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Childhood Obesity: Determinants, Treatment, and Risk Factors for Chronic Disease

By

Geoffery Denis Charles Ball ©

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Doctor of Philosophy

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Geoff Ball

11241 University Avenue
Edmonton, Alberta, Canada
T6G - 1Y7

Date: Jan 16/02.

University of Alberta

Faculty of Graduate Studies and Research

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled **Childhood Obesity: Determinants, Treatment, and Risk Factors for Chronic Disease** submitted by **Geoffery Denis Charles Ball** in partial fulfillment of the requirements for the degree of **Doctor of Philosophy** in **Nutrition and Metabolism.**

Dr. Linda J. McCargar (Supervisor)

Dr. J. Dru Marshall

Dr. M. Tom Clandinin

Dr. Rhonda Bell

Dr. Angelo Tremblay (External Examiner)

Date: Jan 15, 2002

Abstract

The prevalence of childhood obesity has increased dramatically over the past 2 decades. Depending on how obesity is defined, between 20 – 30% of Canadian boys and girls can be classified as *obese*. To achieve a greater understanding of the many questions that relate to obesity in youth, a series of experiments were conducted with 6 – 12 year old boys and girls and their families to (1) assess, cross-sectionally and longitudinally, potential differences in lifestyle behaviours and self-perception between obese and non-obese schoolchildren, (2) evaluate the efficacy of two family-based, health-centred weight management programs for obese children and their parents, and (3) determine whether body composition, body fat distribution, activity, fitness and dietary variables correspond to increased metabolic risk within a subset of obese children. In general, we observed modest differences between obese and non-obese boys and girls in relation to activity, fitness, self-perceptions, and diet. Disparities that were observed at baseline in this sample of schoolchildren did not remain consistent over a one-year interval. Our data suggest that health-centred weight management programs can improve body composition, physical activity levels, and physical self-perceptions in obese children. While increased physical self-perception levels were sustained over follow-up, favourable changes in body composition and physical activity were not maintained, a finding which suggests extended interventions (> 12-weeks) and continued support may be helpful. These data also provide evidence to suggest that obese boys and girls are a

heterogeneous group. Despite a high degree of body fatness, a subset of obese children did not possess additional risk factors for cardiovascular diseases and type 2 diabetes. This may partly be explained by familial and dietary variables, however, the strongest predictor of metabolic risk among obese children related to central body fat mass. Collectively, these observations highlight the importance of establishing healthy behaviours and attitudes early in life through family-, school- and community-based initiatives to maximize the health of all children, and especially obese boys and girls who may be at increased physical and psychological risk.

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Chapter One: Introduction

1.1 Rationale

Obesity is a major risk factor for disease and the most common health condition related to nutrition and physical activity among Canadian children. Hereditary factors may determine a child's predisposition to accumulate increased levels of body fat, however, the increased prevalence of childhood obesity over the past two decades has been predominantly mediated through changes in lifestyle behaviours that have led to an increased energy intake and / or decreased energy expenditure. Establishing healthy nutrition and physical activity behaviours and attitudes in young boys and girls is considered an important factor in maintaining healthy lifestyle patterns that can persist through adolescence and into adulthood.

There is relatively little information on the health of obese children in Canada. As well, there is a paucity of data regarding the similarities and differences in lifestyle behaviours and attitudes between obese and non-obese boys and girls. It is generally believed that obese children are less physically active and aerobically fit, have lower levels of self-esteem, and consume poorer quality diets than non-obese boys and girls. However, the data supporting these behavioural and attitudinal disparities are equivocal and much of the data are derived from research conducted outside of Canada.

Because obesity is associated with immediate and chronic health risks, weight management interventions for obese children offer inherent appeal. Therapeutic approaches for obese boys and girls typically include family-based behavioural models to promote healthy lifestyle behaviours that, in turn, positively influence physical and psychosocial health outcomes. Traditional treatment programs for obese children have been based on energy-restricted diets and prescriptive exercise programs to help induce weight loss and improve body composition.

However, recently developed intervention models have shifted towards a more health-centred philosophy for treating obesity in children. Several programs have been developed, but Health Canada's VITALITY paradigm, a theoretical framework founded on healthy eating, active living, and positive self and body image, provides a theoretical basis for the creation of a health-centred approach in childhood weight management. To date, few published studies have evaluated different approaches for weight management that promote healthy behaviours and attitudes within families to address obesity in young boys and girls.

Physically active individuals tend to possess higher degrees of cardiorespiratory fitness, and a physically active lifestyle is associated with other positive lifestyle behaviours and attitudes, so both activity and fitness are considered important in mediating health determinants. For example, data have indicated that the more boys and girls exercise, the greater the likelihood they feel healthy, have a healthy diet and positive peer relationships, and spend less time viewing television. In adults, emerging evidence has suggested that cardiorespiratory fitness is an independent risk factor for cardiovascular morbidity and all-cause mortality regardless of weight status. Preliminary reports have also found that obese adults, despite a high degree of adiposity, can achieve normal levels of known metabolic risk factors for cardiovascular diseases (CVD) and type 2 diabetes through healthy diet and activity habits. Collectively, these data suggest that a subset of obese individuals can be metabolically healthy despite a high level of body fat. That is, physical activity, cardiorespiratory fitness, and dietary intake, beyond their potential impacts on body weight and composition, can decrease the attendant health risks often associated with obesity.

To our knowledge, no published reports have identified the presence of a subset of obese children who may be healthier than their obese peers. Further, the potential roles that lifestyle behaviours and attitudes play in determining health risks, independent of weight and body composition, in boys and girls have yet to be evaluated. Thus, the overall purpose of this research was to investigate the complex inter-relationships of physical activity, cardiorespiratory fitness, self-perception, and nutrition as determinants of obesity and health in children.

1.2 Hypotheses

The primary hypotheses of this thesis are as follows:

Hypothesis 1. In a sample of 6 – 10 year old children, obese boys and girls will possess lower levels of physical activity, cardiorespiratory fitness, self-perception and higher intakes of total energy and dietary fat than their non-obese peers **(Chapter 3).**

Hypothesis 2. The behavioural and attitudinal differences between obese and non-obese children listed above will be maintained over time (12 months) **(Chapter 4).**

Hypothesis 3. Compared to baseline values, obese 6 – 10 year old children who participate in the 12-week family-based behavioural SHAPEDOWN or VITALITY weight management programs will achieve decreased body fatness and increased levels of physical activity, cardiorespiratory fitness, self-perception, and improved dietary quality **(Chapter 5).**

Hypothesis 4. The SHAPEDOWN program, an intervention that encourages families to monitor body weight changes during treatment, will result in greater losses in body weight and fatness than the VITALITY program **(Chapter 5).**

Hypothesis 5. In a sample of 6 – 12 year old obese boys and girls who are at low or high health risk for CVD and type 2 diabetes:

a. The low health risk group will have lower levels of total body fat and central body fat than the high health risk group **(Chapter 6).**

b. The low health risk group will have higher levels of physical activity and cardiorespiratory fitness than the high health risk group **(Chapter 6).**

c. The low health risk group will have lower intakes of total energy and total dietary fat than the high health risk group **(Chapter 6).**

d. The low health risk group will have higher levels of global self-esteem and physical self-perception as well as body image satisfaction than the high health risk group **(Chapter 6).**

1.3 Objectives

In order to test these hypotheses, our objectives are as follows:

Objective 1. To measure anthropometry, physical activity, cardiorespiratory fitness, self-perception, and dietary intake in a sample of obese and non-obese schoolchildren **(Chapters 3 and 4).**

Objective 2. To determine whether differences are consistent between obese and non-obese children over time using cross-sectional (0-months) and longitudinal (0-, 3-, 6-, and 12-months) analyses **(Chapters 3 and 4).**

Objective 3. To assess anthropometry, physical activity, cardiorespiratory fitness, self-perception, and dietary intake in 2 groups of 6 – 10 year old obese children at 0- (baseline), 3- (post-intervention), 6- (follow-up), and 12-month (follow-up) intervals during participation in two weight management programs **(Chapter 5).**

Objective 4. To evaluate family attendance, dropout rates, and client satisfaction in the SHAPEDOWN and VITALITY weight management programs **(Chapter 5).**

Objective 5. To categorize children as low health risk or high health risk according to the absence (no risk factors) or presence (≥ 1 risk factor) of risk factors for CVD and type 2 diabetes **(Chapter 6).**

Objective 6. To measure physical health outcomes including body composition, cardiorespiratory fitness, blood pressure, serum lipids (total cholesterol, high-density lipoprotein-cholesterol, low-density lipoprotein-cholesterol, and triglycerides), insulin, glucose, and hemoglobin A1c **(Chapter 6).**

Objective 7. To measure behavioural variables including physical activity, time spent viewing television and playing video / computer games, and dietary intake **(Chapter 6).**

Objective 8. To measure demographic and familial outcomes including physical maturation, socioeconomic status, ethnicity, family history of CVD and type 2 diabetes, and mother / father height, weight, and body mass index **(Chapter 6).**

Chapter Two: Review of the literature

2.1 Introduction

In developed nations, obesity is one of the most common metabolic and nutritional disorders in youth (Dietz, 1986). The perception among many individuals is that the high prevalence of obesity in children and adolescents should be cause for concern (Andersen, 2000). Indeed, research suggests that obese boys and girls are at an increased risk of developing a number of physical problems (i.e., hypertension, dyslipidemia, impaired glucose tolerance, and sleep apnea). Of even greater concern are the teasing, discrimination, and victimization obese children are known to endure (Must and Strauss, 1999). While immediate health risks can be elevated in some obese children, the refractory nature of obesity also indicates that long-term health can be compromised (Must et al., 1992). Several longitudinal analyses have revealed that obesity (Srinivasan et al., 1999; Freedman et al., 1997; Clarke and Lauer, 1993) and risk factors for CVD and type 2 diabetes (Srinivasan et al., 1999; Kotani et al., 1997; Webber et al., 1991) can develop early in life and persist into adolescence and adulthood leading to increased morbidity and mortality.

Obesity is associated with many chronic health problems and presents an enormous challenge to our health care system. In Canada, the total direct cost of obesity in 1997 exceeded $1.8 billion (approximately 2.4% of total health care expenditures) with hypertension, type 2 diabetes, and coronary heart disease being the largest contributors (Birmingham et al., 1999). In the United States, it has been estimated that obesity is responsible for between 280,000 – 325,000 deaths each year (Allison et al., 1999), second only to smoking (McGinnis and Foege, 1993). Because of the increased personal, social, and economic costs, the treatment and prevention of childhood obesity have been established as research priorities (Must and Strauss, 1999; Hill and Trowbridge, 1998) with the ultimate aim of fostering positive lifestyle behaviours in youth to enhance both short- and long-term health outcomes.

2.2 Prevalence Estimates of Overweight and Obesity in Canadian Youth

2.2.1 Regional studies: Historically, the use of a variety of anthropometric indicators, cut-off points, and reference populations have precluded direct comparisons between studies of overweight and obese Canadian boys and girls. For example, regional studies in Edmonton, AB (Ball et al., 2001; Marshall and Bouffard, 1997), Montreal, QC (O'Loughlin et al., 1998; Johnson-Down et al., 1997), northern Quebec (Bernard et al., 1995) and northern Ontario (Hanley et al., 2000) have reported different overweight and obesity prevalence levels within the last decade (**Table 2-1**). Ball et al. (2001) reported an *obesity* prevalence of 20.3% (boys) and 17.9% (girls) in a self-selected sample of 6 – 10 year olds using the sum of 5 skinfolds (triceps, biceps, subscapular, suprailiac, and medial calf) $\geq 85^{th}$ percentile as the criterion to determine obesity; data from The Canada Fitness Survey (CFS, 1984) served as the reference population. Because these estimates were based on a relatively small sample (n = 136), the data should be viewed cautiously. Using the same indicator, cut-off point, and reference group in an earlier investigation, Marshall and Bouffard (1997) classified 28.8% (boys: 33.0%; girls: 24.2%) of their sample of mostly Caucasian middle-class schoolchildren as *obese*. However, others have defined *overweight* in boys and girls according to a body mass index (BMI) $\geq 85^{th}$ percentile derived from data collected in the U.S. National Health and Nutrition Examination Surveys (NHANES). Johnson-Down et al. (1997) and Bernard et al. (1995) compared samples of children to NHANES II (1976-1980) data while Hanley and colleagues (2000) used NHANES III (1988-1994) as the reference population. Overall, Johnson-Down et al. (1997) found that 39.4% of 9 – 12 year old children (n = 498) from low-income, urban, multiethnic communities were *overweight*. This sample was subsequently divided into arbitrary sub-categories representing degree of overweight (**Table 2-1**).

Table 2-1. Regional and national overweight / obesity prevalence estimates of Canadian youth

Study	Age	Sample	Indicator	Definition	Prevalence
Bernard et al, 1995 (Northern Quebec)	9-15y	n = 144	BMI	Overweight (> 90^{th} & > 95^{th} percentiles)	>90^{th} percentile: 38% boys & girls >95^{th} percentile: 9.0% boys; 24% girls
Hanley et al, 2000 (Northern Ontario)	2-19y	n = 445	BMI	Overweight (≥ 85^{th} percentile)	27.7% boys; 33.7% girls
Johnson-Down et al, 1997 (Montreal, QC)	9-12y	n = 498	BMI	Somewhat overweight (≥ 85^{th} to < 90^{th} percentile) Moderately overweight (≥ 90^{th} to < 95^{th} percentile) Very overweight (≥ 95^{th} percentile)	≥ 85^{th} to <90^{th} percentiles: 13.8% boys; 10.4% girls ≥90^{th} to <95^{th} percentiles: 6.1% boys; 9.6% girls ≥95^{th} percentile: 21.9% boys; 16.9% girls
Limbert et al, 1994 National data sets from: CFS, 1981 CSWB, 1988	7-12y	CFS, n = 2601 CSWB, n = 337	Triceps skinfold, sum of 5 skinfolds, weight-for-height	Obese (≥ 85^{th} percentile)	1981: 8.7 – 15.5% boys[1] 1988: 13.6 – 22.0% boys[1] 1981: 8.8 – 16.9% girls[1] 1988: 13.0 – 26.9% girls[1]
Marshall & Bouffard, 1997 (Edmonton, AB)	5-6, 9-10y	n = 406	Sum of 5 skinfolds	Obese (≥ 85^{th} percentile)	33.0% boys; 24.2% girls
O'Loughlin et al, 2000 (Montreal, QC)	10-12y	n = 2108	BMI and Triceps skinfolds	Overweight (≥ 85^{th} percentile) Obese (≥ 95^{th} percentile)	≥ 85^{th} percentile: 35.2% boys; 33.0% girls ≥ 95^{th} percentile: 15.1% boys; 13.3% girls

Continued...

Study	Age	Sample	Indicator	Definition	Prevalence
Tremblay & Willms, 2000 National data sets from: CFS, 1981 CSWB, 1988 NLSCY, 1996	7-13y	CFS, n = 4176 CSWB, n = 481 NLSCY, n = 7847	BMI	Overweight (> 85th percentile) Obese (> 95th percentile)	>85th percentile: 1981: 15.0% boys 1996: 28.8% boys 1981: 15.0% girls 1996: 23.6% girls >95th percentile: 1981: 5.0% boys 1996: 13.5% boys 1981: 5.0% girls 1996: 11.8% girls

[T] Estimates vary depending on the indicator and reference population

CFS (Canada Fitness Survey), CSWB (Campbell's Survey on the Well-being of Canadians), NLSCY (National Longitudinal Study of Children and Youth), BMI (body mass index).

In another assessment with a larger sample (n = 2108) of Montreal-area children, O'Loughlin et al. (1998) found that 35.2% of boys and 33.0% of girls were overweight and 15.1% of boys and 13.3% of girls were obese (both BMI *and* triceps skinfold thickness ≥ 85th and 95th percentiles, respectively).

Among students from grades 4, 5, 8, and 9, Bernard et al. (1995) reported a similar overweight prevalence level (38%) in two First Nation Cree communities in James Bay, QC. When > 95th percentile for BMI was used to define overweight status, 17% fell above the cut-off with significantly more girls (24%) than boys (9%) meeting the criterion. In the Sandy Lake First Nation Community in Northern Ontario, Hanley and coworkers (2000) reported an overall overweight prevalence (based on BMI > 85th percentile) of 27.7% and 33.7% among 2-19 year old boys and girls, respectively. However, unlike Bernard et al. (1995), they found that levels of overweight varied depending on age and sex, ranging from 18.6% in 15 – 19 year old boys to 45.2% in 2 – 5 year old girls.

It is important to note that the prevalence estimates in the aforementioned studies may yield discordant results because of the application of different reference populations (i.e., CFS, NHANES II, and NHANES III). With this in mind, it is possible that Hanley et al. (2000) may have underestimated the prevalence of overweight in their sample by using NHANES III data for comparison purposes. This point is highlighted by the exclusion of NHANES III (1988 - 1994) anthropometric data for children ≥ 6 years of age from the newly-revised U.S. growth charts because of the recent upward trend in body fatness among American youth (Kuczmarski et al., 2000). The investigators argued that including these data with height and weight information collected in earlier NHANES rounds would have inflated the 85th and 95th percentiles for BMI thereby decreasing the proportion of children classified above these cutoffs. It has been recommended that American children who possess BMIs above the 85th and 95th percentile cutoffs may be suitable candidates for weight management initiatives (Himes and Dietz, 1994), so under-diagnosing boys and girls as overweight could result in missed opportunities to intervene at a time in life when the enhancement of weight-related behaviours may be most effective (Epstein et al., 1994c).

Another factor that results in different prevalence estimates is the use of different anthropometric indicators. In light of previous research wherein both skinfolds and the BMI have been applied to estimate obesity prevalence levels, Flegal (1993) illustrated the practical consequences of applying two different measures of obesity status. Using data from the same NHANES series, two separate groups of researchers arrived at different conclusions regarding the changes in obesity prevalence among African-American and Caucasian boys and girls between 1966 and 1980. Gortmaker et al. (1987) observed that the prevalence of obesity increased dramatically in all groups over a two-decade period when triceps skinfold thickness (>85th percentile) was used to define obesity. In contrast, Harlan and coworkers (1988) concluded, over the same interval, that average BMI levels were constant across the surveys for all race-, age-, and sex-specific comparisons.

2.2.2 National studies: In agreement with Flegal (1993), Limbert et al. (1994) found that prevalence estimates and changes over time varied depending on the anthropometric indicator *and* the reference population. With nationally-representative data from the CFS (1984) and Campbell's Survey on Wellbeing in Canada (CSWB, 1988), researchers compared *obesity* status in 7 – 12 year olds with the triceps skinfold thickness, sum of 5 skinfolds, and weight-for-height ≥ 85th percentile. Obesity increased 56.3% in boys (from 8.7% to 13.6%) and 47.7% in girls (from 8.8% to 13.0%) between 1981 and 1988 when the triceps skinfold thickness and an American reference standard (NHANES I) were applied. However, when the same triceps skinfold thickness data were compared to a Canadian reference group (CFS, 1981), the prevalence levels, time-associated changes, and disparity between sexes were different. Prevalence estimates increased 33.6% (from 15.2% to 20.3%) and 75.8% (from 15.3% to 26.9%) in boys and girls, respectively. Notable sex differences were also observed when the sum of 5 skinfolds was compared to the same Canadian standard such that obesity prevalence increased by 41.9% (from 15.5% to 22.0%) in boys and 69.3% (from 15.3% to 25.9%) in girls. Interestingly, weight-for-height, with an American reference population used for comparison (Hamill et al., 1977), revealed much smaller gains in prevalence. Boys increased from 14.9% to 15.3% (an increase of 2.7%) while girls increased from 16.9% to 18.9% (an increase of 11.9%) suggesting that weight-for-height is a less sensitive measure of body fatness changes in children.

More recently, Tremblay and Willms (2000) evaluated secular trends in weight status (using the BMI) comparing data from the CFS, CSWB, and the National Longitudinal Survey of Children and Youth (NLSCY, 1996) (**Table 2-1**). They concluded that *overweight* (BMI > 85^{th} percentile) increased from 15% in 1981 to 28.8% in 1996 (a 92% increase) among boys and from 15% to 23.6% (a 57% increase) in girls. *Obesity* (BMI > 95^{th} percentile) also increased -- from 5.0% to 13.5% and from 5.0% to 11.8% in boys and girls, respectively. From a methodological standpoint, it is important to note that the data collected in the CFS and CSWB surveys were based on actual measurements whereas anthropometric information collected in the NLSCY was based on parental reports. The authors acknowledged that the NLSCY data likely underestimated the true prevalence of overweight in their sample, a point supported by previous research suggesting that there are systematic errors involved when proxies report anthropometric data (Marshall and Ball, 1998). This may lead to under-estimations in body weight among girls and significant differences between actual and self-reported weight in overweight children (Strauss, 1999).

There has been long-standing debate regarding the best indicator to use for assessing obesity in youth. Kraemer et al. (1990) described several criteria that should be considered when selecting a measure of adiposity. Ideally, an indicator should be accessible, individual, reliable, and valid. Several convenient indicators (i.e., skinfold thicknesses, weight-for-height, BMI, Ponderal index [$weight^{0.33}$ /

height], Rohrer's index [weight / height^3], circumferences, and visual estimation) have all been used to assess weight status. Yet, while no single indicator satisfies all of the above criteria, if one measure must be used to define overweight and obesity in children and adolescents, the BMI is recommended (Cole et al., 2000; Bellizzi and Dietz, 1999; Himes, 1999; Pietrobelli et al., 1998; Troiano and Flegal, 1998; Power et al., 1997). The BMI is an accurate and valid indicator of weight status in children and adolescents (Malina and Katzmarzyk, 1999), is significantly correlated with total body fatness (Daniels et al., 1997; Goran et al., 1996; Deurenberg et al., 1991) and measurements of height and weight are easy and convenient to perform in most settings. While the aforementioned Canadian studies applied different criteria to establish prevalence estimates of overweight and obesity, the emergence of the BMI as the preferred indicator should provide a universal frame of reference for future surveys, especially since standardized international definitions of overweight and obesity using the BMI have recently been proposed (Cole et al., 2000).

It is possible that the discrepancies between Canadian estimates in regional and national studies represent a true difference in obesity prevalence. However, these differences may also reflect variations in geography, ethnicity, season, maturation, socioeconomic status, reference populations, and the anthropometric indicators used to define relative weight status. Notwithstanding the disparities regarding the methodological issues associated with defining obesity status in children and adolescents, and the terms used to characterize high levels of body fatness, it is clear that obesity is widespread and has increased dramatically over the last two decades among Canadian youth. The present situation in Canada is similar to that of the United States (Ogden et al., 1997; Troiano et al., 1995) and the United Kingdom (Chinn and Rona, 1994) and highlights the growing global trend of increased body fatness among children and adolescents (WHO, 1998).

2.3 Risk Factors Associated with Obesity in Youth

Obesity in youth represents one of the most frustrating conditions to treat (Barlow and Dietz, 1998). Although it may be a matter of semantics, determining whether obesity is a risk factor for disease or a disease entity in its own right is a current topic of debate (Heshka et al., 2001). Interestingly, while childhood obesity has been classified as a disease by US researchers (Bandini and Dietz, 1992), it has not been categorized as such in Canada (Canadian Task Force, 1994). This controversy may be due, in part, to the fact that many obese youngsters do not present with an overt illness and because a larger body size may be more desirable within some populations. As well, childhood obesity has largely been perceived as an aesthetic issue as opposed to a real health concern (Young-Hyman et al., 2000; Steen et al., 1996). However, extensive evidence suggests that a high level of body fat is associated with numerous psychosocial and physiological risk factors and health consequences **(Table 2-2)**.

Table 2-2. Risk factors and health consequences related to obesity in youth

Cardiovascular	Dyslipidemia (increased total cholesterol, low-density lipoprotein-cholesterol, and triglycerides), elevated systolic and diastolic blood pressure, and increased hemostatic measures
Endocrine	Insulin resistance, abnormal glucose metabolism, and polycystic ovary syndrome
Gastroenterological	Gallstone formation and hepatic steatosis
Lifestyle	Low fitness, low physical activity, low movement competence, high fruit juice / pop intake, high television viewing, and low socioeconomic status
Orthopedic	Accelerated growth, capital epiphysis, and Blount's disease
Psychosocial	Low self-esteem, poor body image, barophobia (fear of fatness), and low socioeconomic status
Pulmonary	Asthma, sleep apnea, and Pickwickian syndrome
Persistence into adulthood	The longer obesity is maintained in youth, the greater the likelihood of obesity tracking into later life.

2.3.1 Psychosocial risks and consequences

The impact of obesity on subjective well being has been largely underinvestigated (Kolotkin et al., 1995). This is somewhat surprising given there are few health issues in youth that have as profound an impact on emotional and social development as obesity (Must and Strauss, 1999; Dietz, 1998). Obesity is stereotyped in a highly negative manner in Western countries (Anesbury and Tiggemann, 2000). Research with elementary schoolchildren has found that an overweight body shape is described as lazy, sloppy, ugly, and stupid (Wardle et al., 1995; Kilpatrich and Sanders, 1978) and is associated with poor social functioning, impaired academic success, and low perceived health (Hill and Silver, 1995). Negative attitudes and beliefs of obesity in children have important implications because of the potential unfavourable effects on peer acceptance and psychological health. Strauss et al. (1985) have shown that obese children are less desired as playmates than average weight children and that they perceive themselves as more depressed and as having lower self-concept. These observations reveal that stigma associated with obesity develops at a young age.

It is commonly believed that overweight and obese children are unhappy with their weight, but this assumption has not received universal support (Steen et al., 1996). General conclusions regarding the relationship between obesity and depression are complicated since much of the evidence is derived from clinical samples of children receiving treatment (for psychopathology or obesity) who are compared to otherwise healthy, non-obese boys and girls (Epstein et al, 1994a; Epstein et al., 1994d; Israel and Shapiro, 1985). One of the few population-based studies on body weight and depression observed that overweight girls (but not boys) manifested more depressive symptoms than their non-overweight peers (Erickson et al, 2000). In this study (n = 868 children; 8 – 9 years old), BMI was associated with more weight-related concerns in girls and, in turn, these concerns were associated with depressive symptoms. In a study of adolescents

(Britz et al., 2000), the presence of psychiatric disorders was compared between three groups: a clinical study group of obese adolescents, a population based sample of obese adolescents, and a large population-based control group. The clinical obese group was more likely to have psychiatric disorders (i.e., anxiety and eating disorders) than the other two groups. However, because the average BMI of the clinical study group (BMI = 42.4 kg / m^2) was higher than that of the obese population controls (BMI = 29.8 kg / m^2), it is difficult to clarify whether the high rate of psychopathology in the study group was related to the extreme obesity or to their treatment-seeking behavior. Using information from an extensive database of data on psychological and physical health, Lagerberg et al. (1994) determined that obesity increased the relative risk (RR) of seeking regular contact with school psychologists (RR = 2.68, 95% Confidence Intervals [CI]: 2.22 – 5.88), psychosomatic complaints (RR = 2.30, 95% CI: 1.49 – 3.56), and serious psychological problems (RR = 1.86, 95% CI: 1.18 – 2.93) in a cohort of 1,869 Swedish adolescents. In another assessment of Swedish adolescents (Mellbin and Vuille, 1989), moderately severe stress occurred more frequently among obese 7 – 10 year olds (RR = 4.40, 95% CI: 2.87 – 7.91) and 10 – 13 year olds (RR = 10.83, 95% CI: 10.25 – 11.47) than in average weight boys and girls. These cross-sectional observations that imply an association between depression and obesity are confirmed by at least one longitudinal investigation. Pine and colleagues (2001) found clinical depression in the child and adolescent years to be predictive of obesity in adulthood. Children (6 – 17 years old) with major depressive disorder (MDD) were matched with children having no psychiatric disorder. After 10 – 15 years of follow-up and evaluation, the mean adult BMI was greater for children initially diagnosed with MDD (26.1) compared to controls (24.2). Although the group difference is small, these data suggest that depressive psychopathology early in life acts either directly or indirectly to influence overweight and obesity in later years.

A factor that may confound the relationship between depression and obesity status relates to the criteria used to determine obesity. While the BMI is highly correlated with total body fatness (WHO, 1998; Daniels et al., 1997; Goran et al., 1996), the relationship between depression and obesity assessed using more sophisticated techniques such as dual-energy X-ray absorptiometry (DXA) may help to clarify the relationship between depression, as well as other psychosocial constructs, and obesity.

Low self-esteem has been identified as both a potential contributor (Woody, 1986) and consequence (Mellin et al., 1987) of obesity in youth. Self-esteem (or self-worth) has been defined as *the awareness of good possessed by the self and represents how positive individuals feel about themselves in general* (Fox et al., 2000). Another term often used interchangeably when describing psychological well-being is self-perception, *an umbrella term that denotes all types of self-referring statements about the self ranging from those that have specific content to those that express general feelings* (Fox et al., 2000). Cross-sectional studies comparing self-esteem and self-perception differences between obese and non-obese children have been equivocal, but it appears that obesity status is related to a less favourable self-concept (Ball et al., 2001; Manus and Killeen, 1995). This trend is supported by longitudinal analyses that show decreasing levels of self-esteem as young obese boys and girls mature into adolescents (Strauss, 2000; Brown et al, 1998). While obesity in childhood is not viewed positively by many children (Phillips and Hill, 1998), it seems that adolescence is the period of life when excess adiposity begins to exert a more salient effect on self-perception. This appears logical since sexual and opposite-sex relationships are emerging and new cultural and social roles are defined at this time in life. While levels of global self-worth are influenced by body fatness during adolescence (Strauss, 2000), sub-domains related to perceptions of physical appearance, social acceptance, and body image are impacted as well (Wadden et al., 1991; Mendelson and White, 1985).

Teasing and negative verbal commentary directed toward appearance are known to predict body image disturbance in youth that may extend into later life (Cattarin and Thompson, 1994). In addition, data suggest that negative social feedback may be differentially aimed at overweight or obese individuals placing them at increased psychological risk above and beyond what average weight children and adolescents may encounter (Wertheim et al., 1997). Because a higher body mass index is associated with increased body dissatisfaction (Thompson, 1996), it is necessary to consider the relative contribution of appearance-directed comments and degree of obesity to body image disturbance. Research with overweight boys and girls has revealed that peers and parents alike provide negative comments that are overt, and often less obvious and even non-verbal, that relate to poor body image ratings among children (Schwartz et al., 1999).

Childhood is a critical period for the development of body image (Must and Strauss, 1999). Monello and Mayer (1963) observed that obese girls are likely to possess obsessive concern with body image as well as expectations of rejection by peers. Stunkard and Burt (1967) found that women who became obese as children were more likely to have persistent and severe disturbances in body image. Conversely, adult women who became obese as adults demonstrated only minimal alterations in body image. While documented primarily in girls, *fear of fatness* has been identified as a common condition that affects both average weight and overweight girls. Girls as young as 5 years old have been reported to endure stress, anxiety, and fear regarding the potential of future weight gain (Feldman et al., 1988). A study of adolescent girls (n = 270) revealed that approximately 50% believed they were *too fat*; however, 83% of girls in this subset were, in fact, of normal weight-for-height (Feldman et al., 1986). Fear of fatness among adolescent girls has also been associated with growth failure and delayed onset of puberty likely as a function of severe energy restriction (Pugliese et al., 1983). Another related and substantial concern is that a growing minority of young girls has reported smoking as a means of controlling their weight (Ryan et al., 1997).

Discrimination against overweight adolescents has also been documented and may contribute to the lower academic achievement observed among obese adolescents. The perceptions schoolteachers have of obese children suggest that biased perceptions may partly influence academic performance and scholastic experiences and opportunities. Teachers perceive obese students to have lower energy levels, diminished leadership ability, lower self-esteem, and be less socially outgoing as well as less attractive than their average weight peers (Schroer and Flett, 1985). In a group of girls spanning grades 7 – 11 (n = 5201), obese adolescents were more likely to experience feelings of hopelessness, endure problems over the past year, attempt suicide, perceive themselves to be a poor student, and expect to not complete college in the future (Falkner et al., 1999). Although they possessed similar achievement scores on college entry examinations, overweight adolescents have had approximately 50% the college acceptance rates into elite universities in the United States compared to average weight adolescents (Canning and Mayer, 1966). Goldblatt and coworkers (1965) have reported that obese women are twice as likely to experience downward social and economic mobility as upward mobility. In one of the more comprehensive assessments of the influence of overweight status on economic and social outcomes, Gortmaker and colleagues (1993) analyzed data from adolescents and young adults who were followed prospectively for seven years in the National Longitudinal Survey of Youth (n = 10,039; 16 – 24 years of age). They determined that women who were overweight at the start of the study completed 0.3 years less schooling, had lower household incomes ($6710 less per year), and had greater rates of poverty (10% increased risk) compared with those who were initially average weight. While similar observations were found in men, the impact of overweight was less dramatic. Others have confirmed that obese women are less socially desirable than their average weight peers. Data suggest that obese women are less likely to date or marry than average weight women and that adolescent boys emphasize thinness in their potential mates more than girls do (Sobal et al., 1995).

Investigators have recently begun to explore health-related quality of life (HRQOL) issues in overweight and obese adults (Fontaine et al., 2000; Mannucci et al., 1999; Han et al., 1998). Presently, research in this area for younger populations including obese children and adolescents is lacking and is primarily hampered by a lack of appropriate measurement tools (Kushner and Foster, 2000). However, an argument can be made for the need to address HRQOL in youth in population-based studies to assess whether differences based on obesity exist among obese children and adolescents and their average weight peers. If meaningful differences exist, it may be appropriate to design interventions that specifically target HRQOL as an outcome; this may be especially relevant for severely obese children and adolescents who may be at greatest risk. This sub-group is more likely to experience weight-related morbidity (i.e., orthopedic problems) and the resultant benefits associated with successful weight management. While overweight and obese boys and girls may be less concerned with weight-related health issues such as hypertension or risk for type 2 diabetes, the influence of body fatness on their physical and psychosocial health perceptions stands to improve our understanding of the impact of weight on health perceptions in youth.

The physical risks and consequences of obesity in youth have been well documented (Must and Strauss, 1999; Power et al., 1997). However, it is equally (if not more) important for researchers and health professionals to recognize and understand the role of obesity in psychosocial health in boys and girls. Extensive evidence underscores the myriad constructs that may cause or reflect obesity. The measurement of outcomes including self-perception / self-esteem, depression, body image, and HRQOL should be critically evaluated in obese boys and girls so a greater understanding of potential enabling factors can be identified. Future research should focus on whether positive family, school, and / or community interactions can alleviate the negative psychosocial affects of obesity in youth. These steps are necessary so that children and adolescents may receive the requisite screening, care, and support required to achieve and maintain psychological well-being.

2.3.2 Multiple risk factors for cardiovascular diseases (CVD) and type 2 diabetes

Chronic illnesses such as CVD and type 2 diabetes have traditionally been considered adult phenomena, but this perception may be changing. For example, recent reports suggest that type 2 diabetes has become more common among sub-groups of overweight boys and girls (Fagot-Campagna et al., 2000; Libman and Arslanian, 1999; Rosenbloom et al., 1999; Dean, 1998). Although such findings merit concern, most studies linking obesity with adverse health consequences are based on clinical samples of children receiving medical treatment and may not reflect the true prevalence within the population. An especially alarming trend is that risk factors for diseases such as CVD and type 2 diabetes can manifest themselves early in life and often emerge in *clusters* among obese children. This clustering of risk factors (i.e., dyslipidemia, hypertension, hyperinsulinemia, and obesity) has been given several names including Syndrome X (Reaven, 1988), the Insulin Resistance Syndrome (IRS) (Haffner et al., 1992) and, more recently, the Metabolic Syndrome (Alberti and Zimmet, 1998) and the Metabolic Cardiovascular Syndrome (Tremblay, 1998). It is fairly clear that obesity and a genetic susceptibility combined with a lifestyle characterized by low levels of physical activity and high fat / high energy diets places susceptible individuals at increased health risk (Beck-Nielsen, 1999; DeFronzo and Ferrannini, 1991).

