children aged 3–8 years based on sex, age, weight, and height (IOM, 2002).

During the first 6 months of life, the average nutrient intakes of full-term, exclusively breastfed infants born to healthy mothers are assumed to be optimal, and were the standard from which the IOM developed recommended nutrient intakes (IOM, 2002). A healthy diet from 0 to 6 months of age is therefore one in which the infant is exclusively fed breast milk, with the inclusion of a vitamin D supplement until the infant obtains 10 µg (400 IU) of vitamin D from dietary sources, or until 1 year of age (Health Canada, 2005; WHO, 2001). Water, breast milk substitutes, other liquids, and solid foods should not be included before 6 months (WHO, 2001).

From 6 to 24 months, infants transition from an exclusive breast milk or formula-based diet, to one that includes a variety of foods. Health Canada (2005) recommends breastfeeding for up to 2 years and beyond, with the introduction of nutrient-rich complementary solid foods at 6 months. High nutrition needs for growth and development necessitate the adoption of a nutrient-dense diet during this period of rapid dietary change (Picciano et al., 2000). Health Canada (2005) has recently updated its recommendations regarding the introduction of solid foods to young children, and recommends iron-containing foods, and others found in Canada’s Food Guide as children are developmentally ready. Although suggested portion sizes exist (Health Canada, 2007a; Fox et al., 2006b), evidence indicates that infants and young toddlers are able to self-regulate their energy intake to match their energy needs (Fox et al., 2006c). Intakes of several key nutrients may, however, be low (Picciano et al., 2000; Fox et al., 2004).
Health Canada has translated the DRIs into a healthy eating pattern for Canadians aged 2 years or older. “Eating Well with Canada’s Food Guide” (Health Canada, 2007a) provides a suggested number and portion size of daily servings from each of four food groups: vegetables and fruit, grain products, milk and alternatives, and meat and alternatives, and suggests an additional small amount of unsaturated fat daily. Children who follow the recommended eating pattern are more likely to meet their nutrient requirements, achieve overall health and vitality, and lower their risk of chronic disease (Health Canada, 2007a). In addition to quantitative recommendations, Health Canada suggests that healthy eating for children includes eating small amounts of food throughout the day, eating on a regular schedule in familiar surroundings, and eating according to physiological cues of hunger and satiety (Health Canada, 2007a).

Dietary patterns of young children
The Canadian Community Health Survey (CCHS) is the first large-scale Canadian nutrition survey to characterize the diets of children under the age of 5. For this reason, it is not possible to ascertain how changes in the consumption patterns of young Canadian children may have contributed to the current obesity crisis. The energy intake of Canadian children in the 2004 CCHS averaged 1,475 kcal/day for 1–3 year olds and 1,894 kcal/day for 4–8 year olds (Health Canada, 2007b). While almost all children were consuming appropriate quantities of carbohydrate and protein, 47% of 1–3 year olds derived fewer than 30% of their calories from fat (Acceptable Macronutrient Distribution Range, AMDR, is 30%–40% of kcal) (Health Canada, 2007b), and up to 7% of 4–8 year olds exceeded the upper limit of the AMDR for fat (AMDR is 25%–35% of kcal) (Health Canada, 2007b). The food consumption patterns of 4–8 year olds outlined in the CCHS (data for the 1- to 3-year-old age grouping have not been released) suggest that dietary patterns linked to an increased risk for obesity were prevalent among young children. Notably, 71% of 4- to 8-year-old children did not meet the recommended daily minimum number of servings of vegetables and fruit, 37% did not consume 2 servings of milk products daily, and 27% did not consume sufficient grain products in a day (Garriguet, 2004). Children who consumed fewer than 5 vegetables and fruit daily were significantly more likely to be overweight or obese (Shields, 2004). Just over one quarter (26.8%) of the total daily calories of 4–8 year olds were ingested between regular meals, of which the majority was supplied by nutrient-poor, high fat/sugar foods (Garriguet, 2004). These snacks supplied more calories than were consumed at breakfast (18%) and lunch (25.6%) (Garriguet, 2004). Nearly one fifth of 4–8 year olds had eaten in a fast food outlet on the day before the survey (Garriguet, 2004).

Dietary survey data in children 4–24 months of age collected for the Feeding Infants and Toddlers Study (FITS) in the US showed that infant formula, breast milk, and cows milk are the main sources of energy and most nutrients for infants and toddlers (Fox et al., 2004). Although the American Academy of Pediatrics (AAP) recommends avoidance of cows milk before 1 year of age (AAP, 1992), appreciable amounts of cows milk were evident in the diets of infants 9–11 months of age, as 20.3% were already consuming cows milk (Fox et al., 2004). Other fluids such as fruit juices and drinks were major sources of energy for toddlers, while fortified foods were an important source of essential nutrients for both infants and toddlers, suggesting an over-reliance on fortified foods rather than naturally nutrient-rich whole foods (Fox et al., 2004). In support of this hypothesis, 18%–33% of infants and toddlers consumed no distinct fruit and
vegetables during a day (Fox et al., 2004). Indeed, by 15 months, french fries were the most common vegetable in children’s diets (Fox et al., 2004). Few infants under 9 months were fed plain meats of any kind (Fox et al., 2004). There was no shortage of desserts, sweets and sweetened beverages in the diets of infants and toddlers, however. Most children older than 8 months consumed at least one serving daily, and by 19–24 months almost all children (91%) were consuming these foods (Fox et al., 2004). Nearly half of toddlers consumed at least one meal or snack away from home (any location excluding daycare) on any given day (Ziegler et al., 2006), which is a concern because 35% of away-from-home lunches included french fries, and 30% included sugar-sweetened beverages (Ziegler et al., 2006). Overall, lunches consumed away from home had a lower nutrient density, and were higher in trans fats compared to home and daycare lunches (Ziegler et al., 2006). These data demonstrate that infants and toddlers are being fed the same foods as the rest of the family (Fox et al., 2004), despite their substantial need for nutrient-dense foods to support rapid growth and development. Dietary patterns commonly exhibited in older children and adult populations were evident as early as 9–11 months of age (Fox et al., 2004).

In the US, the total daily fibre intake of 2- to 5-year-old children declined significantly between 1977-78 and 1987-88 (Saldanha, 1995). Up to 60% of children in 1987-88 failed to meet minimum fibre recommendations at the time, which were substantially lower than current recommendations of 19–25 g (Saldanha, 1995; IOM, 2002). More recently, fibre intake at snacks and lunches was consistently low in the FITS because of limited intakes of fruit, vegetables, and whole grains (Ziegler et al., 2006).

The beverage intake of preschool-aged Canadian children has not been evaluated, and can therefore only be inferred from US sources. US data suggest that milk consumption has declined and fruit juice intake has risen among young children (Dennison, 1996). Although milk was the most commonly consumed beverage among preschool-aged children sampled in NHANES 1999-2002, the average intake fell short of the recommended intake, amounting to only 1.5 servings daily (O’Connor et al., 2006). Fruit juices, drinks, and sodas were consumed by 48%, 44%, and 39% of preschool-aged children, respectively (O’Connor et al., 2006). Indeed, fruit juice accounts for one third of all vegetables and fruit consumed by preschoolers (Dennison, 1996), and intakes above 12 oz/day have been associated with a higher BMI among preschool-aged children (Dennison et al., 1997).

Sugar-sweetened beverage consumption, defined as regular soft drinks and fruit drinks, has increased among preschool-aged children (Nielsen and Popkin, 2004). These beverages may displace more healthful foods and beverages such as milk (Marshall et al., 2005), and may increase the risk of overweight (Troiano et al., 2000; Dubois et al., 2007). The 1998-2002 Longitudinal Study of Child Development in Quebec revealed that 14%–16% of children aged 2.5–4.5 years consumed regular soda or fruit drinks between meals every day, while only 31% avoided these beverages entirely (Dubois et al., 2007). Thirty nine percent of 2–5 year olds consumed soda the day before the NHANES 1999-2002 survey (O’Connor et al., 2006). As children age they appear to consume more of these sugar-sweetened beverages, fuelling concerns that these unhealthy beverage patterns learned in childhood may persist in later years (Dubois et al., 2007). Indeed, intake of sugar-sweetened beverages nearly doubles from 2 to 6 years of age (Skinner and Carruth, 2001), such that 12% of US preschool-aged children drink at least 9 oz of
soft drinks daily (Harnack et al., 1999). Recent analysis of NHANES data, however, suggests that BMI among 2- to 5-year-old children does not show a statistically significant increase on the basis of the quantity of milk, fruit juice, fruit drinks or soft drinks consumed (O’Connor et al., 2006).

Many children under the age of 6 spend a considerable amount of time in childcare facilities; however, little is known regarding the dietary patterns of Canadian children in childcare. There are no national nutrition guidelines for Canadian childcare facilities, whereas in the US, meals and snacks must coincide with federal guidelines (ADA, 2005; Fox et al., 1997). Despite the US guidelines, however, more than 25% of federally funded daycares in the US do not provide the recommended minimum number of daily servings of fruits and vegetables (Fox et al., 2006a, 2006b). French fries and baked potatoes are the most common vegetables provided in US daycares, while sweetened beverages represent the major source of fruit (Ziegler et al., 2006). Overall, children in childcare consistently fail to meet food pyramid recommendations for grains and vegetables (Bruening et al., 1999; Padget and Briley, 2005; Oakley et al., 1995). Some American childcare facilities do not appear to provide sufficient nutritious foods to children, and may even promote dietary patterns associated with obesity, indicating a need to revise and/or enforce national nutrition guidelines.

Tracking refers to the likelihood that an individual will maintain their relative rank for a given measurement within an age–sex group over time (Janz et al., 2000). Some aspects of younger children’s eating patterns have been shown to track over periods of up to 6 years (Skinner et al., 2002; Singer et al., 1995; Wang et al., 2002; Stein et al., 1991; Resnicow et al., 1998). In particular, tracking of food preferences, snacking patterns, macronutrient intakes, and fruit and vegetable consumption is evident among young children (Skinner et al., 2002; Singer et al., 1995; Wang et al., 2002; Stein et al., 1991; Resnicow et al., 1998; Nicklas et al., 1991), and limited data suggest the same may be true for micronutrients (Stein et al., 1991; Singer et al., 1995; Mannino et al., 2004). Diet quality typically declines from early childhood through to adolescence (Lytle et al., 2000; Mannino et al., 2004), as older children are less likely to consume breakfast, fruit, vegetables, and dairy products, and are substantially more likely to consume soft drinks (Lytle et al., 2000; Mannino et al., 2004). Deficiencies in the diets of young children may therefore persist and worsen over time.

**Optimal physical activity for young children**

Physical activity is the only component of energy expenditure that can be modified by the individual, and may account for 15%–65% of expenditure across different activity levels (Maffeis and Castellani, 2007). Physical activity includes both programmed exercise and the energy required to perform the activities of daily living, known as NEAT (non-exercise activity thermogenesis) (Maffeis and Castellani, 2007).

Physical activity during childhood can be depicted as a continuum. Young children begin by learning basic movement patterns that are progressively integrated into more specialized and complex movement skills as neuromuscular control develops (Strong et al., 2005). The opportunity to engage in a wide range of movement experiences should be encouraged and reinforced from birth, as opportunities to play foster the development of more complex skills, whereas sedentary behaviours can be reinforcing (Hills et al., 2007). Limited data suggest that as
little as 60 additional minutes of physical activity per week may improve bone properties, motor skills, and aerobic fitness in young children (Timmons et al., 2007).

As children mature, the emphasis on general physical activity and motor skills declines, and the importance of prescriptive physical activity emphasizing health, fitness and behavioural outcomes increases (Strong et al., 2005). Young children should not be viewed as miniature adults, however; the intensity, duration, frequency, and mode of physical activity recommended for adults is not appropriate for young children (NASPE, 2002). Whereas physical activity guidelines for adults are based on preventing chronic disease and unhealthy weight gain, the outcomes of physical activity for young children centre on enjoyment of movement, developing motor skill confidence and competence, and establishing the foundation for a future active lifestyle (NASPE, 2002).

A firm evidence base does not exist from which to develop physical activity guidelines for children (Rennie et al., 2006). Although it is generally agreed that physical activity is important for children, it is difficult to demonstrate a health benefit because most of the negative health outcomes of inactivity are not commonly found in children (Hills et al., 2007), and the amount of play needed for optimal motor skill development has not yet been identified (Timmons et al., 2007). Limited data from studies in children, combined with extrapolation of evidence in adults, has been used as the basis for recommendations that all children engage in at least 60 minutes of moderate intensity activity daily. There are even fewer data regarding the optimal amount and nature of physical activity for the unique subgroup of children under the age of 6, and it is often assumed that young children are sufficiently active (Timmons et al., 2007). The playful nature of young children’s physical activity, and the health and developmentally important reasons for being active are distinct in this age group for reasons previously described, and therefore separate guidelines are needed for younger children.

Canadian and American governments have not developed physical activity guidelines for young children. Canada’s Physical Activity Guide for Children is intended for 6–9 year olds (Janssen, 2007), and recommends that children dedicate progressively more time to physical activity, and less time to sedentary activity over a 5-month period (Health Canada, 2002). Specifically, children are advised to increase the daily time spent in moderate physical activity in increments of 20–60 minutes, and in vigorous activity in progressions of 10–30 minutes, while decreasing the time spent in sedentary pursuits by 30–90 minutes/day (Health Canada, 2002). Endurance, flexibility and strength activities are all suggested, and can be accumulated in bouts of as little as 10 minutes. The Health Canada recommendations are unique and do not specify the minimum number of minutes that children should be physically active each day, as do the IOM (2002) and the USDA (2005), which both recommend 60 minutes of moderate intensity daily activity for children.

The National Association for Sport and Physical Education (NASPE, 2002) is the only national body in North America that has developed physical activity recommendations specific to infants, toddlers and preschoolers. The NASPE guidelines were based on limited research data, theories and principles of infant and child development, and theories, principles, and acceptable practices of daily physical activity (NASPE, 2002). The five guidelines for infants emphasize allowing them to explore their surroundings, develop movement skills, and use large muscle groups in a
safe environment (NASPE, 2002). Toddlers are advised to accumulate at least 30 minutes of structured physical activity daily, and preschooilers 60 minutes (NASPE, 2002). Both groups should ideally accumulate a minimum of 60 minutes of unstructured physical activity, while avoiding periods of inactivity longer than 60 minutes (NASPE, 2002). Toddlers and preschoolers should also have safe play areas where they can focus on using large muscle groups and develop movement skills that are building blocks for more complex movement tasks (NASPE, 2002). Some Canadian bodies, including Alberta Health and Wellness (Healthy U Alberta, 2006), have adopted the NASPE recommendations.

In addition to promoting physical activity among children, it is equally important to limit sedentary activities beginning in the preschool years (Strong et al., 2005). In this regard, the American Academy of Pediatrics (1999, 2001) recommends that children 2 years or older spend no more than 2 hours with entertainment media daily, and that children under the age of 2 watch no television (TV).

**Physical activity patterns of young children**

Children’s movements tend to be sporadic, varied, and multi-dimensional (Rennie et al., 2006), and are perhaps most appropriately described as “play” (Timmons et al., 2007). These characteristics make it extremely difficult to objectively quantify the physical activity patterns of young children. Quantification of physical activity levels on the basis of self-reported data is equally problematic, as children are unable to accurately recall their activities and time spent in these activities (Rennie et al., 2006). Because of these limitations and the significant inter-individual variability in children’s activity levels (Timmons et al., 2007), there are no nationally representative data describing the physical activity levels of young children (Rennie et al., 2006).

Children appear to engage in very brief bouts of movement of varying intensity, and do not spend much time in vigorous activity (Danner et al., 1991; Pate et al., 2004; Benham-Deal, 2005). A longitudinal study of infants found that the PAL (physical activity level, which is an index of physical activity defined as the total energy expenditure divided by basal energy expenditure) increases significantly during the first 2 years of life, from 1.2 at 3 months to 1.4 at 24 months (Butte et al., 2000). These PAL levels are consistent with a sedentary lifestyle (IOM, 2002). Similarly, in their review of the activity levels of children, Molnar and Livingstone (2000) reported average PAL values of 1.29–1.44 among 1.5–5 year olds. Torun et al. (1996) documented slightly higher mean PALs of 1.4–1.5 in children under 5, as did Reilly et al. (2004) where the PAL averaged 1.56 at age 3 and 1.61 at age 5 among Scottish children. Three-year-old children spent 79% of monitored hours in sedentary behaviours, while only 2% were spent in moderate to vigorous activity (Reilly et al., 2004). Two years later at the age of 5, the median values were virtually unchanged at 76% and 4%, respectively (Reilly et al., 2004). These data suggest that young children are more commonly involved in light to moderate intensity activities, and place young children in the sedentary to low active category.