Numerous researchers have used cross-sectional investigations to determine the presence of risk factor clusters related to chronic diseases in children and adolescents. Among 10 – 15 year old black (n = 251) and white (n = 285) boys, Morrison et al. (1999a) found that overweight boys in both racial groups were more likely to possess risk factors for CVD than non-overweight boys. More specifically, boys with a BMI ≥ 85th percentile possessed higher low-density lipoprotein-cholesterol (LDL-C), triglycerides (TG), systolic blood pressure (SBP), diastolic blood pressure (DBP), central adiposity, and lower high-density lipoprotein-cholesterol (HDL-C) values than boys with a BMI < 85th percentile. Overweight boys were also much more likely to have ≥ 2 risk factors than non-overweight boys (whites: 55.3% versus 12.7%; blacks: 41% versus 13.7%). The same research group (Morrison et al., 1999b) made similar observations in a sample of 9 – 10 year old black (n = 918) and white (n = 953) girls. Overweight girls (BMI ≥ 85th percentile) scored less favorably than non-overweight girls (BMI < 85th percentile) with regards to serum lipids and blood pressure values. As in boys, overweight girls from both races were more likely to possess at least 2 risk factors for CVD than their non-overweight peers.

In a report from the Bogalusa Heart Study, Freedman et al. (1999) found that the proportion of children who were overweight increased as the number of risk factors increased. Among 5 – 17 year olds, overweight children represented 9% (n = 335) of the 3884 boys and girls with no risk factors, 23% (258 / 1141) of the children with 1 risk factor, and 74% (82 / 111) of the children with ≥ 3 risk factors for CVD. In this large sample, overweight subjects were more likely to have high TG and low HDL-C levels, and 90% of children with high levels of insulin and TG were overweight. Overweight 5 – 10 year old boys and girls were 9.7 times as likely to have 2 risk factors and 43.5 times as likely to have 3 risk factors than normal weight children. Similar observations were found in a group of Taiwanese schoolchildren (n = 1366) in which multiple risk factors for CVD and type 2 diabetes were much more prevalent in obese boys and girls than in non-obese children (Chu et al., 1998). Approximately 70% of obese boys had at least 1 risk factor, twice the prevalence of non-obese boys. The prevalence of ≥ 2 risk factors was 4 – 5 times greater in obese compared to non-obese boys and girls.

In a sample of Swedish adolescents (n = 1032) categorized according to BMI quartiles, boys and girls in the highest quartile were more likely than their peers in the lowest quartile to possess a cluster of risk factors (Bergstrom et al., 1996). Specifically, adolescents in the high quartile were more likely to have ≥ 2 risk factors than those in the low quartile (boys: 54% versus 32%; girls: 56% versus 22%). Risk factors also tended to cluster in a sample of obese Hungarian adolescents (Csabi et al., 2000). Hypertension, hyperinsulinemia, hypercholesterolemia, hypertriglyceridemia, and low levels of HDL-C were more prevalent among obese boys and girls than in controls and only 14.4% of obese children were free from any risk factors. Obese children were at ~19 times greater risk of developing 1 risk factor and ~6 times more likely to possess > 1 risk factor. Overall, the metabolic syndrome was present in 8.9% of the obese children while clustering of risk factors was almost non-existent in controls.

The cross-sectional studies linking overweight with adverse risk factors highlight important relationships between health-related variables. However, longitudinal investigations are necessary to evaluate changes over time. Bao and colleagues (1994) observed that risk factors persisted (tracked) from childhood into young adulthood in a sample of 5 – 17 year olds (n = 1176). Over an 8-year period, a multiple risk index score (derived from the relative rankings of individual SBP, TC:HDL-C ratio, and insulin levels) was found to track better than individual risk factors alone. Overall, the Spearman correlation coefficient between year 1 and year 8 multiple risk index scores was 0.64 ($p = 0.0001$) while the individual risk factor correlations were slightly lower (TC-HDL-C, $r = 0.57$; SBP, $r = 0.54$; and insulin level, $r = 0.34$). Webber and colleagues (1991) followed 1,586 children and found approximately 50% of children with TC and LDL-C levels >75th percentile at baseline had elevated levels 12 years later. Following lipid or lipoprotein levels, obesity status was the next best predictor of follow-up lipid levels. In a group of 2,433 Finnish youth (9 – 24 years of age), 30% - 44% who were in the highest fasting insulin quartile at baseline remained there 6 years later (Ronnemaa et al., 1991). Not unexpectedly, high TG, SBP, and low HDL-C levels clustered among subjects within the highest insulin quartile. Taken together, these data support the concept that children and adolescents who possess risk factors for CVD and type 2 diabetes early in life tend to maintain their increased metabolic risks later in life.

Along with risk factors for CVD and type 2 diabetes, obesity is also known to track from childhood into adulthood (Clarke and Lauer, 1993). Whitaker et al. (1997) calculated that the odds ratio (OR) of becoming an obese adult increased with greater degrees of obesity and older age. After adjusting for parental obesity, the OR of developing obesity in adulthood associated with childhood obesity varied from 1.3 (95% confidence interval [CI]: 0.6 – 3.0) at 1 – 2 years of age to 17.5 (95% CI: 7.7 – 39.5) at 15 – 17 years of age. As well, Guo and Chumlea (1999) showed that children who were above the 95th percentile for BMI were 1.3 – 6.1 more likely to be overweight at 35 years of age than those who were at the 75th percentile in their youth, suggesting that tracking is more likely at higher degrees of body fatness. Research also suggests that the persistence of obesity from youth to adulthood may be more deleterious from a health perspective than if obesity develops later in life (Vanhala et al., 1998). Prolonged insulin resistance associated with the multiple risk factors of the metabolic syndrome may be mediated through high levels of body fatness that track from youth to adulthood. Because the tracking of both body fatness and risk factors for CVD and type 2 diabetes is evident among overweight boys and girls, the likelihood that youngsters will experience premature weight-related morbidity and mortality later in life is increased (Must et al., 1992).

Upon review, the prevalence of multiple risk factors in overweight children in the aforementioned studies may appear high. However, to put the metabolic syndrome in youth into perspective, definitions of risk factors in children and adolescents and the prevalence of the syndrome in adult populations must be considered. Determining the true prevalence of risk factors for CVD and type 2 diabetes in youth is complicated since abnormal levels have not been clearly defined for all variables. Specific guidelines have been proposed to characterize the metabolic syndrome in adults (Alberti and Zimmet, 1998), but no such recommendations exist for younger populations. Consequently, most researchers have compared boys and girls to population-specific norms. For example, Batey et al. (1997) defined an adverse risk factor when a value for a specific variable was greater than the median value for the study population. Chu et al. (1998) classified children with hypertension, hyperlipidemia, and hyperglycemia if individual values were ≥ 90^{th} age- and sex-specific percentile, while Freedman et al. (1999) used a combination of absolute (for blood lipids) and percentile (for insulin) cut-offs. Still others have used > 75^{th} percentile as a cut-off point (Chen et al., 1999; Bergstrom et al., 1996; Bao et al., 1994). In adults, the metabolic syndrome has been defined numerous ways, but it appears that the prevalence of the metabolic syndrome is low in population-based studies. Prevalence estimates have ranged from 0.7% (Haffner et al., 1992) to 2.9% (Wannamethee et al., 1998) to 3.7% (Eriksson et al., 1992), but is likely greater in high risk groups (i.e., overweight / obese, pre-existing CVD or type 2 diabetes).

While it has been hypothesized that hyperinsulinemia plays the dominant pathophysiologic role in Syndrome X (Reaven, 1988), to our knowledge, only one study in young people (5 – 38 years of age) has supported this concept (Chen et al., 1999). In contrast, several studies of adult populations have faiied to support the idea that a single independent process is involved (Gray et al., 1998; Donahue et al., 1997; Meigs et al., 1997). Despite the uncertainty regarding potential mechanisms, a key putative factor involved in the metabolic syndrome is body fatness and, more specifically, abdominal body fat distribution (Goran and Gower, 1999; Gower et al., 1999; Ferguson et al., 1998; Slyper, 1998; Wannamethee et al., 1998; Jarrett, 1992; Bao et al., 1993).

2.3.3 The measurement of body fat distribution

Traditionally, anthropometric indicators such as the waist circumference, waist-to-hip ratio and trunk-to-extremity skinfold thickness ratio (i.e., subscapular-to-triceps) have been used to estimate abdominal body fatness in youth (Sangi and Mueller, 1991; Mueller et al., 1989; Weststrate et al., 1989). Convenience and low cost make these choices desirable, however, the correlations between these indirect estimates and more precise measures have been weak and inconsistent (Goran et al., 1995b; Brambilla et al., 1994; Fox et al., 1993; de Ridder et al., 1992). Also, anthropometry cannot be used to determine the relative influence of visceral adipose tissue (VAT) and subcutaneous abdominal adipose tissue (SAAT) on health outcomes. The emergence of imaging techniques such as computed tomography (CT) and magnetic resonance imaging (MRI) in body composition research have allowed for the accurate quantification of and distinction between VAT and SAAT (Baumgartner et al., 1993; Ross et al., 1993). Both CT and MRI are useful, but their high cost and limited availability prevent widespread application beyond the clinical setting. Because individuals who undergo CT measurements are exposed to ionizing radiation, MRI is the more popular choice within pediatric populations, especially when repeated measurements are performed over time. The use of dual-energy X-ray absorptiometry (DXA) has also been useful in assessing regional body fat depots (Daniels et al., 1999). While DXA is unable to distinguish VAT from SAAT, preliminary research suggests that regional scans may be beneficial for estimating total abdominal and visceral fat in obese children and adolescents (Tershakovec et al., 2001). The recent development of regression equations based on combinations of anthropometric and demographic data have been created to estimate VAT in children (Owens et al., 1999; Goran et al., 1998). These formulae should be useful for health professionals and researchers working in non-clinical settings and when imaging techniques are unavailable or impractical.

2.3.4 Body fat distribution and risk factors for CVD and type 2 diabetes

Using anthropometric indicators, researchers have observed positive correlations between risk factors for CVD (Zonderland et al., 1990; Zwiauer et al., 1990) and type 2 diabetes (Legido et al., 1989) and central body fat distribution in youngsters. However, newer imaging techniques have led to more precise determinations of body fat depots and their relationship to corresponding health outcomes. Using MRI to assess body fat patterning, Caprio et al. (1996) revealed that VAT was positively correlated with fasting insulin ($r = 0.55$, $p<0.03$) and TG ($r = 0.53$, $p<0.04$) and negatively associated with HDL-C ($r = -0.54$, $p<0.04$) levels among obese adolescent girls. As well, femoral adipose tissue was negatively related to LDL-C ($r = -0.56$, $p<0.05$) and TG ($r = -0.51$, $p<0.05$) suggesting that, as in adults (Emery et al., 1993), this body fat depot may exert either a neutral or protective effect with respect to health outcomes. Interestingly, VAT was not related to any risk factors for CVD in non-obese girls and the only significant relationship in the non-obese group was between SAAT and fasting insulin levels ($r = 0.69$, $p<0.02$). In a biracial group of obese 7 – 11 year old boys and girls ($n = 64$), Owens et al. (1998) found VAT to be positively associated with TG, TC/HDL-C ratio, and fasting insulin levels and negatively correlated with HDL-C and LDL-C particle size. SAAT, % total body fatness and total fat mass (TFM) were also related to lipid and lipoprotein risk factors, but only VAT (determined using MRI) explained a significant proportion of the variance in lipid levels. While VAT was most strongly associated with lipid-related risk factors, TFM proved to be the strongest predictor of non-lipid risk factors (i.e., fasting insulin and SBP values). In prepubertal children, Gower et al. (1999) concluded that VAT was positively related to TG and fasting insulin, independent of subcutaneous and total body fat. However, contrary to earlier research in a group of adolescent girls (Caprio et al., 1995), insulin sensitivity was significantly related to TFM and *not* VAT.

Further investigation into the role of VAT and different body fat depots is warranted, yet the findings to date suggest that different fat depots correspond to different risk factors depending on TFM and the presence of risk factors is likely dependent upon age and physical maturation. Although the interrelationships are complex, data suggest that risk factors in youth vary depending on a number of other factors as well.

2.3.4.1 Ethnicity: Comparisons between Caucasian, African-American, and Mexican-American children have revealed some important racial differences. For example, African-American children are known to have lower insulin sensitivity (Ku et al., 2000; Svec et al., 1992) and higher insulin secretion (Ku et al., 2000; Arslanian and Suprasongsin, 1996) than whites which may partly explain the greater prevalence of type 2 diabetes among African-American adults (Brancati et al., 2000; Robbins et al., 2000) and especially adult women (Okosun, 2000). Daniels et al. (1996) observed higher blood pressure values in African-American versus Caucasian girls, a finding likely related to differences in maturation and body size. In a report from the Bogalusa Heart Study (Freedman et al., 1999), overall risk factor clustering was less prevalent among African-American than Caucasians, but the odds ratios between overweight and multiple risk factors were similar between groups. In a comparison of 403 Mexican-American (MA) and non-Hispanic white (NHW) third grade children, Batey et al. (1997) observed that clusters of risk factors were exhibited to a greater degree in MA children than in NHW. Overall, more MA children had ≥ 3 risk factors than NHW (55% versus 37%, respectively) and three times as many MA (15.8%) as NHW (5.2%) had 5 risk factors. Differences were more pronounced in boys than in girls; MA boys had higher fasting insulin, glucose, SBP, BMI, and lower HDL-C levels than NHW boys whereas MA girls differed from the NHW peers in fasting insulin and glucose values only.

Several researchers have observed lower levels of VAT in African-American boys and girls than Caucasians (Owens et al., 2000; Gower et al., 1999; Yanovski et al., 1996). Using anthropometric indicators, Caucasian children have been shown to have less central body fat than Native American (Goran et al., 1995a) and

Mexican (Greaves et al., 1989) children, but similar amounts compared to Asian youngsters (Wardle et al., 1996). These data suggest that, along with differences in body fatness, there appears to be an underlying genetic susceptibility in some populations to developing a central body fat distribution and the accompanying metabolic complications (Fagot-Campagna et al., 2000; Sievers et al., 1999; Hanis et al., 1991).

2.3.4.2 Maturation and Sex: As children physically mature during puberty, the hormonal milieu has a profound impact on body fat deposition and distribution. Levels of estrogen, testosterone, and growth hormone rise during this period; concomitantly, body fat tends to shift from peripheral (i.e., arms and legs) to central regions (i.e., trunkal) and from subcutaneous to internal sites (i.e., intra-abdominal). As well, sex differences become more marked; boys deposit more muscle tissue during this time while girls accumulate more fat tissue. However, while boys increase their lean body mass (LBM) by 33 – 35 kg between 10 – 20 years of age, the increase seen in girls is about half as much (16 – 18 kg) (Groff et al., 1995). The rapid increase in LBM that occurs during the growth spurt is accompanied by a decrease in body fatness among boys. Although adolescent girls also gain LBM during the adolescent growth spurt, a greater percentage of weight gain is the result of fat accretion. Data from the Canada Fitness Survey (1984) revealed a sexual dimorphism in body fatness with greater skinfold thicknesses (biceps, triceps, subscapular, suprailiac, and medial calf) becoming more marked in girls after 12 years of age.

Collectively, these data suggest that VAT is linked to some risk factors for CVD and type 2 diabetes, but other fat depots (i.e., SAAT and TFM) also play important roles. As well, ethnicity, physical maturation, and sex all have independent roles in the etiology of multiple risk factors for CVD and type 2 diabetes.

2.4 The Treatment of Obesity in Youth

2.4.1 To treat or not to treat

Typically, weight management programs for obese boys and girls promote weight loss and / or weight maintenance through prudent lifestyle behaviours intended to improve or prevent immediate and future health problems. This is a logical tactic since elevated weight status in youth is associated with increased risk of immediate morbidity (Rosenbloom et al., 1999; Freedman et al., 1999; Dean, 1998) and future morbidity and mortality (Vanhala et al., 1998; Must et al., 1992). Obesity has been classified as a disease in its own right and as a risk factor for several chronic health conditions (World Health Organization, 1998), so there are clear economic advantages in favour of treatment (Birmingham et al., 1999). Further, the modest success of obesity treatment initiatives in adults (Glenny et al., 1997; Brownell et al., 1986) provides indirect support for treating obesity in youth, before increased adiposity and unhealthy diet and activity patterns have the opportunity to become ingrained over an extended period (Epstein et al., 1998). In fact, Epstein and coworkers (1995a) have demonstrated that obese children may be more successful at maintaining weight loss long-term than their obese parents. Finally, successfully treating obesity at a young age may prevent boys and girls from having to deal with numerous psychosocial consequences (i.e., lack of acceptance, ostracism, and discrimination) since a high degree of body fat has very low social value in our culture (Marshall, 1995).

However, whether or not to treat obesity in children is debatable (Brownell and Rodin, 1994; Garrow et al., 1994; Brownell, 1993). While many overweight and obese individuals are at an increased health risk, being overweight or obese may not pose a significant health risk for some individuals (Robinson, 1993). Accumulating evidence from overweight and obese adults suggests that cardiorespiratory fitness may be a more important determinant of morbidity and mortality than obesity status alone (Brodney et al., 2000; Lee et al., 1998).

Studies linking child and adolescent obesity to long-term outcomes such as cardiovascular diseases and mortality while controlling for cardiorespiratory fitness levels are lacking, but it is presumptuous to assume that obese boys and girls cannot be fat and metabolically healthy as well.

The treatment of childhood obesity may also be complicated by the potentially negative clinical and cognitive effects involved with labeling a child as obese. Inappropriate eating and exercise behaviours may be used to facilitate weight reduction (Cole et al, 2000, Petersmarck, 1999) and the stigma of being classified as an obese boy or girl may have adverse psychological consequences (Cameron, 1999). However, ensuring that interventions emphasize establishing and maintaining healthy lifestyle behaviours and supportive family, school, and community environments should minimize these risks.

Another factor to consider in childhood weight management involves the anthropometric indicators used to screen young individuals for inclusion or exclusion. Depending on the indicator (e.g., sum of 5 skinfolds) and cutoff value (e.g., $\geq 85^{th}$ percentile), under- and over-diagnosing obesity may occur. For example, under-diagnosing childhood obesity with a conservative indicator and / or high cutoff level represents a missed opportunity to intervene at a time when treatment may be beneficial. Conversely, over-diagnosing obesity with a liberal indicator and / or low cutoff level has the potential to cause harm if treatment is very intensive and a child is only temporarily at an elevated weight status due to body composition changes associated with physical maturation. New guidelines have been established to define overweight and obesity in children and adolescents (Cole et al., 2000), however, the potential ramifications of incorrect classification as they relate to obesity treatment are infrequently discussed in the literature. It has been suggested that only children at the highest end of the obesity continuum (i.e., BMI $>95^{th}$ percentile) should participate in treatment programs since this group is at greatest risk for becoming obese adults (National Task Force, 1994). It may also be judicious to consider enrolling children in obesity interventions only after making a longitudinal assessment of their weight status since decisions based on cross-sectional assessments may lead to children being incorrectly classified as obese (Ball, Marshall, and McCargar, unpublished observations).

Recommendations have been developed to guide the management of child and adolescent obesity in the U.S. (Barlow and Dietz, 1998; Himes and Dietz, 1994). Presently, no definitive guidelines have been established in Canada. The most recent update of the Canadian Task Force on the Periodic Health Examination (1994) regarding obesity in childhood concluded that there was insufficient evidence of short- or long-term benefits from screening for or treatment of childhood obesity to recommend such screening or recommend against it. Yet, our understanding of the correlates, causes, and consequences of child and adolescent obesity has advanced considerably over the last decade (Goran, 2001). While many questions remain, policy makers, scientists, and clinicians may need to re-evaluate weight management guidelines for Canadian boys and girls. In the meantime, the issue of whether or not to treat obesity in Canadian youth will remain a decision made by individual children, parents, and health care professionals based on their perception of the problem, availability of resources, and readiness to establish behaviour changes within the family.

2.4.2 Weight management in childhood and adolescence

Numerous reports have been published on the treatment of obesity in children and adolescents. Physical activity (Epstein et al., 2000; Gutin et al., 1999b), diet (Spieth et al., 2000; Kiortsis et al., 1999), and comprehensive lifestyle management programs (Sothern et al., 2000; Ebbeling and Rodriguez, 1999) have been tested in young obese populations since establishing healthy activity and nutrition behaviours at an early age is thought to increase the likelihood of these lifestyle behaviours tracking into adulthood. With regards to weight management practices, a combination of treatment regimens (diet, exercise, and behavior modification) are considered more likely to be effective, both in the short- and the long-term, than a single-regimen approach or no intervention (Douketis et al., 1999). While subtle differences exist, several strategies are common to most comprehensive family-based interventions (**Table 2-3**).

Table 2-3. Common behavioural and support strategies incorporated into most family-based weight management programs for obese children

1. Increased levels of physical activity or exercise to facilitate weight loss / weight maintenance and to improve measures of health such as cardiorespiratory fitness, body composition, and metabolic / biochemical indicators (i.e., serum cholesterol and blood pressure).
2. Energy- and / or fat-reduced diets combined with nutrition education to support dietary changes (i.e., choosing less-energy dense foods, increasing vegetable and fruit intake, and improving nutrition knowledge and attitudes).
3. Individual and / or group counseling for parents and children.
4. Multi-disciplinary health care team (i.e., dietitian, pediatrician, activity specialist, psychiatrist / psychologist).
5. Parental involvement and support that includes lifestyle changes and strategies the entire family can adopt.

Obesity treatment is usually considered successful if positive changes in body fat, weight loss, and / or weight maintenance are made. Reporting absolute changes in a measure of weight status alone may obscure subtle changes in the somatic growth and development of boys and girls (Gillis et al., 2000; Glenny et al., 1997). Because boys and girls are in a dynamic state of growth, presenting changes in body composition and using relative weight terms (i.e., percent overweight) are considered most meaningful.

It is not uncommon for treatment programs to elicit short-term improvements in weight status, but the ability to sustain positive changes in attitudes, behaviours, and objective indices of health over time need to be considered when defining treatment goals and overall success (Miller, 1998; Goodrick and Foreyt, 1991; Reybrouck et al., 1990). Since obesity is considered a chronic health problem, research involving long-term follow-up of *successful* participants post-intervention would provide the most compelling support for treatment. Unfortunately, but not surprisingly, given the complex genetic, behavioural, and environmental interactions, along with the time and resources required to carry out longitudinal analyses, there are few published reports of the long-term results of treating obesity in youth. However, some examples exist.

Over the past two decades, Epstein and coworkers have published more on the behavioural treatment of childhood obesity than any other research group (Myers et al, 1998; Epstein et al., 1995a; Epstein et al., 1995b; Epstein et al., 1994b; Epstein et al., 1993; Epstein et al., 1991; Epstein et al., 1990; Epstein et al., 1985a; Epstein et al., 1985b; Epstein et al., 1984; Epstein et al., 1982). They are one of the few groups to demonstrate that obese children can successfully lose weight and maintain positive weight changes over an extended period. With data combined from 4 randomized studies (n = 158 children), 34% of children decreased their percentage overweight by ≥ 20% and 30% were no longer obese after 10 years of follow-up (Epstein et al., 1994c). These observations were consistent with earlier data on weight changes at 5-years follow-up (Epstein et al., 1990). The factors that best predicted long-term maintenance of weight loss (at 10-years post-treatment) were weight change during the first 5 years, participation in regular exercise, and an intact family environment (a two-parent household). While it can be argued that some children may naturally *grow into* their weight over time through normal growth and maturation processes, participants in this investigation were approximately 40% overweight at onset. Observational research suggests that children with this relatively high degree of obesity tend to retain their elevated obesity status as they mature through adolescence and into young adulthood (Guo and Chumlea, 1999; Stark et al., 1981). Thus, it is likely that the behavioural interventions were largely responsible for facilitating these positive weight changes.

Epstein and colleagues have included numerous activity / exercise (i.e., calisthenics, prescriptive exercise, and lifestyle activity) and behavioral (i.e., contingency contracting, self-monitoring, praise, and problem solving) strategies in their weight management programs. However, virtually all interventions have used the Traffic Light Diet (Valoski and Epstein, 1990) to guide dietary changes. The diet is balanced (based on the US Food Pyramid) and provides 900 – 1200 kcal / day with foods grouped into 3 categories based on caloric density per average serving (Epstein et al., 1998): Green (*go foods* -- may be consumed in unlimited quantities and contain < 20 calories per serving), yellow (*caution foods* -- have average nutritional value for the foods within their food group, are the staples of the diet, and provide most of the basic nutrition), and red (*stop foods* -- provide less nutrient density per kilocalorie because of high fat or simple carbohydrate content). Consuming calorie-restricted diets of this magnitude are more likely to induce weight loss than a more moderate dietary prescription (i.e., increase intake of vegetables and fruit, and consume lean dairy products more often). However, restrictive diets are also known to play a causative role in establishing unhealthy attitudes towards food, disordered eating patterns, and dietary restraint (Drucker et al., 1999; Birch and Fisher, 1998; Satter, 1996; Garner and Wooley, 1991). As well, some concern has been expressed over the potentially harmful effects of energy restriction on physical development. The chronic effects of short-term energy restrictions on psychosocial functioning within obese children (specifically) are largely uninvestigated, but elevated weight status is known to predict dietary restraint in overweight boys and girls (Braet and Wydhooge, 2000).

Notwithstanding the psychological implications of dieting, it appears that long-term somatic growth in children and adolescents is not adversely influenced by short-term (8 – 12 weeks) energy-reduced diets (Epstein et al., 1993). In their 10-year follow-up report, Epstein and coworkers (1994a) also evaluated the presence of eating disorders among children who underwent family-based behavioral interventions for obesity. While these data do not preclude the presence of sub-clinical eating disturbances, only 4% (7 / 158) of the surveyed individuals had received treatment for an overt eating disorder, a level lower than the population eating disorder prevalence rate estimate of 5 – 9% (Fairburn and Beglin, 1990).

Modest, but long-term improvements in relative weight have also been observed among a group of obese Finnish children who underwent obesity treatment (Nuutinen and Knip, 1992). Almost 50% of children (22 / 45) who were defined as *successful weight losers* (decreased at least 10% of relative weight by the end of the 2-year study period) were able to maintain a significantly lower relative body weight at follow-up 5 years later. Yet, despite their decreased relative weight, concomitant changes in serum lipids, blood pressure, and fasting insulin levels were not found (Knip and Nuutinen, 1993). To our knowledge, this study is the first to document follow-up analyses on both weight status *and* metabolic outcomes over an extended period. General findings based on this relatively small sample of obese children (n = 45) should be interpreted cautiously. Information on nutrition and physical activity patterns (while controlling for sex differences and physical maturation) was not collected in follow-up analyses, so the role of lifestyle behaviours in weight management and their impact on objective health outcomes cannot be assessed. As well, improvements in obesity status were considered successful despite relative weight remaining significantly elevated (140 – 150%). Whether the attainment of a non-obese weight (or close-to-normal weight) would have normalized the metabolic aberrations linked to obesity in this sample of boys and girls remains unknown.

In adults, regular physical activity is known to facilitate weight loss (WHO, 1998), improve risk factors for CVD and type 2 diabetes (Tremblay and Doucet, 1999), and assist weight maintenance (Haapanen et al., 1997; Klem et al., 1997). However, less information is available on the role of physical activity in the treatment of child and adolescent obesity. Epstein and colleagues (1996) reviewed 13 studies that included exercise to help treat child and adolescent obesity. However, the authors conceded that limited conclusions could be made given the small number of controlled trials and the mixed outcomes of the studies. They recommended that additional research was needed on the best type of exercise program to promote weight loss and long-term maintenance of activity in children.

More recently, Gutin and colleagues (1999a) have published data on the effects of a 4-month physical training program (5 days / week) followed by a 4-month observation phase in a sample of obese children (n = 79). This investigation is unique since a number of techniques were employed to maximize program adherence. For example, children were provided monetary compensation for attending activity sessions ($1 / session), transported to the exercise facility after school and returned home afterwards, and awarded *points* that could be exchanged for prizes if heart rates were maintained within the target range during training sessions. The exercise sessions provided a substantial stimulus to the cardiovascular system by maintaining average heart rate > 150 beats per minute for the 40 minute sessions. Overall attendance was good (80%; 4 days / week) and no nutrition education or dietary information was included in the intervention. In this study, exercise led to decreased percent body fat and increased bone density (Gutin et al., 1999a). As well, cardiorespiratory fitness improved, SAAT declined, fat-free mass increased, and VAT increased (Owens et al., 1999). While VAT increased during both 4-month periods, accumulation was lower during the intervention phase; regular participation in vigorous physical activities is known to limit VAT accumulation in youngsters (Dionne et al., 2000). Exercise also led to improvements in some (plasma triglyceride and fasting insulin), but not other (TC, HDL-C, LDL-C) components of the insulin resistance syndrome (Ferguson et al., 1999). While no children decreased their adiposity to a non-obese level, these observations suggest that beneficial changes in body composition and risk factors for CVD and type 2 diabetes can be achieved in obese youngsters through a controlled, intensive exercise program. However, once the formal exercise program ended, the benefits found during the treatment phase were lost over the 4-month follow-up observation phase (Ferguson et al., 1999; Owens et al, 1999; Gutin et al., 1999a). These data underscore the influence of exercise on objective health outcomes and show clearly the physical consequences of physical training and subsequent detraining. These results provide further evidence that successful weight management likely requires long-term support, encouragement, skill building, and empowerment to help most obese individuals maintain healthy lifestyle behaviours and a healthy weight (WHO, 1998).

There are few examples from which to draw conclusions, but it appears that the treatment of childhood obesity can be successful over the long-term (5 – 10 years post-intervention) using a family-based behaviour modification approach. While there is potential for restrictive diets to negatively affect psychological and emotional aspects of eating in boys and girls, there is little evidence of overt long-term negative physical consequences of behavioural treatment of obesity in youth. Exercise interventions hold promise in treating obesity since they possess the ability to improve a number of health- (i.e., body composition, serum lipids and insulin levels) and fitness-related (i.e., flexibility, muscular endurance, and cardiorespiratory fitness) outcomes. Encouraging reports of obesity treatment in youth have been documented, however, more research is warranted since many studies had small sample sizes, used inadequate control groups, and the majority of the supportive data originated from the United States (Glenny et al., 1997).

2.5 The Prevention of Obesity in Youth

An emphasis in research on the prevention of obesity has recently been recommended (Dietz and Gortmaker, 2001; Hill and Trowbridge, 1998). The publication of several reviews regarding obesity prevention has signaled an unprecedented interest in this area (Campbell et al., 2001). Prevention initiatives in schools (Story, 1999; Resnicow and Robinson, 1997), Native populations (Davis et al., 1999), and in adults (Douketis et al., 1999) have all been recently reviewed. These approaches hold promise since they would theoretically be beneficial for all individuals regardless of obesity status whereas weight management programs focus on a select group of obese children, adolescents, and families. Obesity treatment initiatives have almost exclusively focused on changing the behavior of individuals, an approach that has proven largely unsuccessful (Nestle and Jacobson, 2000). Considering the many factors in Western culture that promote increased body fatness, reversing current trends will require a multifaceted public health policy approach. Clearly, the need for well-designed prevention studies that examine a range of interventions in schools and communities remains a priority (Campbell et al., 2001).

While multi-faceted community-wide efforts are needed to address the growing problem of obesity, schools are in a unique position to play a pivotal role in promoting healthy lifestyles and helping to prevent obesity (Story, 1999; Sallis et al., 1995). However, some professionals have expressed disappointment in the results of school health education. Often, this stems from misconceptions and unrealistic expectations of the classroom as the sole provider of health education (Kolbe et al., 1986). Prevention programs in schools have increased knowledge in nutrition, physical activity, and health among participants, but such improvements have not generally been translated into substantial behaviour changes; favourable improvements in short- to intermediate-term health outcomes have also been limited (Atkinson and Nitzke, 2001). The positive reports from family-based behavioural interventions indicate that parental participation plays a vital role in the behaviour modification of overweight children. Thus, the active involvement of family members in school-based obesity prevention strategies may enhance outcomes.

Overall, there appears to be limited quality data on the effectiveness of obesity prevention programs. However, it seems reasonable to suggest that focussing on strategies that encourage the reduction of sedentary behaviours hold promise. More research is necessary to enable a better understanding of a range of effective settings and strategies for the prevention of childhood obesity (Dietz and Gortmaker, 2001). Obesity treatment will remain important from a health service delivery standpoint, but the primary prevention of obesity in youth has a much broader scope to impact measures of health in all children.

2.6 Conclusions

The prevalence of obesity in Canadian youth is increasing. Associated with this are corresponding health risks such as dyslipidemia, hypertension, and decreased insulin sensitivity. Childhood obesity has emerged as an epidemic that will have profound public health consequences as children with high levels of body fat become overweight and obese adults. The increase in the rate of type 2 diabetes diagnosed at a younger age has been attributed, in part, to the increase in childhood obesity. Some risk factors for CVD and type 2 diabetes appear to be influenced by total body fat, while others are related to specific fat depots, and knowledge of this is somewhat limited by availability of precise measurement techniques. Other factors such as ethnicity, maturation, and sex also play a role in the development of obesity-related health risks. In view of the increasing prevalence of childhood obesity and its impact on health and well being, it is time to take action to address this problem.

Because obesity in youth and its corresponding risk factors are likely to persist, health promotion and disease prevention programs for overweight children and adolescents are warranted. Specific, targeted approaches may be useful for overweight youngsters whose families seek out treatment since obesity in youth has been considered a chronic medical problem that can be treated (Barlow and Dietz, 1998). However, to have a substantial impact on the increasing problem of obesity in Canada, a more comprehensive perspective is necessary. The coordinated efforts of policy makers, health professionals, community leaders, school administrators, teachers, and parents are necessary. It is vital that preventive strategies for all children are developed and implemented through schools, community-based initiatives (Andersen, 2000; Hill and Trowbridge, 1998; Cole, 1997), and in families, as a means of reducing the prevalence of adult obesity and its related diseases in the future (Limbert et al., 1994). Ultimately, obesity treatment and prevention will require a multi-level approach to produce an environment which supports healthy eating and physical activity habits throughout the community with a comprehensive and integrated range of strategies (Zwiauer, 2000).

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Chapter Three: Adiposity- and sex-related differences in physical activity, cardiorespiratory fitness, self-perception, and diet among 6 – 10 year-old children[1]

3.1 Introduction

Obesity is defined as a condition of excessive body fat accumulation to an extent that health may be compromised (World Health Organization, 1998). In both Canada (Tremblay and Willms, 2000) and the United States (Troiano et al., 1995), the prevalence of obesity in boys and girls has increased dramatically over the last two decades. Numerous health-related indicators, behaviours, and attitudes are either directly or indirectly associated with body fatness and further inquiry into these areas may help to shed light on the environmental and sociocultural variables that relate to obesity. Of particular interest are the potential differences in physical activity, cardiorespiratory fitness, self-perception, and dietary intakes between obese and non-obese children.

While a cause-and-effect relationship has been difficult to elucidate, it is generally believed that obese children engage in lower levels of physical activity and possess decreased cardiorespiratory fitness compared to their non-obese peers. Research has mostly supported the presence of lower cardiorespiratory fitness in obese children (Raudsepp and Jurimae, 1996; Hager et al., 1995; Malina et al., 1995; Huttunen et al., 1986), but the same cannot be said of physical activity values. Using the doubly labeled water technique, Treuth et al. (1998) reported that overweight and non-overweight prepubertal girls did not differ with respect to physical activity energy expenditure or physical activity level. However, their inability to observe group differences may have been the result of limited sample size and statistical power. Conversely, Manos et al. (1993) found 7 – 10 year old

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[1] A form of this chapter has been published: Ball GDC, Marshall JD, Roberts M and McCargar LJ. Adiposity- and sex-related differences in physical activity, aerobic fitness, and self-esteem among 6-10 year-old children. Avante 2001;7:14-26.