Whether a reduction in physical activity has contributed to the current epidemic of obesity among young children is not clear. In 1996-97 Davies et al. concluded that the total energy expended by children aged 9 months to 6 years was approximately 20% lower than WHO (FAO/WHO/UNU, 1985) recommendations at the time (Davies, 1996; Davies et al., 1997). It has since become clear, however, that the 1985 WHO recommended energy intakes were too high,
and the energy expenditure of infants in the aforementioned studies was actually very similar to current recommendations by the IOM (2002). These limited data suggest that children may have been sufficiently active a decade ago; however, more current data are not available for comparison.

An increase in sedentary behaviours among young children may be contributing to the increase in obesity. Sedentary behaviours such as TV viewing can compete with physical activity, thereby lowering energy expenditure (Taras et al., 1989; Buchowski and Sun, 1996; DuRant et al. 1994). A link between time spent watching TV and obesity has been documented in preschool-aged children (Dennison et al., 2002); however, this association is not conclusive (DuRant et al., 1994). The benefit from reduced TV viewing depends upon how children reallocate their time, as they may choose to be more physically active, or to engage in other sedentary behaviours (Epstein et al., 1991, 1995a, 1995b). Furthermore, the relationship between TV viewing and obesity may be mediated by factors other than energy expenditure such as concurrent consumption of energy-dense snacks (Fox, 2004a), increased consumption of advertised foods (Borzekowski and Robinson, 2001), or inattention to satiety cues (Epstein et al., 1992, 1997; Temple et al., 2007).

Data from the US National Longitudinal Survey of Youth conducted from 1990 to 1998 revealed that 17% of 0- to 11-month-old, 48% of 12- to 23-month-old, and 79% of 24- to 35-month-old children watched 1 or more hours of TV daily (Certain and Kahn, 2002). Furthermore, 7%, 22%, and 41% of children in each of these age groups watched 3 or more hours of TV daily (Certain and Kahn, 2002). The children in this study watched slightly more TV than children in a national cross-sectional study in which 1 year olds averaged 6 hours, and 3 year olds 13 hours of TV per week (Hofferth, 1998). Low-income children may watch even more TV, averaging 14.9, 16.3, and 18.4 hours/week for 2, 3 and 4 year olds, respectively (Dennison et al., 2002). Overall, daily TV viewing increases by approximately 1 hour/year for the first 3 years of life, and then remains relatively constant around a mean of 3–4 hours/day until the age of 7 (Certain and Kahn, 2002). In comparison to earlier data reporting average TV viewing times of 14 hours/week among 3–10 year olds (Bernard-Bonnin et al., 1991), these data suggest that sedentary behaviours may be more prevalent among young children today than in past decades; however, the data in young children are extremely limited (Certain and Kahn, 2002).

Given the absence of objective data demonstrating a reduction in young children’s physical activity levels or an increase in sedentary behaviours, claims that children are becoming less active can only be inferred from indirect evidence such as more TVs per household, less time devoted to physical activity in schools, and increased car use (Fox, 2004a). American data suggest that the energy intakes of 2- to 5-year-old children changed very little between the early 1970s and the early 1990s, and on this basis some have inferred that a decline in the energy expended in the form of physical activity must have contributed to the current epidemic of overweight and obesity (Troiano et al., 2000). These types of data have limited value and cannot establish causality. Furthermore, there is no standard for comparison, as the level of activity needed to maintain health and prevent obesity among young children is not known. The increased prevalence of obesity, however, suggests that the activity levels of children at the population level have not been sufficient to prevent a rise in obesity (Fox, 2004a), and hence may be suboptimal.
Physical activity patterns are established during the early childhood years (Birch and Fisher, 1998) and may track during early childhood (Pate et al., 1996), from late childhood to adolescence (Janz et al., 2000), and from early childhood to adulthood (Dennison et al., 1988; Powell and Dysinger, 1987; Sallis et al., 1992; NASPE, 2002), declining progressively with age (Janz et al., 2005). Contrary evidence, however, indicates that physical activity is a complex, unstable trait (Malina, 1996), determined by conditions or characteristics unique to the individual (Taylor et al., 1999). Sedentary behaviours may track to later ages, as children who watched more TV in early childhood also watched more TV at school age (Certain and Kahn, 2002). Child preferences for TV viewing developed at an early age may therefore interact with environmental influences to further increase TV viewing at older ages (Certain and Kahn, 2002).

D. Genetic contributions to obesity among young children

Although it is unlikely that the rise in obesity is due to genetic changes in the population, the development and severity of obesity in genetically predisposed individuals is exacerbated by obesity-prone lifestyles and environmental conditions (Maffeis and Castellani, 2007). The obese phenotype has been associated with more than 430 genes, markers and chromosome regions, and may be responsible for more than 50% of the inter-individual variations in BMI (Snyder et al., 2004). Genetic effects on BMI increase during early childhood, from 24% at birth, to 55% at 1 year of age, and 59% at 2 years of age (van Dommelen et al., 2004).

Twin studies suggest that most non-genetic influences on obesity risk arise from non-shared environmental influences, and not from the shared family context (Wardle et al., 2008). The shared-environment impact on obesity risk is estimated at just over 10% (Wardle et al., 2008). According to this line of evidence, excessive weight gain among children is more likely to be the result of the child’s inherited susceptibility to the obesity-promoting aspects of the environment, rather than as the consequence of parental action or inaction (Wardle et al., 2008). Control over 10% of the variance in an important health risk factor is significant, however, and therefore modifications to the home environment may help to protect children who are vulnerable to obesity (Wardle et al., 2008).

Although genetic factors clearly play a substantial role in obesity, as a non-modifiable risk factor they will not be discussed further. The reader is encouraged to consult Lobstein et al. (2004) for a review of this topic.
II. Prevention of Obesity Among Young Children

A. Role of lifestyle factors in obesity prevention in young children

It is estimated that approximately 50% of children have “obesity susceptibility genes” on which environmental changes have acted in the past 25 years (Koplan and Dietz, 1999). Thus, it appears somewhat unrealistic to expect significant reductions in obesity from individual behaviour change strategies. It has become widely accepted that to reverse the upward trends in obesity rates, multi-level strategies are required that reach beyond the individual to the family and the community, on a local, national and global level. These types of strategies are needed for every age group throughout the lifespan. Following is a summary of the limited data that exist with respect to the role of lifestyle factors in preventing obesity in young children.

Diet

Despite the increased interest in the role that diet plays in the development of obesity, information in young children is currently limited, perhaps due to the difficulty in obtaining accurate dietary intake data in this age group. Much of the available evidence is focused on the impact of the amount and quality of dietary fat, particularly for the reduction of cardiovascular disease risk, along with weight change. Predictors of weight gain and/or overweight or obesity in young children have been identified in several observational studies. Klesges et al. (1995) followed a group of preschool-aged children (n=145) over 3 years to investigate predictors of weight gain. Two dietary variables were significant in the analysis: a higher baseline percentage of kilocalories from fat predicted a greater weight gain (baseline mean values were 33 ± 5%), while a decrease in the percentage of kilocalories from fat predicted a reduction in BMI over time. In a study of 4,370 German children (5–6 years of age), data from obligatory school entry health examinations showed increased meal frequency was associated with reduced overweight and obesity (Toschke et al., 2005). It was suggested that greater meal frequency led to a modulation of insulin response and a sustained thermogenesis throughout the day (Toschke et al., 2005). Finally, a French study investigated portion sizes of different types of foods consumed by 748 children aged 3–11 years (Lioret et al., 2007). Portion sizes of croissant-like pastries and sweet pastries were positively correlated to overweight in 3- to 6-year-old children (Lioret et al., 2007).

Sample interventions

Nutrition Education Aimed at Toddlers was an intervention comprised of four nutrition lessons and reinforcing activities over 6 months for low income families (Horodynski and Stommel, 2005). Parent–toddler pairs were divided into treatment (n=43) and control (n=53) groups for comparison (Horodynski and Stommel, 2005). Although the intervention resulted in higher knowledge scores, child and parent mealtime behaviours were not different between the treatment and control groups (Horodynski and Stommel, 2005).

The Healthy Start Project was designed to lower cardiovascular risk in preschool-aged children via reduced intake of total and saturated fat (Williams et al., 2004). This dietary approach was effective in reducing serum cholesterol in the study population as a whole, and specifically in “at risk” children (Williams et al., 2004).
The STRIP (Special Turku Coronary Risk Factor Intervention Project) baby study of Finland was a prospective randomized trial that evaluated the efficacy of a low saturated fat, low cholesterol diet for children from 7 months to 3 years of age (Niinikoski et al., 1996). Intervention families (n=540) received extensive nutrition and health counseling on 10 occasions, and blood lipids were measured at 7, 13, 24, and 36 months. Dietary fat intakes of 30%–35% of energy and a 1:1:1 ratio of saturated, monounsaturated, and polyunsaturated fat were targeted for the children. Children in the control group (n=522) were seen for blood lipid determination, and on two other occasions received general health advice. The intervention group of children did not achieve the goal polyunsaturated to saturated (P:S) fat ratio of 1:1, although their P:S ratios were consistently higher than controls. A 3%–6% reduction in serum cholesterol concentrations persisted in the intervention group up to 3 years of age, although the effect was only significant in boys. If sustained, reductions of this magnitude could have a marked effect on the incidence of coronary heart disease in adulthood. Notably, infant growth was carefully monitored and was not adversely affected by the intervention (Niinikoski et al., 1996). This is an important finding, as this concern is often raised when fat restriction for infants and toddlers is contemplated.

Infants in the STRIP baby study were followed and received counseling (targeted nutrition guidance versus general health) bi-annually for 10 years. After 5 years, 202 children were randomly selected for an assessment of diet (4-day food records) and serum lipids levels (Salo et al., 1999). The intervention group (n=109) had lower intakes of saturated fat (% kcal) and a higher P:S ratio compared to control (n=99) children. Total serum cholesterol and LDL cholesterol were also lower in the intervention group. As per the previous study (Niinikoski et al., 1996), the lower cholesterol effect was mainly due to differences between boys. This suggests a sustained effect of the targeted counseling on some lipid levels.

After 7 years, another sub-group of families (n=98 intervention, n=89 control) from the STRIP trial were evaluated to assess the impact of child-targeted nutrition counseling delivered to the parents over a 6.5-year period (Rasanen et al., 2003). Compared to controls, the parents who received counseling had greater knowledge of the relationship between food choices and coronary heart disease, and of the nutritional composition of foods. These parents also consumed higher quality fats and less salt overall than parents in the control group. The authors inferred that these parents may consequently provide better nutritional advice or choices for their children (Rasanen et al., 2003). Child-targeted nutrition intervention delivered to the parents improved parental nutrition knowledge and diet quality. Parental nutrition knowledge was, however, only weakly correlated with dietary intake, suggesting that factors other than knowledge influence parental dietary selection.

The prevalence of overweight was evaluated after 10 years among the remaining 585 children in the STRIP baby cohort (Hakanen et al., 2006). The dropout rates and growth patterns were not different between groups. Overweight was defined as >20% above the mean of the healthy Finnish population for age and sex. Girls in the intervention group had a lower prevalence of overweight (10.2%) compared to controls (18.8%), with no differences between boys in either group (11.6% vs 12.1%, respectively). Three intervention children and 14 control children were obese at some age during the follow-up period. The prevalence of overweight and obesity would have been higher if the IOTF or the CDC growth charts were used for analysis. The reasons for the differences between genders are not known.
Results from the STRIP baby study suggest that targeted nutrition interventions for preschool-aged children and their parents can improve nutrition knowledge and dietary behaviours of parents, and can improve dietary fat quality, lower lipid levels (mainly boys) and reduce overweight (mainly girls) among young children.

**Physical activity**

Indirect evidence from countries where the use of active modes of transportation is common suggests that children in nations with a culture of physical activity are less likely to be obese (Fox, 2004a); however, there is surprisingly little evidence that increased physical activity controls adiposity among young children (Timmons et al., 2007). Of 17 studies reviewed by Hawkins and Law (2006), 7 reported an inverse relationship between physical activity and body fatness, 8 reported that physical activity and body fatness were unrelated, and 1 found evidence of a direct relationship. Goran et al. (1997) found that only 10% of the variance in body fat mass in 5- to 6-year-old children was explained by recreational activity assessed via a structured activity questionnaire (Kriska et al., 1990). Klesges et al. (1995), on the other hand, reported that higher levels of physical activity were associated with lower BMI in preschool-aged children, and Moore and colleagues (1995) suggested that this effect confers protection against future weight gain. Overweight boys have also been shown to be significantly less active than their non-overweight peers during the preschool day, although the same was not true for girls (Trost et al., 2003). Other data suggest that overweight children find sedentary activities more reinforcing than active pursuits (Epstein and Roemmich, 2001).

In the Framingham Children’s Study, children aged 3–5 years (n=97) were followed until they entered the first grade (Moore et al., 1995). Physical activity was monitored with an electronic motion sensor and body fatness was determined by triceps and subscapular skinfold measures. Active girls gained less in their triceps skinfold (1.0 mm) than inactive girls (1.75 mm), and active boys lost 0.75 mm, whereas inactive boys gained 0.25 mm. In a 3-year follow-up of another cohort of 3- to 4-year-old children (n=149), physical activity (measured by heart rate monitoring and direct observation) and TV viewing (direct observation) were significant predictors of BMI in the third year of measurement (Jago et al., 2005). There was an inverse relationship between BMI and activity and a positive relationship between BMI and TV viewing, and these associations grew stronger over the course of the study. Dietary factors and other sedentary behaviours were not predictive of obesity in this cohort (Jago et al., 2005).

Very little research exists to support the assumption that greater levels of physical activity among preschool children will prevent overweight or significantly improve health outcomes (Timmons et al., 2007). Although the environment and other factors may limit opportunities for children to be physically active, Wilkin et al. (2006) argue that in young children, activity is biologically regulated and the environment plays only a minor role in between-subject variation. These arguments stem from their study of a group of children 4.9±0.3 years of age (n=307) who wore accelerometers for 7 days at baseline, and then again one year later at 5.9 years of age. Even though two thirds of the group walked to school and one-third were driven, the non-walkers compensated for the missed activity such that there were no differences between groups in activity levels over the 7-day period, and that walking represented just 2% of their total weekly activity (Wilkin et al., 2006). Geographic location (children living in Plymouth vs. Glasgow), TV watching, and awake time were also not correlated with activity levels. The authors suggest that
young children may have an “activitystat” similar to the concept of an “appestat” (Wilkin et al., 2006).

Results from an earlier Canadian study (Bernard-Bonnin et al., 1991), reported that children aged 3–10 years watched an average of 14 hours of TV per week. Of the 3–5 year olds (n=170), approximately 13% were watching more than 24 hours per week. Children’s viewing times were higher if they did not attend daycare, and although most programs viewed were children’s programs or cartoons, many preschoolers were watching movies (33%), teleseries (17%) and wrestling (8%). Of the 387 parents surveyed, 51.2% perceived that TV viewing had no influence on eating habits (Bernard-Bonnin et al., 1991).

Although TV viewing is associated with obesity in older children (Robinson, 1999; Gortmaker et al., 1999), it is not clear whether the same is true in preschool-aged children, with some studies reporting no association (Burdette and Whitaker, 2005; DuRant et al., 1994) while others report a positive association (Dennison et al., 2002; Lumeng et al., 2006). If an association does exist, it is likely to be multi-factorial, operating through a combination of reduced physical activity, increased exposure to advertising for unhealthy foods (Lewis and Hill, 1998), and/or a tendency to snack during viewing times (Lumeng et al., 2006). In one study, obesity in 5-year-old Pima Indian children was positively associated with time spent watching TV (Salbe et al., 2002), while another study showed a weak negative correlation between TV viewing and physical activity (but not body composition) in 3- to 4-year-old children (DuRant et al., 1994). Activity during TV-viewing time was significantly lower than activity during non-TV-viewing time among these children (DuRant et al., 1994). Recently, Taveras et al. (2006) found that TV and video viewing was associated with fast food intake in preschool children. This effect may have been related to fast food advertising on TV and/or the fast food messages within the content of the programs (Taveras et al., 2006). Mothers’ perceptions of neighbourhood safety has also been linked to TV viewing, with lower perceived safety associated with increased TV time (Burdette and Whitaker, 2005).

Sample interventions
In a randomized controlled trial in kindergarten children (mean age 4.5 years), an intervention group (n=158) was supervised during a 15-minute walk and 20 minutes of aerobic activity 3 times per week for 30 weeks (Mo-suwan et al., 1998). The prevalence of obesity decreased equally in the intervention and control (n=152) groups during the course of the intervention.

Dennison et al. (2004) introduced a health promotion program in daycare centres and nursery schools to reduce TV viewing by children (~4 years of age) and their parents. The seven-session program led to a reduction in the number of children watching >2 hours/day of TV in the intervention compared to the control group.

Recently, Epstein and colleagues (2008) described a randomized controlled trial designed to reduce screen time by 50% in the intervention group (n=70 children aged 4–7 years). After 2 years, significant reductions in sedentary behaviour, BMI Z-score (a comparison of children’s BMI to their age- and sex-matched peers) and energy intake were observed in the intervention group compared to a monitoring-only control group. Reduced TV viewing was significantly
correlated with the decline in energy intake, but not with changes in physical activity (Epstein et al., 2008).

Reduced TV viewing appears to be a feasible behaviour change strategy among preschool-aged children; however, this does not necessarily translate into increased physical activity.

**Sleep duration**

Short sleep duration is associated with an increased risk of overweight among 3- to 6-year-old children (Kagamimori et al., 1999; Locard et al., 1992; von Kries et al., 2002). Children as young as 2 years old who have reduced sleep time appear to be more susceptible to obesity later in childhood (Reilly et al., 2005; Agras et al., 2004). Chen et al. (2008) confirmed these findings in a recent meta-analysis, concluding that early life shortness of sleep increases the risk of childhood obesity (Chen et al., 2008). The size of the impact of sleep duration on obesity risk in young children is considerable, and similar to other known risk factors for overweight (von Kries et al., 2002). A significant linear dose–response relationship between short sleep duration and obesity in children under 10 years of age is also evident (Chen et al., 2008; Reilly et al., 2005; von Kries et al., 2002; Sekine et al., 2002; Chaput et al., 2006).

Several biologically plausible mechanisms such as changes in hormonal levels (leptin, ghrelin) or metabolism are thought to be the key mediators linking short sleep duration and weight gain (Astrup, 2006). Alternatively, adipocyte function and circadian rhythms may be adversely affected by short sleep (Astrup, 2006). Environmental factors such as stress, pain, and inactivity could also be responsible (Astrup, 2006). Finally, persons who are tired may expend less energy throughout the day, or may simply have more time for eating than those who sleep more (Astrup, 2006). It is not clear whether reduced sleep is a cause or consequence of overweight (von Kries et al., 2002); however, sleep duration may be a modifiable risk factor important for obesity prevention (Chaput et al., 2006; Chen et al., 2008). A combination of earlier bedtime and later wake time may be a low-cost strategy to reduce obesity risk among young children (Chen et al., 2008).

**B. Combined lifestyle approaches**

Researchers and practitioners generally agree that multi-component interventions are likely to be the most efficacious. Toschke et al. (2007) evaluated the theoretical impact of modifying individual risk factors for childhood obesity at the population level (% population attributable risk factor; PARF). They studied 5472 children aged 5–6 years with a group prevalence of overweight and obesity of 11.3% and 3.2%, respectively. Five risk factors accounted for 48.2% of obesity risk in these children: low meal frequency, decreased physical activity, watching more than 1 hour of TV daily, formula feeding and smoking in pregnancy. The authors concluded that modification of these risk factors could lower the overall obesity prevalence to 1.7%, representing a reduction from 176 to 93 obese preschoolers in this sample population. (Toschke et al., 2007).

**Sample multi-component interventions**

Several school-based interventions have been implemented at the preschool level. Eliakim et al. (2007) studied the outcomes of a combined nutrition and physical activity intervention implemented for 14 weeks among 5- to 6-year-old children (intervention group n=54; control
group n=47). Nutrition education was provided to children in the intervention group as part of the weekly preschool curriculum, along with 45 minutes of supervised physical activity per day (circuit training, games). Pre- and post-intervention measurements revealed that the intervention group, compared to controls respectively, showed significant improvements in weight (0.35 kg vs. 0.90 kg gain), BMI percentile (-3.8 vs. +2.9), % body fat (-0.65 vs. +1.64), and fitness (-3.55% vs. +3.16% time required for a 600-m run), and had higher activity levels at post-test (6927 vs. 5489 steps/day registered on pedometers).

An obesity prevention study among preschool-aged Native American children introduced a parenting education program during home visits to provide information and support to 43 mother–child pairs (Harvey-Berino and Rourke, 2003). Mothers (BMI>25) and children (at least one child between the ages of 9 months and 3 years who was walking) were randomized to an intervention (obesity prevention strategies plus parenting support; OPPS) or control group (parenting support; PS) for 16 weeks. The OPPS group children showed a trend (p=0.06) for decreased weight-for-height Z scores and a trend (p=0.06) for decreased energy intake, while the PS group children had non-significant increases in both of these measures. The authors of this pilot study suggested that this strategy showed promise for obesity prevention in this high-risk population. The authors were also able to demonstrate that eating and activity behaviours of preschool Native American children could be adequately measured by 3-day food records completed by the mother, and accelerometers worn by the children (Harvey-Berino et al., 2000; Harvey-Berino and Rourke, 2003).

McGarvey et al. (2004) evaluated the effect of a parent-focused intervention on changes in parent or child eating behaviours within an existing program of the Women, Infants and Children (WIC) Clinics in the US. Women (n=336) with 2- to 4-year-old children were recruited from two WIC clinic areas with a high prevalence of childhood obesity in Virginia. As such, they were considered a higher risk group. One clinic provided the standard WIC nutrition program and visits, while the second (intervention) clinic provided the same number of visits but the educational program was called Fit WIC and included six key messages: (1) increase physical activity, (2) monitor mealtime behaviour, (3) limit household TV viewing, (4) drink water instead of sweetened beverages, (5) consume five fruits or vegetables daily, and (6) increase family activities to promote fitness (McGarvey et al., 2004). After one year, there was a significant change in the Fit WIC group, resulting in an increased frequency of offering their child water (instead of sweetened beverages) and an increased frequency of active play with their child.

A more recent study, also with women recruited through WIC or public health units (n=91), evaluated lifestyle behaviour change in mother–child (1–3 year olds) pairs (Klohe-Lehman et al., 2007). The mothers were recruited for an 8-week weight control program which included a 2-hour class each week of lifestyle and nutrition education and an activity session. Over the 8-week period, this maternal weight control program led to positive changes in children’s diets including reduced energy intakes to acceptable levels (123% to 102% of requirements), and decreases in total and saturated fat, desserts, added fats, sweetened beverages, and fast food consumption. Children also ate more home-prepared meals and had improved physical activity scores. Mothers’ results were comparable and they appeared to be acting as “agents of change” for their children, at least in the short term (Klohe-Lehman et al., 2007).
In 1991 an obesity prevention and management program for preschool children was implemented among Primary Health Care clinics in Singapore (Ray et al., 1994). The program used a variety of means (pamphlets, demonstrations, videos, counseling, education on growth monitoring) to provide information on healthy eating and physical activity during regularly scheduled clinic visits. Children’s growth was routinely monitored from 6 weeks to 5 years of age (over 10 visits). After one year, the prevalence of obesity among 3- to 6-year-old children (n=1,228) decreased significantly. The prevalence of children with severe, moderate and mild obesity decreased from 6.3% to 5.9%, 29.3% to 23.2%, and 64.4% to 50.7%, respectively, with 20.2% of children achieving normal weight status (Ray et al., 1994).

In the Chicago area, twelve predominantly Latino Head Start programs participated in a 2-year obesity prevention trial (Hip Hop to Health) that incorporated both dietary and physical activity strategies (Livingstone et al., 2006). Children aged 3–5 years were recruited for the study. Six programs received the diet–activity intervention (14 weeks at 3 sessions/week) (n=176 children) and six programs received an unrelated general health intervention (n=160 children). The weekly sessions included 20 minutes of nutrition activities and 20 minutes of physical activity. At post-intervention, 1 year and 2 years, there were no differences between groups in the primary outcome (BMI) or secondary outcomes (diet and physical activity variables). Previous versions of this program had helped to reduce BMI in children in African American Head Start programs (Fitzgibbon et al., 2005), suggesting that further “cultural tailoring” of the program may be required for the Latino community (Livingstone et al. 2006).

Finally, O’Brien et al (2007) performed a unique longitudinal analysis of the ecology of childhood overweight in a sample of 960 children followed from 2 to 12 years of age. Three ecological levels were studied: sociocultural, home environment and proximal child experiences. The height and weight of children were measured seven times and the home and family environment was assessed nine times. During the preschool years, maternal sensitivity (assessed by videotaping of mother–child interactions) was lower for overweight children compared to never-overweight children. The authors suggested that maternal sensitivity may be a marker for mothers who engage in activities with their children, eat meals together as a family, and promote a healthful home environment (O’Brien et al., 2007).

While single-strategy interventions have generally not been successful, comprehensive obesity prevention programs that target several behaviours have been shown to promote positive dietary and physical activity behaviours in preschool-aged children over the short and long term, thereby reducing body weight and body fatness. Parents, childcare providers, and preschool teachers are important to the success of interventions instituted among young children. “Do no harm” should be the essential guiding principle underlying behaviour change strategies (Livingstone et al., 2006; Whitaker, 2003).

Appendix 1 summarizes recent literature reviews of obesity prevention strategies in preschool-aged children.
C. Critical periods for obesity prevention in young children

Critical periods refer to periods of development when negative factors (or “insults”) may induce permanent changes in the structure and function of organs and tissues (Daniels et al., 2005; Small et al., 2007). Intrauterine life, infancy and the preschool years may all include critical periods that program the long-term regulation of energy balance (Reilly et al., 2005). Experiences during critical periods that increase the risk for obesity are those that lead to a positive energy balance through excess caloric intake, insufficient physical activity, or metabolic changes that affect energy balance (Agras et al., 2004). Intervention to reduce or eliminate these risk factors may be an important means of reducing the risk for subsequent obesity.

Predictors of obesity in young children

The relative importance of pre- versus postnatal factors to obesity risk remains controversial (Wells et al., 2007), as the predictive value of childhood obesity for adult obesity differs across the spectrum of development. Ells et al. (2005) suggest that intervention during the pre- and early postnatal periods may be most efficacious because of the opportunity to impact obesity-promoting genes and to alter environmental and behavioural stimuli important to future obesity risk. Several studies have followed children during early childhood in an attempt to determine which factors exert the most influence on obesity risk in early life. These studies are summarized below with additional discussion of those factors considered to be important targets for prevention efforts.

In Canada, Dubois and Girard (2006) concluded that maternal smoking during pregnancy, low socioeconomic status, parental overweight, and a high rate of weight gain during the first 5 months of life were the most influential for the risk of overweight at 4.5 years of age. In the United Kingdom, Reilly et al. (2005) offered a longer list of eight factors that increased the likelihood that young children would be obese by age 7; these factors were parental obesity, higher birth weight, early adiposity rebound, increased TV viewing at age 3, catch-up growth in the first 2 years of life, greater weight gain in the first year of life, greater BMI in infancy, and short sleep duration. Similarly, 1- to 5-year-old children living in Greece were more likely to be overweight if they had a high birth weight, were not exclusively breastfed, had mothers who smoked during pregnancy, or had an overweight father (Moschonis et al., 2008). In a much smaller sample of children, Agras et al. (2004) identified parental overweight, low parental concern about their child’s thinness, persistent child tantrums over food, and reduced sleep duration as important familial risk factors for obesity in young children (Agras et al., 2004). Overall, the evidence suggests that prenatal insults including smoking, malnutrition, and maternal diabetes are the most important for future obesity risk, as described in a recent systematic review (Huang et al., 2007).

In utero programming

In utero programming refers to the capacity for fetal conditions to impact postnatal health outcomes (Wells et al., 2007). Suboptimal maternal health creates an unfavorable intrauterine environment that can program adipose tissue mass and distribution (Wells et al., 2007), and may increase the risk of metabolic abnormalities such as obesity, hypertension, and type 2 diabetes in the offspring (Power and Parsons, 2000). Children born to mothers who are over- or undernourished prior to, or during, pregnancy are more likely to be obese during early childhood (Whitaker and Dietz, 1998; Johnson et al., 2006; Li et al., 2005; Whitaker, 2004; AAP, 2003;
Bergmann et al., 2003). This effect may be mediated through maternal glucose intolerance (Gillman et al., 2003; Dabelea and Pettitt, 2001) greater birth weight (Li et al., 2003), shared genetics, or pre- and postnatal environmental factors, although the latter explanation seems most probable (Whitaker et al., 1997; Oken and Gillman, 2003; Whitaker, 2004; Loos et al., 2001; Dubois and Girard, 2006). Importantly, breastfeeding may reduce the risk of overweight among children of overweight or obese mothers (Li et al., 2005). Obesity prevention can therefore begin by encouraging and supporting mothers in maintaining healthy dietary and physical activity behaviours.

Normalizing maternal metabolism through proper glucose control in cases of gestational diabetes appears to be an important target for obesity prevention (Wells, 2007). The intrauterine diabetic environment causes excessive transfer of glucose from mother to fetus (Wells et al., 2007), and is associated with an elevated risk for high birth weight, obesity, impaired glucose tolerance and type 2 diabetes in the offspring (Pettitt et al., 1983, 1988; Dabelea et al., 1998, 2001; Silverman et al., 1995, 1998; Vohr et al., 1999; Rodrigues et al., 1992; Whitaker et al., 1998a). The risk of childhood obesity and glucose intolerance may be up to 10 times higher among children whose mothers have diabetes (Silverman et al., 1998; Pettitt et al., 1987), and is the strongest predictor of obesity among Pima Indian children (Dabelea et al., 2001; Pettitt et al., 1983, 1987). Treatment of gestational diabetes appears to attenuate the risk of childhood obesity substantially, making gestational diabetes a potentially modifiable risk factor for childhood obesity (Hillier et al., 2007).

Smoking during pregnancy has consistently emerged as one of the most important risk factors for childhood obesity at any age (Bergmann et al., 2003; von Kries et al., 2002; Power and Jefferis, 2002; Vik et al., 1996; Montgomery and Ekbom, 2002; Mizutani et al., 2007; Oken et al., 2008), and especially for greater weight gain from birth to 2 years of age (Ong et al., 2000). This increased obesity risk may, in fact, persist until adulthood (Power and Jefferis, 2002; Oken et al., 2008). Maternal smoking may act to increase obesity risk through slowing prenatal growth, with subsequent postnatal catch-up growth (Oken et al., 2008); however, in a recent meta-analysis the increased risk of child overweight associated with smoking was independent of birth weight and postnatal weight gain (Oken et al., 2008). Alternatively, maternal smoking may affect appetite regulation centres in the developing fetal brain (Jo et al., 2002; Grove et al., 2001; Oken et al., 2008), or may simply be a marker of unhealthy lifestyle habits (Mizutani et al., 2007; Oken et al., 2008). Maternal smoking may increase the risk of overweight by up to 50%, and is therefore quantitatively significant (Oken et al., 2008). In the US, 11% of pregnant women smoke, suggesting that a potential 715,000 US children may become overweight (Oken et al., 2008).

**Extremes of birth weight**

The relationship between birth weight and obesity risk has been described as a J- or a U-shaped curve, with a high prevalence of obesity among those born at both extremes (too low or too high) of birth weight (Rogers and EURO-BLCS Study Group, 2003; McMillen and Robinson, 2005; Fall et al., 1995; Curhan et al., 1996a, 1996b). Barker (1995) was the first to put forth the hypothesis that fetal deprivation, as evidenced by low birth weight, may program a propensity for insulin resistance, hypertension and obesity (Hales and Barker, 1992; Prentice, 2005). Barker’s hypothesis has become known as developmental programming. Consistent with Barker’s fetal origins hypothesis (1995), low birth weight due to malnutrition in utero has been
associated with greater central adiposity (Law et al., 1992), obesity (Curhan et al., 1996a), and insulin resistance (Newsome et al., 2003) later in life, and an increased risk of health problems such as coronary heart disease and stroke (Clayton et al., 2007), type 2 diabetes, and the features of the metabolic syndrome (Hales et al., 1991; Newsome et al., 2003; Barker, 1998; Eriksson et al., 2001, 2003; Rich-Edwards et al., 1999). These effects may be mediated by programming of insulin and glucose metabolism during fetal life by factors such as maternal nutrition, nutrient supply to the fetus, or alterations in endocrine function (Newsome et al., 2003).