African-American *overweight* girls to be significantly less active than their non-overweight peers. In this pilot study of 13 girls, physical activity was presented as a relative *movement index* (physical activity energy expenditure / body weight). Yet, because of the small sample size, these results should be considered cautiously. Others (Maffies et al., 1997) have observed a positive relationship between physical inactivity and adiposity in a study of 9-year-old boys suggesting that inactivity may be a contributing factor in the maintenance of high levels of body fat in children. With these findings in mind, additional research is necessary to clarify potential differences between obese and non-obese children according to physical activity levels to help better understand how this behaviour relates to childhood obesity.

Disparities in self-perception levels between obese and non-obese children have also been equivocal. In a comprehensive review, French et al. (1995) reported that the literature was inconsistent with regards to identifying differences in self-esteem between obese and non-obese youngsters (19 studies; 7 – 12 years old) and that no consistent sex- or age-specific relationships were evident. However, the results of several of the studies in this review were questioned due to small sample sizes and a lack of control groups. Despite recent large-scale investigations into the relationship between weight and self-esteem (Strauss, 2000; Brown et al., 1998; Neumark-Sztainer et al., 1997), present data suggest that further investigation is warranted. Interpreting data from different studies of self-esteem can make establishing a consensus a difficult task. Some evaluation tools employ a format whereby responses to numerous and heterogeneous questions are summed and averaged to arrive at an 'overall' self-esteem score (Coopersmith, 1967; Piers and Harris, 1964). This procedure assumes that children do not or are unable to make distinctions between the different domains in their lives (Harter, 1982). Other questionnaires (Harter, 1985) have utilized a multi-domain approach which incorporates several domains believed to influence self-perception. The latter approach is preferable since domains of competence such as physical appearance and social acceptance are considered especially relevant to overweight youth (Phillips and Hill, 1998).

With regards to dietary intakes, some research suggests that body fatness is related to greater total energy intakes (Tucker et al., 1997; Maffeis et al., 1996; Moussa et al., 1994; Obarzanek et al., 1994) and higher intakes of dietary fat (Tucker et al., 1997; Gazzaniga and Burns, 1993). However, others have failed to observe significant dietary differences based on obesity status in children (O'Loughlin et al., 2000; Dwyer et al., 1998; Johnson-Down et al., 1997). Despite a commonly held belief that obesity is the result of excessive intakes (Prentice and Jebb, 1995), collecting data to support this idea has been hampered by a variety of factors (i.e., methodological differences between studies and respondent bias) that may influence the accuracy of dietary assessments.

Notwithstanding current research findings, several questions remain with respect to obesity and how it relates to lifestyle behaviours and self-perception in children. Thus, the goal of the current study was to identify whether obese children possessed lower levels of physical activity, cardiorespiratory fitness, and self-perception and higher intakes of total energy and dietary fat than non-obese children in a sample of 6 – 10 year old boys and girls. Measurements obtained over a 4-week period in the fall of 1997 are presented.

3.2 Methods

3.2.1 Participants: Thirteen grade 2, 3, and 4 teachers from a convenience sample of 7 Edmonton-area elementary schools were asked to have their classrooms participate in this investigation; all of them agreed. Subsequently, parents and children provided informed consent. This research project was not a component of the class curriculum and no incentives were used to encourage teachers, parents, or children to participate in the study; as such, the present sample of 6 – 10 year old boys and girls was self-selected. However, upon completion of the study, tokens of appreciation (e.g., stickers, pencils, and erasers) were provided to all children and draw prizes (e.g., T-shirts, shorts, and sweat pants) were awarded to one child per class. To remain sensitive to children's feelings and to avoid labeling boys and girls, the distinction between *obese* and *non-obese* was used only during data analysis.

3.2.2 Procedures:

3.2.2.1 Anthropometry: Skinfold measurements (to the nearest 0.2mm) were taken at five sites (triceps, biceps, subscapular, suprailiac, and medial calf) on the right side of the body using Harpenden Skinfold Calipers (Health Dimensions, Plymouth, MI). To minimize measurement error, three trained researchers performed all of the skinfold measurements; one male researcher appraised males while two female researchers assessed girls. To verify the classification of obesity, children whose age- and sex-specific sum of 5 skinfold thickness was between the 85^{th} and 95^{th} percentiles (n = 14; 5 girls, 9 boys) were compared to those $\geq 95^{th}$ percentile (n = 12; 7 girls, 5 boys). No differences were observed between these groups with respect to any of the outcome measures (data not shown). Thus, based on Canadian population normative data (Canada Fitness Survey, 1984), these groups were combined so that all children with a sum of 5 skinfolds $\geq 85^{th}$ percentile were classified as obese. Height was assessed (to the nearest 0.1cm) using a setsquare and a wall-mounted tape measure and weight was determined (to the nearest 0.1 kg) using a portable medical scale (Health-o-meter, Inc., Bridgeview, IL). Body mass index (kg / m^2) was subsequently calculated. All anthropometric data were collected in accordance with Canadian Standardized Test of Fitness (CSTF) procedures (CSTF Manual, 1986).

3.2.2.2 Physical activity: Numerous techniques have been applied to measure physical activity in children (Pate, 1993). Although most instruments have limitations, recent research suggests that the Physical Activity Questionnaire for older Children (PAQ-C) is an appropriate method of assessing general physical activity levels in Canadian children (Kowalski et al., 1997). Based on preliminary evidence, the instrument does not reveal a gender bias based on overall activity levels in boys and girls (Crocker et al., 1997). The PAQ-C is a self-administered 7-day recall questionnaire that evaluates the sports, leisure activities, and games performed throughout school days and weekends. It is comprised of nine items that are converted to a 5-point scale with higher scores indicating greater levels of physical activity. Once completed, summing and calculating the means of nine items forms a composite score with final scores ranging between 1.00 – 5.00 (Crocker et al., 1997).

3.2.2.3 Cardiorespiratory fitness: A 20-metre shuttle run (20-MST) was used to determine cardiorespiratory fitness since it has been well established as a valid and reliable field test among youth (McNaughton et al., 1996; Mahoney, 1992) and adults (Leger and Gadoury, 1989; Leger and Lambert, 1982). The 20-MST is a weight-bearing test that may lead to biased results when comparing obese and non-obese children. However, it more closely resembles a real-life situation since ability and performance in playing games and sports are influenced by body fatness. Therefore, self-perceptions (i.e., athletic competence and global self-worth) of obese children would more likely be influenced by this measure of fitness than a weight-independent test (i.e., cycle ergometry). As well, the 20-MST is practical since it is administered quickly, is non-invasive, requires limited skill and habituation, and several children can be tested simultaneously.

The 20-MST requires subjects to run back and forth between two markers that are spaced 20 metres apart. The pace is established by auditory signals played by audiocassette; the starting speed is 8.5 km / h with a 0.5 km / h increase every minute. As the test advances, the time between signals decreases such that running speed must progressively increase to keep pace. The test is discontinued either when the participant stops voluntarily or is not within two steps of the marker cone for two consecutive signals. Subjects are assigned a 'stage' (0.0 - 20.0) that represents the final level successfully attained. Higher scores reflect higher levels of cardiorespiratory fitness.

3.2.2.4 Self-perception: Self-perception was measured using the Self-Perception Profile for Children (SPPC), a validated instrument (Harter, 1985) that has been used extensively in this population (Brown et al., 1998; Phillips and Hill, 1998; Rose et al., 1997). It was selected because it consists of the following 6 individual sub-scales that differentiate between domains that collectively influence overall self-perception: Scholastic competence (the child's perception of competence or ability within the realm of scholastic performance. eg. how well he / she does at classwork and how smart or intelligent he / she feels); social acceptance (the degree to which the child is accepted by peers, feels popular, has a lot of friends, and feels he / she is easy to like); athletic competence (the child's perceptions of athletic ability and competence at sports. eg. feelings that he / she is good at sports and athletic activities); physical appearance (the degree to which the child is happy with the way he / she looks, likes his / her body, and feels that he / she is good-looking); behavioural conduct (the degree to which the child likes the way he / she behaves, does the right thing, acts the way he / she is supposed to, and avoids getting into trouble); and, global self-worth (the extent to which the child likes himself / herself as a person, is happy with the way he / she is leading his / her life, and is generally happy with the way he / she is; it constitutes a global judgment of an individual's worth as a person, rather than domain-specific competence or adequacy). The 6 sub-scales are each comprised of 6 questions. Average values are calculated for each subscale, scores range between 1.00 to 4.00, and higher scores represent more positive ratings of self-perception.

3.2.2.5 Dietary intake: Twenty-four hour dietary recalls were used to estimate quantitative and qualitative dietary variables. Detailed, written instructions along with a sample recall were provided to parents and children. Recalls were completed by having children bring the instrument home for families to complete together as *homework*; teachers collected the forms on behalf of researchers the following day. Two registered dietitians telephoned all families within one week of the recall day to review and confirm the data with parents (usually the mother). Thus, nutrition data were collected using the multiple-pass technique, a validated procedure that involves gathering food consumption information from participants in three steps: a quick list, a detailed description, and a review of all items (Johnson et al, 1996). Collecting nutrition data on specific days of the week throughout the duration of the study was not possible due to logistical reasons (i.e., holidays, school assemblies, field trips, and exams). Therefore, because recall forms were distributed to classrooms from Monday to Friday, dietary information was recorded for 5 days of the week only (Sunday to Thursday). Nutrition data were entered and analyzed by a registered dietitian using the Food Processor for Windows (v 7.02, 1997, ESHA Research, Salem, OR) with a Canadian database. If individual foods were absent from the Canadian database, the American database was used and new foods and recipes were added accordingly. Approval for this project was obtained from the Faculty of Agriculture, Forestry and Home Economics Human Ethics Review Committee, University of Alberta, the Cooperative Activities Program, University of Alberta, and both the Edmonton Public and Catholic School Districts.

3.2.3 Statistical analyses: The main effects of sex (boys, girls) and obesity status (obese, non-obese) and sex × obesity status interaction were evaluated using a 2 × 2 multivariate analysis of variance (MANOVA). MANOVA was employed to minimize the probability of committing a Type I error and to maximize statistical power (Goodwin, 1984). Significant MANOVA results were followed up with protected univariate statistics on the dependent variables. Servings from 5 food groups (Grain Products, Milk Products, Meat and Alternatives, Vegetables and Fruit, and Other Foods) were adjusted for total caloric intake prior to analyses. All data are expressed as means ± standard deviation. Analyses were performed using SPSS (version 7.5, 1995, SPSS Inc, Chicago, IL) with significance set *a priori* at $p < 0.05$.

3.3 Results

Although socioeconomic status was not formally assessed, principals and research coordinators from both the Catholic and Public School Boards considered the children from participating schools in this sample to be from middle- to upper-middle class families. Participation rates did not differ between sexes and the majority of children in this study were Caucasian (92%). Overall, 136 / 276 (49.3%) of boys and girls from participating classrooms consented to take part in the study.

3.2.1 Anthropometry: The multivariate F values for both sex ($F = 4.8$, $p<0.001$) and obesity status ($F = 13.6$, $p<0.001$) were significant. The follow-up univariate comparisons are described below. However, no sex × obesity status interaction was observed ($F = 1.0$, $p = 0.415$). **Table 3-1** provides data on the anthropometric data of the sample grouped by sex and obesity status. Within this sample of children, 26 / 135 (19.3%) were categorized as obese (12 girls; 14 boys). The univariate F values for variables within each factor revealed that boys were heavier ($F = 4.4$, $p = 0.029$) and leaner (smaller sum of 5 skinfolds) ($F = 15.5$, $p<0.001$) than girls. Further, obese children were heavier ($F = 56.5$, $p<0.001$), possessed higher BMIs ($F = 78.2$, $p<0.001$), and had greater sums of skinfolds ($F = 140.8$, $p<0.001$) than their non-obese peers.

3.2.2 Physical activity, cardiorespiratory fitness, and self-perception: The results of the PAC-Q, 20-MST, and SPPC comparisons for each sex and obesity status category are presented in **Table 3-2**. Between sexes, boys rated themselves as more physically active ($F = 6.8$, $p = 0.003$) than girls. Obese boys and girls were less aerobically fit ($F = 14.9$, $p<0.001$) and scored lower on self-perceptions of scholastic competence ($F = 2.2$, $p = 0.019$) and social acceptance ($F = 3.8$, $p = 0.002$) than their non-obese peers. While differences based on obesity status were observed in two of the SPPC sub-scales, no sex differences in self-perception were found. No additional univariate comparisons revealed differences related to sex or obesity status.

Table 3-1. Anthropometric comparisons between boys and girls, obese and non-obese groups

Variable	Boys (n = 69)	Girls (n = 67)	P Value[a]	Obese (n = 26)	Non-obese (n = 110)	P Value[a]
Age (y)	8.2 (0.8)[b]	8.3 (0.9)	0.471	8.0 (0.7)	8.3 (0.9)	0.152
Height (cm)	130.6 (7.1)	129.5 (7.2)	0.080	132.6 (7.2)	129.8 (6.7)	0.065
Weight (kg)	29.5 (6.1)	28.3 (5.7)	0.029	35.5 (7.2)	27.4 (4.0)	<0.001
BMI (kg / m^2)	17.1 (2.4)	16.7 (2.6)	0.222	20.0 (2.6)	16.1 (1.7)	<0.001
Sum of 5 skinfolds (mm)	39.8 (18.5)	50.1 (18.7)	<0.001	71.7 (22.2)	38.5 (11.2)	<0.001

[a] Univariate analyses
[b] Mean (standard deviation)
Abbreviations: y (year), cm (centimetre), kg (kilogram), BMI (body mass index), kg (kilogram), and mm (millimetre)

Table 3-2. Group differences in the PAQ-C, 20-MST, and sub-scales from the SPPC based on sex and obesity status

Variable	Boys (n = 69)	Girls (n = 67)	P Value[a]	Obese (n = 26)	Non-obese (n = 110)	P Value[a]
PAQ-C	3.29 (0.79)[b]	2.93 (0.74)	0.003	2.90 (0.82)	3.22 (0.77)	0.110
20-MST	2.8 (1.6)	2.5 (1.5)	0.132	1.6 (0.9)	2.9 (1.6)	< 0.001
Athletic Competence	3.24 (0.55)	3.01 (0.69)	0.095	2.96 (0.65)	3.22 (0.60)	0.088
Behavioral Conduct	3.20 (0.61)	3.21 (0.65)	0.890	3.04 (0.66)	3.27 (0.60)	0.085
Global Self-Worth	3.42 (0.55)	3.28 (0.68)	0.452	3.24 (0.69)	3.41 (0.58)	0.125
Physical Appearance	3.31 (0.64)	3.26 (0.70)	0.560	3.08 (0.83)	3.20 (0.60)	0.068
Scholastic Competence	3.17 (0.63)	3.08 (0.68)	0.108	2.88 (0.57)	3.22 (0.65)	0.019
Social Acceptance	3.04 (0.69)	2.98 (0.73)	0.542	2.74 (0.87)	3.17 (0.62)	0.002

[a] Univariate analyses
[b] Mean (standard deviation)
Abbreviations: PAQ-C (Physical Activity Questionnaire for older Children), 20-MST (20-Metre Shuttle Run Test), and SPPC (Self-Perception Profile for Children)

3.2.3 Dietary intake: Results of the 24-hour dietary recalls are presented in **Tables 3-3** and **3-4** with comparisons based on sex and obesity status, respectively. Significant main effects of sex ($F = 2.9$, $p = 0.001$) and obesity status ($F = 7.3$, $p < 0.001$) were found with boys consuming more total energy ($F = 4.2$, $p = 0.043$), protein (g) per 1000 kcals ($F = 4.1$, $p = 0.044$) and protein (%) ($F = 4.5$, $p = 0.036$) than girls. Univariate analyses yielded no difference in absolute energy intake between obese and non-obese children, but obese children consumed less than their non-obese peers when energy intake was adjusted for kg body weight, ($F = 26.3$, $p < 0.001$). Group differences were not observed regarding dietary quality assessed according to food group servings from Canada's Food Guide (Health Canada, 1992) and no sex × obesity status interaction was observed (F = 1.1, p = 0.371).

Table 3-3. Group differences (based on sex) in nutrition-related variables assessed using 24-hour dietary recalls

Variable	Girls (n = 67)	Boys (n = 68)	P Value[a]
Energy intake (kcal)	1759 (393)[b]	1944 (457)	0.023
Energy intake (kcal) / kg Body weight	63.9 (17.3)	68.0 (18.1)	0.544
Carbohydrate (g) / 1000 kcal	141.2 (21.2)	139.9 (21.8)	0.439
Carbohydrate intake (%)	55.6 (7.8)	54.3 (6.7)	0.146
Fat (g) / 1000 kcal	34.8 (7.0)	35.2 (8.9)	0.734
Fat intake (%)	30.7 (6.3)	30.5 (5.8)	0.834
Protein (g) / 1000 kcal	35.1 (9.5)	39.2 (8.6)	0.006
Protein intake (%)	13.8 (3.8)	15.2 (3.2)	0.004
Vegetables and Fruit (svgs / d)[3]	4.3 (2.4)	3.8 (2.0)	0.331
Milk Products (svgs / d)[c]	2.0 (1.2)	2.6 (1.3)	0.217
Grain Products (svgs / d)[c]	5.7 (2.6)	5.8 (2.6)	0.638
Meat and Alternatives (svgs / d)[c]	1.2 (1.1)	1.5 (1.0)	0.085
Other Foods (svg / d)[c,d]	13.4 (10.4)	14.5 (9.6)	0.231

[a] Univariate analyses
[b] Mean (standard deviation)
[c] Food groups based on Canada's Food Guide to Healthy Eating (Health Canada, 1992)
[d] The "Other Foods" category represents added fat and sugar that do not naturally occur in the food item. It also accounts for foods (i.e., salad dressings and oils, cream, butter, margarine, sugars, soft drinks, candies, and sweet desserts) that provide calories and little else nutritionally.
Abbreviations: g (grams), kcal (kilocalorie), svgs/d (servings per day)

Table 3-4. Group differences (based on obesity status) in nutrition-related variables assessed using 24-hour dietary recalls

Variable	Obese (n = 26)	Non-obese (n = 109)	P Value[a]
Energy intake (kcal)	1890 (580)[b]	1843 (395)	0.704
Energy intake (kcal) / kg Body weight	54.9 (19.7)	68.6 (16.2)	<0.001
Carbohydrate (g) / 1000 kcal	137.3 (20.3)	141.3 (21.8)	0.431
Carbohydrate (%)	54.5 (7.1)	55.0 (7.3)	0.800
Fat (g) / 1000 kcal	34.8 (6.6)	35.1 (8.3)	0.847
Fat (%)	30.7 (5.8)	30.6 (6.1)	0.950
Protein (g) / 1000 kcal	37.6 (9.6)	37.1 (9.2)	0.902
Protein (%)	14.9 (3.9)	14.4 (3.5)	0.689
Vegetables and Fruit (svgs / d)[c]	4.4 (2.2)	3.9 (2.2)	0.350
Milk Products (svgs / d)[c]	2.1 (1.5)	2.4 (1.2)	0.317
Grain Products (svgs / d)[c]	5.5 (2.5)	5.8 (2.6)	0.718
Meat and Alternatives (svgs / d)[c]	1.5 (1.1)	1.3 (1.0)	0.643
Other Foods (svgs / d)[c,d]	15.3 (12.3)	13.6 (9.4)	0.491

[a] Univariate analyses
[b] Mean (standard deviation)
[c] Food groups based on Canada's Food Guide to Healthy Eating (Health Canada, 1992)
[d] The "Other Foods" category represents added fat and sugar that do not naturally occur in the food item. It also accounts for foods (i.e., salad dressings and oils, cream, butter, margarine, sugars, soft drinks, candies, and sweet desserts) that provide calories and little else nutritionally.
Abbreviations: g (grams), kcal (kilocalories), svgs/d (servings per day)

3.4 Discussion

In this cross-sectional study, we observed that boys are heavier, leaner, more physically active, and consume more total energy and percent dietary protein than girls. As well, obese children possess lower levels of cardiorespiratory fitness and score lower in self-perceptions of scholastic competence and social acceptance compared to their non-obese peers. However, physical activity and other domains of self-perception including athletic competence, behavioural conduct, global self-worth, and physical appearance did not differ between groups based on obesity status.

3.4.1 Anthropometry: The obesity prevalence reported here (19.1%) is somewhat lower than recent estimates made by others using the CSTF obesity criterion

(Limbert et al., 1994; Marshall and Bouffard, 1997) which suggested that 23.9 - 28.8% of Canadian children are obese. Earlier research (Marshall et al., 1991; Marshall et al., 1990) found 18.8 - 20.7% of 7 - 16 year old children to be obese. However, regardless of the true prevalence level, the degree of obesity in Canadian children remains a significant and growing concern (Tremblay and Willms, 2000).

Sex differences revealed that boys possessed less body fat and were heavier than girls suggesting that they also have greater lean body mass. These anthropometric data are in general agreement with other research that has shown boys have less body fat than girls (Docherty and Gaul, 1991; Ku et al., 1981; Stewart et al., 1995), although maturational changes that coincide with puberty tend to amplify body composition differences between sexes during youth (Groff et al., 1995).

3.4.2 Physical activity: Consistent with earlier research (Myers et al., 1996; Simons-Morton et al., 1997; Stewart et al., 1995), boys had higher levels of self-reported physical activity than girls. These observations have been confirmed using objective criteria (i.e., heart rate monitoring and doubly labeled water) that also suggest boys possess greater levels of activity than girls. In a review of physical activity and fitness in 6 –16 year olds, Sallis (1993) reported that females are less active than males at all ages in childhood and adolescence. Using self-assessments, boys tend to rate themselves more physically active than girls since activity-related attributes such as strength, power and endurance are traditionally valued more among males (Worsley et al., 1984). Physical activity levels tend to decrease in all children as they age, but the decline is steeper among girls suggesting that (assuming all other factors remain equal) girls may possess a greater risk of becoming obese or developing activity-related health problems due to a more sedentary lifestyle (Sallis, 1993).

While sex differences with respect to physical activity were observed, differences were not found according to obesity status. Previous studies have been equivocal with overweight children displaying lower (DeLany et al., 1995) and similar (Muecke et al., 1992; Waxman and Stunkard, 1980) levels of physical activity compared to their leaner peers. It is possible that children in this study were similar in their frequency of activity, but obese / non-obese groups may not have participated in activities for an equivalent duration or intensity. This potential disparity may explain part of the variation in body weight and fatness. Unfortunately, the method used to measure physical activity (7-day recall) in this study did not evaluate intensity or duration of physical activities.

The relative importance of different aspects of physical activity in regulating body weight is unknown. Factors such as intensity, duration, metabolic efficiency, and overall energy cost all deserve consideration (Goran, 1997). The cross-sectional nature of this study precludes establishing any cause-and-effect relationship. Obesity is a complex and multi-factorial condition that involves several developmental stages in which physiological and behavioural changes determine the accumulation of excess body fat (Dietz, 1994). Assessing physical activity over a longer period of time (e.g., several weeks or months) would likely strengthen the reliability of this measure. While 7-day recalls have proven to be valid measures of physical activity (Sallis et al., 1990), it has not been established that activity patterns over a short period accurately reflect long-term habits, and subsequent energy balance, in all individuals.

3.4.3 Cardiorespiratory fitness: While boys rated themselves as more physically active than girls, cardiorespiratory fitness levels between sexes did not differ. Similar findings have been observed by other researchers using the 20-MST (Manios et al., 1999). However, other testing protocols have found boys to be fitter than girls. When cardiorespiratory fitness was measured according to VO_{2peak} (Armstrong et al., 1998; Armstrong et al., 1995), VO_{2max} (Docherty and Gaul, 1991), and physical work capacity (Stewart et al., 1995), boys score higher than girls. The difference between sexes has generally been attributed to boys' greater muscle mass and hemoglobin concentrations (Armstrong and Welsman, 1994), although comparisons between studies are complicated by the variety of testing protocols used and inadequately controlling for potential differences in physical maturation. The present study, along with the research by Manios et al. (1999), involved children 6 – 10 years of age. Studies that have observed sex differences (Armstrong et al., 1998; Armstrong et al., 1995; Docherty and Gaul, 1991) have included older participants (i.e., 11 – 14 years of age) suggesting that differences may be related to puberty-associated growth and development. However, others (Marshall and Bouffard, 1997) have observed group differences in young children (grade 1), so it appears the 20-MST is a useful field test to assess sex differences across a range of ages.

Sex differences related to cardiorespiratory fitness did not emerge in the current study, however, obese children were less fit than their non-obese peers. Other researchers (Hager et al., 1995; Huttunen et al., 1986; Malina et al., 1995) have found that heavier children have lower cardiorespiratory fitness levels as well, especially when fitness tests involve weight bearing protocols such as the 20-MST or distance walk / run tests. In both Quality Daily Physical Education (QDPE) and non-QDPE schools, Marshall and Bouffard (1997) found obese children (grades 1 and 4) to be less fit than non-obese children when assessed by the 20-MST.

The cardiorespiratory fitness differences we observed between obese and non-obese children are likely physiological in nature; however, cognitive or emotional influences cannot be completely excluded. Obese children may be conditioned through low societal expectations to perform poorly on fitness tests. Because obese individuals are commonly portrayed in the media as inactive, heavier children may believe that vigorous activities are not for them (Worsley et al., 1984). In the present study, the pretest conditions and testing environment were given appropriate consideration. We attempted to establish a supportive and positive atmosphere and provided equal encouragement to all participants regardless of final performance to maximize enjoyment and as a means of eliciting maximal effort during fitness testing.

3.4.4 Self-perception: Obese children tended to score lower than non-obese children on all SPPC subscales, but significant differences were observed only in self-perceptions of scholastic competence and social acceptance. The finding that obese children scored lower in these specific domains and not in others often associated with body fatness (i.e., physical appearance and global self-worth) was somewhat unexpected. Furthermore, to our knowledge, no other reports have documented lower levels of perceived scholastic competence among obese children.

Strauss (2000) found no difference between obese and non-obese children with regard to perceived scholastic competence at baseline among children born to mothers participating in the U.S. National Longitudinal Survey of Youth. While obese and non-obese children had similar ratings of perceived global self-worth at baseline (9 – 10 years of age), follow-up data collected four years later (13 – 14 years of age) revealed that obesity in children was associated with decreased levels of perceived global self-worth among both boys and girls. Perceived global self-worth scores were adversely affected by increasing levels of body fatness in this cohort, but obesity was not related to any changes in perceived scholastic competence. In a study of Australian adolescents, both boys and girls ranked scholastic competence as 'important', but no association was observed between this specific domain and obesity status (O'Dea and Abraham, 1999). However, perceived physical appearance scores decreased as body weight increased suggesting that a higher level of body fatness may lead to negative self-perceptions in this domain. Manus and Killeen (1995) reported lower scores of perceived social acceptance, physical appearance, and global self-worth in overweight children, but scholastic competence, athletic competence and behavioural conduct ratings did not differ between overweight and non-overweight 10 – 13 year olds.

Scholastic competence has typically been evaluated by self-assessments, but data on more objective measures of intelligence in overweight children have also been noted. Li (1995) found intelligence scores (based on IQ) varied with degree of overweight among 6 – 13 year old children. Subjects with a more extreme degree of overweight (>50% overweight) had lower performance-based and total IQ scores than non-overweight individuals, but group differences were not observed at lower degrees of overweight. Because intelligence is determined by numerous genetic, cultural, and environmental factors, further research in other populations is needed to corroborate these preliminary data.

Overall, previous research fails to confirm the present findings related to lower perceived scholastic competence among obese children. However, at an early age, children (regardless of obesity status) are known to internalize negative attitudes and stereotypes regarding obesity (Cramer and Steinwert, 1998; Shapiro et al., 1997; Lifshitz, 1993). While our finding may be unique, it is a logical hypothesis that unhealthy attitudes regarding obesity could extend to negative self-perceptions in the scholastic domain among some children, particularly since negative attitudes towards obese students have been reported among schoolteachers (Schroer and Flett, 1985).

Along with lower perceived scholastic competence ratings, obese children also scored lower in perceived social acceptance compared to their non-obese peers. Previous findings have been equivocal in this regard. In a sample of 5th grade students (n = 45), Manus and Killeen (1995), found lower perceived social acceptance scores among obese (>20% overweight) children compared to their overweight (>10% overweight) and average weight (<10% overweight) peers. These findings also revealed that obese children used high levels of distortion, a cognitive technique associated with self-perceptions that are more positive.

Higher distortion scores indicate inflated perceived competence in weight scores relative to actual weight status. Conversely, Phillips and Hill (1998) studied 313 9-year old girls and found no difference in perceived social acceptance scores between overweight (BMI $\geq 85^{th} - 95^{th}$ percentile) or obese ($> 95^{th}$ percentile) and non-overweight ($10^{th} - 85^{th}$ percentile) girls. However, obese girls rated social acceptance as a less important domain than non-overweight girls. Although speculative, if obese children in the present study used distortion and / or considered social acceptance to be less important, it may help to explain why perceived physical appearance and global self-worth scores were not adversely affected. In other words, the negative social impact of being obese may not be so ingrained that perceptions of physical appearance and global self-worth (subscales considered to be most salient among obese children) were negatively affected by body fatness. Age may also be a contributing factor since others have suggested that not until boys and girls mature into adolescents do sex- and adiposity-related differences have a meaningful impact on relationships linked to physical appearance and global self-worth (Phillips and Hill, 1998; French et al., 1995).

It is noteworthy that, compared with previous research using the SPPC, both obese and non-obese children in this study scored within normal ranges on these subscales (Harter, 1985). Accordingly, the lower perceived scholastic competence and social acceptance ratings among obese children are not absolute, but relative to the non-obese group. Further, based on American BMI reference values (Himes and Dietz, 1994), the obese children (group mean) in this investigation would rank near the 85^{th} percentile (ours: 20.2; U.S.: 20.0). Thus, as a group, the impact of their adiposity on self-perceptions may not be as great as would be expected within a more severely obese (i.e., $>95^{th}$ percentile) group of children.

3.4.5 Dietary intake: Group comparisons revealed that boys consumed more total energy than girls. This sex disparity is consistent with other research of similar aged Canadian (Johnson-Down et al., 1997) and American (Crespo et al., 2001; Gazzaniga and Burns, 1993) children. As well, boys consumed a greater proportion of dietary protein than girls, but despite this difference, intakes of all macronutrients were consistent with Canadian recommendations (Health and Welfare Canada, 1990). Dietary quality, assessed using the number of servings per day from food groups in *Canada's Food Guide to Healthy Eating* (Health Canada, 1992), did not reveal any significant group differences. However, when nutrition data from the entire sample were combined, mean intakes of Grain Products and Milk Products were within recommended levels whereas servings from the Vegetables and Fruit and Meat and Alternatives groups were below current guidelines (Health Canada, 1992). While a specific recommendation does not exist for the Other Foods group, it appears that children in this study consumed high intakes of foods containing added sugar and fat. Overall, the dietary quality of the children in this study did not satisfy recommendations established by Health Canada; these data are in line with other dietary reports of boys and girls in this age range and suggest intakes of sub-optimal dietary quality. Factors including the intra-subject variance and sample size can influence the precision of the dietary estimates. It is known that intra-subject variation is lower for macronutrients since they are widely distributed in foods (Liu et al., 1978), because of the small number of children in the obese group (n = 26), these results and the group comparisons performed should be interpreted carefully (Gibson, 1990).

Munoz and colleagues (1997) analyzed nutrition data from the U.S. Continuing Surveys of Food Intakes by Individuals (CSFII), 1989 – 1991, derived from a large sample of children (n = 3307; 2 – 19 years of age). When intakes were compared to the U.S. Food Guide Pyramid (U.S. Department of Agriculture, 2000), only 1% of children met all of the recommendations, and only 5% met the recommendations of at least 4 of the 6 food groups. For 6 – 11 year old boys and girls (n = 1172), average intakes from all food groups (except for Dairy Products and the 'tip' of the Pyramid which represents fats, oils, and sweets) were below recommendations. In a sample of 226 8 – 15 year old boys and girls from Saskatchewan, Whiting et al. (1995) had children complete 24-hour food recalls 6 times over a 12-month period and average values were calculated according to age category (8 – 9y, 10 – 12y, and 13 – 15y). Overall, intakes of Vegetables and Fruit were low among both sexes while Meat and Alternatives were low in girls only. Boys and girls consumed Grain Products and Milk Products in adequate amounts while consumption of Other Foods was relatively high and rose with age in both boys and girls. More recently, the same research group (Lemke et al., 1998) reported marginally low intakes of Meat and Alternatives (1.9 ± 0.7 svgs / d) and Vegetables and Fruit (3.9 ± 1.9 svgs / d) in 9 – 13 year old children. Intakes of Grain Products (5.5 ± 1.3 svgs / d) were adequate for the group, but Milk Products, while adequate for 7 – 9 year old children (2.7 ± 1.1 svgs / d), were inadequate for the 10 – 12 year old group. Collectively, these findings are consistent with other data (Brady et al., 2000; Leaman and Evers, 1997) that suggest nutrition education programs may be helpful for promoting healthier dietary choices in children.

Obese and non-obese children in this study did not report different absolute energy intakes, but obese boys and girls had a lower energy intake than non-obese children after body weight was considered. These findings are supported by other research suggesting that obese individuals have a lower energy intake than their non-obese peers when differences in body size are taken into account (Gazzaniga and Burns, 1993; Miller et al., 1990). We did not employ an independent method of assessing validity of the nutrition data (Schoeller, 1995) and it is known that under-reporting energy intakes has been previously reported among obese children (Fisher et al., 2000; Johnson-Down et al., 1997). Collecting nutrition data from groups using the 24-hour recall technique via parental reports is considered accurate and valid (Johnson et al., 1996; Baranowski et al., 1991), but we did not formally assess under-reporting of energy intake in this sample.

For a variety of reasons, some individuals may have been less willing to participate in this study. Because of the nature of the project, the self-selection of participants was unavoidable; the extent to which self-selection bias influenced the results cannot be determined. Since this study included the measurement of body weight and adiposity, those children sensitive about their weight or shape may have decided not to participate because they were uncomfortable with these assessments. Further, parents and children who were more interested in health may be over-represented. Parents who place a high value on health-related behaviours may have been more inclined to allow or encourage their children to participate in this study. Children who chose to participate had to devote 12 – 15 hours of school time over a 1-year period to complete the measurements. Therefore, some families may have decided that this was too great of a commitment, especially since all of the testing occurred during school hours.

In summary, this cross-sectional evaluation of 6 – 10 year old children revealed that boys are heavier, leaner, more physically active, and consume more total energy and percent dietary protein than girls. As well, obese children are less aerobically fit, score lower in self-perceptions of scholastic competence and social acceptance, but do not differ in physical activity, and self-perceptions related to athletic competence, behavioural conduct, global self-worth, and physical appearance compared to their non-obese peers. These data also indicate that obesity may be related to some, but not all, aspects of self-perception in children and that obese children consume less total energy / kg body weight when compared to their non-obese peers. It appears that obese children in this study may already have internalized a negative perception of being obese that has unfavorably affected their perceptions in the scholastic and social domains, but not physical appearance or global self-worth. Based on these data, it is recommended that continued school- and community-based efforts should be directed toward delivering positive health messages to all children, but especially young obese boys and girls who may be more susceptible to developing less healthy behaviours and self-perceptions.

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Chapter Four: A prospective study of physical activity, cardiorespiratory fitness, self-perception, and dietary intake in obese and non-obese children

4.1 Introduction

The prevalence of overweight and obesity among Canadian children has increased dramatically over the past 2 decades. Recently, it has been estimated that 23.6% of girls and 28.8% of boys are overweight (BMI > 85^{th} percentile) while 11.8% of girls and 13.5% of boys are obese (BMI > 95^{th} percentile) (Tremblay and Willms, 2000). It is generally believed that the high prevalence of overweight and obesity in Canadian youngsters is cause for concern since high levels of body fat are known to persist from youth to adulthood (Guo and Chumlea, 1999; Clarke and Lauer, 1993) and because heavier children are more likely than their leaner peers to possess risk factors for cardiovascular diseases and type 2 diabetes (Freedman et al., 1999; Chu et al., 1998; Ferguson et al., 1998). Such observations may explain the increased risk of morbidity and mortality seen among overweight and obese children who grow up to become overweight and obese adults (Must et al, 1992). The evidence linking increased adiposity with unfavourable levels of objective indicators of physical health is well documented. However, findings are equivocal when health-related behaviours and perceptions are contrasted according to obesity status, especially in younger populations.

For example, some research suggests that boys and girls with higher levels of body fat consume higher intakes of total energy (Tucker et al., 1997; Maffeis et al., 1996; Moussa et al., 1994; Obarzanek et al., 1994) and dietary fat (Tucker et al., 1997; Gazzaniga and Burns, 1993) and engage in lower levels of physical activity (Moussa et al., 1994; Obarzanek et al., 1994; Manos et al., 1993) than leaner children. On the contrary, others have failed to observe substantial differences in diet (O'Loughlin et al., 2000; Johnson-Down et al., 1997; Boulton and Magarey, 1995) and physical activity (Treuth et al., 1998; Romanella et al., 1991) in children according to obesity status. As well, it is generally believed that obese children have lower levels of self-perception than their non-obese peers. However, this belief has not been widely supported in the literature. In a comprehensive review, French and colleagues (1995) concluded that overall self-esteem levels in obese 7 – 12 year old children were either similar or just slightly lower than those of average weight boys and girls.

Because the majority of data linking body fatness in youth with unfavourable lifestyle behaviours and perceptions are derived from cross-sectional investigations, it has been suggested that the relationships between obesity status and lifestyle variables may be transitory. This is a plausible theory since many health-related behaviours and attitudes are still being established in childhood (Birch, 1998). Thus, using a longitudinal design, the purpose of the present study was to evaluate differences related to physical activity, cardiorespiratory fitness, self-perception, and dietary intake in a sample of obese and non-obese 6 – 10 year old boys and girls at 0- (fall), 3- (winter), 6- (spring), and 12-month (fall) intervals.

4.2 Methods

4.2.1 Participants: In the fall of 1997, 13 teachers (grades 2, 3, and 4) from a convenience sample of 7 Edmonton-area elementary schools were asked to have their classrooms participate in this investigation. Parents and children provided informed consent and assent, respectively. This research was not a component of class curricula, participation was voluntary (the sample was self-selected), and no incentives were used to encourage teachers, parents, or children to participate in the study. However, upon completion of the study, tokens of appreciation (e.g., stickers, pencils, and erasers) were provided to all children. At each of the 4 measurement intervals, one draw prize (e.g., U of A T-shirt) per class was awarded as an incentive for returning completed 24-hour food recall questionnaires. Approval for this project was obtained from the Faculty of Agriculture, Forestry and Home Economics Human Ethics Review Committee (University of Alberta), the Cooperative Activities Program (University of Alberta), and the Edmonton Public and Catholic School Districts.

4.2.2 Procedures:

4.2.2.1 Anthropometry: Skinfold measurements (to the nearest 0.2mm) were taken at 5 sites (triceps, biceps, subscapular, suprailiac, and medial calf) on the right side of the body using Harpenden Skinfold Calipers (Health Dimensions, Plymouth, MI). To minimize measurement error, three trained researchers performed all of the skinfold measurements; one male researcher appraised all of the boys while two female researchers assessed the girls. Based on Canadian population normative data (Canada Fitness Survey, 1984), all children with a sex- and age-specific sum of 5 skinfolds $\geq 85^{th}$ percentile were classified as obese. Height was assessed (to the nearest 0.1cm) using a setsquare and a wall-mounted tape measure and weight was determined (to the nearest 0.1 kg) using a portable medical scale (Health-o-meter, Inc., Bridgeview, IL); body mass index (BMI; kg/m^2) was subsequently calculated. Obesity status designations (obese, non-obese) were only used for data analysis to preclude the possibility of labeling and stigmatizing children. All anthropometric data were collected in accordance with Canadian Standardized Test of Fitness (CSTF) procedures (CSTF Manual, 1986).

4.2.2.2 Physical activity: Numerous techniques have been used to measure physical activity in children (Pate, 1993). Although most instruments have limitations, research suggests that the Physical Activity Questionnaire for older Children (PAQ-C) is an appropriate method of assessing general physical activity levels in Canadian children (Kowalski et al., 1997). Based on preliminary evidence, the instrument does not reveal a gender bias based on overall activity levels in boys and girls (Crocker et al., 1997). The PAQ-C is a self-administered 7-day activity recall questionnaire that evaluates the sports, leisure activities, and games performed throughout school days, evenings, and weekends. It is comprised of nine items that are converted to a 5-point scale with higher scores indicating higher levels of physical activity. Once completed, summing and calculating the means of the nine items yields a composite score with final values ranging from 1.00 – 5.00 (Crocker et al., 1997).

4.2.2.3 Cardiorespiratory fitness: The 20-metre shuttle run (20-MST) was used to determine cardiorespiratory fitness since it has been well established as a valid and reliable field test of cardiorespiratory fitness in children (McNaughton et al., 1996; Mahoney, 1992). Participants are required to run back and forth between two markers that are spaced 20 metres apart. The pace is established by auditory signals played by audiocassette with a starting speed of 8.5 km / h that increases by 0.5 km / h every minute. As the test advances, the time interval between signals decreases such that running speed must progressively increase to keep pace. The test ends when the subject stops voluntarily or when the subject is not within 2 steps of the marker cone for 2 consecutive signals. Ultimately, individuals were assigned a 'stage' (ranging from 0 – 20) that represents the final level successfully attained, with higher scores indicative of higher degrees of cardiorespiratory fitness. The 20-MST has many practical advantages since it can be administered quickly (10 – 15 minutes), several children can be tested simultaneously, it requires limited skill and habituation, and it is non-invasive.

4.2.2.4 Self-perception: Self-perception was measured using the Self-Perception Profile for Children (SPPC), a validated instrument (Harter, 1985) that has been used extensively in this population (Brown et al., 1998; Phillips & Hill, 1998; Rose et al., 1997). It was selected because it consists of the following 6 individual sub-scales that differentiate between domains that collectively influence overall self-perception: Scholastic competence (the child's perception of competence or ability within the realm of scholastic performance. eg. how well he / she does at classwork and how smart or intelligent he / she feels); social acceptance (the degree to which the child is accepted by peers, feels popular, has a lot of friends, and feels he / she is easy to like); athletic competence (the child's perceptions of athletic ability and competence at sports. eg. feelings that he / she is good at sports and athletic activities); physical appearance (the degree to which the child is happy with the way he / she looks, likes his / her body, and feels that he / she is good-looking); behavioural conduct (the degree to which the child likes the way he / she behaves, does the right thing, acts the way he / she is supposed to, and avoids getting into trouble); and, global self-worth (the extent to which the child likes himself / herself as a person, is happy with the way he / she is leading his / her life, and is generally happy with the way he / she is; it constitutes a global judgment of an individual's worth as a person, rather than domain-specific competence or adequacy). The 6 sub-scales are each comprised of 6 questions. Average values are calculated for each subscale, scores range between 1.00 to 4.00, and higher scores represent more positive ratings of self-perception.

4.2.2.5 Dietary intake: Twenty-four hour dietary recalls were used to estimate dietary intake as this methodology is known to provide a relatively precise estimate of usual intakes for groups of children (Rasanen, 1979). Detailed, written instructions and a completed sample recall were provided to parents and children. Recalls were administered by having children bring the instrument home for families to complete together as *homework*; teachers collected the forms on the following day. Two registered dietitians telephoned all families within 1 week of the recall day to review and confirm the data with parents (usually the mother). Nutrition data were collected using the multiple-pass technique, a validated procedure that involves gathering food consumption information from participants in three steps: a quick list, a detailed description, and a review of all items (Johnson et al, 1996). Collecting nutrition data on specific days of the week throughout the study was not possible for logistical reasons (i.e., holidays, school assemblies, field trips, and exams). Therefore, because recall forms were distributed to classrooms from Monday to Friday, dietary information was recorded on 5 days of the week only (Sunday to Thursday). Nutrition data were entered and analyzed by a registered dietitian using the Food Processor for Windows (v 7.02, 1997, ESHA Research, Salem, OR) with a Canadian database. If individual foods were absent from the Canadian database, the American database was used and new foods and recipes were added accordingly.

4.2.3 Statistical analyses: At baseline, the main effects of sex (boys, girls) and obesity status (obese, non-obese) and sex × obesity status interaction were evaluated using a 2 × 2 multivariate analysis of variance (MANOVA). Significant MANOVA results were followed up with protected univariate statistics on the dependent variables. A 2 × 2 × 4 repeated measures analysis of variance (ANOVA) model was used to assess differences between sex and obesity status over time (0-, 3-, 6-, and 12-month intervals). Significant main and interaction effects were followed-up with independent and paired t-tests to determine within- and between-subject differences. Because cardiorespiratory fitness and self-perception subscale data were not normally distributed among the sample, these values underwent data transformations. As well, servings from 5 food groups (Grain Products, Milk Products, Meat and Alternatives, Vegetables and Fruit, and Other Foods) were adjusted for total caloric intake. All data are expressed as means ± standard deviation and statistics were performed using SPSS (version 7.5, 1995, SPSS Inc, Chicago, IL) with significance set *a priori* at $p < 0.05$.

4.3 Results

4.3.1 Obesity classification: Earlier, we reported differences between obese and non-obese boys and girls from this cohort at baseline (Ball et al., 2001). In that analysis, 26 children (14 boys, 12 girls) met the classification for obesity (a sex- and age-specific sum of 5 skinfolds ≥ 85^{th} percentile). In the present report, the obese group is comprised of 19 children (a subset of 10 boys and 9 girls from the original group of 26) who were classified as obese at all 4 measurement intervals. Thus, 7 children who were initially classified as obese at baseline did not maintain this status for the duration of the study. Because of this change, the longitudinal analyses were performed two ways – (1) with these 7 children included in the non-obese group and (2) with them omitted from the data set entirely. The analyses did not differ, so for the sake of inclusion, comparisons were calculated with these 7 participants included in the non-obese group.

Participation rates did not differ between sexes (50.4% boys, 49.6% girls) and the majority of children in this study were Caucasian (92%). Overall, 136 / 276 (49.1%) of boys and girls from the sample of classrooms participated in the study. Follow-up data were not available for one non-obese boy who completed baseline measurements, but moved out of the area during the school year, so these analyses are based on 135 children. Although socioeconomic status was not formally assessed, school principals and research coordinators from both the Catholic and Public School Boards considered the children from participating schools in this sample to be from middle- to upper-middle class families.

4.3.2 Anthropometry: At baseline, significant main effects of sex ($F = 5.3$, $p < 0.001$) and obesity status ($F = 42.4$, $p < 0.001$) for the anthropometric variables were observed. Follow-up univariate comparisons are presented in **Table 4-1**. Boys were heavier ($F = 4.4$, $p = 0.029$) and leaner ($F = 15.5$, $p < 0.001$) than girls. Further, obese children were taller ($F = 4.8$, $p = 0.020$), heavier ($F = 56.5$, $p < 0.001$), possessed higher BMIs ($F = 78.2$, $p < 0.001$), and had a greater sum of 5 skinfolds ($F = 140.8$, $p < 0.001$) than their non-obese peers. No sex × obesity status interaction was found ($F = 1.0$, $p = 0.419$).

Table 4-1. Anthropometric comparisons between obese and non-obese boys and girls at baseline

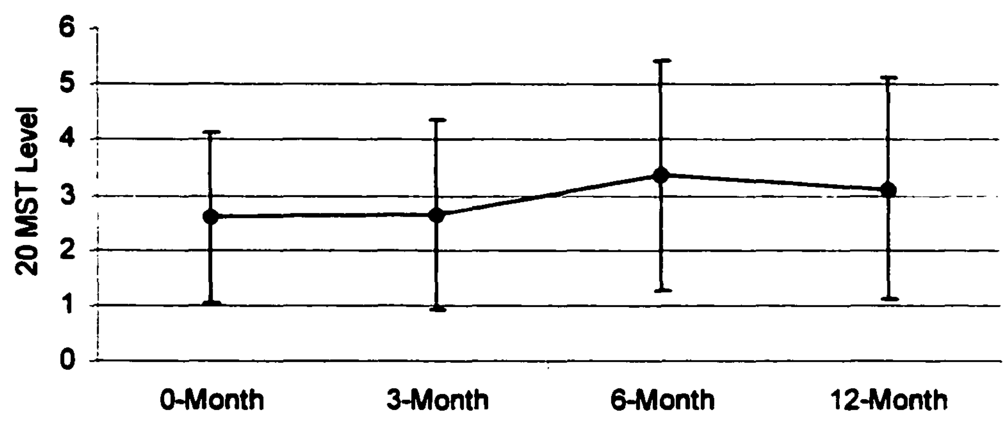
	Boys (n = 68)	Girls (n = 67)	p value[a]	Obese (n = 19)	Non-Obese (n = 116)	P Value[a]
Age (y)	8.2 (0.8)	8.3 (0.9)[b]	0.471	8.1 (0.8)	8.2 (0.9)	0.806
Height (cm)	130.6 (7.1)	129.5 (7.2)	0.080	133.8 (6.9)	129.7 (6.7)	0.020
Weight (kg)	29.5 (6.1)	28.3 (5.7)	0.029	37.6 (6.9)	27.5 (4.1)	<0.001
BMI (kg/m^2)	17.1 (2.4)	16.7 (2.6)	0.222	20.9 (2.5)	16.2 (1.7)	<0.001
Sum of 5 skinfolds (mm)	39.8 (18.5)	50.1 (18.7)	<0.001	80.3 (19.2)	39.2 (11.2)	<0.001

[a] Univariate analyses
[b] Mean (standard deviation)
Abbreviations: y (year), cm (centimetre), kg (kilogram), BMI (body mass index), m (metre) and mm (millimetre)

Using repeated measures ANOVA, we observed several 2-way interactions. Girls maintained higher values for the sum of 5 skinfolds ($F = 20.9$, $p < 0.001$) than boys while height ($F = 1.9$, $p = 0.126$), weight ($F = 0.6$, $p = 0.593$), and BMI ($F = 1.2$, $p = 0.325$) differences were not found between the sexes over the 4 intervals. As expected, obese children possessed greater sum of 5 skinfolds values ($F = 17.5$, $p < 0.001$) and weight ($F = 7.6$, $p < 0.001$) than their non-obese peers, but height ($F = 0.1$, $p = 0.933$) was similar over time. A trend also revealed that BMI was marginally different between obese and non-obese groups over the course of the year ($F = 2.6$, $p = 0.058$). No significant 3-way time × sex × obesity status interactions were observed.

4.3.3 Physical activity and cardiorespiratory fitness: No time-related group differences in physical activity were revealed. However, a significant time effect ($F = 3.6$, $p = 0.015$) was observed for 20-MST scores with cardiorespiratory fitness levels increasing between 3- and 6-months ($t = -5.6$, $p < 0.001$) within the cohort as a whole (**Figure 4-1**). However, no significant time × obesity status ($F = 2.1$, $p = 0.110$), time × sex ($F = 1.3$, $p = 0.282$), or time × sex × obesity status ($F = 0.7$, $p = 0.565$) interactions were observed.

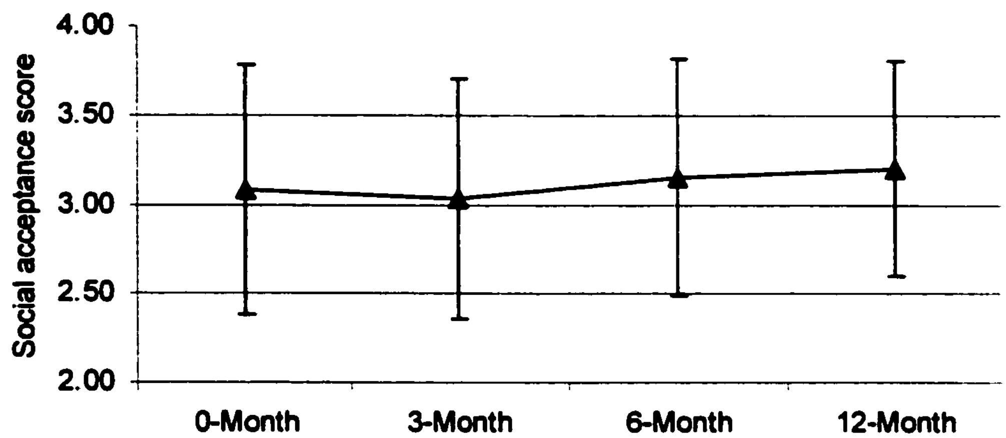
Figure 4-1. 20 MST scores of cohort (n = 135) over one-year



Main effect: Time ($F = 3.6$, $p = 0.016$)

4.3.4 Self-perception: For the SPPC sub-scales, a significant time effect was found for social acceptance (F = 3.0, p = 0.032) with values increasing between 3- to 6-months (t = -2.9, p = 0.004) **(Figure 4-2)**. No other significant time effects or interactions between groups were observed in self-perceived ratings of athletic competence, behavioural conduct, global self-worth, physical appearance, or scholastic competence **(Appendix 1)**.

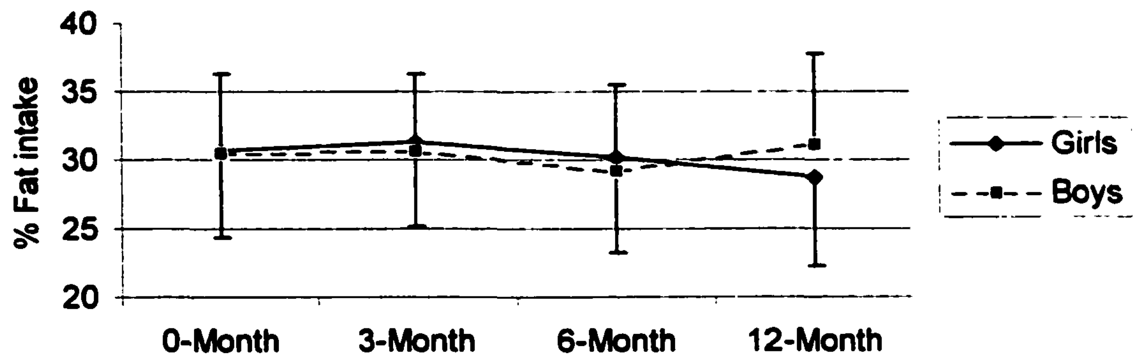
Figure 4-2. Self-perceived rating of social acceptance of cohort (n = 135) over one-year



Main effect: Time (F = 3.0, p = 0.032)

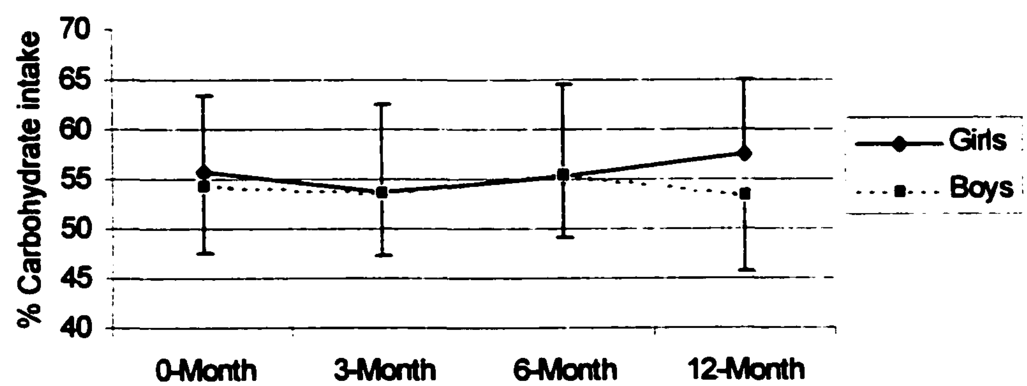
4.3.5 Dietary intake: A significant time × sex interaction emerged regarding relative intakes of dietary fat (F = 3.5, p = 0.017; **Figure 4-3**) and carbohydrate (F = 3.6, p = 0.016; **Figure 4-4**). Percent fat intake differed between boys and girls at 12-months only (t = -2.3, p = 0.025) as boys' relative fat intake increased between 6- and 12-months (t = -2.2, p = 0.029). Percent carbohydrate intake was similar to fat intake in that boys and girls differed at 12-months only (t = 3.1, p = 0.002). However, the pattern of change differed as boys intake of percent carbohydrate increased from 3- to 6-months (t = -2.1, p = 0.038) and subsequently decreased from 6- to 12-months (t = 2.1, p = 0.036). No sex differences were found for percent protein intakes (F = 2.4, p = 0.073). A significant interaction between time × obesity status was observed for the proportion (%) of dietary protein intake (F = 2.7, p = 0.048; **Figure 4-5**). No within-group differences were noted, but obese children had greater protein intakes at 3-months compared to their non-obese peers (t = -2.7, p = 0.007). The above interactions were confirmed when dietary intakes were represented as grams / 1000 kilocalories (Fat intake: time × sex interaction [F = 3.4, p = 0.019]; carbohydrate intake: time × sex interaction [F = 3.2, p = 0.027]; protein intake: time × obesity status interaction [F = 2.7, p = 0.046]). Over the course of the study, differences were not found between groups with respect to energy intake or intakes of any of the food groups from *Canada's Food Guide to Healthy Eating* (Health Canada, 1992) (**Appendix 2** and **Appendix 3**, respectively).

Figure 4-3. Comparison of % fat intake between girls and boys.



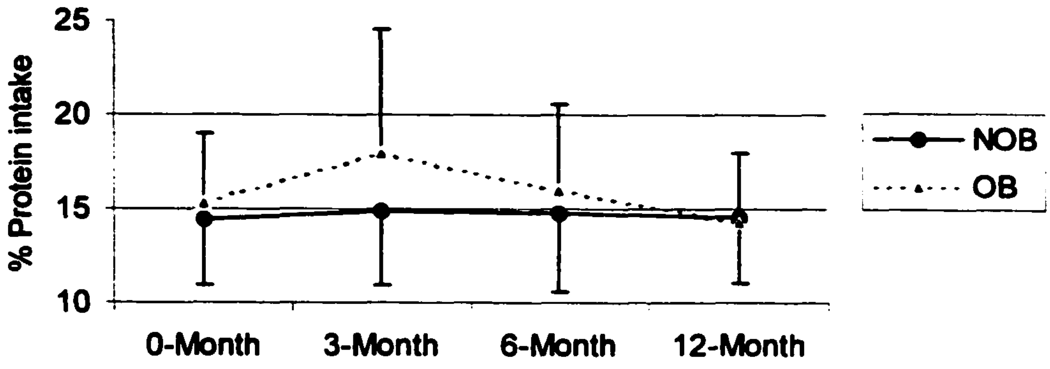
Interaction effect: Time x Sex (F = 3.5, p = 0.017)

Figure 4-4. Comparison of % carbohydrate intake between girls and boys.



Interaction effect: Time x Sex (F = 3.6, p = 0.016)

Figure 4-5. Comparison of % protein intake between non-obese (NOB) and obese (OB) children.



Interaction effect: Time x Obesity status ($F = 2.7$, $p = 0.048$)

4.4 Discussion

Data from this year-long study of obese and non-obese 6 – 10 year old children revealed that girls possessed greater sums of 5 skinfolds than boys; obese children had greater sums of 5 skinfolds and weighed more than non-obese children; cardiorespiratory fitness and self-perception related to social acceptance increased within the cohort; and, dietary intakes of percent fat and carbohydrate (between boys and girls) and percent protein (between obesity and non-obese children) changed differentially over time, but were within recommended macronutrient ranges (Health and Welfare Canada, 1990).

4.4.1 Anthropometry: The anthropometric differences between sexes were in the expected direction with girls having greater levels of body fat than boys. These observations are supported by nationally-representative data from the Canada Fitness Survey (1984) that highlighted a sexual dimorphism in body fatness with greater sums of 5 skinfold thicknesses becoming more apparent in girls in later childhood (10 – 12 years of age). When groups in the present study were compared according to measures of obesity status, obese children possessed greater levels of the sum of 5 skinfold thicknesses and body weight than non-obese boys and girls, but group similarities in height may have contributed to the lack of a difference in BMI. Although it has been debated, the BMI has only recently been recommended for general use when determining overweight and obesity status in children and adolescents (Cole et al., 2000; Bellizzi and Dietz, 1999; Himes, 1999). However, we elected to use the sum of 5 skinfold thicknesses to classify our sample as obese and non-obese because: (1) the classification was consistent with our baseline investigation (Ball et al., 2001); (2) unlike the BMI, a nationally representative database of skinfold measurements from Canadian children was available for comparison purposes (Canada Fitness Survey, 1984); and, (3) skinfold thicknesses represent an adiposity-based criteria while the BMI is an indirect measure of fatness based on height and weight measurements (Limbert et al., 1994).

4.4.2 Physical activity: Overall, the disparities in lifestyle behaviours and self-perceptions within this sample of obese and non-obese boys and girls were modest. We found that boys rated themselves more physically active than girls using the PAQ-C in the baseline assessment (Ball et al., 2001), but group (sex or obesity status) differences were not consistent over time. To our knowledge, we are the first research group to compare obese and non-obese groups using this 7-day activity recall questionnaire.

The PAQ-C has demonstrated moderate agreement with more objective measures of activity (i.e., Caltrac accelerometer) (Kowalski et al., 1997) and is intended to estimate general activity levels in schoolchildren. In 2 reports of Canadian children (8 – 14 years of age) that used the PAQ-C, boys rated themselves as more physically active than girls (Crocker et al., 2000; Crocker et al., 1997), but sex differences have not consistently been observed (Kowalski et al., 1997). While it is possible that there were no true group differences (based on sex and obesity status) in activity in our study, it is also possible that differences existed, but went undetected, since several aspects of physical activity (i.e., duration, intensity, and energy expenditure) are not measured using this tool. It is noteworthy that at all 4 time points in the study, boys scored higher than girls and non-obese children scored higher than obese children, but significant differences were not observed. Normative values for the PAQ-C are not available, but boys and girls in the present study scored similarly on the PAQ-C in comparison to children in other published reports (Kowalski et al., 1997). The PAQ-C was a convenient instrument to use in this school-based investigation since time was limited as all assessments were performed during regular school hours (aside from the 24-hour food recall which was completed at home with parents). However, a more objective field method of assessing physical activity (i.e., heart rate monitor, accelerometer, or pedometer) may have been helpful in determining whether physical activity levels differed between groups (Molnar and Livingstone, 2000).

4.4.3 Cardiorespiratory fitness: Scores in the 20-MST in the cohort increased between 3- (winter) and 6-months (spring). This pattern of change suggests that time of year may be an important factor to consider when assessing fitness in youth (Armstrong et al., 1995) given that physical activity tends to decrease in winter months (Welk et al., 2000) and television viewing (an index of physical inactivity) tends to increase over the same period (Dietz and Strasburger, 1991). Fitness differences related to sex and obesity status did not emerge in the current study. This finding is somewhat surprising since we observed that obese children scored lower in the 20-MST than non-obese boys and girls at baseline (Ball et al., 2001). Marshall and Bouffard (1997) also found lower fitness levels (assessed using the 20-MST) in obese children compared to their non-obese peers. Although differences were not statistically significant, we observed a modest trend ($p = 0.11$) with obese children consistently scoring lower on the 20-MST than non-obese children at all 4 time intervals.

It appears that the 20-MST is sensitive enough to reveal sex differences in cardiorespiratory fitness in older children and adolescents (11 – 16 years of age; Cooley and McNaughton, 1999). As well, Marshall and Bouffard (1997) found that grade 1 boys from schools that offered quality daily physical education (QDPE) were more aerobically fit than grade 1 girls from QDPE schools confirming that differences in cardiorespiratory fitness exist and are measurable in young boys and girls. In pre-pubertal children (Tanner stage 1), Armstrong and colleagues (1995) also found boys to have higher levels of cardiorespiratory fitness than girls (assessed using a treadmill VO_{2max} protocol). Thus, it appears that the sensitivity of the 20-MST to detect differences in fitness between groups and the relatively young age of the participants in the current study do not explain the lack of group differences in this investigation. While speculative, it is possible that our inability in observe differences in fitness related to obesity status may be a function of the discordant sample sizes between the obese and non-obese groups. Aside from this limitation, measuring other aspects of physical fitness including muscular endurance and strength may have been useful in characterizing more completely any group differences within this sample of young obese and non-obese boys and girls.

4.4.4 Self-perception: We observed that self-perceived ratings of social acceptance increased among the entire sample between 3- and 6-month intervals, but no group (sex or obesity status) differences in the SPPC sub-scales emerged. Obese children scored lower than their non-obese peers in most of the self-perception sub-scales throughout the study, however, no statistically significant differences were found. Compared with data from other reports that have used the SPPC, children in this study scored similarly or slightly higher in all 6 of the sub-scales (Brown et al., 1998; Harter, 1985). While obese children rated themselves lower in scholastic competence and social acceptance than their non-obese peers at baseline (Ball et al., 2001), these differences did not persist over time. Other reports using the SPPC to assess self-perception patterns over time have also been equivocal.

Using a modified version of the SPPC, Kolody and Sallis (1995) found no baseline differences related to sex or obesity status in a group of 4th grade boys and girls (n = 567). Yet, follow-up measures performed one year later revealed that an increase in BMI was associated with a change toward a less favourable self-concept in physical activity and global self-worth domains. Strauss (2000) assessed global self-worth and scholastic competence in obese and non-obese children (9 – 10 years of age; n = 1520) and failed to observe group differences at baseline. In follow-up measurements carried out 4 years later, however, global self-worth scores decreased in obese boys, obese Hispanic girls, and obese white girls when compared to their nonobese peers (no changes in scholastic competence were observed). In a biracial (black and white) sample of American girls (9 – 14 years old; n = 2379), social acceptance increased, global self-worth decreased (in white girls only), and physical appearance decreased similarly in both groups over a 5-year period (Brown et al., 1998). Collectively, these data affirm that adolescence is an important transition period in self-perception in boys and girls (Stunkard and Burt, 1967). While we did not find group differences in any of the SPPC subscales over a one-year period, it is likely that follow-up measurements done over a longer interval may have allowed changes in growth and maturation to exert greater influence on these self-perceptions. As previous research has highlighted (Strauss, 2000; Brown et al., 1998; Kolody and Sallis, 1995), it is likely that (at least part of) the inconsistencies found in the self-esteem / obesity relationship in youth may be caused by an inability of cross-sectional research to evaluate psychosocial changes associated with puberty.

4.4.5 Dietary intake: Boys consumed more total energy and a greater proportion of dietary protein than girls at baseline, but differences according to obesity status were not found (Ball, Marshall and McCargar, unpublished observations). Subtle sex- (for percent fat and carbohydrate) and obesity-related (for percent protein intake) differences in dietary macronutrient intakes were observed in the present longitudinal study. Despite these disparities, the macronutrient composition of the diets of all groups were similar to Canadian recommendations (Health and Welfare Canada, 1990) indicating that the group differences were sample-specific. It should also be noted that the repeated dietary measurements (on the same children) taken over the course of the study increase confidence in the validity of the dietary data. These observations are likely more reflective of habitual intakes than a single 24-hour measurement (Gibson, 1990). Factors including the intra-subject variance and sample size can influence the precision of the dietary estimates. While it is known that intra-subject variation is lower for macronutrients since they are widely distributed in foods (Liu et al., 1978), because of the small number of children in the obese group (n = 19), these results and the group comparisons performed should be interpreted carefully (Gibson, 1990).

Overall, children in this study reported energy intakes on the low end of the recommendation levels for 6 – 12 year old Canadian boys and girls (Health and Welfare Canada, 1990) (our study: 1600 – 2000 kcals / d; Health Canada recommendations: 1800 – 2500 kcals / d). Although the difference was not statistically significant over time, boys tended to consume more total energy than their girls. This sex disparity is consistent with other research of similar aged Canadian (Hanley et al., 2000; Johnson-Down et al., 1997) and American (Crespo et al., 2001; Gazzaniga and Burns, 1983) children. We also noted that obese girls had lower absolute and adjusted (per kg body wt) energy intakes than non-obese girls at all 4 time intervals; a similar trend was seen when obese and non-obese boys were contrasted. We did not employ an independent method of assessing accuracy of the nutrition data (Schoeller, 1995). However, under-reporting of total energy intakes has been previously reported among obese youngsters (Fisher et al., 2000; Johnson-Down et al., 1997) despite findings that suggest the 24-hour dietary recall (obtained through parental reports) is accurate and valid (Johnson et al., 1996; Baranowski et al., 1991).

With respect to dietary quality, the 24-hour dietary recall revealed that the entire cohort consumed intakes of Grain Products and Dairy Products within the recommended ranges. However, servings of Vegetables and Fruit and Meat and Alternatives were lower than recommended by *Canada's Food Guide to Healthy*

Eating (Health Canada, 1992). Specific recommendations do not exist regarding intakes of servings from the Other Foods group, but it is suggested that foods from this category be consumed in moderation. There are few published studies on the dietary intakes of Canadian children and no recent nationally representative samples to use for comparison purposes. One of the few available regional studies (Whiting et al., 1995) reported findings similar to the present study. Twenty-four-hour recalls were completed by children (n = 226) 6 times over a 12-month period and average values were calculated according to age category (8 – 9y, 10 – 12y, and 13 – 15y). Temporal patterns were not investigated, but overall, intakes of Vegetables and Fruit were low among both sexes while Meat and Alternatives were low in girls only. In both sexes, boys and girls consumed Grain Products and Milk Products in adequate amounts while the consumption of Other Foods was relatively high and increased with age. More recently, the same research group (Lemke et al., 1998) reported marginally low intakes of Meat and Alternatives (1.9 ± 0.7 svgs / d) and Vegetables and Fruit (3.9 ± 1.9 svgs / d) in 9 – 13 year old children. Intakes of Grain Products (5.5 ± 1.3 svgs / d) were adequate for the group, but Milk Products, while adequate for 7 – 9 year old children (2.7 ± 1.1 svgs / d), were inadequate for the 10 – 12 year old group. The diets of pre-school children (n = 306) from several low-income communities in Ontario have also been assessed using parent-completed 24-hour recalls (Leaman and Evers, 1997). While Meat and Alternatives intakes were adequate (2.0 svgs / d), Grain Products (4.4 svgs / d), Vegetables and Fruit (3.4 svgs / d), and Milk Products (1.9 svgs / d) were low. Thus, while nationally representative data for Canadian children are lacking, it appears that children in the present study consumed diets similar to children in other regions of the country. These data are consistent with reports from the U.S. suggesting that intakes of Vegetables and Fruit in children are low whereas Other Foods, typically high in sugar and fat, are consumed in greater quantities (Brady et al., 2000; Wolfe and Campbell, 1993).

In contrast to our baseline observations (Ball et al., 2001), this longitudinal study showed that the initial group differences in behavioural and perceptual data did not remain consistent over the duration of the study. The variables we measured may be transient in nature, but other factors may explain these discrepancies. First, changes in skinfold thickness measurements resulted in differences in the number of children in the obese and non-obese groups. Nonetheless, we are confident that the 19 children categorized as obese in this longitudinal investigation truly are obese. And, while plausible, it is unlikely that they have been incorrectly categorized as obese due to measurement error or differences related to maturational timing. Second, there may have been inadequate sample sizes and statistical power to detect group differences between obese (n = 19) and non-obese (n = 116) children. This is underscored by the observed patterns with obese children possessing lower scores in fitness and self-perception measurements. Third, because children are in a dynamic period of growth and development, a time when many health-related behaviours and perceptions are being developed (Birch, 1998), some of the outcomes (i.e., physical appearance and global self-worth subscales) may have been in a transient state. However, it might also be expected that as boys and girls mature, physical differences between sexes become more pronounced and opposite sex relationships become more salient, thus influencing certain domains (i.e., physical appearance) more than others (i.e., behavioral conduct). The relatively short duration of this study (1-year) may have precluded us from observing any substantial changes. Fourth, research suggests that tracking (persistence) of lifestyle behaviours is low to moderate in youngsters. For example, the tracking of physical activity in adolescents over a 3-year period varies ($r = 0.4 - 0.5$ in boys; $r = 0.3 - 0.4$ in girls) with slightly higher tracking in older age groups (Raitakari et al., 1994). Poor to fair tracking in both sexes for total energy, macro- and micro-nutrients, and food groups has also been reported (kappa coefficients < 0.50), indicating either substantial drift, true changes, and / or measurement error over time (Robson et al., 2000; Resnicow et al., 1998). Finally, while obese and non-obese groups in the current study were significantly different according to anthropometric indicators, based on American BMI reference values (Himes and Dietz, 1994), the average BMI of the obese group would rank them near the 85th percentile. Thus, as a group, the impact of their body fatness on physical activity, cardiorespiratory fitness, self-perceptions, and nutrition variables, in relation to the non-obese group, may not be as dramatic as would be expected in a more obese (i.e., >95th percentile) sample of children. Overall, the discordant observations between our cross-sectional and longitudinal analyses in this sample of children underscores the importance of longitudinal studies, especially when assessing obese and non-obese groups undergoing developmental and social changes.