Higher birth weights have been consistently linked with an increased risk for subsequent obesity (Armstrong et al., 2002; von Kries et al., 2002; Oken and Gillman, 2003). A direct positive relationship between birth weight and later BMI has been demonstrated, with each kilogram increase in birth weight leading to a 0.5–0.7 kg/m² increase in BMI (Parsons et al., 1999), and a 20%–30% higher risk of obesity during adolescence (Gillman et al., 2003). The relationship between high birth weight and obesity may reflect the influence of both genetics and in utero programming (Koletzko, 2006) from insults such as gestational diabetes (Rodrigues et al., 1992, Whitaker et al., 1998a).

Whereas early research used BMI as a surrogate for body composition, more recent studies have measured body composition directly. When body composition rather than the BMI is the independent variable, a strong and consistent association between birth weight and lean mass is evident across a range of populations, whereas the association with fat mass is weaker and disparate (Wells et al., 2007). This new evidence, combined with the fact that the population prevalence of extreme birth weights is low (Dietz and Gortmaker, 2001), suggest that birth weight may not be an important target for obesity prevention.

Breastfeeding

Breastfeeding initiation and duration is higher in Europe and Australia than in Canada, and higher in Canada than in the US (Callen and Pinelli, 2004). The initiation rates of breastfeeding range from 69% to 83% in Canada, compared to 27% to 69.5% in the US (Callen and Pinelli, 2004). Thirty eight percent to 59% of Canadian infants are breastfed for 3 months, while between 31% and 41% are breastfed for 6 months (Callen et al., 2004). By comparison, US rates for exclusive breastfeeding from 2000 to 2004 increased to a national high of 30.5% at 3 months and 11.3% at 6 months (CDC, 2007). These rates remain below the 2007 Healthy People 2010 targets of 60% at 3 months and 25% at 6 months (CDC, 2007). Women who initiate and continue to breastfeed are consistently older, married, better educated, and have higher incomes compared to those who do not (Callen and Pinelli, 2004).

Four systematic reviews concluded that breastfeeding is protective against later obesity both in childhood and adulthood, although the degree of protection was small in some cases (Owen et al., 2005a, 2005b; Arenz et al., 2004; Harder et al., 2005). Owen et al. (2005a) found that breastfeeding was associated with a reduced risk of obesity later in life, with an odds ratio of 0.78. However, after considering additional unpublished data and adjusting for potential confounders, the team later concluded that the protective effect of breastfeeding was small, and not likely to result in meaningful protection against later overweight or obesity (Owen et al., 2005b). Arenz et al. (2005) similarly concluded that the protective effect of breastfeeding on obesity risk in later childhood was small, with an odds ratio of 0.87. A third review by Harder
and colleagues (2005) suggested a much stronger and dose-dependent protective effect of breastfeeding on subsequent obesity risk, with a maximum odds ratio of 0.67. Many of the studies included in these reviews found evidence for a protective effect of breastfeeding on obesity risk during the early childhood period.

Longer duration of breastfeeding is associated with a reduced risk of obesity (Owen et al., 2005a; Harder et al., 2005). In a recent meta-analysis, Harder et al. (2005) found that the risk of overweight was reduced by 4% for each month of breastfeeding up to a maximum risk reduction of more than 30% with 9 months of breastfeeding (Harder et al., 2005). Longer duration of breastfeeding has also been specifically linked with a reduced risk of obesity during early childhood. In one of the largest studies of its kind, Grummer-Strawn and Mei (2004) found that children who were breastfed for a minimum of 3 months were less likely to be overweight at 4 years of age. Similarly, a minimum of 16 weeks of exclusive breastfeeding was associated with a reduced risk of obesity at 4 years of age, although only among white children whose mothers did not smoke while pregnant (Bogen et al., 2004). Von Kries et al. (1999) found a 57% reduction in the odds of being overweight at 5 or 6 years of age among infants who were breastfed for at least 12 months.

Although a longer duration of breastfeeding appears to protect against obesity, the optimal duration of breastfeeding for obesity protection is uncertain. Concurrent breast and bottle feeding appear to diminish the protective effect of breastfeeding on obesity risk (Bogen et al., 2004). The risk of obesity at age 4 was reduced when infants were exclusively breastfed for a minimum of 16 weeks, whereas infants fed a combination of breast milk and formula required a minimum 26 weeks of feeding before protection was conferred (Bogen et al., 2004). Exclusive breastfeeding for 9 months may protect maximally against obesity according to Harder et al. (2005), with smaller benefits from partial breastfeeding.

Several theories have been proposed to explain the protective effect of breastfeeding on obesity risk (Arenz and von Kries, 2005). Behavioural explanations suggest that breastfed infants learn to self-regulate food intake in response to hunger and satiety signals (Birch and Fisher, 1998; AHA, 2006), or that enhanced emotional bonding of mother and child plays a role (Klaus, 1998; Mezzacappa, 2004). Another theory suggests that the lower weight gain of breastfed infants during the critical neonatal period (a difference of 400 g over 9 months and up to 650 g over 12 months; Dewey, 1998) protects from later obesity (Heinig et al., 1993). Alternatively, the association may be explained by the unique nutrient composition of breast milk, such as its bioactive nutrients that may inhibit adipocyte differentiation (Hauner et al., 1995; Petruschke et al., 1994), its lower protein and energy content that lower plasma insulin levels (Groh-Wargo et al., 2005; Heinig et al., 1993; Scaglioni et al., 2000; Taylor et al., 2005; Lucas et al., 1981), or even its distinctive flavours that encourage preference for a greater variety of foods (Mennella et al., 2001).

Beyond its potential benefits in obesity prevention, breastfeeding is safe and has many other benefits that warrant its implementation. Important social and environmental barriers to breastfeeding exist, however, and must be overcome to improve the viability of breastfeeding as an obesity prevention strategy (Daniels et al., 2005). Notably, women who are overweight or obese demonstrate reduced initiation of breast feeding (Donath and Amir, 2000; Hilson et al.,
1997; Kugyelka et al., 2004; Li et al., 2003), and earlier cessation of breastfeeding (Oddy et al., 2006; Donath and Amir, 2000; Hilson et al., 1997; Li et al., 2003) compared to mothers of normal weight. It is not clear why this is the case; however, Oddy et al. (2006) suggest that obese women may have different hormonal profiles than normal weight women, and/or infants may have trouble latching onto the breast tissue of overweight mothers. Alternatively, the association may be confounded by other factors that cause obese women to avoid breastfeeding such as pregnancy and birth complications.

While breast milk is clearly the best way to nourish newborn infants, some evidence suggests that breastfeeding does not protect against obesity in young children (Burdette et al., 2006; Hediger et al., 2001; Wadsworth, 1999; Agras et al., 1990; Dubois and Girard, 2006; Parsons et al., 2003) or adults (Michels et al., 2007). These discrepant results may be the result of inadequate control for confounding variables in studies reporting a protective effect, such that the observed benefits were actually due to residual confounding by unmeasured attributes of the family and parents (Singhal, 2007), or may constitute evidence of a publication bias (Kramer et al., 2007; Owen et al., 2005b). A major limitation has been the inconsistent assessment of exposure to breastfeeding among studies (Arenz et al., 2004). Furthermore, most studies use the BMI as a surrogate for adiposity, whereas most studies that have assessed body composition directly have not reported an association between breastfeeding and obesity risk (Wells et al., 2007).

Given these conflicting data, there is no consensus as to whether breastfeeding is a useful public health strategy for obesity prevention. Dubois and Girard (2006) argue against its use as a public health strategy, whereas Arenz and von Kries (2005) suggest that even a small protective effect of breastfeeding on obesity risk may be significant on a population level. In one study, the prevalence of overweight would have been reduced from 10.4% to 9.6% if 100% rather than 76% of the children had been breastfed (Arenz and von Kries, 2005). More than 7% of the risk for childhood overweight was attributable to not breastfeeding in this cohort (Arenz and von Kries, 2005). The American Academy of Pediatrics, Committee on Nutrition (2003) found evidence for a protective effect of breastfeeding on obesity risk, and regard it as a strategy to prevent pediatric overweight and obesity. In summary, breast milk is already acknowledged to be the best source of nourishment for infants, and therefore although the protective effect of breastfeeding on obesity risk may be small, it is nevertheless a low cost, readily available strategy that may help to combat childhood obesity (Dietz, 2001).

Early feeding experiences
Bottle feeding (Bergmann et al., 2003) and/or prolonged bottle feeding (Bonuck et al., 2004) may increase obesity risk. In a sample of more than 3,000 children aged 3–5 years from NHANES III, each additional month of bottle use led to an approximate 3% greater likelihood of being in a higher BMI category (Bonuck et al., 2004). Interestingly, breastfeeding was not significant in the model (Bonuck et al., 2004). Formula provides a more concentrated source of energy and nutrients than breast milk, leading to more rapid weight gain in early infancy (Lewis et al., 1986; Waterland and Gaza, 2002), and an earlier adiposity rebound (Bergman et al., 2003), both of which may confer a greater likelihood of childhood and adult obesity. The growth accelerating effects of infant formula have been confirmed in large epidemiological studies (Kramer et al., 2004), and may be the most pronounced during the first 2 weeks of life. From
2 weeks until 2 months of life there is little difference in growth between breast- and formula-fed infants, whereas from 2 to 12 months, formula-fed infants gain weight and length more rapidly than their breast-fed counterparts (Ziegler, 2006). Ziegler (2006) notes that this pattern of growth coincides with the period when the protein intake of formula-fed infants begins to exceed requirements, and posits that the lower protein intake of breast-fed infants from 2 to 12 months may beneficially limit growth. This is consistent with Singhal and Lucas’ (2004) growth acceleration hypothesis, whereby rapid growth during infancy is thought to program the major components of the metabolic syndrome. This theory, in addition to others previously described, may at least partially explain why some of the health outcomes of breast-fed infants are superior to those among formula-fed infants.

Children develop important feeding behaviours during infancy and the toddler years. During these early years children learn to feed themselves, try new foods, and experience changes in their level of appetite (Coleman et al., 2005). Indeed, meal and snack patterns are well established by the end of the first year of life (Skinner et al., 2004). Early feeding experiences may impact obesity risk through the dietary patterns and behaviours they may engender (Snethen et al., 2007). Infants who are encouraged to empty their bottles, for example, may not learn to control their food intake via internal physiological cues, and may be at increased risk for overfeeding compared to breastfed infants (Bergmann et al., 2003; Stettler et al., 2005). When feeding is used as a mechanism to soothe the frustrated, crying infants, weight gain may result, leading to increased body weight in childhood (Wells et al., 1997). Notably, the timing of the introduction of solid foods may also affect obesity risk. Children who were fed solid foods before 15 weeks of age had a higher risk of obesity (Wilson et al., 1998); however, the evidence is not consistent (Burdette et al., 2006; Forsyth et al., 1993). Exposure to flavours in utero (Mennella et al., 2001, 2004) or during infancy (Mennella and Beauchamp, 2005) can further shape future food preference.

**Rapid growth**

Singhal and Lucas’ (2004) growth acceleration theory suggests that it is not birth weight per se, but accelerated weight change from birth (catch-up growth) that preprograms a higher risk of metabolic abnormalities later in life. This theory is a potentially unifying hypothesis that might also account for why breastfed infants who typically grow slower than formula-fed infants have long-term cardiovascular advantages, and why an earlier adiposity rebound, indicative of a faster growth trajectory, may be associated with an increased risk for later adiposity (Singhal, 2007). The relative contribution of the growth rate at different stages of childhood to the risk of later adiposity is not yet clear. The effects of rapid growth rates differ when the gain occurs in infancy or the toddler years, and the outcomes may be mediated by different mechanisms (Singhal, 2007).

Rapid weight gain in infancy is most commonly observed among low-birth-weight infants undergoing catch-up growth to compensate for intrauterine growth restriction, and usually occurs during the first year of life (Ekelund et al., 2006). Rapid growth, and especially weight gain, during infancy predicts future obesity in children (Eid, 1970; Ong et al., 2000; Stettler et al., 2002) and adults (Stettler et al., 2003; Monteiro and Victora, 2005; Ekelund et al., 2006; Ong et al., 2006). The relationship between rapid growth in infancy and subsequent obesity risk has been summarized in three recent systematic reviews. Following their review of the literature, Baird et al. (2005) concluded that infants with the highest BMIs and/or those who grew more
rapidly during the first 3 months to 2 years of life were more likely to be obese later in life. They did not find any evidence of heightened sensitivity at a specific stage of infancy; however, they noted that the association was consistent across a range of developed nations, across ages, and over the period 1927–1994 (Baird et al., 2005). Monteiro and Victora (2005) and Ong and Loos (2006) reached similar conclusions. The increased risk of obesity due to rapid early weight gain was not influenced by birth weight; however, infants with a longer period of weight gain may have a higher obesity risk (Ong and Loos, 2006). In addition, despite their slower growth rate compared to formula-fed infants, breastfed infants who exhibit accelerated growth during infancy are also at a higher risk of becoming obese (Agras et al., 1990). It is difficult to quantify the strength of the relationship between rapid early weight gain and later obesity; however, as variability in the definition of catch-up growth and its outcomes led to a wide range in the reported odds ratios for obesity (1.17 to 5.70) among the studies reviewed (Ong, 2007).

Low birth weight infants who subsequently exhibit catch-up growth typically have low lean mass and may continue to be susceptible to central fat accumulation (Clayton et al., 2007; Ibanez et al., 2006; Hediger et al., 1998; Garnett et al., 2001; Loos et al., 2002), a known risk factor for chronic disease. Rapid weight gain during the early childhood period has been shown to predict insulin resistance (Bavdekar et al., 1999; Ong et al., 2004; Crowther et al., 1998), which may emerge during the first year of life (Soto et al., 2003). Thus, in addition to a greater risk for obesity, children who undergo early catch-up growth may also have a heightened long-term risk for metabolic disease (Ong, 2007). Despite this apparently heightened endocrine and metabolic risk, expert bodies contend that the public health impact of routine evaluation of metabolic parameters among small-for–gestational-age infants would be small, and therefore do not recommend such routine monitoring (Clayton et al., 2007).

Despite the potential negative outcomes of early catch-up growth, it may also have important health benefits for children. The benefits of early catch-up growth include reduced infant mortality due to nutritional recovery (Monteiro and Victora, 2005) and improved resistance to infection, particularly in developing nations (Victora et al., 2001). If catch-up growth does not occur at a young age, approximately half of small-for-gestational-age infants will remain short as adults (Karlberg and Albertsson-Wikland, 1995). Cognitive function also appears to be ameliorated by early catch-up growth (Lundgren et al., 2001). According to the International Society of Pediatric Endocrinology and the Growth Hormone Research Society (Clayton et al., 2007), infants born small for gestational age who do not exhibit catch-up growth during the first 6 months of life should be monitored for adverse effects on stature and other neurological and intellectual impairments.