In summary, we found significant anthropometric differences in the expected directions between children according to sex and obesity status. While these data suggest modest group differences in physical activity, cardiorespiratory fitness, self-perception, and dietary intake, we cannot say with certainty that sex and obesity status influenced these variables in this sample of obese and non-obese boys and girls. These results highlight the importance of conducting longitudinal investigations to assess anthropometric, behavioural, and perceptual differences between groups of obese and non-obese boys and girls since findings from cross-sectional studies may only reflect transient differences in health-related variables.

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Chapter Five: SHAPEDOWN and VITALITY: A comparison of two weight management programs for obese children[2]

5.1 Introduction

Childhood obesity has increased dramatically in Canada (Tremblay and Willms, 2000; Limbert et al., 1994) and the United States (Flegal et al., 2001) over the last two decades. Concomitantly, the volume of research published on issues related to child and adolescent obesity has grown considerably (Goran, 2001). Extensive data suggest that a high level of body fat in youth is associated with elevated health risks (Must and Strauss, 1999; Power et al., 1997). With the recognition that obesity in youth is more than just a cosmetic concern, developing new and improving upon currently available treatment options is a research priority (Dietz and Gortmaker, 2001; Hill and Trowbridge, 1998). Given the high rate of recidivism in the treatment of adult obesity (WHO, 1998), establishing healthy eating and activity patterns early in life to positively influence short- and long-term health outcomes is a logical strategy.

All weight management programs have the same primary objective -- to improve the health of obese individuals. Yet, the manner in which this goal is achieved may vary widely depending on the philosophical perspectives of health professionals and clients involved in treatment (Neumark-Sztainer, 1999). In the past, some child and adolescent weight management programs have been based on restrictive, energy-reduced diets and structured exercise plans designed to help individuals lose weight by establishing negative energy balance (Reybrouck et al., 1990; Epstein et al., 1985). However, concerns have been expressed regarding the use of such prescriptive approaches in young populations. For example, restrictive diets are known to play a role in establishing

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[2] A form of this chapter (abstract) has been previously published: Ball GDC, Marshall JD & McCargar LJ. A comparison of two weight management programs for treating childhood obesity. Obesity Research 2000;8:45S.

unhealthy nutrition attitudes, disordered eating patterns, and dietary restraint in adults (Steinhardt et al., 1999) and children (Drucker et al., 1999; Birch and Fisher, 1998; Satter, 1996). It also appears that, when compared to structured exercise programs, encouraging obese boys and girls to participate in lifestyle activities and games (Epstein et al., 1996) and discouraging sedentary activities (Epstein et al., 1995) may lead to greater long-term maintenance of physical activity behaviours. In response to these issues, many health professionals working in the obesity area have proposed a paradigm shift away from restrictive and prescriptive lifestyle recommendations that promote dieting and exercising for weight loss. In contrast to this *weight-centred* philosophy, a *health-centred* model has been proposed (Berg, 2000; Cogan, 2000) **(Table 5-1)**.

Table 5-1. Overview of the weight-centred and health-centred weight management paradigms[a]

	Weight-Centred Paradigm	Health-Centred Paradigm
Nutrition	• Restrictive eating and dieting • Foods are either 'good' or 'bad' • Rigid and controlling; willpower is needed	• Enjoy a variety of foods • Listen to your body – eat when hungry, stop when full • All foods fit into a healthy eating style
Physical Activity	• Exercise to burn calories and achieve negative energy balance • No pain, no gain	• Be active your way, everyday • Celebrate activity as a way of life • Choose fun activities • Enjoy numerous benefits (i.e., improve bone health, lower stress, sleep better)
Body Image	• Weight obsessed • Unrealistic goals for body shape and size	• Beauty, health, and strength come in all sizes • Involve size- and self-acceptance
Attitude	• Perfectionist • All-or-nothing	• Health enhancing • Positive, empowering, freedom

[a] Adapted from Berg (2000)

While the health-centred paradigm has a number of different names (i.e., the non-diet approach, size acceptance, health-at-any-size, and health-at-every-size) (Berg and Marchessault, 2000), a philosophy entitled VITALITY was created by Health Canada in 1991 (Health Canada, 2000). The VITALITY concept grew out of a national strategy to promote healthy weights (Health and Welfare Canada, 1988) and focuses on health-enhancing behaviours to achieve and maintain a healthy weight rather than focusing on weight itself. Overall, the principles are summarized by the following statement: "Enjoy eating well, being active and feeling good about yourself. That's VITALITY." (p. 8, Health Canada, 2000). The VITALITY approach has been widely promoted in Canada and abroad. A few weight management programs have been developed for adults that embody a health-centred philosophy (Carrier et al., 1994; Polivy and Herman, 1992), but at the present time, there are few examples of weight management programs for obese children based on this model (Gillis, 2001).

There has been growing interest among health professionals in recent years to provide weight management programs to obese children and their families (Epstein et al., 1998). Many dietitians, nurses, pediatricians, and fitness professionals may be interested in delivering weight management interventions to obese children and their families, but the task of developing a comprehensive program including appropriate guidelines, lessons, and resources can be prohibitive. As well, there may be limited opportunities for health professionals to gain skills and knowledge in issues related to child and adolescent obesity, especially if their scope of practice has not traditionally included weight management. To address these shortcomings, programs have been developed that include extensive training modules and resources that allow health professionals to learn about and subsequently offer obesity treatment programs to children and their families.

The SHAPEDOWN weight management program was developed at the University of California (San Francisco) in 1979 and has been offered by health professionals throughout North America. Numerous cognitive, behavioural, affective, and interactional techniques are used to guide gradual improvements in diet, physical activity, relationships, communication, and attitudes (Mellin et al., 1987). Research suggests that the SHAPEDOWN program can be successful at helping obese youngsters to lose weight and improve physical and psychosocial health outcomes. Mellin and colleagues (1987) enrolled obese adolescents (12 – 18 years old; n = 66) from four communities in northern California in the SHAPEDOWN intervention and a control group. Compared to baseline values, significant improvements were observed in relative weight, weight-related behaviour, affect, self-esteem, and weight management knowledge at 3- (post-treatment) and 15-month (follow-up) intervals. Thomas-Dobersen et al. (1993) delivered the SHAPEDOWN program to a group of obese adolescents with type 1 diabetes (14 – 15 years old; n = 11) and found the program to be effective at improving body image and self-esteem. However, treatment did not lead to significant improvements in adiposity-based criteria. A modified version of the SHAPEDOWN model (*The Solution Method*) that incorporates a developmental skills model of obesity treatment has also been developed for men and women. Long-term improvements (over a 2-year period) in both physical and functional outcomes have been reported within a sample of obese individuals who participated in the Solution Method (Mellin et al., 1997).

It appears that SHAPEDOWN is beneficial in improving selected health outcomes in obese adolescents, but many questions remain unanswered. Despite the widespread use of the program, no data exist on whether SHAPEDOWN leads to positive changes in younger obese boys and girls (< 12 years of age). Family-based behavioural approaches are considered important in child weight management strategies (Bar-Or et al., 1998), yet the involvement of parents in the studies conducted by Mellin et al. (1987) and Thomas-Dobersen et al. (1993) was limited to just a few sessions over the intervention periods. Incorporating consistent parental involvement throughout the treatment process may lead to improved outcomes. Further, the role of nutrition and physical activity behaviours in the long-term maintenance of weight status in response to the SHAPEDOWN program has not been adequately explored.

Both SHAPEDOWN and VITALITY interventions can be considered lifestyle education programs. However, VITALITY is a health-at-any-size intervention that universally endorses healthy behaviours and attitudes for all individuals whereas SHAPEDOWN advocates improving lifestyle behaviours, attitudes, and family communication as a means to improve obesity status. Thus, the goals of the current study were: (1) to assess whether the SHAPEDOWN and VITALITY weight management programs would lead to decreased body fatness and increased levels of physical activity, cardiorespiratory fitness, self-perception, and improved dietary quality in 6 – 10 year old obese children and their families and (2) to determine whether SHAPEDOWN, an intervention that encourages families to monitor body weight changes during treatment, results in greater losses of body weight and fatness than the VITALITY program.

5.2 Methods

5.2.1 *Description of the SHAPEDOWN program:* SHAPEDOWN is a validated program (Mellin et al., 1987) designed for obese children and adolescents aged 6 – 18 years. There are four program levels: Level 1 (6 - 8 years), Level 2 (8 - 11 years), Level 3 (11 - 13 years), and Level 4 (13 - 18 years). Each level is sensitive to the physical, emotional, cognitive, and social needs of that age group. Specific goal setting, behaviour modification, and self-monitoring, reinforced through weekly homework and quizzes for both children and parents, are integral components of the program. SHAPEDOWN is delivered in either individual or group counselling settings and consists of a leader's guide (Mellin, 1987) including approximately 40 hours of training, self-assessments, and videotaped lessons and workbooks for both children (Mellin, 1991) and parents (Mellin, 1998).

5.2.2 Description of the VITALITY program: The VITALITY philosophy was developed to integrate enjoyable healthy eating, physical activity, and positive self and body image (Health Canada, 2000). VITALITY encourages individuals to make positive choices and promotes environments that make healthy choices easier. It is not a program *per se*, but is an ideology that recommends a shift from negative to positive thinking about how to achieve and maintain a healthy lifestyle. VITALITY discourages categorizing foods as *good* or *bad* and encourages taking pleasure in eating a variety of foods. It minimizes the role of exercise as a means to burn calories and improve body composition, and supports enjoyable, sustainable physical activity and active living. VITALITY also excludes obsessive attitudes and behaviours regarding body weight and recognizes that healthy bodies come in a range of weights, shapes, and sizes. The paradigm is intended to empower all individuals, families, and communities (regardless of obesity status) to make sound lifestyle choices. Our research group built upon the information, sample tools, and techniques provided in the VITALITY leader's guide (Health Canada, 2000) and included other available resources to establish an outline for the program. However, instead of providing prescriptive instructions in a pre-determined format, families helped to determine the topics for discussion and activities for this participant-guided program. Accordingly, VITALITY was presented in a way to encourage family involvement in its development. In both the SHAPEDOWN and VITALITY programs, children were not weighed during weekly group sessions. While weight loss / weight maintenance is an integral component of the SHAPEDOWN program, weekly 'weigh-ins' are considered optional. Conversely, changes in body weight or body composition are neither emphasized nor overtly encouraged in the VITALITY program.

Participants: Boys and girls were recruited from the community through television and newspaper advertisements, pediatrician and dietitian referrals, and word of mouth. Children were eligible for the study if they were 6 – 10 years of age, possessed a sex- and age-specific sum of 5 skinfolds $\geq 85^{th}$ percentile (Canada

Fitness Survey, 1984), had at least 1 parent willing to regularly attend the program, and were not presently taking medications that could potentially influence dietary intake or physical activity patterns. Parents and children provided informed consent and assent, respectively. Approval for this project was obtained from the Faculty of Agriculture, Forestry, and Home Economics Human Ethics Review Committee at the University of Alberta.

Children were randomly assigned to either the SHAPEDOWN or VITALITY program in the spring of both 1997 and 1998. The initial treatment period lasted 3-months with families attending weekly meetings (1.5 – 2.0 hours long) for 12 consecutive weeks. Follow-up group meetings were held monthly for 3 additional months. Approximately half of each session was spent with families together while the other half involved specific activities and discussions for children and parents in separate groups and rooms. Experienced registered dietitians facilitated the programs; two guided the SHAPEDOWN program (after completing the requisite training) while two different dietitians led the VITALITY intervention. One of the researchers (GB) attended all of the group meetings for both programs to provide additional support; several nutrition and physical education undergraduate students provided assistance as well. Both programs were delivered free-of-charge in a community setting at the University of Alberta.

5.2.4 Procedures:

5.2.4.1 Client satisfaction: Satisfaction with the SHAPEDOWN and VITALITY programs was measured at 3-months (post-intervention) using a modified version of the questionnaire developed by Hauchecorne et al. (1994). This instrument was developed based on a framework of client satisfaction that includes improved well being, fulfillment of interpersonal psychological need, reduction of uncertainty, control, and accessibility. It was initially designed to assess the impact of nutritional counseling. In the present study, *nutrition counselling* was substituted with *lifestyle counselling*. Parents completed the questionnaire on behalf of the family so we could determine the influence the interventions had on the family's self-perceived health and well being.

5.2.4.2 Anthropometry: All of the remaining outcome variables were measured at 0- (baseline), 3- (post-intervention), 6- (follow-up), and 12-month (follow-up) intervals. Skinfold measurements (to the nearest 0.2 mm) were taken at 5 sites (triceps, biceps, subscapular, suprailiac, and medial calf) on the right side of the body using Harpenden Skinfold Calipers (Health Dimensions, Plymouth, MI). To minimize measurement error, three trained researchers performed all of the skinfold measurements; one male researcher appraised all of the boys while two female researchers assessed the girls. Based on Canadian population normative data (Canada Fitness Survey, 1984), all children with a sex- and age-specific sum of 5 skinfolds $\geq 85^{th}$ percentile were classified as obese. Height was assessed (to the nearest 0.1 cm) using a setsquare and a wall-mounted tape measure and weight was determined (to the nearest 0.1 kg) using a portable medical scale (Health-o-meter, Inc., Bridgeview, IL); body mass index (BMI; kg/m^2) was subsequently calculated. All anthropometric data were collected in accordance with Canadian Standardized Test of Fitness (CSTF) procedures (CSTF Manual, 1986).

5.2.4.2.1 Mathematical index: Height and weight data were also entered into a Mathematical Index (MI) developed by Gillis et al. (2000). The MI integrates observed height and weight changes during obesity treatment and follow-up periods as well as expected naturalistic height and weight changes based on U.S. National Center of Health Statistics growth charts (Hamill et al., 1979). Subsequently, these values are entered into the following formula:

$$MI = \{[\Delta \text{ height}_{(observed)} \times \Delta \text{ weight}_{(expected)} / \Delta \text{ height}_{(expected)}] - \Delta \text{ weight}_{(observed)}\} \times 10$$

Each child's age- and sex-specific height and weight percentiles were assessed at 0-, 3-, and 6-months and expected values (based on computer-generated estimations provided by L. Gillis) for height and weight changes at 3-, 6- and 12-months were calculated. MI values were generated for each child by entering their observed and expected height and weight data into the formula. If the result was negative, the child gained excessive weight; if the value was positive, the individual slimmed down. MI values were calculated for three intervals: 0- to 3-months (treatment), 3- to 6-months (follow-up), and 6- to 12-months (follow-up). The following provides a theoretical example of how the MI is applied:

> *An MI score of "0" suggests the child grew at the expected rate according to his/her percentile rankings. Compared to body composition changes measured by bioelectrical impedance analysis, a change of +10 units is equivalent to a 0.6% loss of body fat (p. 1649, Gillis et al., 2000).*

5.2.4.3 Physical activity: The Physical Activity Questionnaire for older Children (PAQ-C), a self-administered 7-day activity recall questionnaire that evaluates the sports, leisure activities, and games performed throughout school days, evenings, and weekends, was used to assess physical activity (Kowalski et al., 1997). Based on preliminary evidence, the instrument does not reveal a gender bias based on overall activity levels in boys and girls (Crocker et al., 1997). The PAQ-C is comprised of nine items that are converted to a 5-point scale with higher scores indicating higher levels of physical activity. Once completed, summing and calculating the means of the nine items forms a composite score with final values ranging between 1.00 – 5.00 (Crocker et al., 1997).

5.2.4.4 Cardiorespiratory fitness: The 20-metre shuttle run (20-MST) was used to determine cardiorespiratory fitness since it has been well established as a valid and reliable field test in children (McNaughton et al., 1996; Mahoney, 1992). The 20-MST requires subjects to run back and forth between two markers spaced 20 metres apart. The pace is established by auditory signals played by audiocassette with a starting speed of 8.5 km/h that increases by 0.5 km/h every minute. As the test advances, the time interval between signals decreases such that running speed must progressively increase to keep pace. The test ends when the subject stops voluntarily or when the subject is not within 2 steps of the marker cone for 2 consecutive signals. Ultimately, individuals were assigned a *stage* (ranging from 0.0 – 20.0) that represented the final level successfully attained, with higher scores representing higher degrees of cardiorespiratory fitness. The 20-MST has many practical advantages since it can be administered quickly (10 – 15 minutes), several children can be tested simultaneously, it requires limited skill and habituation, and it is non-invasive.

5.2.4.5 Self-perception: Self-perception was measured using the Self-Perception Profile for Children (SPPC), a validated instrument (Harter, 1985) that has been used extensively in young populations (Brown et al., 1998; Phillips and Hill, 1998; Rose et al., 1997). This tool was selected because it consists of the following 6 individual sub-scales that differentiate between domains that collectively influence self-perception: Scholastic competence (the child's perception of competence or ability within the realm of scholastic performance. eg. how well he / she does at classwork and how smart or intelligent he / she feels); social acceptance (the degree to which the child is accepted by peers, feels popular, has a lot of friends, and feels he / she is easy to like); athletic competence (the child's perceptions of athletic ability and competence at sports. eg. feelings that he / she is good at sports and athletic activities); physical appearance (the degree to which the child is happy with the way he / she looks, likes his / her body, and feels that he / she is good-looking); behavioural conduct (the degree to which the child likes the way he / she behaves, does the right thing, acts the way he / she is supposed to, and avoids getting into trouble); and, global self-worth (the extent to which the child likes himself / herself as a person, is happy with the way he / she is leading his / her life, and is generally happy with the way he / she is; it constitutes a global judgment of an individual's worth as a person, rather than domain-specific competence or adequacy). The 6 sub-scales are each comprised of 6 questions. Average values are calculated for each subscale, scores range between 1.00 to 4.00, and higher scores represent more positive ratings of self-perception.

5.2.4.6 Dietary intake: Twenty-four hour dietary recalls were used to estimate dietary intake. Detailed instructions and a completed sample recall were provided to parents and children. Families completed the instrument together and the dietary information was immediately reviewed by the researcher team. Nutrition data were collected using the multiple-pass technique, a validated procedure that involves gathering food consumption information from participants in three steps: a quick list, a detailed description, and a review of all items (Johnson et al, 1996). Because the SHAPEDOWN and VITALITY groups met on weekday evenings (Tuesday, Wednesday, and Thursday), recalls recorded dietary intakes from weekdays only (Monday, Tuesday, and Wednesday). Nutrition data were entered and analyzed by a registered dietitian using the Food Processor for Windows (v 7.02, 1997, ESHA Research, Salem, OR) with a Canadian database. If individual foods were absent from the Canadian database, the American database was used and new foods and recipes were added when necessary.

5.3.5 Statistical analyses: At baseline, the main group (SHAPEDOWN, VITALITY) effect was evaluated using multivariate analysis of variance (MANOVA). A 2 group (SHAPEDOWN, VITALITY) × 4 time (0-, 3-, 6-, and 12-months) repeated measures analysis of variance (ANOVA) model was used to assess differences in outcome variables between groups over time. This relatively conservative statistical technique was chosen because it decreased the intra-individual variation and reduced the group variations which increased the power of the analysis (Stevens, 1992). Significant main effects were followed-up with paired t-tests to determine whether changes occurred compared to baseline scores; this was done to highlight the specific effects of the interventions. Because cardiorespiratory fitness and self-perception subscale scores were not normally distributed among the sample, these values underwent data transformations. As well, servings from 5 food groups (Grain Products, Milk Products, Meat and Alternatives, Vegetables and Fruit, and Other Foods) were adjusted for total caloric intake prior to analyses. All statistics were performed using SPSS (version 7.5, 1995, SPSS Inc, Chicago, IL) with significance set *a priori* at $p < 0.05$.

5.3 Results

5.3.1 Participation and dropout: In year one, 37 children and at least 1 parent from each family signed up for the study while 25 families were recruited in year two. The majority of families were Caucasian (97%). After random assignment in each year, 31 children were enrolled in the SHAPEDOWN program (year one: 18; year two: 13) and 31 children in the VITALITY program (year one: 19; year two: 12). One family dropped out of the SHAPEDOWN program in year one after random assignment, but before the start of the intervention. The dropout rates were as follows: SHAPEDOWN (year one: 23.5% [4/17]; year two: 38.5% [5/13]) and VITALITY (year one: 21.1% [4/19]; year two: 16.7% [2/12]). When data were pooled from both programs, the overall dropout rate was 24.5%. Twenty-two children completed the SHAPEDOWN program while 25 children completed the VITALITY program. To assess whether degree of obesity or sex influenced dropout rates, children who dropped out of the study were compared to those who completed the programs; no group differences emerged with respect to age, sex, BMI, or the sum of 5 skinfolds (data not shown). Families who left the programs before completion gave the following reasons: *schedule conflicted with other activities* (n = 5); *not enough time* (n = 4); *no longer interested* (n = 3); *too far to commute to the sessions* (n = 2); and, *moved out of the area* (n = 1). The overall attendance of both programs for both years ranged from 85.0 – 91.7%. In absolute terms, children in the SHAPEDOWN and VITALITY programs attended an average of 10.5 / 12 and 10.6 / 12 sessions, respectively. No families dropped out of either program (in either year) after the 5^{th} week of the study.

5.3.2 Client satisfaction: The results of the client satisfaction questionnaire are presented in **Table 5-2**. Overall, both SHAPEDOWN and VITALITY programs were rated positively by parents who participated in the interventions with their children. The majority of families felt that the programs provided useful information, catered to their individual needs, and led to positive lifestyle changes that improved the emotional and physical health of their family. Responses were also positive regarding the information, support, encouragement, and empathy provided by the group facilitators.

Table 5-2. Client satisfaction assessed by parents using the modified questionnaire by Hauchecorne et al. (1994)

Statement	SHAPEDOWN (n = 22)	VITALITY (n = 25)
	"Agree" or "Strongly Agree"	
1. Program staff provided useful information	100%	92%
2. The advice from program staff was suited to my family's special needs	95%	80%
3. After talking to program staff, my family made positive lifestyle changes	73%	76%
4. After talking with program staff, the emotional health of my family improved	95%	88%
5. After talking with program staff, the physical health of my family improved	68%	76%
6. Program staff provided support and encouragement	100%	92%
7. Program staff cared about my family	95%	96%

5.3.3 Anthropometry and Mathematical Index: Anthropometric data of the children in the SHAPEDOWN and VITALITY groups are presented in **Table 5-3**. MANOVA revealed there were no significant group differences between outcome measures at baseline ($F = 1.1$, $p = 0.403$). Repeated measures ANOVA did not reveal significant time × group interactions for any of the anthropometric variables. However, significant time effects for height ($F = 250.7$, $p < 0.001$; **Figure 5-1**), weight ($F = 47.8$, $p < 0.001$; **Figure 5-2**), BMI ($F = 11.7$, $p < 0.001$; **Figure 5-3**), and the sum of 5 skinfolds ($F = 11.4$, $p < 0.001$; **Figure 5-4**) were observed.

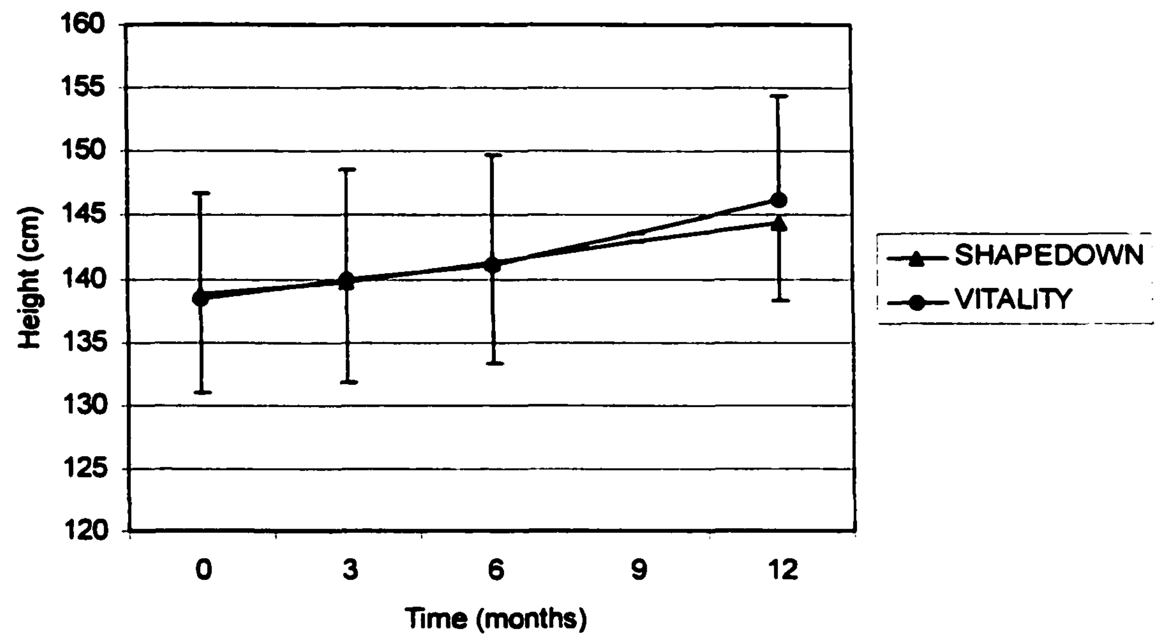
Table 5-3. Baseline anthropometric comparisons between the SHAPEDOWN and VITALITY groups

Variable	SHAPEDOWN	VITALITY
Sex (boys / girls)	11 / 20	15 / 16
Age (y)	8.7 (1.2)[a]	8.8 (1.1)
Height (cm)	138.8 (7.9)	138.4 (8.3)
Weight (kg)	54.3 (13.9)	50.4 (9.8)
BMI (kg / m^2)	27.8 (4.3)	26.1 (3.0)
Sum of 5 skinfolds (mm)	125.0 (25.0)	108.7 (17.9)

[a] Mean (standard deviation)

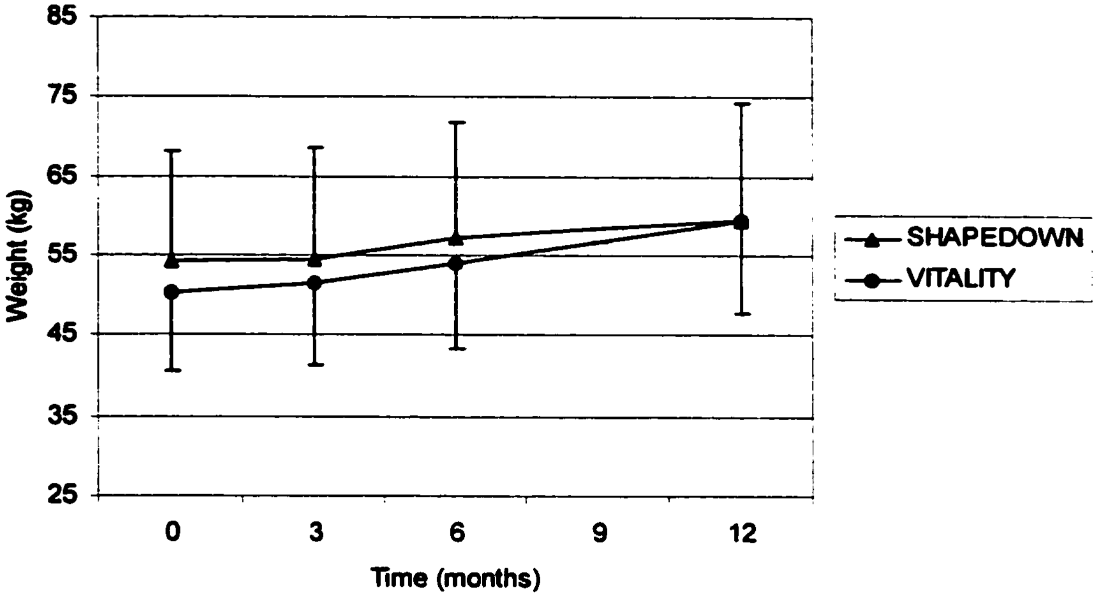
Abbreviations: y (years), cm (centimetre), kg (kilogram), m (metre), and mm (millimetre)

Figure 5-1. Group changes in height over treatment (0 to 3 months) and follow-up (6- and 12-months) periods.



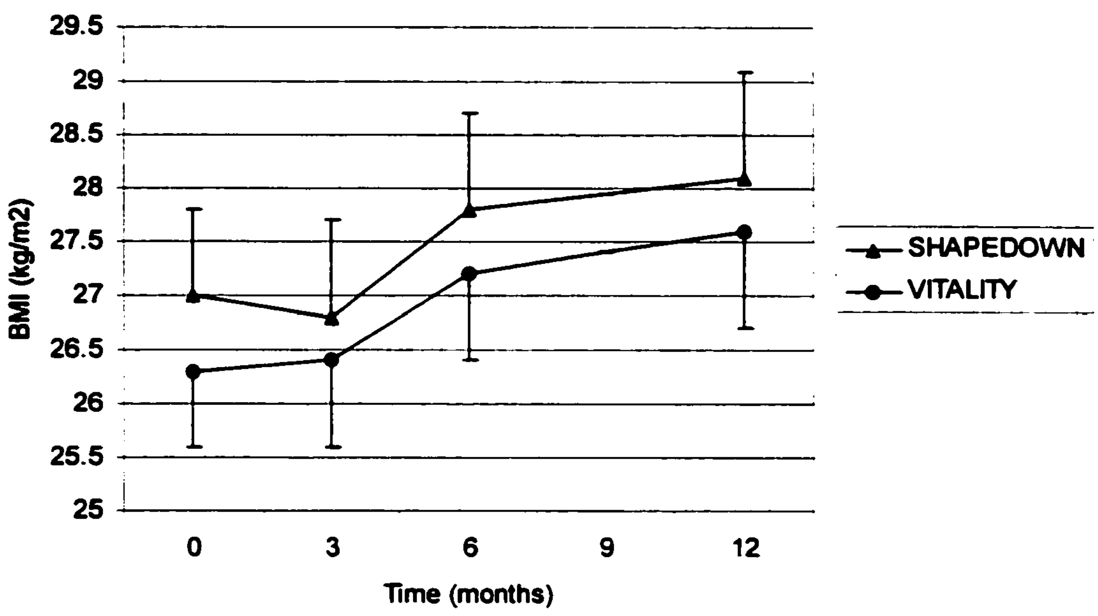
Main effect: Time ($F = 250.7$, $p < 0.001$)

Figure 5-2. Group changes in body weight over treatment (0 to 3 months) and follow-up (6- and 12-months) periods.



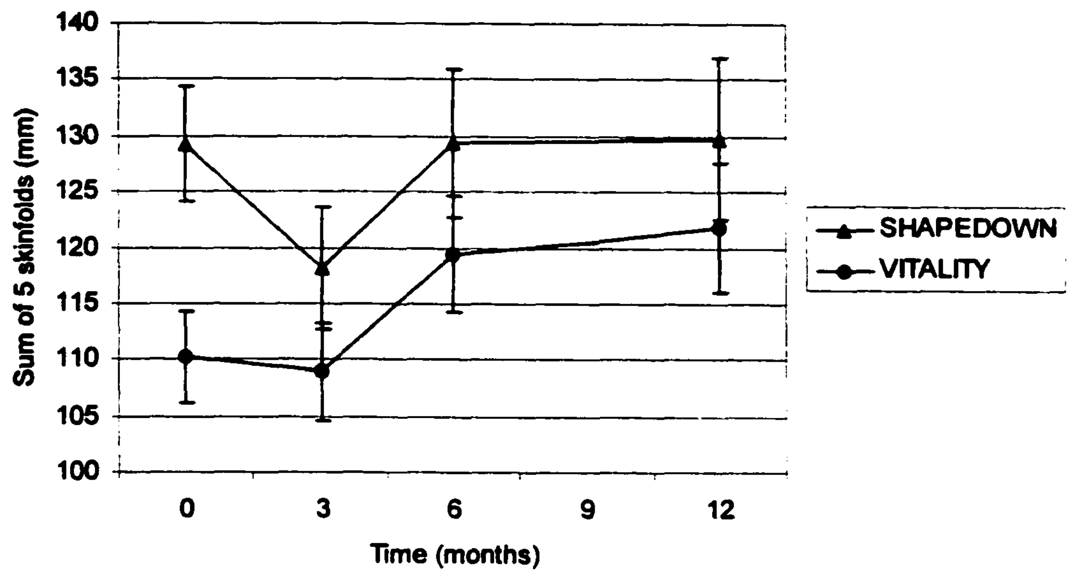
Main effect: Time (F = 47.8, p < 0.001)

Figure 5-3. Group changes in BMI over treatment (0 to 3 months) and follow-up (6- and 12-months) periods.



Main effect: Time (F = 11.7, p < 0.001)

Figure 5-4. Group changes in sum of 5 skinfolds over treatment (0 to 3 months) and follow-up (6- and 12-months) periods.



Main effect: Time ($F = 11.4$, $p < 0.001$)

The results of the follow-up paired t-tests (for the SHAPEDOWN and VITALITY groups combined) are presented in **Table 5-4**. When compared to baseline levels, both height and weight increased at the 3-, 6-, and 12-month intervals. BMI values at 3-months were not different from baseline, but were increased at 6- and 12-months follow-up. The sum of 5 skinfold thicknesses decreased at 3-months, returned to near-baseline levels at 6-months, and increased at 12-months. The MI **(Table 5-5)** revealed minimal changes between baseline and the end of the treatment period (3-months). However, average group values were negative between the 3- and 6-months intervals suggesting an increase in body fatness. Minor group changes were observed between 6- and 12-months follow-up.