The “catch-up dilemma” is the term used to describe the balance between the significant benefits and disadvantages associated with catch-up growth (Victora and Barros, 2001). In reality, genetic and nutritional factors might moderate the translation of rapid weight gain into actual physiologic outcomes (Yeung, 2006). A pathway of healthy catch-up has been proposed whereby the benefits of catch-up growth can be realized without the disadvantages (Ong et al., 2006). Emerging evidence suggests that healthy catch-up may be achieved through several means, including the use of growth hormone therapy (van Pareren et al., 2004; Dahlgren and Wikland, 2005; Hokken-Koelega et al., 2004), increased dietary protein intake (Yeung, 2006), or exclusive breastfeeding for a minimum of 24 weeks (Rao et al., 2002).
Rapid weight gain during infancy may be more significant to future obesity risk than weight gain during the toddler years. The worst outcomes are typically found among those babies born small who subsequently become large, suggesting that a lower birth weight (Jones-Smith et al., 2007) or a faster trajectory of growth (Adair and Cole, 2002; Barker et al., 2002, 2005) programs a higher obesity risk. In one study, the population attributable risk (the proportion of overweight that could be prevented if risk factors were removed) for weight gain during infancy (0–6 months) was 15.7%, compared to 11.7% for rapid weight gain in early childhood (3–6 years) (Ekelund et al., 2006). A high rate of weight gain during the first 5 months of life was the most influential risk factor for being overweight at 4.5 years of age (Dubois and Girard, 2006), while rapid weight gain during the first 4 months of life markedly increased the risk of being obese at age 20 (Stettler et al., 2003). Twenty percent of the risk of obesity at age 7 was attributed to having a weight gain in the highest quintile during the first 4 months of life (Stettler et al., 2002). Finally, a high weight gain during the first 24 months of life has been linked to general and central adiposity at 5 years of age (Ong et al., 2000), and was the best predictor of overweight at school entry in a large sample of children living in southern Germany (Toschke et al., 2004). The effects of infant growth rate may be population-specific, as accelerated infant growth predicts fat mass only in developed countries (Wells et al., 2007). Overall, rapid weight gain during the first 6 months of life appears to be a good predictor of overweight during childhood (Eid, 1970) and young adulthood (Stettler et al., 2003). Twenty-nine percent of infants aged 0–4 months exhibited rapid growth in one study (Stettler et al., 2003), suggesting that this may be a common phenomenon with important public health implications (Flynn et al., 2006).

Data among toddlers suggest that 60% of children who were ever overweight during the preschool period were overweight at 12 years of age (Nader et al., 2006). Even children whose BMIs were above the 50th percentile were more likely than those with lower BMIs to be overweight at 12 years (Nader et al., 2006). Whereas rapid weight gain during infancy is typically associated with intrauterine growth restriction and consequent low birth weight, toddlers who experience rapid weight gains do not differ in size at birth from other children (Ekelund et al., 2006). The determinants of weight gain among toddlers (e.g. food and activity patterns) may therefore be more amenable to change, as they depend upon environmental and lifestyle influences, including the early home environment and the level of mental stimulation (Strauss and Knight, 1999).

The period of the adiposity rebound may be a time of increased risk for the development of obesity during the toddler years (Dietz, 1994). Most children grow rapidly during the first year of life. Thereafter, BMI declines and reaches a minimum at 3–7 years of age before it subsequently begins to rise again (Flynn et al., 2006). The age at adiposity rebound is the point of minimal BMI beyond infancy (Cole, 2004). An early adiposity rebound is associated with a higher BMI in adolescence (Rolland-Cacher et al., 1984; Prokopec and Bellisle, 1993; Siervogel et al., 1991) and early adulthood (Rolland-Cacher et al., 1987). The BMI centile is determined by plotting BMI against age and sex, providing a basis for comparing the BMI of children relative to their peers. The BMI centile, and upward BMI centile crossing (the result of weight gain without corresponding growth in height), each predict the age at rebound, with a high centile and centile crossing leading to an earlier rebound (Cole, 2004). An early rebound may therefore simply be a marker for upward centile crossing (Cole, 2004). Because upward centile crossing
predicts obesity at whatever age it occurs, Cole (2004) contends that the period of the adiposity rebound does not meet the definition of a critical period for obesity development.

**Optimal age of intervention**

Success in obesity prevention is most likely to be achieved when preventive measures are initiated early and are sustained throughout childhood and adolescence (Livingstone et al., 2006). Indeed, there may be a very narrow window of opportunity when prevention is possible, given that obesity may be programmed in utero and during early infancy. Early intervention is also warranted because excess weight tracks from childhood to adulthood, and becomes more difficult to treat as one becomes older (Dietz, 1999). The available evidence indicates that critical periods for obesity development occur in utero and in the early postnatal years, and does not justify waiting until the toddler years to initiate preventive measures. Following an extensive review of the literature, Flynn et al. (2006) concluded that a minimum of 6 months of exclusive breastfeeding was the only well-established safe and effective intervention in early infancy for obesity prevention (Bergmann et al., 2003; Gillman et al., 2001). Preventive efforts should be directed toward all women of childbearing age and throughout pregnancy, including promotion of a healthy body weight, smoking cessation, and exclusive breastfeeding for the first 6 months of life.

**D. Parental and caregiver roles and responsibilities in obesity prevention in young children**

**Weight loss**

The influence of parental obesity on the weight status of children is substantial among younger children, and is the best predictor of childhood obesity (Parsons et al., 1999; Whitaker et al., 1997). Maternal BMI significantly predicts pediatric BMI (Gyovai et al., 2003; Melgar-Quinonez and Kaiser, 2004; Whitaker, 2004), and therefore children with obese mothers are at particularly high risk for obesity (Strauss and Knight, 1999), as are children with two obese parents (Whitaker et al., 1997). Indeed, one of the most effective obesity prevention measures may be for parents, guardians, and other caregivers to adopt healthy lifestyles and avoid becoming obese themselves (Summerbell, 2007).

Parental obesity is also influential in the development of adult obesity in their offspring. Regardless of the child’s obesity status, parental obesity status was the primary predictor of obesity in adulthood among 3-year-old children, and more than doubled the likelihood of adult obesity among children under 10 years of age (Whitaker et al., 1997). The influence of parental obesity on their children’s future obesity risk appears to decline substantially with age, as parental obesity was much less important to future obesity risk among 10–17 year olds (Whitaker et al., 1997).

Parents play a significant role in influencing the development of practices that can support the maintenance of a healthy body weight, or conversely that can contribute to overweight in their children (Lindsay et al., 2006). The influence of parents is the most substantial during early childhood, and therefore parental involvement is key to the success of early obesity prevention programs (Lindsay et al., 2006). Epstein (1996) has summarized the reasons for involving parents: first, it may be difficult to intervene with a single family member while the others are modeling unhealthy lifestyles; second, parents are role models for their children; and lastly,
Parental use of behaviour change strategies appears to dramatically alter children’s behaviour. Indeed, pediatric weight control outcomes are superior when parents receive training in behavioural parenting methods and weight control (Israel et al., 1985; Epstein et al., 1985, 1990; Golan et al., 1998a). Authoritative parenting styles (Golan et al., 1998a, 1998b) and positive reinforcement (Epstein et al., 1985) are particularly effective parenting strategies with respect to weight loss outcomes.

For parents to engage in obesity prevention efforts directed toward their young children, they must be aware of their children’s weight status and the associated health risks (Baughcum et al., 2000). Fewer than 20% of mothers with overweight children, however, correctly identify their children as overweight (Baughcum et al., 2000; Jackson et al., 1990). This may not be surprising given that many adults do not recognize overweight in themselves (Timperio et al., 2000). Parents may not view childhood overweight as harmful, and may be more likely to view adolescent and adult obesity as a more serious health concern (Crawford et al., 2006). Mothers often believe that “bigger is better” with respect to infant and toddler growth, and view weight gain as an indication of parental competence (Baughcum et al., 1998).

In their review of the effectiveness of interventions for the treatment and prevention of childhood obesity, Wilson et al. (2003) found some evidence that family-based programs help children to lose weight. Similarly, the American Dietetic Association (ADA, 2006) concluded that multi-component, family-based interventions are effective for the reduction of overweight in children 5–12 years of age. The inclusion of the family in counseling sessions improved short- and long-term outcomes for children in this age range (ADA, 2006). The ADA also found fair evidence to support the inclusion of a parental component in school-based primary prevention programs in elementary-aged school children (ADA, 2006). Livingstone et al. (2006), however, believe that while the family environment is key to the evolution and resolution of childhood overweight, family-focused programs only modestly improve short-term dietary behaviours, and have not been shown to result in long-term reductions in adiposity (Perry et al., 1989). Recently, family dietary coaching improved the dietary quality of children (mean age 7.7 years) and parents over an 8-month period, with additional benefits for weight control in parents (Paineau et al., 2008).

Although this body of evidence concerns obesity treatment rather than prevention, and is not specific to influences during early childhood, it nevertheless illustrates the importance of parents in influencing the weight status of their children. Studies that engage parents as “agents of change” help to reduce childhood adiposity over the short and long term (Golan et al., 1998a, 1998b; Golan and Crow, 2004a, 2004b; NHS Centre for Reviews and Dissemination, 2002). It is reasonable to assume that parental involvement is just as instrumental for obesity prevention initiatives among younger children (Livingstone et al., 2006; Bluford et al., 2007).

**Dietary intake**

The importance of parents in influencing the dietary behaviours of their children may be the most pronounced at younger ages (Oliveria et al., 1992). Young children depend entirely upon their parents for the provision of food (Roblin, 2007), and parents determine the types and amount of food offered as well as the emotional context of the eating environment (Davis et al., 2007). Parent–child interactions and encouragement are also closely associated with the eating behaviours and body weights of young children (Klesges et al., 1983, 1986).
Parents modulate their feeding practices for their children according to the child’s current weight, the importance of weight and appearance to the parent, and their perception of the child’s risk for overweight (Costanzo et al., 1985). Although some taste preferences are innate, the feeding practices of caregivers play a key role in shaping the dietary patterns and eating styles of the children in their care (Birch and Davison, 2001), and these habits persist into adulthood (Satter, 1988). Authoritative parenting styles may be superior in encouraging healthy lifestyle behaviours among children (Niklas et al., 2001; Schmitz et al., 2002; Davis et al., 2001). Authoritative parents maintain close, nurturing relationships with their children, albeit with a reasonably high level of rules and guidelines. Data support the importance of authoritative parenting styles of mothers (Rhee et al., 2006) and fathers (Wake et al., 2007; Stein et al., 2005) in influencing the weight status of their children.

Four broad aspects of parental feeding style have been examined with respect to their influence on children’s food intake (Wardle and Carnell, 2007). The first two practices relate to the mealtime pressure exerted by parents on their children to eat more healthy foods, more food overall, or to restrict foods that are perceived as unhealthy (Birch et al., 2001). Children are sensitive to parental attempts to control or restrict their food intake. Self-regulation of food intake is an important developmental task of infancy that can be derailed by well-intentioned parents who attempt to control their children’s food intake, thereby limiting opportunities for their children to develop self-control (Vaughn and Waldrop, 2007; ADA, 1999; Birch and Davison, 2001). Excessive parental control such as over-restriction of “unhealthy” foods, overly encouraging “healthy” foods, or requiring children to eat when they are not hungry may have the opposite of the desired effect, fostering dislike rather than acceptance of “healthy” foods (Birch and Davison, 2001; Birch et al., 1982, 1984). Parental pressure to consume specific foods has also been shown to interfere with children’s innate ability to self-regulate food intake in response to physiological hunger and satiety signals, causing them to focus on other cues such as the presence of palatable foods (Birch and Fisher, 1998; Birch, 1998, 1999; Fisher and Birch, 2002; Birch et al., 2003). Although in the short term parents may perceive that restrictive practices protect from overweight, as children age and have free access to foods, the negative consequences may emerge as difficulty in regulating hunger and satiety (Farrow and Blissett, 2008).

Parents can positively influence the specific food choices that their children will make throughout their lifetimes without exerting excessive control over their young children’s food intake. Young children are naturally neophobic, initially rejecting new foods (Birch and Davison, 2001). When weaning begins, all foods are new to the child. Young children’s food preferences and intake patterns appear to be largely shaped by the foods parents choose to make available at an early age, and their persistence in offering them (Birch and Davison, 2001). Foods that are initially rejected may be accepted through repeated exposure (Birch and Davison, 2001).

Relatively extensive experience may be required for acceptance of some foods such as those that are not sweet or salty (e.g. meats, grains and vegetables) (Birch and Davison, 2001). The context in which foods are offered is also important, as children develop preferences for foods offered in positive contexts (Koivisto Hursti, 1999). Parents can therefore shape their children’s current and
future dietary patterns by repeatedly offering their young children a variety of nutritious foods in a positive and supporting atmosphere.

Parents must be careful, therefore, to avoid pressuring their children to eat, or attempting to rigidly control their food intake. Parents should instead observe a clearly defined role, which is to offer a variety of nutritious food options in a supportive eating context, while allowing their children to decide when and how much to eat (Robinson et al., 2001). This feeding style is believed to promote optimal health by fostering the development of healthy lifestyle habits, self-control, and sensitivity to internal hunger and satiety cues (Robinson et al., 2001). Most children will eat the amount of food that they require, although it is inevitable that some will make “errors in energy balance” and may become overweight (Robinson et al., 2001). More research is needed to determine whether this division of food responsibilities is associated with a lower incidence of obesity (Dietz and Gortmaker, 2001).

The last two aspects of parental feeding styles that have received attention in the literature are the use of food as a reward, or to manage children’s negative moods (Wardle et al., 2002). Children learn to prefer foods that are offered as rewards, and to dislike those that must be eaten to obtain a reward (Harbaugh et al., 2007). Parents should therefore avoid using food in these ways.

Parental knowledge of, and appreciation for the relationship between, food and health influences the dietary patterns of young children. Food availability substantially influences young children’s food choices (Lindsay et al., 2006), and parents tend to buy foods that they themselves like to eat. Mothers who modify their food habits in positive ways make similar changes for their young children (Klohe-Lehman et al., 2007). Children of mothers who recognized the role of nutrition in disease prevention consumed more fruits and vegetables (Gibson et al., 1998), and less total energy and fat (Contento et al., 1993). Parental education regarding the relationship between food and health may therefore improve the dietary patterns of children.

Because of their considerable influence over children’s intake, it is important that parents teach and model healthful eating behaviours during the formative years of childhood. Studies that have sought to change parental, but not children’s, behaviour have shown that changes in parental behaviours produce corresponding changes in children’s behaviours (Kremers et al., 2003; Maccoby, 2000). Preschool children are more likely to eat foods that they observe adult role models eating (Harper and Sanders, 1975), and their nutrient intakes are moderately and significantly correlated with those of their parents, and especially of their mothers (Oliveria et al., 1992). The problem areas in adults’ diets are often evident in the diets of their young children (Skinner et al., 2002; Fox, 2004b). Family meals provide an important opportunity for parents to role model healthy eating for their children (Roblin, 2007). Families who eat together tend to have healthier diets (Gillman et al., 2000; Taveras et al., 2005), and the children in these families may have a lower risk of being overweight (Veugelars and Fitzgerald, 2005). The eating behaviours of parents and other role models may therefore shape the dietary behaviours of young children, and influence their risk of becoming overweight (Hood et al., 2000).
Physical activity
Few data exist with respect to the relationship between parental physical activity and that of their offspring (Lindsay et al., 2006). In general, children with overweight parents are less active, and are more likely to prefer sedentary activities (Wardle et al., 2001; Klesges et al., 1990). In the Framingham Children’s Study, 4- to 7-year-old children were twice as likely to be active if their mothers were active, and were 5.8 times more likely to be active if both parents were active (Hood et al., 2000). By contrast, Trost et al. (2003) did not observe a significant influence of parental physical activity on the physical activity behaviours of 3- to 5-year-old children, nor were the activity levels of mothers and their 1- to 3–year-old children related in a recent study (Kloehe-Lehman et al., 2007).

Although it is not clear whether parents need to be active for their children to become active, children’s perceptions of competence, self-efficacy, enjoyment, beliefs, and attitudes strongly influence their activity levels (Brustad, 1993; Welk, 1999). Parental encouragement can therefore significantly impact children’s activity levels (Gustafson and Rhodes, 2006). Parents are also responsible for determining the activities that young children engage in during their free time, and for creating an active lifestyle in their household that minimizes sedentary behaviours (Harbaugh et al., 2007).

Childcare environments
Many young children spend considerable time in childcare, and the effects of the childcare experience on body weight are not known. A study of the relationship between attendance of childcare and the risk of overweight showed that attendance at limited centre-based childcare from ages 3–5 was independently associated with a reduced risk of overweight at ages 6–12, whereas attendance at extensive centre-based childcare was not associated with the risk of overweight at ages 6–12 (Lumeng et al., 2005). These findings are difficult to explain given the lack of similar studies. Lumeng et al. (2005) suggest that these data may be capturing a difference in quality between the two types of centres, or that some unmeasured characteristic of the families who use part-time versus full-time care may be responsible. Similarly puzzling findings have emerged from Germany. In that country, nearly all 3- to 6-year-old children spend 4–10 hours per day in kindergarten; however, the prevalence of overweight or change in relative BMI appears to be unaffected by the length of time children spend in care (Rapp et al., 2005). By contrast, the risk of obesity at 3 years of age among British children increased with the number of weekly hours worked by the mother (Hawkins et al., 2008).

Further studies are needed to clarify the relationship between attendance of childcare and obesity risk among young children. It is plausible that adult modeling and encouragement to eat healthier foods may be less effective in childcare settings where children necessarily receive less individual attention (Lumeng et al., 2005). Adults tend to eat more food in group situations (de Castro and Brewer, 1992), and this may also be true in young children (Lumeng et al., 2005). Families who use childcare may also have greater time constraints, relying on pre-prepared or fast food meals, with reduced time for active pursuits (Lumeng et al., 2005). If true, these factors may predispose children in childcare to weight gain; however, there is currently no evidence to support this hypothesis. Childcare providers spend considerable time with many children, and therefore it is reasonable to assume that children’s lifestyle patterns may be shaped not only by
the food and activity patterns in the childcare environment, but also by the attitudes and behaviours of caregivers.

E. Roles and responsibilities of health professionals in obesity prevention in young children

Pediatricians and family physicians are ideally placed to identify children at risk for overweight and obesity, as most visit their physicians regularly, and weight and height monitoring is routine in pediatric care. Younger children visit the pediatrician more frequently than do older children (Perrin et al., 2007), making the preschool years a natural focus for obesity prevention by physicians. In one study, obesity identification was the lowest in children under 5 years (O’Brien et al., 2004). A recent national survey of health professionals reported that only 49% intervened in cases of preschool obesity (Barlow et al., 2002b). These data suggest that opportunities for intervention at younger ages are often missed; however, little is known regarding physicians’ identification and management of childhood obesity (O’Brien et al., 2004).

The American Academy of Pediatrics (AAP, 2006) recently reaffirmed its recommendation that pediatricians calculate and plot the BMI annually for all children, and address excess weight gain in children of all ages. Despite the fact that they routinely measure height and weight, 6% or less of pediatricians actually plot the BMI for children (Barlow et al., 2007a; Dorsey et al., 2005). BMI plotting was recently associated with identification of excess weight in overweight children, but not in those who were obese (Barlow et al., 2007a). This suggests that BMI plotting may be more useful for early recognition of children who are at risk for obesity, and therefore is important for obesity prevention. Notably, many physicians may still be using the 1977 growth charts rather than the more recent CDC 2000 growth charts (Barlow et al., 2007a).

Pediatricians may not be actively seeking to intervene early in the course of obesity, as they identify obesity in only 53% of obese children (O’Brien et al., 2004). The lowest rates of obesity identification were for children under the age of 5, and those with milder degrees of obesity (O’Brien et al., 2004; Dorsey et al., 2005). Similarly, pediatricians identified overweight or obesity in 27% of 6- to 17-year-old children with a BMI at the 85th to 94.9th percentile, and in 86% of those with a BMI at or above the 95th percentile (Barlow et al., 2007a). By missing children with lesser degrees of overweight, physicians may lose opportunities to intervene early in the course of the disease (Dorsey et al., 2005). They may furthermore end up focusing their efforts on the subset of patients for whom weight management is the most difficult, thereby exaggerating the perception of futility in obesity prevention (Dorsey et al., 2005).

It is not clear why pediatricians do not routinely screen for overweight among children; however, almost 80% report frustration with their ability to impact childhood obesity (Jelalian et al., 2003). Several barriers have been identified in the literature, including parental and patient resistance to change, lack of time to provide care and counseling, lack of knowledge, lack of widely accepted treatment methods, and limited or no reimbursement for these services (Barlow et al., 2002a, 2002b).

Even for children identified as obese, physician evaluation and treatment are often not consistent with current recommendations (O’Brien et al., 2004; Dorsey et al., 2005). While dietary changes were recommended for many children (71%), increased physical activity (33%) and a reduction
in TV viewing time (5%) were rarely advised (O’Brien et al., 2004). Although the management of obese children did not meet current guidelines, it was far better than that of children who were not identified as obese, as these children received little to no advice regarding diet, activity, and other obesity-associated behaviours (O’Brien et al., 2004). These data highlight the importance of timely identification of childhood obesity (O’Brien et al., 2004).

The efficacy of physician counseling for obesity prevention is not known; however, overweight adolescents who have been counseled by their doctor are more likely to report attempting to improve their dietary habits and to lose weight (Kant and Miner, 2007). The Canadian clinical practice guidelines (Lau et al., 2007) and the American Academy of Pediatrics (AAP, 2007) encourage healthcare providers to incorporate assessment and anticipatory guidance about diet, weight and physical activity into routine clinical practice in a sensitive manner, and to screen for comorbidities (AAP, 2006). The focus of these discussions should be on healthy lifestyle habits, not weight (AAP, 2006), and only one or two goals should be identified per visit if the family exhibits readiness to change (Perrin et al., 2007). One strategy that may be promising is the use of motivational interviewing, a patient-centred counseling technique that helps patients understand and resolve their ambivalence to change (Schwartz et al., 2007). A small pilot study used motivational interviewing to encourage lifestyle change for overweight 3- to 7-year-old children (Schwartz et al., 2007). Although the BMI reductions were small and not statistically significant, the reductions were nevertheless greatest in the group that received motivational interviewing (Schwartz et al., 2007). Over 90% of parents reported that the intervention made them think about changing their family’s eating habits (Schwartz et al., 2007).

These data demonstrate that physicians are missing opportunities to intervene early in life, and early in the course of overweight/obesity when lifestyle change may be most effective. If physician identification and management of obese children is poor, then it can reasonably be assumed that obesity prevention is not a part of routine clinical care. This failure results in missed opportunities for risk factor assessment, counseling about lifestyle changes, and screening for comorbidities (Dorsey et al., 2005; Miller and Silverstein, 2007). By calculating and plotting BMI for all children, and initiating obesity prevention strategies in utero, physicians can play a significant role in helping to curb the rise in overweight and obesity among young children.

Other health professionals that frequently come into contact with parents of young children such as public health nurses also can participate in obesity prevention. Home visiting programs that provide social support to first-time mothers are an effective means of improving the health of parents and children (Olds et al., 1997; Hodnett and Roberts, 2001; Armstrong et al., 2000), and may positively affect parental feeding practices during the first 2 years of life (Wen et al., 2007). These programs should start before the child is born, and continue until the child starts school (NSW Government, 2000).

**F. The role of population health strategies and public policy in obesity prevention in young children**

A *population health perspective of obesity prevention*

A population health perspective of obesity prevention considers how individual/behavioural and environmental factors interact to affect health outcomes (Raine, 2004). While an excess of
energy intake compared to expenditure is the primary individual/behavioural factor responsible for obesity, it is the larger obesity-promoting environment within which behaviours are situated that is the fundamental cause of the epidemic of obesity (Raine, 2004). The sociocultural context also plays an important role in obesity, and Canadian data suggest that low social status groups are at increased risk for obesity (Raine, 2004). These individual, environmental, and social determinants of obesity are situated within an integrated global environment, and therefore a comprehensive public health approach to obesity prevention must also include global measures (Sobal, 2001).

An ecological approach to obesity prevention

Diet and physical activity alone are not sufficient to characterize the etiology of energy imbalance in early childhood (Wen et al., 2007); rather, obesity arises from a complex interplay of genetics with environmental factors from multiple interacting contexts. Given this complexity, obesity prevention must be viewed as a community responsibility that is best addressed using multi-level (including multiple interacting individual, environmental, and population-level strategies), multi-sectoral public health strategies, rather than as the sole prerogative of individuals (Dietz et al., 2002; Raine, 2004). This type of ecological approach combines strategies that support individuals in their efforts to lead healthy lifestyles, with efforts to influence policies that encourage broader social and cultural change (McLeroy et al., 1988).

Under the traditional medical model of obesity, the individual is responsible for changing his or her own personal and home environment to assist with weight maintenance and/or loss. Individual-oriented approaches are, however, not likely to be successful without supporting social and environmental changes (Lobstein et al., 2004). Schwartz and Brownell (2007) contend that interventions based on a medical model of obesity are much less effective than those that are based on a public health model, as the latter are far reaching, less costly, and less intensive (Daniels et al., 2005). Successful population-based approaches focus on changing the environment in which individual behaviours occur, thereby enabling positive change without the involvement or awareness of the individual (Gill, 1997; Wilson et al., 2003; Schwartz and Brownell, 2007). Under this approach, preventive dollars are allocated outside of the traditional healthcare sector, and are redirected towards places where young children spend time such as to kindergarten or preschool programs, daycares, community sports programs, and community kids camps. A comprehensive, ecological approach to obesity prevention must include both individual and population health strategies (Raine and Wilson, 2007).

The increased prevalence of obesity among young children reflects the potency of environmental influences on body weight, and suggests that public health actions are needed to address these influences (Lobstein et al., 2004). Environmental strategies to prevent childhood obesity include institutional and community-based interventions that focus on promoting healthy living, rather than on obesity per se (Raine, 2004). Environmental policies likely to impact young children include legislation surrounding food intake and time spent in physical activity at childcare facilities. Population-level strategies include a comprehensive range of integrated actions at multiple levels (Stockley, 2001). Population-wide policy interventions likely to impact young children may include regulating portion sizes, subsidies for low-energy nutritious foods, and restrictions on advertising unhealthy foods to children.
Public and political will to implement change are essential for the uptake and implementation of public health strategies (Schwartz and Brownell, 2007). Public support for change increases as the public begins to see the environment as the key causal agent in obesity (Schwartz and Brownell, 2007). Obesity-promoting social and environmental trends are often viewed as desirable, and therefore public support is essential to successfully challenge and redirect these forces (Lobstein et al., 2004). Extensive efforts may be needed both to change social norms and to encourage political action (Schwartz and Brownell, 2007). History provides several examples in which environmental and population-level strategies have been used to successfully alter practices in areas of public health significance, namely in the areas of tobacco use, seatbelts, breastfeeding, and recycling (Raine, 2004). Social change at a similar level will be needed to address the current obesity epidemic (Raine, 2004). Traditional public health approaches that focus on disseminating information and helping people to understand the consequences of their health behaviours are, however, not effective with young children, as young children are not able to understand this information, nor are they able to control the circumstances in which they live (Desjardins and Schwartz, 2007). It is not effective, for example, to tell young children to be more active; rather adults need to provide safe and accessible places for children to play (Desjardins and Schwartz, 2007).

Obesity is better prevented than treated from a population health perspective (McIntyre, 2005). Policy and regulation can work in concert with supportive environments to enhance the success of obesity prevention strategies, and have been used to successfully address issues of public health importance, including supplementation of milk with vitamin D to eliminate rickets, and the fluoridation of drinking water to reduce dental caries (Dietz et al., 2002). Policies that could be enacted to prevent childhood obesity include subsidizing the cost of nutritious foods, taxing less healthful foods, implementing restrictions on food advertising to children, providing funds to improve the availability of physical activity-related facilities, and undertaking urban planning to improve the safety and walkability of neighbourhoods (Auld and Powell, 2005). Sound public policy must be informed by knowledge of the determinants of obesity, and should be evaluated first to determine whether a particular course of action will do more harm than good, and to anticipate unintended consequences (McIntyre, 2005).

It is not possible to fully characterize the risk factors for obesity, nor to identify all children who may be at risk. In reality, all children are potentially at risk of developing obesity and could benefit from interventions that promote increased physical activity and a healthy diet (Ells et al., 2005). A comprehensive public health approach circumvents these difficulties by targeting all children (Power et al., 1997b), and may be the most efficacious means of preventing obesity among young children. This should not, however, eliminate the use of targeted interventions in subpopulations that are clearly at increased risk (Ells et al., 2005), nor should broad-based strategies be implemented at the expense of local grassroots movements. Engagement at the community level is key to the success of larger programs, local champions are needed to shepherd initiatives and build enthusiasm, and community sponsorship and partnerships are required to maintain ongoing support for programs (Desjardins and Schwartz, 2007).

In summary, the Public Health Approaches to the Prevention of Obesity Working Group of the IOTF (Kumanyika et al., 2002) recommends that a comprehensive approach to obesity prevention should:
Address both dietary intake and physical activity patterns;
Address population- and individual-level factors;
Address immediate and distant causes;
Have multiple focal points and levels of intervention;
Include policies and programs; and
Build links among sectors.

Government actions to address childhood obesity
The contribution of pediatric obesity to adult morbidity and mortality indicates that childhood obesity prevention should be a high public health priority. Governments have an important role to play in coordinating action among various sectors, and in developing, implementing, and monitoring policies and strategies that support the maintenance of healthy body weights (Raine and Wilson, 2007). Government involvement is most commonly seen in the form of obesity prevention programs, consumer education, obesity surveillance, and investment in research (Ells et al., 2005).

Inadequate surveillance limits our understanding of the context of obesity among young Canadian children and appropriate targeting of prevention efforts. A comprehensive, coordinated and rigorous surveillance program that includes measured BMI, and detailed food intake and physical activity data, is an essential component of an obesity prevention plan (Raine and Wilson, 2007). Canada urgently needs such a formal, large-scale surveillance program with strong links among program developers, advocates, policy makers and other stakeholders (Raine and Wilson, 2007) to inform, monitor and evaluate obesity prevention programs, to determine obesity prevalence and levels of overweight/obesity that signal increased risk for health problems, to assess children’s lifestyle habits, and to identify children who are at increased risk of becoming obese.

Several Government of Canada agencies have been charged with improving the health and well-being of Canadians by promoting and supporting regular physical activity and healthy eating (Health Canada, 2006). These agencies include Health Canada (including the Office of Nutrition Policy and Promotion, and the Food Directorate), the Public Health Agency of Canada (including the Centre for Chronic Disease Prevention and Control), and the Centre for Health Promotion at the University of Toronto (Health Canada, 2006). The Canadian Population Health Initiative (Canadian Institute for Health Information) has specifically identified obesity as a research priority in Canada, and is seeking answers to three key policy questions: 1) What are the determinants of obesity at the population level? 2) What policy instruments have been tried to prevent obesity, in Canada and elsewhere? and 3) What works and does not work, and why?

The Government of Canada is addressing childhood obesity in the following areas, as outlined in the document entitled, Childhood Obesity and the Role of the Government of Canada (Government of Canada, 2007a):
- Leadership, coordination and strategic policy development
  - e.g. Pan-Canadian Healthy Living Strategy, mandatory nutrition labeling, the Public Health Council Network, the federal, provincial and territorial forum on Sport, Physical Activity and Recreation
Knowledge development, exchange and dissemination
- e.g. funding obesity-related research through the Canadian Institutes of Health Research’s Institute of Nutrition, Metabolism and Diabetes, the Canadian Best Practices Portal, establishment of six National Collaborating Centres by the Public Health Agency of Canada to focus on knowledge translation of public health priority areas

Surveillance
- e.g. the Canadian Community Healthy Survey, the Canadian Physical Activity Levels Among Youth Survey

Community-based programming and community capacity building
- e.g. the Maternal Child Health Program, the Aboriginal Head Start, the Aboriginal Diabetes Initiative, the Canada Prenatal Nutrition Program, the Healthy Living and Chronic Disease Initiative

Public information
- e.g. Eating Well with Canada’s Food Guide, the Food Guide for First Nations, Inuit and Métis, the Physical Activity Guides for Children and Youth, the annual WinterActive and SummerActive initiatives, a campaign to promote the Children’s Fitness Tax Credit

Monitoring and evaluation
- e.g. Policy Observatory on Non-Communicable Diseases

The Standing Committee on Health of the House of Commons released a report entitled, Healthy Weights for Healthy Kids in March 2007 (Government of Canada, 2007b). The Committee made 13 recommendations to address the problem of obesity among Canadian children. The Government of Canada (2007c) responded by indicating that it is well positioned through existing activities and partnerships to foster healthy eating, physical activity and body weights among Canadian children, and pledged to continue to build upon these initiatives, and to undertake further research and consultation. This response document outlines the full range of federal government programs designed to address childhood obesity.

Non-government actions to address childhood obesity
Obesity is not only a problem of public health; there is a need for coordination among many sectors to identify and implement potential solutions (Raine and Wilson, 2007). Public health initiatives can improve the awareness of the contribution that many sectors of society make to obesity-promoting environments, and can focus their attention on minimizing this adverse role (Lobstein et al., 2004). Targets may include changes in the nature of the food supply and in the mechanization of physical activity (Lobstein et al., 2004). Thus, in addition to governments, health-related agencies, educators, healthcare providers, health professional bodies, the research community, families, consumers, and industry must work cooperatively to address the problem (Raine and Wilson, 2007). Natural alliances include partnering obesity prevention with proponents of sustainable transportation, safer neighbourhoods, or those seeking to build parks and recreational facilities (Lobstein et al., 2004). This coordination avoids duplication of efforts, and leverages resources efficaciously toward a common goal (Desjardins and Schwartz, 2007).