Table 5-4. Height, weight, BMI, and sum of 5 skinfold values at baseline and changes compared to baseline levels at 3- (post-treatment), 6- (follow-up), and 12-months (follow-up) for the SHAPEDOWN and VITALITY groups combined[a]

Variable	Baseline (0-m)	3-m change	p-value (0–3 m)	6-m change	p-value (0–6 m)	12-m change	p-value (0–12 m)
Height (cm)	138.6 (8.0)[b]	1.3 (0.3, 2.2)[c]	0.008	2.7 (2.1, 3.3)[c]	< 0.001	6.8 (6.3, 7.3)[c]	< 0.001
Weight (kg)	52.2 (11.9)	0.8 (0.5, 1.5)	0.037	3.6 (2.7, 4.5)	< 0.001	7.9 (6.5, 9.2)	< 0.001
BMI (kg / m^2)	26.9 (3.9)	0.1 (-0.4, 0.3)	0.738	0.8 (0.3, 1.3)	0.003	1.2 (0.6, 1.8)	< 0.001
Sum of 5 skinfolds (mm)	116.4 (22.8)	-4.8 (-9.4, 0.2)	0.043	3.9 (-2.3, 10.1)	0.211	7.6 (0.2, 15.0)	0.045

[a] Repeated measures ANOVA revealed a significant time effect for height, weight, BMI, and sum of 5 skinfolds; no group × time interaction was observed, so the SHAPEDOWN and VITALITY groups were combined for these analyses.
[b] Mean (standard deviation)
[c] Mean (95% confidence interval)
Abbreviations: m (month), cm (centimetre), kg (kilogram), m (metre), mm (millimetre)

Table 5-5. Mathematical Index[a] (MI) of the SHAPEDOWN and VITALITY groups at 3-(post-treatment), 6-(follow-up), and 12-month (follow-up) intervals

	3-month[b]	6-month[c]	12-month[d]
SHAPEDOWN (n = 22)	2.4 (-9.5, 14.3)[e]	-15.6 (-30.4, -0.8)	-3.2 (-21.4, 15.0)
VITALITY (n = 25)	2.2 (-8.4, 12.8)	-13.1 (-22.6, -3.7)	-0.5 (-18.1, 17.1)
TOTAL (n = 47)	2.3 (-5.3, 9.9)	-14.3 (-22.4, -6.1)	-1.7 (-13.8, 10.5)

[a] The Mathematical Index (MI) integrates observed height and weight changes over the treatment and follow-up periods as well as expected height and weight changes based on U.S. National Center of Health Statistics growth charts (Hamill et al., 1979). Height and weight values are entered into the following formula:

$$MI = \{[\Delta \text{ height}_{(observed)} \times \Delta \text{ weight}_{(expected)} / \Delta \text{ height}_{(expected)}] - \Delta \text{ weight}_{(observed)}\} \times 10$$

[b] Relationship between observed & expected growth in height & weight between 0 – 3 months
[c] Relationship between observed & expected growth in height & weight between 3 – 6 months
[d] Relationship between observed & expected growth in height & weight between 6 – 12 months
[e] Mean (95% confidence interval

5.3.4 Physical activity and cardiorespiratory fitness: A significant time effect ($F = 8.1$, $p < 0.001$) was found for the PAQ-C scores, but no significant time × group interaction was identified. Follow-up t-tests **(Table 5-6)** revealed that activity levels increased from baseline to post-treatment (3-months) when data from both SHAPEDOWN and VITALITY groups were combined. Subsequent analyses showed that PAQ-C scores at 6-months were not different from baseline, but were increased (compared to baseline) at 12-months. No significant time or time × group effects related to cardiorespiratory fitness were observed.

5.3.5 Self-perception: For the SPPC sub-scales, significant time effects were noted for athletic competence ($F = 4.4$, $p = 0.010$), physical appearance ($F = 6.5$, $p = 0.001$), and social acceptance ($F = 2.9$, $p = 0.050$). No time × group interactions for any of the sub-scales were observed. To determine whether the SHAPEDOWN and VITALITY interventions led to changes in these self-perception sub-scales, follow-up paired t-tests were done (for combined groups) to compare baseline values with scores at 3-, 6- and 12-month intervals **(Table 5-6)**. Self-perception of physical appearance was the only sub-scale that increased from baseline to post-treatment (3-months) and this improvement was maintained at 6- and 12-months follow-up. Athletic competence and social acceptance were not different from baseline at 3- or 6-months, but increased levels of these self-perceptions were seen at 12-months.

5.3.6 Dietary intake: No significant time or time × group interactions were observed in any of the dietary variables. For descriptive purposes, total energy and macronutrient intakes are presented in **Appendix 4** and servings from 5 food groups are displayed in **Appendix 5**.

Table 5-6. Physical activity (PAQ-C[a]) and self-perception (SPPC[b]) sub-scale values (transformed data) at baseline and changes compared to baseline levels at 3- (post-treatment), 6- (follow-up), and 12-months (follow-up) for the SHAPEDOWN and VITALITY groups combined[c]

Variable	Baseline (0-m)	3-m change	p-value (0–3 m)	6-m change	p-value (0–6 m)	12-m change	p-value (0–12 m)
PAQ-C	2.95 (0.64)[d]	0.21 (0.01, 0.43)[e]	0.050	-0.07 (-0.26, 0.12)[e]	0.495	0.42 (0.20, 0.63)[e]	< 0.001
Athletic Competence	29.7 (20.3)	0.2 (-4.2, 4.6)	0.942	2.5 (-1.6, 6.6)	0.224	9.4 (4.2, 14.6)	0.001
Physical Appearance	22.2 (17.6)	8.0 (2.5, 13.5)	0.005	9.2 (3.9, 14.6)	0.001	13.1 (6.7, 19.4)	< 0.001
Social Acceptance	31.0 (19.9)	-1.7 (-6.8, 3.4)	0.500	1.1 (-4.3, 6.6)	0.674	7.4 (0.8, 14.0)	0.029

[a] PAQ-C (Physical Activity Questionnaire for older Children)
[b] SPPC (Self-Perception Profile for Children)
[c] Repeated measures ANOVA revealed a significant time effect for the athletic competence, physical appearance, scholastic competence, and social acceptance sub-scales; no group × time interactions were observed, so SHAPEDOWN & VITALITY groups were combined for analyses.
[d] Mean (standard deviation)
[e] Mean (95% confidence interval)
Abbreviations: m (month)

5.4 Discussion

The SHAPEDOWN and VITALITY interventions led to decreased sums of 5 skinfold thicknesses (short-term) and increased levels of physical activity (short-term) and self-perceptions of physical appearance (long-term) when data were pooled from both programs. However, the two interventions did not lead to differential changes in any of the selected health-related outcomes. We reported high attendance levels and families rated the group facilitators very positively, however neither program was effective at improving obesity status within this sample of children. Despite the promotion of weight loss / weight maintenance in the SHAPEDOWN program, it was not more effective at producing changes in adiposity-based criteria than the VITALITY program which focussed exclusively on the achievement and maintenance of healthy lifestyle behaviours.

5.4.1 Participation and dropout: The overall attendance and dropout rates of families in the SHAPEDOWN and VITALITY programs in the present study compare favourably to other lifestyle interventions for obese children. In a study of adolescents, Mellin et al. (1987) reported a low dropout rate (16%) with participants attending an average of 11.4 / 14 (81.4%) of the SHAPEDOWN sessions. Family involvement was minimal with a parent attending only two sessions for 19.1% of subjects and one session for 68.1% of subjects. As well, for 12.8% of subjects, parents did not attend any of the meetings. The level of parental participation in the SHAPEDOWN study by Thomas-Dobersen and colleagues (1993) was not explicitly reported. However, sessions were available for 13 group meetings (separate from the teen sessions) and parents were required to attend at least 3 sessions; it is unknown what proportion of parents attended the meetings. Other research has demonstrated that including parents in weight management efforts for obese children leads to increased treatment success (defined by weight loss) when parents are either the exclusive agents of change (Golan et al., 1998a) or active participants with their children (Epstein et al., 1990; Israel et al., 1990).

Owens et al. (1999) reported an average attendance rate of 87% (4.4 / 5.0 days) for a cardiorespiratory exercise training study (4 month duration) for obese children. Only 7.5% (3 / 40) dropped out before the completion of the intervention and parents did not actively participate. The high attendance level and low dropout rate in this study may have been enhanced by the transportation of children by bus to and from the exercise facility. Participants were also given nominal financial incentives ($1 / session attended) and awarded prizes for maintaining target heart rates during training sessions (Ferguson et al., 1999). In the current study, families were reimbursed for parking expenses, sessions were offered free-of-charge during weekday evenings, and parents attended all meetings with their children. Each of these variables may have contributed to the high attendance and low dropout rates compared to other studies of childhood weight management (Dietz, 1981). These results, along with information collected using the client satisfaction questionnaire, revealed that the programs and group facilitators were very well accepted by the families. It is known that group dynamics, camaraderie, timing of the sessions, commitment to the project, and instructor sensitivity and enthusiasm all influence program adherence (Sale et al., 1996). Further, the high level of family participation in this study is noteworthy when considering other competing activities such as children's soccer, baseball, swimming, day camps, and summer vacations occurred during the 12-week intervention period. However, unlike previous research with obese children (Golan et al., 1998b; Epstein et al., 1990), the inclusion of parents and the high degree of participation in the SHAPEDOWN and VITALITY groups did not lead to substantial improvements in obesity status.

5.4.2. Anthropometry and the Mathematical Index: By the end of the 12-week treatment period, height and weight had increased, BMI remained unchanged, and sums of 5 skinfold thicknesses decreased in relation to baseline levels. While skinfold thicknesses decreased over this period, changes in total body fatness were not supported by the MI group changes. The inclusion of "0" in the 95% confidence interval for the mean MI group change suggested that no changes in total body fatness occurred between 0- to 3-months. Negative MI values between the 3- to 6-month period implied that greater than expected growth occurred over this interval, above that anticipated based on growth estimates from individual height and weight percentiles (Hammill et al., 1979). Although speculative, the fact that skinfold thicknesses increased over the same period (3- to 6-months) argues that compensatory growth may have occurred over this interval and that the treatment-related changes in skinfold thicknesses were transient. Despite the BMI receiving international support for use in defining obesity in children and adolescents (Cole et al., 2000), our observations support the inclusion of supplementary anthropometric measures, such as skinfold thicknesses, in monitoring body composition changes during obesity treatment since subtle changes in body fat or body fat distribution may go unnoticed if only changes in height and weight data are recorded.

Collectively, the SHAPEDOWN and VITALITY programs produced minor individual (none of the children achieved non-obese status) and group changes in anthropometric outcomes. This finding is not surprising considering the health-centred approaches of the interventions. Obese children were not encouraged to lose weight through energy-restrictive diets and exercise changes. Families in both programs received positive reinforcement to make healthy lifestyle choices, so dramatic reductions in BMI, body weight, or skinfold thicknesses were not anticipated. The health-centred philosophies support the belief that it is more important for health and fitness professionals to help people of all sizes to be healthy rather than instruct obese people to lose weight (Smith, 1995). With regard to obesity intervention, it has been recommended that efforts should focus on developing healthful behaviours and attitudes and using outcome measures aside from body weight and body composition to evaluate effectiveness of treatment (Miller, 1999; Goodrick and Foreyt, 1991). Dramatic lifestyle changes were not documented in the present study, but some improvements in behaviours and perceptions were observed.

5.4.3 Physical activity: One of the primary goals of both interventions was to emphasize positive physical activity habits. As such, the SHAPEDOWN and VITALITY programs were able to produce increased physical activity levels at 3-months (summer) compared to baseline (spring). Seasonal changes may have partially contributed to the increased physical activity levels since activity tends to be higher in spring and summer months in adults (Matthews et al., 2001; Dannenberg et al., 1989) and children (Hagger et al., 1997; Baranowski et al., 1993). Compared to baseline levels, physical activity at 6-months was decreased (winter) and increased again at 12-months (spring), observations that suggest a seasonal effect. Interestingly, seasonal changes in activity were not noted in a sample of obese schoolchildren (n = 19) who were administered the same activity questionnaire over a one-year period (Ball, Marshall and McCargar, unpublished observations). Regardless of whether the interventions or time-of-year modified physical activity levels, these findings indicate that an increased level of activity may have played a role in the decreased skinfold thicknesses detected at the end of the 12-week intervention period.

5.4.4 Cardiorespiratory fitness: SHAPEDOWN and VITALITY did not induce measurable changes in cardiorespiratory fitness. This finding is not surprising given that the 20-MST is a weight-dependent test and the interventions did not lead to decreased body weight. If the participants had lost weight, their scores in the 20-MST may have improved as a result of a decreased body mass being transported during the shuttle run testing protocol. Cardiorespiratory fitness levels in children can improve through training independent of body weight changes, but the potential for improvement is believed to be small (~5%) in the childhood years (Rowland et al., 1996; Rowland and Boyajian, 1995). For comparison purposes, cardiorespiratory fitness levels of the children in the present study rank as *very poor* (below the 20^{th} percentile) compared to normative data based on a sample of Quebec children (n = 7000; 6 – 17 years of age) (Léger et al., 1982). As others have observed (Gutin et al., 1996), it appears that lifestyle education, like that provided by the SHAPEDOWN and VITALITY programs is unable, in and of itself, to elicit improvements in cardiorespiratory fitness in obese boys and girls.

5.4.5 Self-perception: When groups were combined, the SHAPEDOWN and VITALITY interventions led to increased self-perception of physical appearance. While others have shown that obesity treatment programs for children may lead to reductions in self-esteem and physical appearance ratings (Cameron, 1999), the findings from the current study are consistent with other reports of the SHAPEDOWN program. Mellin and colleagues (1987) found that the SHAPEDOWN program improved self-esteem and lowered depression scores immediately following treatment and these changes were maintained at one-year follow-up. Similarly, Thomas-Dobersen et al. (1993) showed that SHAPEDOWN increased body image after treatment and positive changes were maintained at follow-up in a sample of obese adolescents with type 1 diabetes. Although speculative, improvements in physical appearance perceptions in children from the current study may have been partly mediated through intervention-related changes in parental attitudes of obesity. Negative weight-related commentary by parents is known to influence psychological functioning and body image satisfaction in children (Schwartz et al., 1999). The fact that both SHAPEDOWN and VITALITY promoted positive messages to families regarding body image and self-worth may have been one of the enduring aspects of these treatment programs that helped to maintain more positive self perceptions of physical appearance over time (Thompson et al., 1996). It has also been suggested that having obese children *weigh-in* on a weekly basis may lead to feelings of embarrassment and inadequacy, especially if weight changes are not observed (Cameron, 1999). Thus, by promoting the establishment and maintenance of healthy lifestyle behaviours, we likely provided children and families with more positive, health-centred objectives on which to focus.

In one of the few studies to compare a traditional weight-centred program to a health-centred program (Steinhardt et al., 1999), researchers found that both interventions (delivered to adults in a workplace setting over a 10-week period) performed similarly. Neither program led to improvements in any biomedical outcomes (i.e., blood pressure, body weight, and blood cholesterol), but both produced positive changes in attitudes including decreased body preoccupation and increased physical self-esteem. The current study provides support that a program based on the VITALITY philosophy is as effective as other health-centred weight management programs (i.e., SHAPEDOWN) in its ability to positively influence self-perception related to physical appearance in obese children. We also observed elevated levels of self-perceived athletic competence and social acceptance at 12-months compared to baseline levels. Because improvements were not detected immediately following treatment, other factors (i.e., health promotion classes in school) may have led to these positive changes.

5.4.6 Dietary intake: Both the SHAPEDOWN and VITALITY programs included extensive information regarding the importance of establishing and maintaining positive nutrition habits, but no changes were observed in any of the dietary variables we assessed. This was somewhat surprising given that many questions and discussions in the group sessions (for parents and children) centred on nutrition education and ways to improve dietary quality within families (i.e., healthy snack foods, strategies to include more vegetables and fruit in children's diets, and understanding food labels). Quantitative dietary variables recorded at baseline were similar to Canadian recommendations (Health and Welfare Canada, 1990) for carbohydrate (~55%), fat (≤ 30%), and protein (13 – 15%) intakes, so changes in this regard were not warranted. However, the qualitative dietary assessment based on food groups from *Canada's Food Guide to Healthy Eating* (Health Canada, 1992) revealed that intakes of Meat and Alternatives and Vegetables and Fruit were below recommended levels and intakes of Other Foods appeared high for both groups at all measurement intervals. Other studies have shown that weight and lifestyle management programs can increase nutrition knowledge (Mellin et al., 1987) and improve the macronutrient content of the diet (Gutin et al., 1996), but as the present study suggests, increased knowledge does not necessarily translate into measurable changes in dietary behaviour. It is also possible that qualitative dietary changes occurred over the course of the study, but went undetected. Because dietary intakes were assessed on weekdays only, and since that overweight youngsters are known to under-report dietary intakes (Fisher et al., 2000; Bandini et al., 1990), it is possible that other factors may have influenced the accuracy of the nutrient data. Finally, although seasonal nutrition patterns are relevant to consider when conducting longitudinal investigations (Van Staveren et al., 1986), as in our study of obese schoolchildren (Ball, Marshall and McCargar, unpublished observations), we did not observe seasonal changes in dietary intakes.

There are several limitations that should be considered when reviewing these observations. First, no control group was included. Doing so would have allowed us to evaluate independently the treatment and seasonal changes over the duration of the study. However, the decision to randomly assign families to either the SHAPEDOWN or VITALITY programs only was made for practical reasons. Unfortunately, resources were not available to offer the programs more than twice, so families in the control group could not have received any intervention at the end of formal study period. Second, both SHAPEDOWN and VITALITY programs were facilitated by registered dietitians. Although the group leaders received very positive ratings from participating families, behaviour changes and objective outcomes may have been enhanced through the coordinated involvement of other health professionals. It is possible that an interdisciplinary team including, but not limited to, a pediatrician, exercise physiologist / active living consultant, physiotherapist, social worker, and psychologist would have helped families to address the myriad issues that directly and indirectly influence a family's ability to maintain healthy lifestyle behaviours (Barlow and Dietz, 1998). Third, because socioeconomic status (SES) was not formally assessed, children from families of lower SES may have responded differently to treatment. Research suggests that physical self-esteem in lower SES groups is lower in overweight *versus* normal weight children and adolescents (O'Dea and Caputi, 2001), so the improvements reported in the current study may have been more dramatic if treatment effects were evaluated after controlling for differences in SES. Fourth, despite the promotion of weight loss and weight maintenance in the SHAPEDOWN program, both programs can be considered health-centred paradigms since they target lifestyle behaviours and do not include specific dietary and exercise plans. Further investigation of health-centred weight management programs and the long-term impacts such programs have on health- and obesity-related criteria in obese children and their families would be informative. Our data support previous research in that health-centred approaches can improve specific aspects of psychosocial health among obese children. While positive changes in obesity status have been reported (Mellin et al., 1987), the ability of health-centred programs to elicit long-term improvements in physical and metabolic risk factors (i.e., blood pressure, insulin sensitivity, and serum lipids) in obese youth remains to be clearly demonstrated.

In summary, the SHAPEDOWN and VITALITY weight management programs led to decreased sum of 5 skinfolds and increased physical activity and self-perceptions of physical appearance. In this study, both health-centred interventions led to positive changes in physical perceptions that were maintained long-term. Overall attendance and participation levels were very positive as were family ratings of the group facilitators. Because the treatment phase in the current study spanned only 12-weeks, it is possible that longer intervention and follow-up periods may be helpful in sustaining positive changes in adiposity and physical activity behaviours.

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Chapter Six: Risk of cardiovascular diseases and type 2 diabetes in obese children: The role of body composition and lifestyle behaviours

6.1 Introduction

In view of the increased prevalence of obesity (Tremblay and Willms, 2000; Troiano et al., 1995) and type 2 diabetes (Rosenbloom et al., 1999; Dean, 1998) in youth, evaluating risk factors for cardiovascular diseases (CVD) and type 2 diabetes may provide insight into the processes that moderate disease risk early in life. Risk factors such as elevated lipid and lipoprotein levels, serum insulin concentrations, and blood pressure are present in children and are more common among obese boys and girls than in their non-obese peers (Freedman et al., 1999; Chu et al., 1998; McMurray et al., 1998). While the mechanisms linking obesity to these risk factors for CVD and type 2 diabetes in children have yet to be clearly defined (Goran and Gower, 1999; Sinaiko et al., 1999), it is known that body fatness and central body fat distribution are related to an adverse risk profile in youth (Daniels et al., 1999; Gower et al., 1999). However, the interrelationships between metabolic risk factors for CVD and type 2 diabetes, body composition, body fat distribution, and lifestyle behaviours require further clarification.

Lifestyle behaviours are important mediators of objective health outcomes. In adults, physical activity is positively related to high-density lipoprotein cholesterol (HDL-C), negatively related to triglyceride (TG) and blood pressure levels (Donahue et al., 1988; Folsom et al., 1985), and reduces the risk of developing type 2 diabetes (Lynch et al., 1996). However, the pediatric data are inconsistent (Tolfrey et al., 2000). Some reports suggest that physical activity exerts a protective effect (Sallis et al., 1988; Durant et al., 1983) while others have found that obesity mediates metabolic disturbances independent of activity levels (McMurray et al., 1998; Stewart et al., 1995). Similarly, the exercise literature does not support a consistent relationship between cardiorespiratory fitness and disease risk in children. While cardiorespiratory fitness is not a lifestyle behaviour *per se*, it is considered an objective marker of activity habits since regular physical activity enhances aerobic fitness levels (Luepker, 1999). A higher degree of cardiorespiratory fitness has been shown to relate to a healthier metabolic profile in children (Stewart et al., 1995; Tell and Vellar, 1988). Yet, the effect of fitness may be dependent on its relationship to body fatness (Gutin et al., 1997; Kwee and Wilmore, 1990; Vaccaro and Mahon, 1989). In adults, there is evidence to suggest that cardiorespiratory fitness is an independent risk factor for morbidity and mortality (Lee et al., 1999; Wei et al., 1999), but it is still unclear whether "fatness or fitness" is most relevant to health risk in children. Although effects may vary depending on the individual, dietary factors are also known to play a role in the development of risk factors for CVD and type 2 diabetes (Ku et al., 1998). Total dietary fat (and saturated fat) adversely affects total cholesterol (TC) concentrations in children (Glueck et al., 1982), adolescents (Post et al., 1997), and adults (Iribarren et al., 1997). Furthermore, total fat intake is associated with reduced insulin sensitivity in adults (Mayer et al., 1993). Collectively, these observations underscore the potential role of lifestyle variables in the genesis of CVD and type 2 diabetes.

Healthy lifestyle behaviours have the potential to elicit beneficial physical and psychosocial outcomes (Sothern et al., 1999; Abernathy and Black, 1996; Barlow et al., 1995). For example, it is known that the more boys and girls exercise, the greater the likelihood they feel healthy and possess healthy peer relationships (Health Canada, 1998). Physical activity and exercise behaviours are also positively related to psychosocial outcomes such as global self-concept (Overbay and Purath, 1997), physical self-competence (Crocker et al., 2000) and self-efficacy (Trost et al., 1999) in children. To date, most of these observations have been based on non-obese populations. However, because physical activity levels are highest during the childhood years (Rowland, 1998), and since approximately 25 – 30% of Canadian children are overweight (Tremblay and Willms, 2000), it is likely that a subset of obese children may possess a high level of physical activity. It follows, therefore, that regular physical activity among obese children may contribute to decreased physical health risks in comparison to their less active obese peers.

Obese children face increased health risks, yet the success of weight management programs is modest (Epstein et al., 1990). While a number of variables may explain the shortcomings of obesity treatment programs, the heterogeneity of the obese pediatric population may contribute to this lack of success. Therefore, it may be prudent for health care providers to target specifically those obese children who have the greatest potential to benefit from intervention. This objective could be achieved by classifying obese boys and girls as *low health risk* or *high health risk*. Identifying children who are obese, but with no other risk factors for disease (low health risk), may improve the utilization of therapeutic resources and increase treatment efficacy. In other words, obese children at high health risk may be more appropriate candidates for intervention since metabolic risk factors are likely to persist into later life (Bao et al., 1995; Bao et al., 1994; Srinivasan and Berenson, 1995) leading to premature morbidity and mortality. To our knowledge, an evaluation of relative degrees of health risk within a sample of obese children, and the influence that lifestyle behaviours and self-perceptions exert on objective health outcomes, has not been assessed. Thus, the purpose of the current study was to investigate whether body composition, body fat distribution, and lifestyle behaviours and perceptions explained the presence of risk factors for CVD and type 2 diabetes in a sample of obese children at *low* and *high health risk*.

6.2 Methods

6.2.1 Participants: Children were recruited for this project through local newspaper articles and advertisements, television news stories, health professional referrals, and word-of-mouth. Boys and girls were eligible for the study if they satisfied the following criteria: 6 – 12 years of age, obese (defined by an age- and sex-specific sum of skinfolds ≥ 85th percentile; Canada Fitness Survey, 1984), and were not presently taking any medication that could potentially influence dietary intake or physical activity behaviours. Following initial contact and preliminary screening by telephone or e-mail, families attended a 45-minute orientation session at the University of Alberta. The study objectives were explained and families viewed a 20-minute video that outlined the testing protocol for the research project. Subsequently, children who agreed to participate in the study had skinfold thickness measurements taken to confirm that they met the inclusion criteria. Families then booked appointments to return to the University within the next 1 – 2 weeks to complete measurements. Aside for reimbursing families for parking expenses and providing children with small tokens of appreciation ("loot bags") upon completing the study measures, children and parents were not offered any financial incentives for participating. All families also received a comprehensive report of their child's health status, how he / she compared to other children in the study, and, wherever possible, how the entire sample compared to Canadian children in general. As such, this research project satisfied two goals: (1) to assess health and fitness parameters in a group of obese children and (2) to provide parents with a detailed and comprehensive assessment of their child's health. Informed, written consent and assent were provided by parents and children, respectively. The study protocol was approved by the Human Ethics Review Committee of the Faculty of Agriculture, Forestry, and Home Economics (University of Alberta).

6.2.2 Procedures:

6.2.3.1 Risk factor definitions: Traditional cutoff points of quantitative cardiovascular variables for adults are not applicable to children (Chu et al., 1998), and, to our knowledge, no comprehensive database of risk factors for CVD and type 2 diabetes exists for Canadian boys and girls. Thus, dyslipidemia, hyperinsulinemia, and hypertension were defined for boys and girls using age-specific cut-off values at >75th percentile from a reference population of children (n = 700) participating in the Bogalusa Heart Study (Chen et al, 1999). For each disorder, only one single quantitative variable was used for defining the disorder. Based on previous research (Chen et al., 1999), the TG:HDL-C ratio was used to define dyslipidemia, fasting insulin level for insulin resistance, and MAP for hypertension. High TG and low HDL-C defined dyslipidemia since they represent the dyslipidemic components of Syndrome X (Haffner et al., 1992; Reaven, 1988). Fasting insulin level was used as a measure of insulin resistance since fasting insulin is considered a reasonably good marker of insulin resistance (Reaven et al., 1998; Petrie et al., 1997; Laasko, 1993). The combination of SBP and DBP were used to calculate mean arterial pressure (MAP) using the following equation: MAP = DBP + (1/3)(SBP - DBP). Once the presence of risk factors was assessed for all participants, children were categorized as *low health risk* if they did not possess any risk factors for CVD and type 2 diabetes; boys and girls in the *high health risk* group possessed ≥ 1 risk factor. It is possible that each of these individual risk factors does not represent an equivalent degree of health risk. As well, children who possess two or three risk factors may be at greater health risk than children who possess only one. However, to perform adequate statistical comparisons within the current sample and to remain consistent with other analyses of metabolic risk assessments in youth (Higgins et al., 2001), the high health risk group was not subdivided.

6.2.3.2 Anthropometry (child and parent): Skinfold measurements (to the nearest 0.2 mm) were taken at 5 sites (triceps, biceps, subscapular, suprailiac, and medial calf) on the right side of the body of all children using Harpenden skinfold calipers (Health Dimensions, Plymouth, MI). To minimize measurement error, 2 trained researchers performed all of the skinfold measurements; one male researcher appraised the boys while one female researcher assessed the girls. In all children and at least one parent from each family, height was assessed (to the nearest 0.1 cm) using a setsquare and a wall-mounted tape measure and weight was determined (to the nearest 0.1 kg) using a portable medical scale (Health-o-meter, Inc., Bridgeview, IL); body mass index (BMI; kg / m^2) was then calculated.

All anthropometric data were collected in accordance with Canadian Standardized Test of Fitness (CSTF) procedures (CSTF Manual, 1986). All children were included in the study if they satisfied the obesity criterion of a sex- and age-specific sum of 5 skinfold thicknesses ≥ 85^{th} percentile (Canada Fitness Survey, 1984).

6.2.3.3 Maturation and demographics: Physical maturation was determined by having children complete a Tanner stage questionnaire based on published pictorial figures (Tanner and Whitehouse, 1976). Because a physician was not available to assess physical maturation, self-assessments were performed since previous research has indicated good agreement between self- and physician-assessed Tanner stage ratings (Taylor et al., 2001; Brooks-Gunn et al., 1987). Parents completed the two-factor index of social position to estimate socioeconomic status (Hollingshead, 1975), reported ethnicity, and included information regarding maternal and paternal family history of CVD and type 2 diabetes.

6.2.3.4 Body composition and body fat distribution: Total body and regional body composition was determined using dual-energy X-ray absorptiometry (DXA; Hologic QDR-4500A, Waltham, MA). All measurements were performed using standardized procedures by the same trained technician at Medical Imaging Consultants (Edmonton, AB). A series of transverse scans from head to toe were made with participants wearing a hospital gown and lying in the supine position. The total scan time was approximately 3 minutes. DXA partitions the body into 3 compartments (bone, fat, and fat-free soft tissue) and provides values for total fat mass, percent body fat, and fat-free mass. While DXA is unable to resolve subcutaneous from visceral body fat, once each child's image was scanned, computer software was used to determine the amount of total body fat mass present between lumbar (L) vertebrae 1 – 4. The superior border of the designated region passed just above the L1 vertebrae and the inferior border passed just below the L4 vertebrae, so the L1 – L4 region was encompassed.

This depot of body fat was of interest because it is (1) positively correlated with visceral fatness in children assessed using computed tomography (CT) (Tershakovec et al., 2000) and (2) related to metabolic risk factors for disease in boys and girls (Daniels et al., 1999). DXA has been used extensively to evaluate body composition in young populations (Bray et al., 2001; Gutin et al., 1999; Owens et al., 1998) and is a reliable and safe technique (Bachrach, 2000; Pintauro et al., 1996).

6.2.3.5 Physical activity / inactivity: The Physical Activity Questionnaire for older Children (PAQ-C), a self-administered 7-day activity recall questionnaire that evaluates the sports, leisure activities, and games performed throughout school days, evenings, and weekends, was used to assess physical activity (Kowalski et al., 1997). Based on preliminary evidence, the instrument does not reveal a gender bias based on overall activity levels in boys and girls (Crocker et al., 1997). The PAQ-C is comprised of nine items that are converted to a 5-point scale with higher scores indicating higher levels of physical activity. Once completed, summing and calculating the mean of the nine items forms a composite score with final values ranging between 1.00 – 5.00 (Crocker et al., 1997). While it was not an original component of the PAQ-C, the amount of time children viewed television and played video / computer games (in minutes per day) was concurrently reported as a means of approximating the level of physical inactivity. Time (in minutes) spent in these activities was recalled over the same previous 7 days and daily average values were calculated. It is considered important to assess both activity and inactivity behaviours since a lack of reported physical activity is not an appropriate surrogate for sedentary behaviour (Troiano et al., 2001).

6.2.3.6 Cardiorespiratory fitness: All cardiorespiratory fitness testing was conducted in the Exercise Physiology Laboratory in the Faculty of Physical Education (University of Alberta) by 2 trained exercise physiologists. Participants were prepared for the cycle ergometer (Monark, Sweden) test with detailed verbal instructions and were subsequently fitted with a nose-clip and mouthpiece. Pedal speed (50 – 55 rotations per minute [rpm]) and heart rate (Polar Pacer, Quebec, Canada) were monitored and recorded every minute. Following a brief warm-up at minimal workload (0 kiloponds [Kp]), the cycle resistance was increased by 0.5 Kp every 2 minutes until ventilatory threshold (VT) was achieved. VT was defined as a decrease and plateau in ventilatory equivalent for carbon dioxide ratio before a systematic increase with increasing power outputs (Bhambhani and Singh, 1985). Subsequently, resistance (but not rpm) was increased every minute by 0.25 Kp until VO_{2max} was attained or the child ended the test voluntarily. Oxygen consumption data was recorded by Medical Graphics CardiO_2 CPX/D (Medical Graphics Corp., St. Paul, MN) and Horizon (Sensormedics Corp, Anaheim, CA) metabolic carts every 15 seconds. Aerobic power was recorded as oxygen consumed per minute (L O_2 / min), and oxygen consumed per minute adjusted per kg body weight (ml O_2 / min / kg). Ideally, all fitness testing would have been carried out using a single metabolic cart, however, due to unexpected mechanical problems, two carts were required. Calibrations for CO_2 / O_2 were done before and after each test. Participants attained VO_{2max} if they achieved a plateau of oxygen consumption ($\leq$ 100 ml/min), a respiratory exchange ratio (RER) >1.1, and a heart rate of at least 200 beats per minute (bpm). Typically, when the criteria for the attainment of VO_{2max} are not satisfied, the term VO_{2peak} is frequently used. VO_{2peak} refers to the highest value of oxygen consumption measured per minute during the fitness assessment (McArdle et al., 1991).

6.2.3.7 Self-perception / body image: A number of psychosocial outcomes were assessed by questionnaire to evaluate their potential influence on health risk. Participants completed sub-scales related to global self-worth, behavioural conduct, and social acceptance derived from the Self-Perception Profile for Children (SPPC; Harter, 1985). The Children's Physical Self-concept Scale (CPSS; Stein et al., 1998) was used to measure sub-scales of physical performance, physical appearance, and weight control behaviours; the aggregate global physical self-concept was also calculated. Body image was measured using a 7-figure sex-specific silhouette pictorial scale (Collins, 1991) with body image dissatisfaction (BID) scores calculated through: BID = "self" – "ideal self".

6.2.3.8 Dietary intake: Dietary intake was assessed over the previous 7-day period using the Kids' Food Frequency Questionnaire (KFFQ; Block Dietary Data Systems, Berkeley, CA). The KFFQ was developed using the same theoretical framework as the Block Food Frequency Questionnaire (FFQ; Block et al., 1986), but with a few revisions. First, the food list (comprised of 76 items) and the nutrient values assigned to the items were based on population data from the nutrition database of the United States Department of Agriculture (USDA, 2001) and from diet records of children who participated in the U.S. National Health and Nutrition Examination Survey (NHANES) (the original Block FFQ was based on a database on nutrition information that was collected from adults). Second, dietary information for the KFFQ was derived from NHANES III (1988 – 1994) while earlier versions of the Block FFQ incorporated data from NHANES II (1976 – 1980). Third, the method of asking portion sizes for non-unitary foods, such as green beans, was revised. Rather than having options such as "small, medium, and large" from which to choose, photos based on 3-dimensional abstract models were provided with the KFFQ to aid in estimating usual portion sizes for each food. The method of assigning nutrient values to the database was also updated. Gram amounts were assigned based on the gram weight of the volume of the chosen model for each particular food. Children and parents completed the KFFQ together and answers were immediately reviewed and verified by a registered dietitian. Upon completion, questionnaires were mailed to the supplier where they were scanned and scored by computer. Data reports were subsequently generated for each participant that detailed individual intakes of total energy, macronutrients, micronutrients, fibre, and food group servings.

6.2.3.9 Biochemical indices: Blood samples were provided by children between 0700 - 1000 hours at the University of Alberta Hospital (UAH) after an overnight fast. A trained laboratory assistant drew 3 tubes of blood (approximately 14 ml) from the antecubital vein in the right arm. The serum sample was separated by centrifugation at 1500*g* immediately following blood collection and was subsequently used to analyze serum lipids and lipoproteins at UAH. The Roche Hitachi 917 (Roche, Laval, QC) measured TC (using the cholesterol oxidase method), TG (using a fully enzymatic colorimetric assay reaction for glycerol following the removal of all serum-free glycerol), and HDL-C (using a photometric method after the addition of polyethylene glycol-modified enzymes). LDL-C was calculated using the following formula: LDL-C = TC - HDL-C × (TG / 2.2). The whole blood specimen was used to analyze hemoglobin A1c (HbA1c) with the Roche Hitachi 917 as well. HbA1c (using a turbidimetric method) and hemoglobin (using a photometric method) were determined with HbA1c levels reported as the fraction of total hemoglobin. The remaining serum was frozen at –70° C at UAH, and at the conclusion of the study, frozen samples were transported following standard biosafety procedures to the Department of Agricultural, Food and Nutritional Science where a trained laboratory technician performed the following analyses. Glucose levels were determined using a quantitative, enzymatic diagnostic assay that was modified to a 96-well microtitre plate (Sigma Diagnostics, St. Louis, MO). The standards used ranged from 100 – 800 mg/dL and all samples fell within the range of the curve. The plates were measured at an optical density of 505 nm on a Spectramax 190 plate-reader (Molecular Devices, Sunnyvale, CA). All glucose samples were measured in duplicate (intra-assay coefficient of variation [CV] = 6.4%). Insulin levels were measured using a solid-phase radioimmunoassay (Coat-A-Count, Diagnostic Products Corp., Los Angeles, CA) with the following modifications. A 'zero' standard was used as the initial standard value to ensure all samples fell in the range of the curve (correlation coefficient = 0.99; detection limit of curve at 98%). Cross-reactivity of this assay with proinsulin is ~20% at mid-curve; C-peptide is not detected. All insulin samples were also completed in duplicate (intra-assay CV = 1.9%).