“Stealth nutrition” refers to attempts to work more nutritious ingredients into children’s meals (Friedland, 2008). Using this concept, industry could collaborate to gradually reformulate their
food products over time, such that the change is imperceptible to consumers (Schwartz and Brownell, 2007). A reduction of 2% per year in the sodium content of foods, for example, may have positive health impacts without requiring any behaviour change on the part of consumers, and with relatively little effort and expense to industry (Schwartz and Brownell, 2007). On the other extreme, the entire span of food companies could undertake a comprehensive reformulation of food products, although it is not clear if there would be sufficient benefit to justify taking such action (Schwartz and Brownell, 2007).

Health-related agencies and industry can partner to effect significant change. In the US, for example, the Alliance for a Healthier Generation and the American Beverage Association (2007) have established the School Beverage Guidelines to limit beverage availability in schools to lower calorie, more nutritious options.

**Areas for future policy development**

Very little public policy specifically addresses the problem of obesity among young children. A review of the state-level childhood obesity prevention legislation introduced and adopted from 2003 through 2005 in the US revealed that most bills and resolutions concerned school nutrition and physical activity standards (Boehmer et al., 2007). Community-related bills and resolutions were also introduced and adopted, although none appears to have been specifically targeted to young children (Boehmer et al., 2007). It is therefore important to impress upon policy makers the importance of prevention in the early years, before unhealthy lifestyle behaviours are established.

According to Raine and Wilson (2007), Canada should consider the following policy options to combat obesity among children:

- Subsidies for the cost of low-energy nutritious foods;
- Taxation policies that promote physical activity;
- Taxation policies that discourage urban sprawl;
- Regulation of food advertising to children; and
- Policies to decrease social vulnerabilities (promote adequate income and higher education).

Several forums have been held in Canada to identify policy priorities for obesity prevention. In 2003, six key priority areas for policy formulation were identified at one forum (Canadian Institute for Health Information, 2003):

- Evidence and surveillance;
- School health;
- Urban design and transportation;
- Policy-related research;
- Evaluation of policy tools and interventions; and
- Social inequities as determinants of obesity.

The built environment and the economy emerged as areas to target for future policy formulation in a 2005 forum convened by the Heart and Stroke Foundation of Canada (2005).
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- The built environment: The built environment is defined as “the arrangement of activities or land uses within urban settings, and the nature of the physical connections between the places where we live, work and play” (Heart and Stroke, 2005). A large body of evidence suggests that by paying attention to proximity, land use mix, and connectivity, communities can create environments that are conducive to healthier, more active lifestyles (Heart and Stroke, 2005). However, in a large study of 7,020 low income preschoolers, overweight was not associated with proximity to playgrounds or fast food restaurants, or with the level of neighbourhood crime (Burdette and Whitaker, 2004).

- Economic policy: Consumers respond to price, and therefore economic policies can be a powerful means of promoting or discouraging certain health-related behaviours (Heart and Stroke, 2005). According to Cawley (2006), markets have contributed to childhood obesity in three main ways: 1) energy-dense foods have become less expensive than less energy-dense foods; 2) rising wages have increased the “opportunity costs” of food preparation; and 3) technological changes have created incentives to use prepackaged meals rather than preparing meals at home. Cawley (2006) also describes three economic rationales that justify government intervention in markets to combat childhood obesity: 1) free markets tend to under-provide information, and therefore government should provide consumers with information to enable informed choices; 2) taxpayers bear the economic burden for obesity, and therefore governments should intervene to lower these costs to taxpayers; and 3) children are not able to critically evaluate information and the consequences of their actions, therefore governments can intervene to protect them from making poor choices that may adversely affect their health.

Economic policy should be evaluated on a cost–benefit basis, whereby the costs and benefits for each intervention are listed, and policies are ranked according to how inexpensively they achieve the policy goal (Cawley, 2006). Although few interventions have been subjected to cost-effectiveness analysis, protecting children from advertising, using taxes and subsidies to change behaviours associated with obesity, and regulating the food environment in childcare centres may be beneficial strategies to implement (Cawley, 2006). Bemelmans et al. (2008) recently estimated that a large-scale community intervention to reduce the prevalence of obesity by 3% would be a cost-effective strategy, at a cost of 7.3 billion euros over 5 years, compared to annual direct and indirect costs attributable to obesity of 168.6 billion euros.

One of the most common economic policy suggestions has been to recommend that governments regulate the marketing of foods to children. The Institute of Medicine (Nestle, 2006), for example, endorses restrictions on the use of cartoon characters, celebrity endorsements or health claims on food packages, while supporting federal actions to educate children and promote the consumption of healthful foods.

Additional policy suggestions relevant to obesity prevention among young children include:

- The elimination of barriers to breastfeeding such as when mothers return to work soon after birth; policies are needed to help mothers continue to breastfeed if they choose to return to work (Dietz, 2001).

- Policies should ensure that families have a range of quality childcare choices available to them, including staying home rather than returning to work (Lumeng et al., 2005).
• Public policy to address risk factors in utero: support healthy maternal lifestyles (reduce maternal smoking, healthy diet and physical activity patterns), facilitate breastfeeding, revise current screening practices for gestational diabetes, address food insecurity (Dubois and Girard, 2006; Huang et al., 2007).

**Examples of obesity programs and policies**
Recent policies and programs to promote optimal health and reduce obesity among young children include the following:

In 2004, the city of New York amended Article 47 to include regulations surrounding physical activity and food in the city’s daycares (2006). The revised regulations stipulate that children who spend a full day in childcare must participate in a minimum of 60 minutes of physical activity daily, that children under the age of 2 years not be permitted to watch TV, and that children older than age 2 may have a maximum of 60 minutes of screen time per day. In addition, regulations were instituted to ensure that all children have access to safe, nutritious foods and beverages throughout the day.

In Australia, the Child and Youth Health Intergovernmental Partnership of the National Public Health Partnership (2005) has developed a National Public Health Strategic Framework for Children 2005–2008 to strengthen Australia’s capacity to promote good health and prevent injury and illness. This evidence-based strategy includes five strategic directions:
- Strengthen the capacity of parents, families and communities;
- Improve the knowledge and skills of key workers;
- Develop partnerships and mobilize resources;
- Build evidence and track progress for policy, programs and practice; and
- Transform health systems and environments.

Fit & healthy Vermonters (Vermont Department of Health, 2006) is a state-wide obesity prevention plan targeting Vermont residents of all ages. The plan includes several elements aimed at reducing obesity among young children, such as ensuring that licensed early childcare providers develop and implement nutrition and physical activity policies, that hospitals, employers and community programs support and encourage breastfeeding for a minimum of 1 year, and that supports including information and programs with little or no cost be provided for families to help them lead healthier lifestyles. The full plan is an excellent model for change, and includes specific measurable outcome objectives, as well as itemized strategies in each area.

Community organizations in the US have collaborated to increase physical activity through improved community design, public policy and communication strategies (Desjardins and Schwartz, 2007). One program developed a “walking school bus” campaign to provide safe passage to school for children (Albuquerque Alliance for Active Living), which could be adapted for use in a younger population of preschool-aged children. Another program, “FitCity”, collaborated with community groups to provide children and caregivers with positive messages to encourage healthy body weights, nutrition and physical activity (Schwartz and Desjardins, 2007).
The Canadian Health Network has partnered with Dietitians of Canada to produce 10 one-minute “Healthy Lunches to Go” videoclips that assist parents in packing healthy and appealing lunches for their children.

Nutricia, part of the baby food manufacturer Royal Numico in the United Kingdom, has partnered with the child obesity group, Mend, to help educate parents about optimal feeding of toddlers (McNally, 2007).

There is some government oversight of media advertising to children in Canada. Advertising Standards Canada’s Broadcast Code for Advertising to Children restricts the use of cartoon characters and children’s entertainers in ads, but not on food packaging (Canadian Association of Broadcasters, 1993). The length of commercial messages to children is also regulated, while in Quebec, advertising to children under 13 years of age is prohibited entirely. Concerned Children’s Advertisers (2005) has programs designed to educate parents and children about media influences on food selection.

Provincial governments, including the Governments of British Columbia, Manitoba, Nova Scotia, and the Northwest Territories, have begun to address childhood obesity through guidelines to promote healthy eating among children and youth.

HealthVision2020 (2008) is a coalition of 15 health organizations in Alberta proposing that a dedicated health promotion foundation be created in Alberta to focus on primary prevention of obesity and other health conditions.
III. Summary and Discussion

A. Summary of the Evidence

Role of lifestyle factors in obesity prevention in young children

- Dietary patterns are established during the early childhood years. Some aspects of younger children’s eating patterns track over periods of up to 6 years, and diet quality typically declines from childhood to adolescence. The deficiencies in the diets of young children may therefore persist and worsen over time.

- Physical activity patterns are established during early childhood and may track from early childhood to adulthood, declining progressively with age.

- Some dietary behaviours (low fruit and vegetable intake, high fat intake) and patterns (snacking on high sugar/high fat foods, low meal frequency) are associated with higher BMIs in young children; however, data are limited.

- A reduction in sedentary activities (TV/computer viewing) may help to maintain energy balance in this age group.

- Short sleep duration among young children increases the risk of childhood obesity. A significant, linear dose–response relationship between short sleep duration and obesity has been documented in children under 10 years of age.

Critical periods for obesity prevention in young children

- Critical periods refer to periods of development when insults may induce permanent changes in the structure and function of organs and tissues.

- Prenatal insults, including smoking, malnutrition, and maternal diabetes, are associated with an increased risk for later obesity.

- Postnatal factors that may increase the risk for obesity include extremes of birth weight (too low or too high), not exclusively breastfeeding, bottle feeding, early introduction of solid foods, and upward centile crossing.

- Critical periods for obesity development occur in utero and in the early postnatal years, and do not justify waiting until the toddler years to initiate preventive measures.

- Preventive efforts should be directed toward all women of childbearing age and throughout pregnancy, including promotion of a healthy body weight and lifestyle behaviours, smoking cessation, and exclusive breastfeeding for the first 6 months of life.

Parental roles and responsibilities in obesity prevention in young children

- Parental obesity is the primary predictor of obesity among young children, and is an important predictor of obesity in adulthood.

- Parental involvement is essential for the success of obesity prevention programs among young children.

- Parental feeding practices shape the dietary behaviours and patterns of young children, and these habits persist into adulthood.
Authoritative parenting styles may be superior in encouraging healthy lifestyle behaviours among young children.

Excessive parental control such as overrestriction of “unhealthy” foods, overly encouraging “healthy” foods, or requiring children to eat when they are not hungry may foster dislike rather than acceptance of “healthy” foods.

Young children are naturally neophobic, rejecting new foods. Foods that are initially rejected may be accepted through repeated exposure.

It has been suggested that parents should offer children a variety of nutritious food options in a supportive eating context, and allow children to decide what and how much to eat of the foods that are offered.

Parents should avoid using food as a reward or to manage their children’s negative moods.

Changes in parental dietary behaviours produce corresponding changes in children’s behaviours, and therefore parental education and role modeling are important.

Parents are responsible for determining the activities that young children engage in during their free time, and for creating an active lifestyle in their household that minimizes sedentary behaviours.

Children’s lifestyle patterns may be shaped by the food and activity patterns in the childcare environment, and the attitudes and behaviours of caregivers.

Roles and responsibilities of health professionals in obesity prevention in young children

Physicians are ideally placed to identify young children at risk for overweight and obesity; however, they are missing opportunities to intervene early in the course of overweight and obesity when lifestyle change may be most effective.

Physicians should follow recommendations to calculate and plot BMI for all children. Obesity prevention should be initiated in utero and continue throughout early childhood in all children.

The role of population health strategies and public policy in obesity prevention in young children

An excess of energy intake compared to expenditure is the primary individual/behavioural factor responsible for obesity; however, it is the larger obesity-promoting environment within which behaviours are situated that is the fundamental cause of the obesity epidemic. Successful population-based approaches focus on changing the environment in which individual behaviours occur, thereby enabling positive change without the involvement or awareness of the individual.

Obesity prevention is a community responsibility that is best addressed using multi-level (including multiple interacting individual, environmental, and population-level strategies), multi-sectoral public health strategies.

Environmental and population-level strategies have been used to successfully alter practices in areas of public health significance such as tobacco use, seatbelts, breastfeeding, and recycling. Social change at a similar level will be needed to address the obesity epidemic.
Policies that could be enacted to prevent childhood obesity include subsidizing the cost of nutritious foods, taxing less healthful foods, implementing restrictions on food advertising to children, providing funds to improve the availability of physical activity-related facilities, and undertaking urban planning to improve the safety and walkability of neighbourhoods.

All children may be at risk of developing obesity and could benefit from obesity prevention efforts. A population-based approach targeting all children in all age groups may be the most efficacious means of preventing obesity among young children.

Canada urgently needs a formal, comprehensive, coordinated and rigorous surveillance program that includes measured height, weight, BMI (≥2 years of age), and detailed food intake and physical activity (≥1 year of age) data for young children.

Governments have an important role to play in coordinating action among various sectors, and in developing, implementing, and monitoring policies and strategies that support the maintenance of healthy body weights. The Government of Canada is working to address childhood obesity through diverse agencies, policies and programs.

In addition to governments, health-related agencies, educators, healthcare providers, health professional bodies, the research community, families, consumers, and industry must work cooperatively to address the problem of obesity among young children.

Public policies and programs targeting the built environment, economic factors, social vulnerabilities, food marketing to children, and in utero and early postnatal risk factors for obesity should be studied and enacted where appropriate.

B. Recommendations and Implications

Obesity prevention should target all children beginning in utero and continue throughout early childhood.

For consumers (parents, children)...

- Women of childbearing age and pregnant women should not smoke.
- Women of childbearing age and pregnant women should maintain a healthy body weight and practice healthy lifestyle behaviours.
- Parents should maintain a healthy body weight and model healthy lifestyle behaviours.
- Exclusive breastfeeding is optimal for the first 6 months of life.
- Parents should be actively involved in obesity prevention strategies for their young children.
- Authoritative parenting styles may be superior in encouraging healthy lifestyles.
- Parents should not overly restrict food or require children to eat when they are not hungry. Parents can avoid the need for overt control over food intake by reducing the availability of non-nutritious foods in the home.
- Parents should repeatedly offer a variety of nutritious foods in a positive and supporting atmosphere, and allow children to decide what and how much to eat of the foods that are offered.
- Food should not be used as a reward, or to manage children’s negative moods.
• Parents should encourage family meals in the home and should limit meals away from home, particularly fast food meals.

• Parents should encourage and support their children to be more active by playing with their children, enrolling them in activity programs, and/or providing transportation to parks and playgrounds (Davis et al., 2007).

• Children under the age of 2 years should not watch TV. The screen time of children over the age of 2 years should be limited to not more than 2 hours per day.

• Earlier bed times and later wake times should be used to ensure children receive an appropriate amount of sleep, ≥11 h for children under age 5, and ≥10 h for children aged 5–10 (Chen et al., 2008).

• Children should have regular physician visits. BMI should be plotted and monitored at each visit. Parents should be aware of their child’s weight status and the associated health risks.

• Parents and children should become involved with obesity prevention initiatives in their community.

• Parents should receive appropriate training on how to foster healthy dietary and physical activity habits in young children.

• Parents must view obesity prevention as a significant lifestyle change that will require dietary and activity changes, changes to parenting styles, and the use of time and finances.

For Government…

“Parenting occurs within a complex, often contradictory and commercially aggressive environment in which personal responsibilities taken by parents may be swamped by broader environmental forces. Obesity prevention is more likely to be effective if government policy and community structures support efforts undertaken by parents” (Ells et al., 2005).

• Governments should be proactive regarding obesity prevention. Intervention may be justified when the potential population health impact is great, despite a lower certainty of evidence (Raine and Wilson, 2007). A wide range of programs should be implemented targeting young children of all ages as well as women who are pregnant or may become pregnant.

• The Canadian Government should formulate a National Obesity Action Plan for the prevention of childhood obesity, as part of a WHO global strategy on diet, physical activity and health.