6.2.3.10 Blood pressure: Resting systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured with a Dinamap automated blood pressure monitor (Critikon, Inc., Tampa, FL) with the arm supported and at heart level. After sitting quietly for 5 minutes, measurements were obtained on each child using an appropriately sized cuff placed on the right arm. Five measurements were taken and the final three values were averaged.

6.2.4 Statistical analyses: To evaluate which of the measured variables explained classification in the low or high health risk groups, a number of statistical analyses were performed. Exploratory statistics including independent samples t-tests and univariate logistic regressions were conducted for continuous variables (i.e., age, anthropometry, body composition, physical activity, cardiorespiratory fitness, dietary intake, television viewing / video game playing, and self-perceptions). Non-parametric chi-square tests and Kendall's tau-b statistics were used to evaluate categorical (i.e., sex, ethnicity, and family history of CVD and type 2 diabetes) and ordinal (i.e., Tanner stage and social class) outcomes, respectively. The nature of the SES data (based on occupation, education, and family income) allowed us to evaluate this variable as both continuous and categorical. Variables that were significant in the univariate analyses were considered as potentially important factors in the logistic regression model.

All variables with $p < 0.250$ were entered in order of significance into a forward stepwise multivariate logistic regression model (Hosmer and Lemeshow, 2000). Once the variables in this subset were considered for inclusion, all of the remaining outcomes were subsequently entered to verify that no additional variables could be accepted. The final model from the forward stepwise procedure yielded a subset of the most important variables. Because low and high health risk classification were based on three select biochemical / metabolic parameters (TG:HDL-C ratio, fasting insulin, and MAP), other 'related' risk factors for CVD and type 2 diabetes (i.e., SBP, DBP, HbA1c, glucose, LDL-C, and TC) were not included in the multiple regression models.

Two separate multivariate logistic regression models were developed. The primary model was based on the complete data set of all boys and girls whereas the secondary model included only those participants who had anthropometric data from their mothers and fathers. Height and weight data were collected from at least one parent per family, however, for a variety of reasons (i.e., single parent households, refusal to be measured, and / or unable to attend testing sessions because of other commitments), measurements were not available for all parents. Both final models were fit for all possible interactions and were subsequently tested for significance of interaction. As well, the models were tested for outliers, co-linearity, and potential interactions using a variety of diagnostic procedures. All statistical tests were performed using SPSS (version 7.5, 1995, SPSS Inc, Chicago, IL).

6.3 Results

6.3.1 Risk factor prevalence and clustering: Study participants were classified as low or high health risk according to the selected risk factors for CVD and type 2 diabetes. Accordingly, 13 / 83 (16%), 32 / 83 (39%), and 34 / 83 (41%) of the children possessed values >75th percentile for TG:HDL-C, insulin, and MAP, respectively **(Table 6-1)**. This resulted in 30 children (36%; 21 boys, 9 girls) being categorized as low health risk and 53 children (64%; 27 boys, 26 girls) as high health risk. Because risk factors for CVD and type 2 diabetes are known to cluster, risk factor clustering was also evaluated **(Table 6-2)**. Within this sample of obese children, 30 / 83 (36%) possessed no risk factors, 29 / 83 (35%) had 1 risk factor, 22 / 83 (27%) possessed 2 risk factors, and 2 / 83 (2%) had all 3 risk factors. Overall, 24 / 83 (29%) children exhibited *clustering* by possessing ≥ 2 risk factors. For descriptive purposes, the calculated Pearson correlation coefficients between the measured risk factors for CVD and type 2 diabetes are presented in **Table 6-3**. The columns representing TG:HDL-C, insulin, and MAP are highlighted to underscore the relationships between the variables used to define health risk in this investigation and other biochemical / metabolic outcomes frequently measured when evaluating risk of CVD and type 2 diabetes.

Table 6-1. Classification of low and high health risk groups according to TG:HDL-C, insulin, and MAP

Risk Factor	Cutoff Points	N	Boys / Girls
TG:HDL-C	High health risk >75th percentile	13	5 / 8
	Low health risk ≤ 75th percentile	70	43 / 27
Insulin	High health risk >75th percentile	32	14 / 18
	Low health risk ≤ 75th percentile	51	34 / 17
MAP	High health risk >75th percentile	34	16 / 18
	low health risk ≤ 75th percentile	49	32 / 17

Abbreviations: TG (triglyceride), HDL-C (high density lipoprotein cholesterol), MAP (mean arterial pressure), n (sample size)

Table 6-2. Risk factor clustering in the complete sample (n = 83)

	Number of risk factors	n	Boys / Girls
Low health risk group	0	30	21 / 9
High health risk group	1	29	19 / 10
	2	22	8 / 14
	3	2	0 / 2

Abbreviation: n (sample size)

Table 6-3. Pearson correlation coefficient matrix of biochemical and metabolic indicators of risk for CVD and type 2 diabetes

	TC	LDL-C	HDL-C	TG	TG: HDL-C	GLU	HbA1c	INS	SBP	DBP	MAP
TC	-	0.93**	0.11	0.38**	0.26*	0.02	0.05	0.22*	0.16	0.13	0.17
LDL-C	0.93**	-	-0.01	0.16	0.11	-0.01	0.05	0.17	0.03	0.02	0.04
HDL-C	0.11	-0.01	-	-0.52**	-0.68**	-0.16	0.15	-0.07	0.06	-0.01	-0.01
TG	0.38**	0.16	-0.52**	-	0.96**	0.19	-0.11	0.22*	0.28**	0.26*	0.32**
TG: HDL-C	0.26*	0.11	-0.68**	0.96**	-	0.17	-0.16	0.20	0.26*	0.24*	0.30*
GLU	0.02	-0.01	-0.16	0.19	0.17	-	0.07	0.06	0.33**	0.16	0.26*
HbA1c	0.05	0.05	0.15	-0.11	-0.16	0.07	-	0.16	0.01	-0.18	-0.11
INS	0.22*	0.17	-0.07	0.22*	0.20	0.06	0.16	-	0.28**	0.18	0.27*
SBP	0.16	0.03	0.06	0.28**	0.26*	0.33**	0.01	0.28*	-	0.58**	0.83**
DBP	0.13	0.02	-0.01	0.26*	0.24*	0.16	-0.18	0.18	0.58**	-	0.93**
MAP	0.17	0.04	-0.01	0.32**	0.30*	0.26*	-0.11	0.27*	0.83**	0.93**	-

* ($p < 0.05$)
** ($p < 0.01$)

Abbreviations: TC (total cholesterol), LDL-C (low-density lipoprotein cholesterol), HDL-C (high-density lipoprotein cholesterol), TG (triglyceride), GLU (glucose), HbA1c (hemoglobin A1c), INS (insulin), SBP (systolic blood pressure), DBP (diastolic blood pressure), MAP (mean arterial pressure)

6.3.2 Anthropometry (child and parent): Descriptive characteristics for all children are presented in **Table 6-4**. When variables were compared using independent samples t-tests, children in the low and high health risk groups did not differ in any of the anthropometric measures. For comparison purposes, and since the BMI has received general acceptance as a measure of overweight and obesity in youth (Troiano and Flegal, 1998), boys and girls were also compared to the current international cutoffs (Cole et al., 2000). Based on the BMI and compared to an international reference population, the group distributions were as follows: low health risk group (n = 30) -- 19 obese (63%), 9 overweight (30%), and 2 average weight (7%); high health risk group (n = 53) – 44 obese (83%), 8 overweight (15%), and 1 average weight (2%). **Table 6-5** shows the anthropometric data from mothers and fathers. While data were not available from all parents, based on this subset, mothers of children in the low health risk group weighed more (84.7 kg *versus* 73.0 kg, p = 0.007) and had a higher BMI (32.3 kg/m^2 *versus* 27.8 kg/m^2, p = 0.005) than mothers of children in the high health risk group. No group differences were reported for fathers. When parents were classified according to overweight (BMI ≥ 25 kg / m^2) and obesity (BMI ≥ 30 kg / m^2) definitions (WHO, 1998), 54% of mothers were overweight (26 / 64) and 34% were obese (22 / 64). All (100%) of the participating fathers (34 / 34) were overweight and a further 44% (15 / 34) were obese. The proportions of overweight and obese mothers and fathers did not differ between groups.

6.3.3 Maturation and demographics: Physical maturation assessments indicated that most children were at Tanner stage 1 or 2 (82%); in other words, they were mainly pre-pubertal or in the initial stages of pubertal development. The majority of boys and girls in this study were Caucasian (88%) and the Hollingshead index revealed that families were predominantly from middle to upper-middle class backgrounds. Because this sample was comprised of a small number of non-Caucasian boys and girls, children from ethnic minorities were combined into one group, and ultimately, participants were classified as either *Caucasian* or *non-Caucasian*. Comparisons of all categorical and ordinal data revealed that there were no differences between the low and high health risk groups according to sex distribution ($\chi^2_{(1)}$ = 2.9, p = 0.091), ethnicity ($\chi^2_{(1)}$ = 0.95, p = 0.331), family history of CVD and type 2 diabetes ($\chi^2_{(3)}$ = 3.7, p = 0.300), Tanner stage (Kendall's tau-b = 1.34, p = 0.180), and social class (ordinal) (Kendall's tau-b = 1.08, p = 0.280).

Table 6-4. Descriptive data for children in the low and high health risk groups

Variable	Low Health Risk Group (n = 30)	High Health Risk Group (n = 53)	P value[a]
Sex (boys / girls)	21 / 9	27 / 26	-
Age (y)	9.9 (1.5)[b]	9.9 (1.4)	0.945
Sum of 5 skinfolds (mm)	123.2 (23.9)	124.4 (19.9)	0.795
Height (m)	1.42 (0.09)	1.44 (0.10)	0.283
Weight (kg)	52.7 (11.4)	57.2 (12.7)	0.104
BMI (kg / m²)	26.1 (3.9)	27.3 (4.0)	0.194
Hollingshead index[c]	28.0 (11.5)	30.8 (11.9)	0.297
Tanner stage:			**Total**
1	22	31	53 (64)[d]
2	4	11	15 (18)
3	2	7	9 (11)
4	2	3	5 (6)
5	0	1	1 (1)
Ethnicity:			**Total**
Caucasian	25	48	73 (88)[d]
Non-Caucasian	5[e]	5[f]	10 (12)

[a] Independent sample t-tests
[b] Mean (standard deviation)
[c] Scores range from 11 to 77 with lower values representing higher socioeconomic status
[d] Number (percentage)
[e] Hispanic (3), Iranian (1), and Metis (1)
[f] East Indian (2), First Nations (2), and 'Other' (1)
Abbreviations: y (year), mm (millimetre), m (metre), kg (kilogram)

Table 6-5. Descriptive data for parents (subset) of children in the low and high health risk groups

Variable		Low Health Risk Group	High Health Risk Group	p value[a]
Mothers	**n**	23	41	-
	Age (y)	38.8 (3.4)[b]	38.9 (4.6)	0.963
	Height (m)	1.62 (0.07)	1.62 (0.06)	0.756
	Weight (kg)	84.7 (22.7)	73.0 (11.1)	0.007
	BMI (kg / m²)	32.3 (8.1)	27.8 (4.5)	0.005
Fathers	**n**	14	20	-
	Age (y)	42.7 (6.7)	41.8 (5.6)	0.693
	Height (m)	1.77 (0.09)	1.77 (0.08)	0.948
	Weight (kg)	98.4 (24.6)	98.8 (21.8)	0.958
	BMI (kg / m²)	31.0 (5.6)	31.4 (6.9)	0.862

[a] Independent sample t-tests
[b] Mean (standard deviation)
Abbreviations: n (sample size), y (year), m (metre), kg (kilogram)

6.3.4 Body composition and body fat distribution: The results of the body composition analyses (using DXA) are shown in **Table 6-6.** Independent samples t-tests revealed that children in the high health risk group had greater total body fat-free mass (34.7 kg *versus* 32.0 kg), lean mass (33.4 kg *versus* 30.8 kg), and fat mass (23.3 kg *versus* 20.5 kg) than children in the low health risk group. While total %body fat did not differ between the low and high health risk groups (38.5% versus 39.8%, respectively), the high health risk group had greater central body fat mass expressed in absolute (1.8 kg) and relative (35.1%) terms compared to the low health risk group (1.5 kg) and (32.6%), respectively.

6.3.5 Physical activity / inactivity and cardiorespiratory fitness: As shown in **Table 6-7**, no group differences were observed according to physical activity, time spent viewing television and / or playing video and computer games, or cardiorespiratory fitness. Based on the established cardiorespiratory fitness criteria for the attainment of VO_{2max}, only 44 / 83 children (53%) achieved a true VO_{2max} test while 39 (47%) achieved VO_{2peak}. In order to include all observations in the analyses, regardless of whether children met the criteria for VO_{2max}, the cardiorespiratory fitness data are best described as measurements of VO_{2peak}.

6.3.6 Self-perception and body image: Group differences in psychosocial outcomes related to global and domain-specific self-perceptions and body image dissatisfaction are presented in **Table 6-8.** No significant differences were observed between low and high health risk groups.

6.3.7 Dietary intake: Groups were also compared according to dietary intakes (**Table 6-9**). In the univariate analyses, no differences were observed between the low and high health risk groups with respect to any of the measured dietary variables.

Table 6-6. Total and abdominal body composition determined using dual-energy X-ray absorptiometry (DXA) in low and high health risk groups

Variable	Low Health Risk Group (n = 30)	High Health Risk Group (n = 53)	p value[a]
Bone mineral density (g / cm^2)	0.85 (0.05)[b]	0.86 (0.07)	0.386
Bone mineral content (kg)	1.2 (0.2)	1.3 (0.3)	0.165
Total body fat-free mass[c] (kg)	32.0 (5.1)	34.7 (6.1)	0.040
Total body lean mass (kg)	30.8 (4.9)	33.4 (5.8)	0.038
Total body fat mass (kg)	20.5 (6.2)	23.3 (5.7)	0.045
Total body fat (%)	38.5 (4.4)	39.8 (4.8)	0.222
Central body fat-free mass[c] (kg)	3.1 (0.6)	3.3 (0.6)	0.109
Central[d] body lean mass (kg)	3.1 (0.6)	3.3 (0.6)	0.143
Central body fat mass (kg)	1.5 (0.6)	1.8 (0.5)	0.026
Central body fat (%)	32.6 (5.5)	35.1 (5.4)	0.048

[a] Independent samples t-tests
[b] Mean (standard deviation)
[c] Fat-free mass is comprised on lean tissue mass and bone mineral content
[d] Central body composition comprised of region between lumbar (L) vertebrae L1 – L4
Abbreviations: g (gram), cm (centimetre), kg (kilogram)

Table 6-7. Physical activity, cardiorespiratory fitness, television viewing, and video game / computer playing comparisons between low and high health risk groups

Variable	Low Health Risk Group (n = 30)	High Health Risk Group (n = 53)	P value[a]
PAQ-C	3.01 (0.65)[b]	3.00 (0.66)	0.939
VO_{2peak} / ml	1725.7 (331.1)	1761.5 (381.5)	0.668
VO_{2peak} / ml / kg	33.6 (4.6)	31.5 (5.9)	0.095
RER	1.15 (0.07)	1.18 (0.09)	0.183
Maximal HR	198 (9)	193 (11)	0.053
Television viewing (min / d)	105.1 (48.8)	111.0 (57.0)	0.637
Video game / computer time (min / d)	32.2 (39.9)	27.7 (27.3)	0.544
TV + video game / computer time (min / d)	137.3 (67.7)	138.7 (64.7)	0.928

[a] Independent samples t-tests
[b] Mean (standard deviation)
Abbreviations: PAQ-C (Physical Activity Questionnaire for older Children), VO_{2peak} (maximal volume of oxygen consumption), ml (millilitre), kg (kilogram), RER (respiratory exchange ratio), HR (heart rate), min (minute), d (day)

Table 6-8. Self-perception comparisons between low and high health risk groups based on sub-scales from the Self-Perception Profile for Children, the Children's Physical Self-Concept Scale, and body image dissatisfaction

Variable	Low Health Risk Group (n = 30)	High Health Risk Group (n = 53)	p value[a]
Global self-worth[c]	3.32 (0.53)[b]	3.10 (0.76)	0.158
Behavioural conduct[c]	3.12 (0.54)	3.26 (0.59)	0.285
Social acceptance[c]	2.81 (0.72)	2.89 (0.98)	0.715
Weight control behaviours[d]	27.9 (3.7)	27.5 (4.2)	0.685
Physical appearance[d]	24.3 (4.2)	24.7 (5.4)	0.754
Physical performance[d]	25.1 (4.2)	25.0 (4.4)	0.908
Global physical self-concept[e]	77.3 (8.3)	77.2 (10.5)	0.955
Body image dissatisfaction[f]	1.70 (1.03)	1.54 (0.75)	0.119

[a] Independent samples t-tests
[b] Mean (standard deviation)
[c] Scores vary between 1.00 – 4.00; higher scores indicate more positive self-ratings
[d] Scores vary between 9.0 – 36.0; higher scores indicate more positive self-ratings
[e] Aggregate score of weight control behaviours, physical appearance and physical performance subscales
[f] Scores represent discrepancy between 'self' and 'ideal self'

Table 6-9. Dietary intake assessed using the 7-day recall Kids' Food Frequency Questionnaire (KFFQ) comparison between low and high health risk groups; average values (per day) are reported

Dietary Variable	Low Health Risk Group (n = 30)	High Health Risk Group (n = 53)	p value[a]
Total energy (kcals)	1776 (366)[b]	1922 (581)	0.218
Protein (g)	58.9 (13.8)	64.1 (18.0)	0.177
Protein (%)	13.3 (1.8)	13.6 (2.5)	0.506
Carbohydrate intake (g)	241.5 (58.2)	252.4 (82.8)	0.528
Carbohydrate intake (%)	53.9 (5.2)	52.4 (6.0)	0.248
Fat (g)	67.7 (15.2)	76.2 (26.4)	0.113
Fat (%)	34.5 (4.0)	35.6 (4.5)	0.284
MUFA (g)	25.3 (5.1)	28.8 (10.2)	0.087
PUFA (g)	14.2 (4.9)	15.4 (6.4)	0.377
SFA (g)	23.2 (4.8)	25.9 (9.0)	0.130
Fibre intake (g)	13.0 (4.6)	14.0 (5.4)	0.430
Vegetables & Fruit (svgs / d)	4.1 (2.0)	4.1 (1.6)	0.982
Grain Products (svgs / d)	4.9 (1.7)	4.8 (1.6)	0.761
Meat & Alternatives (svgs / d)	1.3 (0.4)	1.5 (0.6)	0.105
Milk Products (svgs / d)	1.7 (1.1)	2.0 (1.1)	0.372

[a] Independent samples t-tests
[b] Mean (standard deviation)
Abbreviations: kcals (kilocalories), g (gram), MUFA (monounsaturated fatty acids), PUFA (polyunsaturated fatty acids), SFA (saturated fatty acids), svgs (servings), d (day)

6.3.8 Predictors of high health risk: The final series of analyses included evaluating which independent body composition, lifestyle, and self-perception variables explained designation in the high health risk group (the low health risk group served as the referent group). Results of the univariate logistic regression analyses are shown in **Table 6-10**. To be inclusive, all explanatory variables at $p < 0.250$ are presented. While no psychosocial measures were included in this subset, a number of physiological and behavioural variables, when assessed on an individual basis, were potential candidates for explaining group designation.

Table 6-10. Univariate relationship between independent outcome variables for obese children in the low and high health risk groups (group differences for all variables with p-values < 0.250 are presented)

Variable	Coefficient β (SE)	p value[a]
Child weight (kg)	0.0320 (0.0199)	0.108
Child BMI (kg / m²)	0.0790 (0.0610)	0.195
Maternal weight (kg) (n = 64)	-0.0437 (0.0180)	0.015
Maternal BMI (kg / m²) (n = 64)	-0.1213 (0.0475)	0.011
Bone mineral content (kg)	0.0013 (0.0009)	0.166
Total fat-free mass (kg)	0.0894 (0.0445)	0.045
Total fat mass (kg)	0.0863 (0.0441)	0.050
Total body fat (%)	0.0620 (0.0507)	0.221
Central body fat-free mass (kg)	0.6334 (0.3991)	0.113
Central body fat mass (kg)	1.0901 (0.5048)	0.031
Central body fat (%)	0.0857 (0.0441)	0.052
Cardiorespiratory fitness (VO_{2peak} / kg)	-0.0727 (0.0440)	0.099
Total energy (kcals)	0.0006 (0.0005)	0.219
Carbohydrate (%)	-0.0467 (0.0404)	0.247
Protein (g)	0.0197 (0.0146)	0.178
Total fat intake (g)	0.0183 (0.0118)	0.120
MUFA intake (g)	0.0534 (0.0321)	0.084
Meat and Alternatives (svgs / d)	0.7267 (0.4538)	0.109

[a] Univariate logistic regression

Abbreviations: SE (standard error), kg (kilogram), m (metre), g (gram), VO_{2peak} (maximal volume of oxygen consumption), kcals (kilocalories), MUFA (monounsaturated fatty acids), svgs (servings), d (day)

The results of the primary multivariate logistic regression model are presented in **Table 6-11.** This model was derived by including data from the complete sample of 83 children and, as with the univariate analyses, the low health risk group served as the referent group. After systematically entering all potential predictor variables into the model, central body fat mass (Odds ratio [OR]: 13.1, 95% Confidence Interval [CI]: 2.5 - 67.6), monounsaturated fatty acid intake (MUFA) (OR: 1.1, 95% CI: 1.003 - 1.16), and the sum of 5 skinfolds (OR: 0.96, 95% CI: 0.92 - 0.99) were all significant predictors of categorization in the high health risk group. Considered individually, a 1kg increase in central body fat mass corresponded to a 13.1–fold increased odds of being in the high health risk group whereas an increase of 1mm in the sum of 5 skinfolds related to a 0.96 likelihood of classification in the high health risk group. However, because the correlation between these two variables is not insignificant, these coefficients should be carefully interpreted and are best considered collectively. As such, a 1kg increase in central body fat mass coupled with a 1mm increase in the sum of 5 skinfolds translated into a 12.5-fold[3] increased risk of designation in the high health risk group. Finally, increasing dietary intake of MUFA by 1g translated into a 1.1 increased odds of joining the high health risk group.

No significant interactions between these variables were observed. Intake of MUFA was not correlated with either central body fat mass ($r = -0.069$, $p = 0.537$) or the sum of 5 skinfolds ($r = 0.038$, $p = 0.730$), but the two body fat compartments were significantly related to one another ($r = 0.738$, $p < 0.001$). Despite this significant relationship, in the presence of central body fat mass, the sum of 5 skinfolds could not be removed from the model since it assisted in further explaining group categorization. These findings were confirmed by the Hosmer and Lemeshow goodness-of-fit test ($\chi^2_{(8)} = 4.9561$, $p = 0.7623$) which did not suggest a lack of fit for the regression model.

Table 6-11. Primary multivariate logistic regression model with central body fat mass, sum of 5 skinfolds, and monounsaturated fatty acid (MUFA) intake as predictor variables for inclusion in the high health risk group (n = 83)

Variable	Coefficient β	SE	Wald χ^2	P value	OR	95% CI
Constant	-0.0394	1.6944	0.0005	0.9815	-	-
Central body fat mass (kg)	2.5716	0.8378	9.4210	0.0021	13.0872	2.533 - 67.611
MUFA (g)	0.0743	0.0367	4.1116	0.0426	1.0772	1.003, 1.157
Sum of 5 skinfolds (mm)	-0.0447	0.0192	5.4408	0.0197	0.9563	0.921, 0.993

Abbreviations: SE (standard error), OR (odds ratio), CI (confidence interval), g (gram), mm (millimetre)

The secondary multivariate logistic regression model **(Table 6-12)** included only those children with mothers who had height and weight measurements recorded (n = 64). For this subset, the logistic regression procedure revealed that central body fat mass (OR: 8.8, 95% CI: 2.0 - 38.9) and mothers' BMI (OR: 0.85, 95% CI: 0.76 - 0.96) were predictive of classification in the high health risk group. In

[3] This estimate included each β term and is derived through: $e^{2.5716 - 0.0447} = e^{2.5269} = 12.5$

other words, for every 1kg increase of central body fat mass, the risk of being in the high health risk group increased 8.8–fold. Further, for every unit (kg / m^2) increase in mothers' BMI, the risk of being in the high health risk group decreased by a factor of 0.85.

As found in the primary model, no interaction between variables was observed. In addition, no significant correlation was observed between central body fat mass and mothers' BMI ($r = 0.011$, $p = 0.933$) indicating that both variables contributed independently in helping to explain group categorization. The Hosmer and Lemeshow goodness-of-fit test ($\chi^2_{(8)} = 14.068$, $p = 0.080$) did not suggest a lack of fit for the regression model.

Table 6-12. Secondary multivariate logistic regression model with central body fat mass and mothers' body mass index (BMI) as predictor variables for prediction of inclusion in the high health risk group (n = 64)

Variable	Coefficient β	SE	Wald χ^2	p value	OR	95% CI
Constant	1.9304	1.7759	1.1816	0.2770	-	-
Central body fat mass (kg)	2.1796	0.7557	8.3194	0.0039	8.8425	2.011 - 38.886
Mothers' BMI (kg/m^2)	-0.1624	0.0603	7.2536	0.0071	0.8501	0.755 - 0.957

Abbreviations: SE (standard error), OR (odds ratio), CI (confidence interval), g (gram), kg (kilogram), m (metre)

6.4 Discussion

The results of the current study revealed several key observations. First, risk factors for CVD and type 2 diabetes were prevalent among obese children in this sample and risk factor clustering occurred within a subset of children in the high health risk group. However, a number of obese children (those in the low health risk group) did not possess dyslipidemia, hyperinsulinemia, or hypertension despite having a high degree of total body fat. Participants in the high health risk group had higher levels of total body fat mass and greater central body fat (in relative and absolute terms) than children in the low health risk group, but total body fat (%) did not differ between groups. Second, no anthropometric or demographic differences were observed between children in the low and high health risk groups, but body weight and BMI were higher among mothers of children in the low health risk group when compared to mothers in the high risk group. Third, group differences were not observed in any of the activity / inactivity, fitness, dietary, or psychosocial variables. Finally, with respect to health risk prediction, we found that central body fat mass exerted the strongest influence on classification in the high health risk group. However, once central body fat mass was entered into the multivariate models, the sum of 5 skinfolds, monounsaturated fatty acid intake, and mothers' BMI were also significant, albeit minor, predictors of designation in the high health risk group.

6.4.1 Risk factor prevalence and clustering: Risk factors are more common among obese than non-obese children (Freedman et al., 1999; Dwyer et al., 1998) and, as in adults (Vanhala et al., 1998; Meigs et al., 1997), variables related to increased risk of CVD and type 2 diabetes in youth often appear in clusters (Freedman et al., 1999; Twisk et al., 1999; Chu et al., 1998). However, the presence of risk factor clustering in children has typically been observed in obese children when compared to their non-obese peers. These data indicate that obese children are a heterogeneous group since a substantial proportion did not possess other risk factors. These findings are consistent with an earlier report (Freedman et al., 1999) suggesting that approximately 60% of obese children possess additional risk factors for CVD and type 2 diabetes. One of the unique features of the present study is that risk factors for CVD and type 2 diabetes were determined exclusively in a sample of children who already possessed at least one risk factor (obesity). Thus, the relatively high proportion of boys and girls in the present investigation who possessed risk factors including dyslipidemia, hyperinsulinemia, and hypertension is sample specific and not generalizable to the whole pediatric population.

6.4.2 Anthropometry (child and parent): Children in the low and high health risk groups did not differ in any of the selected anthropometric outcomes, yet mothers' body weight and BMI were higher in the low versus high risk group. Because the height and weight data obtained from parents were incomplete, these observations should be viewed cautiously. It is unknown whether height and weight data from parents who were not measured would alter the present relationships.

Although speculative, a number of reasons may explain the observed differences between mothers. First, these disparities may reflect true differences, regardless of the incompleteness of the data, and represent an intriguing finding between mothers of obese children at low and high health risk. Second, the fact that some mothers (as well as fathers) from both groups were reluctant to have height and weight measurements taken may be related to body weight or shape sensitivities. Parents chose whether or not to be measured and self-reported data were not collected to avoid including additional sources of measurement error (Flood et al., 2000; Smith et al., 1992). Lack of participation may represent a form of bias through either direct and / or indirect mechanisms. While unsubstantiated, it is possible that the individuals who did not participate were heavier than those who did, thereby producing a biased sample estimate. Third, because the majority of mothers were overweight, group differences may be statistically significant, but not necessarily clinically meaningful since, on average, both groups of mothers were at elevated health risk. Finally, the observation that family history of disease did not differ between groups does not preclude the possibility of other variables such as body fat distribution and risk factors for CVD and type 2 diabetes differing between groups of parents. This finding may be especially relevant given the familial resemblance in measures of body fatness and metabolic risk factors for disease between parents and their offspring (Perusse et al., 1997; Rice et al., 1996).

6.4.3 Body composition and body fat distribution: As anticipated, we found higher levels of body fat (for some, but not all measures) in children within the high health risk group. The univariate analyses revealed differences between the low and high health risk groups according to total body fat mass, yet the multivariate logistic regression models showed that the amount of total body fat was less important in determining health risk than central body fat distribution. These findings provide strong evidence to suggest that the amount of central body fat (specifically, within the L1 – L4 region) is the strongest determinant of risk factors for CVD and type 2 diabetes. While cause-and-effect relationships can not be implied based on these cross-sectional observations, other reports have supported the role of central body fat mass in determining metabolic risk.

Traditionally (Williams et al., 1992b) and more recently (Morrison et al., 1999a; Morrison et al., 1999b), body fat distribution has been assessed using anthropometric indicators such as skinfold thicknesses and circumferences. Sophisticated techniques for measuring body fat distribution are impractical for large, population-based studies, however, DXA and other imaging procedures are able to provide objective assessments of body fat and fat distribution within smaller clinical samples. Using DXA and the same region to define central body fat distribution as in the current study (L1 – L4), Paradisi et al. (1999), found this compartment of body fat was best at predicting risk factors for CVD and type 2 diabetes in a sample of obese and non-obese adults. In a group of 9 – 17 year old boys and girls, Daniels et al (1999) observed that DXA-derived android (central) fat mass was consistently a stronger correlate of CVD risk than total body adiposity. Although the region used in categorizing central body fat distribution was slightly different, they concluded that TG, HDL-C, SBP, and left ventricular mass were all significantly and independently related to greater android fat distribution. Other investigations have used computed tomography (CT) or magnetic resonance imaging (MRI) to assess the influence of visceral adipose tissue (VAT) on risk factors. Using CT, Gower and colleagues (1999) found that VAT was related to both TG and fasting insulin levels in prepubertal children and that these relationships were independent of total body fat and subcutaneous abdominal adipose tissue (SAAT). Similarly, others have reported significant associations between VAT (assessed using MRI) and risk factors for

CVD and type 2 diabetes (Owens et al., 1998; Caprio et al., 1996; Brambilla et al., 1994). We were unable to assess individually the roles of VAT and SAAT on group classification in the low and high health risk groups. However, our data are consistent with that of others in suggesting that (1) body fat distribution measured using DXA is useful for evaluating the relationships between central body fat distribution and objective health outcomes and (2) central body fat distribution is clearly inter-related with a host of metabolic risk factors including dyslipidemia, hyperinsulinemia, and hypertension in obese children.

Because traditional definitions of overweight and obesity in children have been based on population-specific percentile cutoffs such as the 85th and 95th percentiles (Tremblay and Willms, 2000; Troiano and Flegal, 1999), identifying an absolute level of body fat that corresponds to increased health risk in youth is a pragmatic objective. Earlier estimates of health-related obesity in children have been based on body fat measurements using skinfold thicknesses (Dwyer and Blizzard, 1996; Williams et al., 1992a). More recently, using DXA and Receiver Operating Characteristic analysis, Higgins et al. (2001), found that children with ≥ 33% body fat *and / or* a waist circumference ≥ 71cm were more likely to have an adverse risk profile (defined by individual risk factors including serum lipids, insulin, and blood pressure) than a normal risk profile. The direct application of these cutoffs to the current study sample is hampered by differences in methodologies and sample demographics. However, our data provide evidence to suggest that, at least within this group of children, a substantial number of obese children do not possess risk factors for CVD and type 2 diabetes despite having body fat levels ≥ 33%. While our findings substantiate the role of central body fat distribution in increased disease risk, the relationship between waist circumference *per se* and risk factors for CVD and type 2 diabetes can not be directly assessed since girth measurements were not collected in the current study. Further, our results, along with those of Higgins et al. (2001), were mainly derived from prepubertal children. It remains to be demonstrated whether these clinical observations and proposed cutoffs are useful in risk classification for more mature children whose body composition is in a dynamic state as a consequence of the hormonal changes that accompany puberty and the concomitant shift of body fat from peripheral to central depots (Rogol, 1994).

6.4.4 Lifestyle behaviours and perceptions: We postulated that lifestyle behaviours and perceptions would be different between obese children at low and high health risk. However, no group differences were revealed for any of the independent variables that were measured. Others have made similar observations with respect to the role of physical activity and diet in determining health risks in boys and girls (Lindquist et al., 2001; Twisk et al.,1999). These findings should not be interpreted to mean that health-related parameters such as physical activity, cardiorespiratory fitness, diet, and self-perceptions are unimportant determinants of physical and psychological health among obese children. It is possible that the manner in which groups were distinguished (based on physical health risks established using objective criteria) may have influenced these findings. Designating low and high health risk groups with a different risk criterion (i.e., physical inactivity) may have yielded different results for both subjective and objective predictor variables. However, from a physical health standpoint, categorizing health risk based on known risk factors and objective variables for chronic diseases such as CVD and type 2 diabetes was a decision based on previously validated observations (Higgins et al., 2001; Chen et al., 1999).

Lifestyle behaviours such as physical activity and nutrition patterns were measured in the current study using self-reports. These techniques were chosen because they were convenient, cost-effective, and exerted little burden on study participants and families. However, instruments such as activity recalls and food frequency questionnaires elicit subjective ratings that may be influenced by several factors. Thus, a number of issues may help to explain the inability to observe differences between the low and high health risk groups.

Intentional (e.g., purposefully omitting relevant information) and / or unintentional (e.g., forgetting or making estimation errors) reporting inaccuracies may have influenced the validity of the nutrition and activity data we collected. Bias in dietary assessments is a well-documented phenomenon and has been reported in a variety of populations (Hur et al., 1998; Paeratakul et al., 1998; Block, 1989). Although we were unable to assess formally the accuracy of dietary intake in the current study, under-reporting has been documented among children (Fisher et al., 2000), obese adolescents (Bandini, et al., 1990), as well as women and individuals who are less educated and heavier (Klesges et al., 1995). At least in adults, attitudes about one's own body weight may also influence reported energy intake (Johansson et al., 1998). In the future, it would be worthwhile to investigate whether parental weight or weight concerns influence the reporting accuracy of mothers (and fathers) who provide information on behalf of their children since proxy reports may lead to misclassification (Nelson et al., 1994). It may also be useful to evaluate reporting accuracy when parents and children complete dietary reports individually compared to when these instruments are completed together. These observations would be relevant for nutrition research with all children (obese and non-obese) since proxy reports are often used by researchers to assess dietary habits in younger boys and girls. Also, it is unknown whether the magnitude of reporting bias is consistent across the overweight and obese weight ranges or if it increases with increasing weight status; under-reporting has typically been documented between obese and non-obese groups (Klesges et al., 1995; Bandini et al., 1990).

Many of the same measurement errors and inaccuracies that effect reporting accuracy in dietary assessments influence physical activity questionnaire determinations as well (Tolfrey et al., 2000; DiPietro, 1995). While under-reporting may occur to a degree, over-reporting of physical activity levels appears to be more prevalent. Compared to more objective criteria such as doubly-labeled water and motion sensors, self-reports have led to over-estimations of physical activity among overweight adults (Buchowski et al., 1999; Jakicic et al.,

1998) and children (Welk et al., 2000). Seasonal effects (Rifas-Shiman et al., 2001) and temporal patterns (i.e., 3-day *vs* 7-day recalls) may also lead to inconsistencies when self-reports are used to identify group differences in activity (Washburn et al., 1980). Assessments made at different points throughout the year or over short periods of time may not adequately reflect usual behaviour patterns thereby providing inaccurate estimates. The activity assessment questionnaire we used (PAQ-C) provided an overall activity *score*. However, it would have been useful for these analyses to compare children on the intensity, frequency, and duration of activity. Additionally, if activity data were converted into metabolic equivalents or energy expenditure, it would have been possible to evaluate groups on both quantitative and qualitative outcomes.

It is possible that group differences in behaviours and perceptions existed, but the manner in which the data were assessed failed to yield significant findings (Margetts et al., 1999). In the current study, we attempted to achieve a balance between measurement practicality and sample size. In the adult literature, the evidence to suggest that cardiorespiratory fitness (for example) is an independent risk for CVD and all-cause mortality regardless of weight is derived from studies comprised of thousands of individuals (Lee et al., 1999; Lee et al., 1998). Given the number of individuals necessary to establish a link between activity- and fitness-related variables and objective health outcomes, sample size may be a limiting factor in the current investigation.

We initially postulated that group differences in physical activity / inactivity, cardiorespiratory fitness, and associated self-perceptions would be different between children at low and high health risk. However, no disparities emerged. Compared to other studies involving obese boys and girls from the Edmonton-area, children in the current study did not differ substantially in physical activity or self-perceptions assessed using the same questionnaires (Ball et al., 2001; Ball, Marshall, and McCargar, unpublished observations). Our ability to detect group differences in indices of physical inactivity may have been confounded by under-reporting of time spent viewing television and playing video games. While participants in the current study viewed approximately 16 hours of television per week, other reports have suggested that American children of similar age view between 17 – 34 hours (Gortmaker et al., 1996; Robinson et al., 1993; AC Nielsen Company, 1990) per week. Data from Canadian children are limited, but reports from older boys and girls (grades 6 – 10) have documented variable amounts of viewing time with approximately 19 – 33% of children viewing > 4 hours of television per day and 5 – 40% of children spending > 4 hours per week playing video games (Health Canada, 1998).

6.4.5 Predictors of high health risk: As previously discussed, we were interested in determining whether specific variables could predict designation in the low and high health risk groups. Although their contributions were minor, the sum of 5 skinfolds, intake of monounsaturated fatty acids, and mothers' BMI (for the subset of 64 children) entered into the multivariate models (once central body fat mass was included) to help explain group classification. The univariate analyses indicated that of these three variables, only mothers' BMI was different between low and high health risk groups. Thus, our evidence suggests that subcutaneous body fat, monounsaturated fat intake, and mothers' BMI (for the subset) all helped to explain health risk in obese children. However, these variables exerted little influence on central body fat mass and its relationship to metabolic risk among obese boys and girls.

The sum of 5 skinfolds represents an indirect measure of subcutaneous body fat. While central adiposity exerted the greatest influence on the presence of risk factors for CVD and type 2 diabetes, it appears that subcutaneous body fat is not benign. In fact, our data suggest that the sum of 5 skinfolds exerted a negative, albeit small, effect on categorization in the high health risk group. The observation that subcutaneous fat is negatively related to risk factors for CVD and type 2 diabetes has been observed previously. Hunter and colleagues (1997) found that intra-abdominal body fat measured using CT was strongly related to

CVD risk whereas a sum of 4 peripheral skinfolds (biceps, triceps, thigh, and calf) was negatively associated with risk factors in a sample of adult men. Others have demonstrated that SAAT (from the abdomen) was negatively related to LDL-C in adolescents (Caprio et al., 1996). Taken together, these two observations offer suggestive evidence that subcutaneous body fat, in both central and peripheral sites, may relate to decreased health risks once visceral adiposity is considered.

The finding that MUFA intake increased (slightly) the odds of classification in the high health risk group is intriguing because it conflicts with both epidemiological and clinical observations. It has been suggested that moderate amounts of MUFA can be incorporated into the dietary treatment of metabolic complications of CVD and type 2 diabetes since these fatty acids do not induce detrimental metabolic effects (Riccardi and Rivellese, 2000). Further, the American Heart Association has recommended that MUFA-containing foods be incorporated into diets since they can be beneficial in reducing risk factors for CVD and type 2 diabetes in adults (Kris-Etherton et al., 1999). While MUFA was included in the multivariate model in the present study, it should be emphasized that it was only included once central body fat mass was already entered. Additionally, univariate comparisons indicated that total dietary fat (absolute and relative) as well as polyunsaturated fatty acid and saturated fat intake were all marginally higher among children in the high health risk group, but did not differ significantly from the intakes of children in the low health risk group. These findings suggest that the influence of MUFA on risk classification in the present study, though significant, is small.

In summary, these observations indicate that risk factors for CVD and type 2 diabetes are common among obese children, tend to cluster, and are strongly linked with central body fat mass. To our knowledge, this is the first report to assess relative degrees of metabolic health risks within a sample of obese children. We provide evidence to suggest that some obese children, despite possessing a high level of body fat, are less likely to develop dyslipidemia, hyperinsulinemia, and hypertension than other obese children. Obese children are a heterogeneous group and the presence of risk factors for CVD and type 2 diabetes are strongly linked with central body fat accumulation. Generally, lifestyle behaviours and perceptions were unable to predict metabolic risk in this group of boys and girls. Further investigation into the heterogeneity of childhood obesity is necessary to help clarify the role of familial and lifestyle factors that may influence metabolic risk in obese boys and girls.

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Chapter Seven: Conclusions and Discussion

7.1 Review of Hypotheses

Hypothesis 1. In a sample of 6 – 10 year old children, obese boys and girls will possess lower levels of physical activity, cardiorespiratory fitness, self-perception and higher intakes of total energy and dietary fat than their non-obese peers **(Chapter 3).**

Hypothesis 2. The behavioural and attitudinal differences between obese and non-obese children listed above will be maintained over time (12 months) **(Chapter 4).**

Hypothesis 3. Compared to baseline values, obese 6 – 10 year old children who participate in the 12-week family-based behavioural SHAPEDOWN or VITALITY weight management programs will achieve decreased body fatness and increased levels of physical activity, cardiorespiratory fitness, self-perception, and improved dietary quality **(Chapter 5).**

Hypothesis 4. The SHAPEDOWN program, an intervention that encourages families to monitor body weight changes during treatment, will result in greater losses in body weight and fatness than the VITALITY program **(Chapter 5).**

Hypothesis 5. In a sample of 6 – 12 year old obese boys and girls who are at low or high health risk for CVD and type 2 diabetes:

a. The low health risk group will have lower levels of total body fat and central body fat than the high health risk group **(Chapter 6).**

b. The low health risk group will have higher levels of physical activity and cardiorespiratory fitness than the high health risk group **(Chapter 6).**

c. The low health risk group will have lower intakes of total energy and total dietary fat than the high health risk group **(Chapter 6).**

d. The low health risk group will have higher levels of global self-esteem and physical self-perception as well as body image satisfaction than the high health risk group **(Chapter 6).**

7.2 Conclusions

A number of conclusions can be drawn from the experimental work conducted in this thesis that relate to the (1) cross-sectional and longitudinal behavioural and perceptual differences between obese and non-obese boys and girls, (2) anthropometric, behavioural, and perceptual effects of family-based, health-centred interventions related to childhood weight management, and (3) influence of body composition, body fat distribution, and lifestyle behaviours and perceptions on the presence of risk factors for CVD and type 2 diabetes in obese children. The primary conclusions are as follows:

Part of hypothesis #1 was verified as obese children had lower levels of cardiorespiratory fitness and scored lower in self-perceptions related to scholastic competence and social acceptance compared to their non-obese peers. However, groups did not differ in physical activity, self-perceptions of athletic competence, behavioural conduct, global self-worth, physical appearance, or in any of the dietary variables. In this cross-sectional evaluation of 6 – 10 year old obese (n = 26) and non-obese (n = 110) children, we also observed that boys were heavier, leaner, more physically active, and consumed more energy and dietary protein (as a percent of energy) than girls. Self-perception domains considered most relevant to body fatness (i.e., physical appearance or global self-worth) did not differ between groups according to sex or obesity status. These findings indicate that obesity may be related to some, but not all aspects of self-perception in children. It appears that obese children in this study have internalized a negative perception of being obese that unfavorably affected their perceptions in the scholastic and social domains, but activity and dietary behaviours do not explain group differences.

Hypothesis #2 was not accepted since the proposed group differences at baseline were not maintained over the duration of the study. With measurements taken at 0-, 3-, 6-, and 12-month intervals, the only difference observed between obese and non-obese children was a transient elevation (at 3-months) in dietary protein (%) intake among obese boys and girls. In this longitudinal investigation of 6 – 10 year old obese (n = 19) and non-obese (n = 116) children, anthropometric differences between groups (based on sex and obesity status) were in the expected direction. Girls possessed greater skinfold values than boys and obese children weighed more and had greater sums of 5 skinfolds than non-obese children. No group differences in physical activity, cardiorespiratory fitness, and self-perception were found. However, girls had a higher intake of carbohydrate (%) and lower intake of fat (%) than boys with differences at 12-months only. These findings highlight the importance of conducting long-term investigations since findings from cross-sectional studies, especially among children and adolescents, may only reflect transient differences in behavioural and perceptual variables. It is possible that the unbalanced sample sizes study design limited our ability to detect differences between obese and non-obese boys and girls. School- and community-based health promotion models should emphasize positive behaviours and perceptions related to health in all children, but especially obese boys and girls who may be at increased health risk.

Part of hypothesis #3 was accepted as the SHAPEDOWN and VITALITY weight management programs led to decreased sum of 5 skinfolds and increased physical activity and physical self-perception at the conclusion of the 12-week intervention period. Both health-centred interventions led to positive changes in physical self-perceptions that were maintained at follow-up. However, improved cardiorespiratory fitness and dietary quality were not observed. Hypothesis #4 was not accepted since, despite the explicit promotion of weight loss in the SHAPEDOWN program, it was no more successful at facilitating weight loss in participants than the VITALITY model which emphasized positive lifestyle behaviours and attitudes exclusively. Group facilitators in both programs were rated very positively by families and attendance levels were high suggesting that these community-based interventions were well-received. An extended intervention (> 12-weeks) period and continued family support may prove beneficial in helping to maintain positive changes in adiposity and physical activity behaviours among obese children.

Hypothesis #5a was accepted as total body fat mass (but not % body fat) and central body fat mass were decreased in the low risk group compared to the high risk group. Risk factors for CVD and type 2 diabetes were common among obese children, tended to cluster, and were positively related to central body fat mass. A subset of obese children, despite having a high level of body fat, did not possess dyslipidemia, hyperinsulinemia, or hypertension, a finding that appears linked to decreased central body fat mass. This observation highlights the heterogeneity of childhood obesity as it pertains to metabolic risk. Body weight and BMI were higher among mothers of children from the low health risk group compared to mothers of children from the high health risk group. Hypotheses #5b, #5c, and #5d were not supported since low and high health risk groups did not differ in physical activity, cardiorespiratory fitness, energy and fat intakes, and global self-esteem and physical self-perception. Using multivariate logistic regression analyses, central body fat mass (positive), MUFA (positive), mothers' BMI (negative), and the sum of 5 skinfolds (negative) were all significant predictors of health risk among obese children. However, notwithstanding the contributions of other lifestyle and familial variables, central body fat mass was the strongest predictor of metabolic risk in this sample of obese boys and girls.

7.3 Discussion

The findings of this thesis highlight a number of salient issues that pertain to the physical and psychosocial health of both obese and non-obese children. Given the high prevalence of childhood obesity in Canada, understanding potential differences between obese and non-obese children, identifying effective treatment initiatives for improving health outcomes, and characterizing determinants of metabolic risk among young obese individuals are all important research directives.

It is generally accepted that longitudinal studies yield more meaningful data than cross-sectional investigations since temporal, seasonal, and maturational patterns can be explored. Because boys and girls are in a dynamic state of growth, a time in life characterized by physical, psychological, and social change, the examination of lifestyle behaviours and attitudes may reveal enabling factors that promote healthy childhood development. However, not unexpectedly, the findings from our yearlong analysis differed from the results of the cross-sectional assessment. These discrepancies may be explained by several factors.

The discordant sample sizes of the obese groups in these analyses (cross-sectional: obese group = 26 children; longitudinal: obese group = 19 children) may have played a role, but our results may also reflect the modest tracking of lifestyle behaviours in youth (Raitakari et al., 1994). Given additional time and resources, it would have been valuable to monitor this sample of children over an extended interval since it is likely that the effect of puberty may have become more influential over an extended period, especially in terms of outcomes related to anthropometry and self-perception that are known to be influenced by maturational changes. Further, measurement error in assessing anthropometric variables (Ulijaszek and Kerr, 1999; Kraemer et al., 1990) and small variations in physiological (Dietz, 1994) or lifestyle factors (Goran et al., 1998) over time can obscure the relationships between health-related variables and prevent the identification of group differences. Assuming that obesity develops gradually and changes in body fatness represent a small energy imbalance, existing methods may lack the requisite precision to reveal meaningful causative determinants.

For practical reasons, many variables in this thesis were assessed using self-report instruments. More objective techniques (e.g., direct observation for assessing activity behaviours) require greater time and resources than self-reports, but some options are available to simplify data collection. One approach may be to focus assessments on key times during the day or specific locations (i.e., recess at school or after-school day care). Monitoring groups for discrete periods of time may be useful to understand variability in activity and dietary patterns since children would all be exposed to the same stimuli or opportunities. It may also be beneficial to implement more than one tool to measure lifestyle behaviours of interest. While it is currently not known which measures are most accurate, reporting results with different instruments would provide a more complete description of children's lifestyle behaviours (in quantitative and qualitative terms) and permit a triangulation of outcomes (Welk et al., 2000).

Interestingly, the initial purpose of conducting the observational school-based study was to monitor naturalistic changes in a sample of obese children to serve as a control group for obese children enrolled in the SHAPEDOWN and VITALITY weight management programs. Both obese and non-obese children were recruited for this investigation to prevent labeling and potentially stigmatizing a group of obese children (Himes, 1999; Brownell, 1984). It was inappropriate to use the obese children from the school-based study as a control group for in the SHAPEDOWN and VITALITY analysis since groups differed in several important outcomes (i.e., adiposity, age, weight, and height). However, the data collected from this school-based sample of obese and non-obese boys and girls were valuable because it allowed us to evaluate group differences in lifestyle behaviours and attitudes over time.

Given the increasing number of obese children in Canada, weight management programs for obese boys and girls are necessary for children and families who perceive obesity to be an important health concern and are ready to make lifestyle changes for the family. It has been argued that the most cost effective action may be to target higher risk children and devote resources to more intensive obesity treatment programs (Atkinson and Nitzke, 2001). As our data suggest, children with a high central body fat mass may be the most appropriate candidates for weight management programs. However, considering the potential of childhood obesity to track into adolescence and adulthood, all obese boys and girls should be considered for inclusion, if not to decrease adiposity, at least to positively influence lifestyle behaviours that may decrease risk of unhealthy weight gain.

Problems of discrimination related to obesity are evident in young children and likely reflect negative attitudes and messages that come from a variety of sources – parents, peers, teachers, and media. It is still widely regarded that excess body fat stems from gluttony and / or sloth, two of the seven deadly sins (Prentice and Jebb, 1995). As long as a negative perception of obesity remains commonplace, it will be difficult to educate health professionals who counsel overweight and obese clients on ways to remain sensitive to the physical, social, emotional, and economic issues faced by obese individuals. If inadequately developed and presented, programs for obese children have the potential to produce more stigmatization. Careful thought and planning are needed to identify the most suitable strategies to treat obesity in children. In the future, novel thinking, public policy changes, and additional research funding will be required to develop and build upon present capacities.

One example of an existing paradigm that can be further developed is VITALITY (Health Canada, 2000). This philosophy has been incorporated into other health promotion programming models for childhood weight management (Gillis, 2001) and school curricula (*Getting There Is Half The Fun!*, 1995). However, few critical analyses of the VITALITY philosophy have been performed. Additionally, its application in health programming in other populations (i.e., adults, elderly, and non-Caucasian ethnic groups) and for other health conditions (i.e., type 2 diabetes) is lacking. The recent focus on combining physical activity and nutrition messages for health professionals (Anonymous, 2001) is predated by the development of the VITALITY model that was initially launched in 1991. While these recent developments are encouraging, efforts to sustain a comprehensive health-centred approach to health promotion and disease prevention strategies should be enhanced by a concerted research effort to develop, evaluate, and implement VITALITY-based initiatives. It is crucial for well-designed VITALITY-based investigations, applied in a variety of settings and offered to different populations, to fuel its growth, evolution, and acceptance as an effective health promotion model.

Aside from individual counseling with health professionals, there are few available weight management programs for obese children and their families. This may be due to a variety of reasons (i.e., health professionals lacking expertise, no health care reimbursement for counseling, high rates of recidivism, multifactorial etiology, and a lack of simple solutions). We have demonstrated that SHAPEDOWN and VITALITY are useful in improving health-related outcomes in obese children. However, an ongoing support network within the community would be a helpful resource. Our data suggest that, for those families who are committed to maintaining healthy behaviours, longer follow-up may be helpful in supporting behaviour changes. Based on personal communication with health professionals and families from the Edmonton-area, there appears to be a demand for an ongoing, multi-disciplinary weight management program in northern Alberta. Encouraging developments by the Capital Health Authority suggest that both treatment and prevention have become health priorities in the region and future initiatives should help to address current shortcomings.

The general lack of success in treating obesity in children is well established. Combined with our evidence that central body fat mass is a strong determinant of health risk in obese children and the observation that some children (Steen et al., 1996) and adults (Jain et al., 2001; Alexander et al., 1991) may not perceive childhood obesity to be an important health issue, preventing obesity at a young age is of paramount importance. While not all children are equally susceptible to obesity, the promotion of positive nutrition and activity behaviours at a young age has benefits beyond weight maintenance and should improve numerous physical and psychosocial outcomes. In recent decades, there has been a dramatic increase in the availability of foods, advertising for foods, and increased time spent viewing television that promotes food consumption. Broad environmental pressures for increased consumption of food and decreased activity during leisure time will undoubtedly continue in the future. However, these pressures do not mean that interventions cannot be effective in preventing obesity.

Obesity is a consequence of pervasive influences that operate across many settings. Hence, a multifaceted approach is necessary and should include numerous, simultaneous strategies. The combined and coordinated efforts of <u>individuals</u> (e.g., consuming less sugar-containing soda and juice), <u>families</u> (e.g., establishing television viewing limits), schools (e.g., providing nutritious choices in vending machines and encouraging the use of 'walking school buses' for transportation to and from school), communities (e.g., offering safe, inexpensive, and easy access to recreation facilities) and governments (e.g., eliminating provincial and federal sales taxes for athletic equipment and apparel) are needed to have a meaningful and broad-based impact. Although there are no definitive data to show that any of these interventions prevent obesity, none of these initiatives are likely to have adverse effects, and all of these strategies should improve the quality of family life (Dietz, 2001). Even if the above mentioned strategies do not lead to demonstrable improvements in adiposity at the population level, many other direct and indirect benefits should be achieved through maintaining healthier lifestyle behaviours. Approaches to change families' patterns of eating and activity must be adapted to the social and economic pressures of today's world. Because the current state of childhood obesity in Canada has been created through gradual changes in energy balance that make it easier to expend less and consume more, nothing short of comprehensive environmental changes will be effective at addressing this prevalent and problematic health condition.

7.4 Future Research Directions

The conclusions and discussion that summarize this thesis provide a foundation from which to pursue future initiatives in the area of childhood obesity.

- In this thesis, providing parents with a comprehensive health assessment of their children was an important incentive that encouraged participation in the study. Future research should include the measurement of health-related variables for both children and parents since it may prevent negative emotions and perceptions that children may experience by being singled out for testing because of their obesity and it should allow for the consideration of a greater number of familial variables that have the potential to influence health risk in children.

- Appropriate surveillance systems will be required to monitor trends in growth, behaviours, and attitudes if initiatives (at community, regional, and national levels) are developed and implemented to prevent obesity. Although currently available systems at the national level (i.e., National Longitudinal Study of Children and Youth) may be useful for assessing certain outcomes over time, such programs may be inappropriate for evaluating growth trends since most data are derived from self or proxy reports. The data generated from surveillance systems should be extremely valuable in monitoring health trends over time and in response to the potential myriad prevention initiatives.

- Further application of the VITALITY paradigm in different populations and for different health conditions is needed since very few critical evaluations of the philosophy have been conducted. If this paradigm is to represent a model for the treatment and / or prevention of obesity among Canadians, further exploration and validation of the tenets of the model must be carried out for VITALITY to receive greater acceptance and integration into behaviour change models.

- To date, very little has been published regarding the use of different theoretical models in supporting behaviour change among obese children and their families. The SHAPEDOWN and VITALITY interventions are primarily based on cognitive behavioural therapy. Applying additional theories related to behaviour change (i.e., trans-theoretical model of behaviour change) may be useful in the development of weight management programs for obese children and for determining whether families are appropriate candidates for intervention.

- The creation of a national resource database and referral centre for families and health professionals on healthy eating and physical activity that relate specifically to obesity in youth. Currently, resources are available through a variety of disconnected agencies. For example, the development of an Internet-based clearinghouse would allow for the dissemination of information to all interested individuals looking for information. Such a service could include resources and information regarding obesity treatment and prevention programs being piloted and in progress with linkages to researchers and health professionals working in the area.

- A more complete characterization of the heterogeneity of obese children, youth, and adults in both the physical and psychosocial domains is warranted given our observations that obese children do not all possess the same health risks. Differentiating health risks among obese children according to sex and ethnicity would also be a logical extension.

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Appendix 1. Self-perceived ratings in the sub-scales[a] from the Self-Perception Profile for Children (SPPC)[b] at 0-, 3-, 6-, and 12-month intervals for non-obese (NOB) and obese (OB) girls and boys[c]

Variable	Time	NOB Girls (n = 58)	NOB Boys (n = 58)	OB Girls (n = 9)	OB Boys (n = 10)
Athletic Competence	0-m	3.06 (0.64)[d]	3.35 (0.52)	2.91 (0.75)	2.90 (0.58)
	3-m	2.98 (0.68)	3.26 (0.60)	2.78 (0.91)	2.82 (0.86)
	6-m	3.16 (0.61)	3.28 (0.63)	2.82 (0.82)	3.00 (0.78)
	12-m	3.27 (0.45)	3.32 (0.63)	3.02 (0.73)	3.19 (0.85)
Behavioural Conduct	0-m	3.23 (0.61)	3.26 (0.61)	3.26 (0.72)	2.98 (0.72)
	3-m	3.21 (0.65)	3.09 (0.71)	3.23 (0.57)	2.65 (0.57)
	6-m	3.19 (0.65)	3.19 (0.60)	3.32 (0.60)	2.74 (0.70)
	12-m	3.38 (0.59)	3.22 (0.56)	3.32 (0.54)	2.55 (0.65)
Global Self-Worth	0-m	3.32 (0.66)	3.51 (0.46)	3.15 (0.65)	3.08 (0.82)
	3-m	3.34 (0.66)	3.43 (0.54)	3.37 (0.63)	2.99 (0.66)
	6-m	3.33 (0.66)	3.48 (0.60)	3.39 (0.62)	3.13 (0.59)
	12-m	3.55 (0.61)	3.50 (0.51)	3.31 (0.73)	3.23 (0.91)
Physical Appearance	0-m	3.40 (0.58)	3.42 (0.60)	2.73 (1.00)	3.03 (0.73)
	3-m	3.26 (0.70)	3.33 (0.61)	3.09 (0.83)	2.70 (0.87)
	6-m	3.36 (0.70)	3.44 (0.61)	3.14 (0.82)	2.75 (0.77)
	12-m	3.54 (0.62)	3.47 (0.54)	2.90 (0.98)	3.13 (0.80)
Scholastic Competence	0-m	3.07 (0.58)	3.27 (0.61)	3.09 (0.58)	2.68 (0.65)
	3-m	3.14 (0.64)	3.26 (0.60)	3.01 (0.76)	2.79 (0.41)
	6-m	3.28 (0.57)	3.27 (0.61)	3.10 (0.75)	2.96 (0.53)
	12-m	3.31 (0.55)	3.32 (0.50)	3.02 (0.81)	2.54 (0.68)
Social Acceptance	0-m	3.14 (0.68)	3.21 (0.58)	2.35 (0.57)	2.67 (1.03)
	3-m	3.08 (0.65)	3.10 (0.63)	2.59 (0.86)	2.75 (0.85)
	6-m	3.22 (0.63)	3.19 (0.66)	2.71 (0.87)	2.91 (0.73)
	12-m	3.35 (0.49)	3.12 (0.64)	2.73 (0.90)	3.16 (0.56)

[a] Possible score out of 4.00 for each sub-scale
[b] Harter S. *Manual for the self-perception profile for children.* University of Denver, 1985.
[c] No significant group differences were observed
[d] Mean (standard deviation)
Abbreviations: m (month)

Appendix 2. Servings of foods from Canada's Food Guide to Healthy Eating assessed by 24-hr food recalls at 0-, 3-, 6-, and 12-month intervals for non-obese (NOB) and obese (OB) girls and boys

Variable	Time	NOB Girls (n = 58)	NOB Boys (n = 58)	OB Girls (n = 9)	OB Boys (n = 10)
Vegetables & Fruit Recommendation: 5 – 10[a]	0-m	4.3 (2.4)[c]	3.8 (2.0)	4.1 (2.8)	3.9 (2.1)
	3-m	3.9 (2.5)	3.9 (2.2)	3.6 (2.8)	3.6 (1.4)
	6-m	4.4 (2.5)	4.8 (2.8)	4.1 (3.0)	4.1 (2.3)
	12-m	4.6 (2.4)	3.8 (2.0)	3.0 (1.7)	3.7 (2.2)
Milk Products Recommendation: 2 – 4[a]	0-m	2.0 (1.2)	2.8 (1.3)	2.1 (1.4)	1.5 (1.2)
	3-m	2.1 (1.3)	2.5 (1.2)	2.5 (1.5)	2.3 (0.7)
	6-m	2.3 (1.2)	2.5 (1.4)	1.7 (1.2)	1.6 (1.0)
	12-m	2.1 (1.1)	2.6 (1.3)	2.0 (1.2)	2.0 (0.9)
Grain Products Recommendation: 5 – 12[a]	0-m	5.7 (2.7)	5.9 (2.6)	6.0 (2.3)	4.6 (2.3)
	3-m	5.1 (2.4)	5.7 (2.5)	5.3 (2.4)	6.1 (2.8)
	6-m	5.5 (2.1)	6.2 (2.0)	6.1 (2.7)	6.1 (1.6)
	12-m	5.3 (2.1)	6.0 (2.2)	5.3 (2.5)	5.3 (2.2)
Meat & Alternatives Recommendation: 2 – 3[a]	0-m	1.3 (1.1)	1.4 (0.9)	0.8 (0.7)	2.1 (1.3)
	3-m	1.4 (1.4)	1.7 (1.1)	2.6 (2.8)	1.7 (1.4)
	6-m	1.5 (1.2)	1.7 (1.1)	1.7 (1.2)	2.0 (1.3)
	12-m	1.1 (0.9)	1.6 (1.3)	1.1 (0.5)	1.4 (1.1)
Other Foods[a,b]	0-m	13.9 (10.8)	14.0 (8.9)	9.7 (7.1)	17.2 (13.4)
	3-m	12.4 (8.0)	12.8 (7.7)	10.1 (5.6)	17.9 (12.6)
	6-m	12.5 (9.2)	15.0 (9.5)	12.1 (7.7)	14.0 (11.8)
	12-m	13.2 (10.1)	11.4 (7.1)	14.2 (6.3)	11.5 (7.8)

[a] Recommendations from Canada's Food Guide to Healthy Eating (Health Canada, 1992)
[b] The "Other Foods" category represents added fat and sugar that do not naturally occur in the food item. It also accounts for foods (i.e., salad dressings and oils, cream, butter, margarine, sugars, soft drinks, candies, and sweet desserts) that provide calories and little else nutritionally.
[c] Mean (standard deviation)

Appendix 3. Total energy and macronutrient intake assessed by 24-hr food recalls at 0-, 3-, 6-, and 12-month intervals for non-obese (NOB) and obese (OB) girls and boys[a]

Variable	Time	NOB Girls (n = 58)	NOB Boys (n = 58)	OB Girls (n = 9)	OB Boys (n = 10)
Absolute Energy Intake (kcals)	0-m	1779 (403)[b]	1953 (414)	1629 (308)	1889 (679)
	3-m	1748 (480)	1911 (423)	1735 (159)	1951 (661)
	6-m	1834 (392)	1975 (407)	1569 (316)	1867 (412)
	12-m	1760 (370)	1926 (468)	1656 (194)	1827 (412)
Adjusted Energy Intake (kcals / kg body wt)	0-m	66.4 (16.5)	71.3 (15.7)	47.9 (13.8)	48.6 (19.5)
	3-m	64.4 (18.9)	69.6 (18.4)	48.3 (10.7)	49.7 (21.4)
	6-m	65.4 (17.8)	69.7 (18.4)	42.0 (12.2)	45.1 (11.1)
	12-m	59.3 (16.6)	63.7 (17.2)	40.7 (10.2)	40.3 (8.3)
Carbohydrate Intake (%) Recommendation: ~ 55% of energy[c]	0-m	55.7 (8.0)	54.6 (6.7)	54.7 (6.9)	52.7 (6.8)
	3-m	54.7 (7.6)	53.9 (6.6)	45.1 (12.0)	52.4 (6.2)
	6-m	56.3 (9.0)	55.4 (6.1)	49.0 (8.6)	55.3 (7.3)
	12-m	57.9 (7.4)	53.6 (7.8)	54.2 (8.4)	51.6 (6.6)
Fat Intake (%) Recommendation: ≤ 30% of energy[c]	0-m	30.6 (6.3)	30.4 (5.7)	31.1 (6.6)	31.0 (6.3)
	3-m	30.7 (5.6)	30.6 (5.6)	35.1 (8.3)	31.3 (6.2)
	6-m	29.4 (6.8)	29.4 (6.3)	35.1 (5.7)	28.4 (6.7)
	12-m	28.3 (6.2)	30.8 (6.7)	31.6 (7.1)	34.0 (4.7)
Protein Intake (%) Recommendation: 13 – 15 % of energy[c]	0-m	13.7 (3.8)	15.1 (3.1)	14.1 (3.7)	16.4 (3.5)
	3-m	14.3 (4.0)	15.5 (3.9)	19.8 (8.1)	16.2 (4.9)
	6-m	14.3 (4.3)	15.3 (4.0)	15.7 (5.1)	16.3 (4.4)
	12-m	13.8 (3.7)	15.5 (3.3)	13.9 (3.9)	14.7 (3.5)

[a] No significant group differences were observed
[b] Mean (standard deviation)
[c] Guidelines from *Nutrition Recommendations* (Health and Welfare Canada, 1990).
Abbreviations: kcals (kilocalories), kg (kilogram), wt (weight), m (month)

Appendix 4. Intakes of carbohydrate, fat, protein, and total energy of participants in the SHAPEDOWN and VITALITY programs[a]

VARIABLE	TIME	SHAPEDOWN	VITALITY
Carbohydrate (%)	0-m	57.5 (7.4)[b]	56.4 (9.9)
	3-m	54.0 (9.0)	59.2 (8.7)
	6-m	52.5 (9.2)	53.6 (9.3)
	12-m	56.4 (7.4)	54.7 (9.2)
Carbohydrate (g)	0-m	276.4 (82.6)	280.1 (75.6)
	3-m	251.8 (69.5)	275.8 (83.4)
	6-m	240.4 (95.5)	252.8 (60.3)
	12-m	245.8 (62.4)	291.2 (104.4)
Fat (%)	0-m	28.1 (6.7)	28.2 (7.8)
	3-m	31.4 (7.0)	27.3 (8.3)
	6-m	32.1 (7.2)	31.6 (8.5)
	12-m	28.4 (6.0)	29.6 (8.5)
Fat (g)	0-m	61.5 (27.5)	64.0 (24.9)
	3-m	66.1 (24.7)	61.3 (30.3)
	6-m	65.0 (27.4)	67.8 (23.5)
	12-m	55.9 (19.7)	71.9 (32.6)
Protein (%)	0-m	14.2 (3.3)	15.5 (4.2)
	3-m	14.5 (3.9)	13.9 (3.1)
	6-m	15.2 (4.9)	15.0 (3.2)
	12-m	15.2 (3.3)	15.8 (4.0)
Protein (g)	0-m	69.0 (27.3)	77.3 (24.0)
	3-m	67.7 (24.6)	64.3 (23.9)
	6-m	70.1 (37.7)	72.5 (26.3)
	12-m	65.6 (18.6)	72.6 (26.9)
Total energy (kcal)	0-m	1893 (570)	1977 (442)
	3-m	1840 (470)	1860 (594)
	6-m	1797 (640)	1881 (404)
	12-m	1725 (422)	2084 (593)
Total energy (kcal) / kg	0-m	36.1 (112)	40.4 (11.6)
	3-m	34.7 (8.3)	37.8 (13.9)
	6-m	32.0 (10.4)	35.6 (8.0)
	12-m	29.9 (7.7)	35.4 (9.6)

[a]Assessed using 24-hour dietary recall
[b] Mean (standard deviation)
Abbreviations: m (month), g (gram), kcal (kilocalories), and kg (kilograms)

Appendix 5. Intakes of Grain Products, Milk Products, Meat and Alternatives, Vegetables and Fruit, and Other Foods of participants in the SHAPEDOWN and VITALITY programs[a]

VARIABLE	TIME	SHAPEDOWN	VITALITY
Grain Products (svgs / d)	0-m	7.1 (3.3)[b]	6.5 (2.1)
	3-m	5.6 (2.2)	5.9 (2.7)
	6-m	5.7 (2.5)	5.7 (3.2)
	12-m	5.5 (2.4)	5.9 (2.5)
Milk Products (svgs / d)	0-m	2.2 (1.3)	2.6 (1.7)
	3-m	1.8 (1.3)	2.3 (1.1)
	6-m	1.8 (1.7)	2.7 (1.7)
	12-m	1.7 (1.0)	2.4 (1.4)
Meat and Alternatives (svgs / d)	0-m	1.1 (1.2)	1.5 (1.6)
	3-m	1.6 (1.3)	1.2 (1.0)
	6-m	1.6 (1.3)	1.3 (1.1)
	12-m	1.3 (0.9)	1.7 (1.5)
Vegetables and Fruit (svgs / d)	0-m	4.3 (2.2)	3.9 (2.3)
	3-m	4.3 (3.2)	3.9 (1.6)
	6-m	2.6 (2.2)	4.3 (2.6)
	12-m	3.2 (2.2)	4.1 (2.7)
Other Foods (svgs / d)[c]	0-m	14.5 (8.5)	14.0 (9.3)
	3-m	14.6 (10.4)	19.7 (12.5)
	6-m	14.0 (9.1)	13.1 (7.9)
	12-m	12.5 (7.8)	19.4 (17.7)

[a] Assessed using 24-hour dietary recall
[b] Mean (standard deviation)
[c] Other Foods (represents added fat and sugar that do not naturally occur in the food item. It also accounts for foods (i.e., salad dressings and oils, cream, butter, margarine, sugars, soft drinks, candies, and sweet desserts) that provide calories and little else nutritionally.
Abbreviation: svgs / d (servings per day), m (month)