• Institute a formal, comprehensive, coordinated and rigorous surveillance program that includes measured height, weight, BMI (≥2 years of age), and detailed food intake and physical activity (≥1 year of age) data for young children.

• Promote and support community efforts to create built environments conducive to active, healthy lifestyles (e.g. construct parks, walking and bicycling paths, recreational facilities).

• Provide programs to assist parents to recognize overweight in their children, and to teach them how to foster healthy dietary and physical activity habits in young children (Crawford et al., 2006).

• Provide reimbursement for health professionals who offer support and counseling to families regarding obesity prevention.
Ensure credible, relevant health information is widely available in an understandable format.

Provide pre- and postnatal programs to support parents in fostering healthy lifestyle behaviours in their children.

Dedicate a portion of healthcare spending to obesity prevention strategies beginning in utero, and continuing throughout early childhood.

Coordinate action across a range of influencers, including community organizations, health-related agencies, industry, educators, health professionals and researchers, to implement broad-based public health obesity prevention strategies for young children.

Initiate social marketing campaigns to raise awareness of the problem and to promote positive health-related behaviours that might have a positive impact on children’s weights, such as breastfeeding, smoking cessation, and healthy lifestyles.

Implement more strict regulations surrounding food advertising to young children.

Consider economic policies to encourage the consumption of healthy foods and discourage consumption of unhealthy foods.

Enact food and activity policies for childcare facilities.

Fund a wide variety of obesity-related research.

Regulate nutrition labeling and health claims on foods sold in grocery stores and restaurants.

Ensure families on social assistance receive adequate funds to purchase food.

For industry…
- Reformulate food products to be more healthful.
- Offer food products in smaller portion sizes.
- Limit or eliminate the advertising of unhealthy foods to children.
- Offer healthy food options in places that children frequent.
- Provide supplementary, credible nutrition information on websites, food packaging, and other resources to educate parents and care providers.
- Provide support and funding for community-based obesity prevention programs.

For childcare…
- Caregivers should maintain a healthy body weight and model healthy lifestyle behaviours.
- Caregivers should not attempt to restrict food or require children to eat when they are not hungry.
- Caregivers should not use food as a reward or to manage children’s negative moods.
- Childcare facilities should create healthy environments that support the consumption of healthy foods and age-appropriate physical activity. Non-nutritious foods and TV should be avoided.
- Caregivers should repeatedly offer a variety of nutritious foods in a positive and supporting atmosphere, and allow children to decide what and how much to eat of the foods that are offered.
- Childcare programs should include dedicated time for children to be physically active.
Children should be given time for age-appropriate naps.

Childcare facilities should participate in obesity prevention initiatives in their community. All children should be targeted in obesity prevention strategies.

Caregivers should receive appropriate training on how to foster healthy dietary and physical activity habits in young children.

For health professionals...

Physicians should calculate and plot BMI for all children (Lau et al., 2007; Barlow et al., 2007b). The CDC growth charts should be used to screen children for overweight, as they contain the full array of percentiles and are therefore more appropriate for individual assessment (Lau et al., 2007; Barlow et al., 2007b). Waist circumference should not be measured (Lau et al., 2007; Barlow et al., 2007b).

Obesity risk assessment should not be judged solely on the basis of BMI, but should also include other risk factors such as parental obesity, family medical history, and current lifestyle patterns (Barlow et al., 2007b).

When a comprehensive dietary and physical activity assessment is not possible, a focused assessment of the most relevant, modifiable health behaviours should be conducted (Barlow et al., 2007b). Practical resources and barriers should also be assessed prior to the implementation of behaviour change strategies (Barlow et al., 2007b).

Obesity prevention should target all children starting in utero and continuing throughout early childhood. Healthcare providers should not wait until children begin to gain weight abnormally before initiating preventive measures.

Healthcare professionals should encourage exclusive breastfeeding for the first 6 months of life.

Pediatric care providers are well positioned to assist families in establishing healthy lifestyle behaviours. All children should receive support in establishing or maintaining healthy lifestyle behaviours, while those at higher risk should receive more active intervention (Barlow et al., 2007b).

Clinicians should focus their discussion on parenting behaviour and strategies to make the home environment as healthy as possible starting from birth (Barlow et al., 2007b).

Healthcare professionals should actively support obesity prevention initiatives in their communities and encourage families to participate.

Healthcare professionals should not focus solely on diet and physical activity, but must assist parents to manage the environmental context in which individual lifestyle behaviours are situated. Families are heterogeneous and a single approach will not meet the needs of all families.

Healthcare professionals should help the entire family to make gradual, permanent lifestyle changes.

Healthcare professionals need to be aware, and make parents aware, that food restriction and weight reduction are not appropriate for young children.

Healthcare professionals should encourage women of childbearing age and those who are pregnant to stop smoking, maintain a healthy body weight and practice healthy lifestyle behaviours.
Healthcare professionals should encourage parents to maintain a healthy body weight and to practice healthy lifestyle behaviours.

For research...
The absence of research related to obesity prevention among young children has been highlighted in recent reviews. Flynn et al. (2006) found that only 6% of childhood obesity prevention or treatment programs targeted children aged 0–5 years, with a single program instituted during the first 6 months of life. Fewer than 3% of programs were implemented in the home environment (Flynn et al., 2006). Conroy and colleagues (2007) identified only six Canadian childhood obesity prevention programs implemented during gestation and/or infancy, with five targeting low income Canadian urban and/or Aboriginal populations (Conroy et al., 2007). Small et al. (2007) located six obesity prevention interventions for 4- to 7-year-old children; however, major areas of weakness were noted, as none was conducted in primary healthcare providers’ offices, only three involved parents, none offered a theoretical foundation to assist in the understanding of any resultant behaviour change, and all relied on self-reported nutrition and physical activity data. There is a clear need to augment the body of evidence related to obesity prevention in young children, particularly in the following areas:

The problem of overweight and obesity among young children
- Research studies should use the IOTF definition of obesity in young children. Future studies should attempt to define child BMI cut-offs that relate to health risks in childhood.
- Future studies should evaluate the utility of waist circumference measurements in assessing health risk among young children.
- Canadian-specific growth curves for BMI and waist circumference should be developed for young children (Lau et al., 2007).
- Future studies should assess adiposity directly wherever feasible, rather than relying on BMI, and should establish standards for healthy body composition in young children.
- Research should investigate factors relevant to a variety of racial/ethnic and socio-economic groups.
- Canada must continue to collect nationally representative survey data to compare future obesity, dietary, and activity trends to those recently summarized in the 2004 Canadian Community Health Survey. The survey should include representative data for young children of all ages, including measured height, weight, BMI (≥2 years of age), and detailed food intake and physical activity (≥1 year of age) data for young children.
- The direct and indirect costs of obesity should be estimated at regular intervals. This information will help to document progress in reducing the burden of obesity, provide valuable estimates of the cost effectiveness of preventive strategies, and focus public attention on the severity of the problem.
- Researchers should continue to study the adverse health impacts of obesity in young children, both in childhood and in future adult life. The relationship between risk factors for chronic disease and the development of overt disease symptoms must be clarified in this group of children. Prospective studies in which risk factors are experimentally manipulated will help to determine which risk factors are important to disease risk in young children.
- The psychosocial implications of obesity in young children should be studied.
Lifestyle-associated behaviours of young children

- Data collected from national surveys of obesity, dietary, and physical activity trends among children should be used to refine dietary recommendations, and to formulate physical activity recommendations for young children. This data can also be used to evaluate the efficacy of obesity prevention programs.

Role of lifestyle factors in obesity prevention in young children

- More detailed information regarding the dietary and physical activity determinants of obesity in young children is required.
- Measurement tools for diet and physical activity assessment in this young age group require validation. Parental involvement in the assessments is critical.
- Preventive TV viewing interventions should also consider targeting infants and toddlers (Certain and Kahn, 2002). Measurement of TV viewing must also use valid tools (Bryant et al., 2007).
- Interventions should be tested longitudinally to assess the sustainability of benefits derived from lifestyle interventions over time. A recent Cochrane review (Summerbell et al., 2005) described 22 intervention studies in which 10 studies were at least 12 months long and 12 were less than 12 months in duration.
- Investigators should evaluate the population reach of interventions.
- Studies are needed to clarify whether short sleep duration is a cause or consequence of obesity, whether a dose–response relationship exists, and the underlying mechanisms.
- Studies are needed to determine the optimal sleep duration for obesity prevention in young children.
- Randomized controlled trials should be conducted to test the effectiveness of sleep extension for obesity prevention among young children.

Critical periods for obesity prevention in young children

- Studies are needed to ascertain the critical periods that program future obesity risk among young children. Additional questions that require clarification include:
  - If breastfeeding is influential, what is the impact of exclusivity and duration of breastfeeding?
  - Does the rapid growth of formula-fed infants predict later obesity?
  - Are extremes of birth weight independent risk factors for obesity, and if so, what are the mechanisms?
  - If catch-up growth is a risk factor, is healthy catch-up growth achievable? If so, how?
  - Is the period of the adiposity rebound a distinct critical period, or is an early rebound simply a marker for upward centile crossing?
  - How well do early childhood risk factors predict adulthood obesity and chronic disease?
- Studies are needed to test the efficacy of obesity prevention interventions initiated during critical periods, and to evaluate the optimal timing and type of interventions.
Parental and caregiver roles and responsibilities in obesity prevention in young children

- Future investigations should explore causal relationships between parental feeding and child weight (Wells et al., 2007).
- Future studies should continue to study the efficacy of family-based obesity prevention interventions where parents act as “agents of change”, and should test this model in concert with a variety of lifestyle interventions.
- The impact of a comprehensive range of parenting styles on the dietary and physical activity patterns of young children should be explored.
- Studies are needed to evaluate the impact of parental role modeling on the dietary and physical activity patterns of young children.
- Future studies should explore the context of parenting and the constraints and opportunities under which parents operate. This information can be used to assess how to best support healthy lifestyle behaviours in the home (Livingstone et al., 2006).
- Much more work is needed to evaluate the impact of diverse childcare environments on obesity risk in young children.

Roles and responsibilities of health professionals in obesity prevention in young children

- Researchers should evaluate the efficacy of healthcare professional (e.g. physician) screening for obesity prevention.
- Studies are needed to determine the barriers to healthcare professional screening and intervention for obesity, and how to overcome them.
- The efficacy of obesity prevention programs initiated by healthcare professionals requires in-depth evaluation.

The role of population health strategies and public policy in obesity prevention in young children

- Studies are needed to evaluate the impact and cost effectiveness of a range of environmental and population level obesity prevention strategies instituted around the world.
  - Evaluate efficacy, appropriate delivery vehicles, and the conditions required for success (Raine and Wilson, 2007).
  - e.g. Taxation policies to promote consumption of healthy foods and discourage consumption of unhealthy foods, limitations on food marketing to children, changes in the built environment.
- Evaluate the efficacy of policy and regulation for obesity prevention.

Position and role for CCFN...

As a multi-sector, multi-stakeholder organization, CCFN can play a key role in coordinating action among government, industry, health professionals, consumers, and health-related agencies.

- Raise awareness of the problem of childhood obesity. CCFN can work at multiple levels with its stakeholder groups to create a national movement around healthy eating and physical activity.
- Reach parents and caregivers with information about the critical role they can play in helping to prevent obesity among young children.
- Advocate at the national level for policies and programs to prevent obesity.
- Offer support to the Government of Canada to develop a National Obesity Action Plan to prevent childhood obesity.
- Link researchers with organizations that fund obesity research in young children.
- Identify knowledge gaps and advocate for increased research and funding in these areas.
- Formulate obesity prevention guidelines for young children.
- Encourage industry to limit advertising of unhealthy foods to children.
- Organize multi-stakeholder meetings for information exchange and to encourage multi-sector collaboration.
IV. Appendix I: Additional Reviews—Lifestyle Interventions

Extensive reviews have been completed regarding the prevention of childhood obesity. A selection of these studies, and their areas of focus, are presented below (from least to most recent).

- Dietz and Gortmaker (2001) reviewed the natural history of obesity in children and youth, as well as different approaches (family-focused, school-focused) to primary and secondary prevention.

- Researchers from Sweden, Denmark, Spain, Italy and Austria (Flodmark et al., 2004) provide a European perspective and a “call to action” regarding childhood obesity. They stated that obesity should be a priority for healthcare systems, scientists and politicians. With respect to the prevention of obesity, they recommend multi-level evidence-based health promotion programs that include the family, schools, health professionals, government, industry and media. (Flodmark et al., 2004).

- The American Dietetic Association developed a Position Statement on Interventions for Pediatric Overweight (ADA, 2006) based on a review of almost 100 papers. Although their inclusion criteria comprised studies with children and youth aged 2–18 years, there was little information on preschool-aged children. Regarding delivery of programs by grade level, the ADA stated that “Evidence is lacking for preschool settings”, adding that prevention programs for preschool-aged children should be a research priority (ADA, 2006). In general, the position statement echoed other reports supporting multi-component programs for primary prevention.

- The IOTF Task Force (Lobstein et al., 2004) produced an important report detailing the ways in which childhood obesity has emerged as a major public health crisis. Obesity prevention is presented as the only realistic solution to the crisis. Home- and school-based settings are described as logical places to initiate interventions. Thus, for preschool children, these settings may include home daycares, childcare facilities, kindergarten and other community programs.

- Flynn et al. (2006) conducted an extensive review of 334 papers in an effort to develop best-practice recommendations for reducing obesity in children and youth. There was a lack of evidence and interventions for obesity prevention in preschool-aged children. Four community-based programs in preschool children that encouraged healthy eating and/or physical activity led to some positive outcomes (Flynn et al., 2006). Flynn et al. (2006) suggested that this lack of programming for 0–6 year olds may represent missed opportunities for obesity prevention. The paper concludes with a comprehensive set of 17 recommendations for obesity reduction in children and youth.

- Sallis and Glanz (2006) reviewed the role of the built environment on activity, eating and obesity in children. They state that “people who have access to safe places to be active, neighborhoods that are walkable, and local markets that offer healthful food, are likely to be more active and to eat more healthful food... ” Strategies to improve the built environment may therefore be effective for obesity prevention; however, a definitive link between the built environment and childhood obesity has not yet been established (Sallis and Glanz, 2006).
Maffeis and Castellani (2007) reviewed the role of physical activity as a weight control strategy in children. They suggest that “Every child should do at least 60 minutes of moderate physical activity a day. However, further studies are needed to provide evidence based intervention procedures ...”.

Hills et al. (2007) reviewed the evidence surrounding the role of physical activity in the growth, development and physical health of young people. They concluded that establishing habitual physical activity patterns during the early years is likely to have the greatest impact on mortality and longevity. They also identified a need for environmental change, and evidence-based physical activity guidelines for children to aid in reducing the current high prevalence of childhood obesity.

Van Sluijs et al. (2007) reviewed the effectiveness of interventions to promote physical activity in children and adolescents (<18 years of age). Following their review of 57 studies, they suggested that multi-level strategies may be an effective means of encouraging physical activity among adolescents, with less strength in the evidence for younger children.

Based on their systematic review in children and youth 0–18 years, Connelly et al. (2007) suggested that compulsory, rather than voluntary, physical activity should be supported for children.

Bluford et al. (2007) reviewed seven interventions to prevent or treat obesity in preschool children, with mixed results. Success was achieved in a multi-component program, with parent involvement in clinic or childcare settings. The authors suggested 1- to 2-year follow-up is necessary (Bluford et al., 2007).

A systematic review assessed the effectiveness of interventions designed to prevent obesity, promote healthy eating and/or physical activity, and/or reduce sedentary behaviours in children from 0 to 5 years of age (Campbell and Hesketh, 2007). All of the nine studies that met specific criteria for inclusion demonstrated some effectiveness on at least one obesity-related behaviour.

A Cochrane review (Summerbell et al., 2005) summarized 22 interventions to prevent obesity in children (<18 years of age). Most studies documented improvements in either eating or activity behaviours, but did not have a significant impact on obesity. This result may have been partly due to the relatively low intensity and duration of the interventions.

In their review, Timmons et al. (2007) investigated the link between physical activity and biological and psychosocial development in young children (2–5 years of age). They reported that physical activity levels among preschool-aged children were associated with available outdoor spaces, time spent outside, parental interactions, parental modeling of active behaviours, and child gender (boys generally being more active than girls).
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