TARGETING CHILDHOOD OBESITY THROUGH A SCHOOL-BASED

PHYSICAL ACTIVITY INTERVENTION:

ACTION SCHOOLS! BC

by

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Abstract

Introduction: Overweight and obesity, conditions defined by an excess amount of fat mass, have become increasingly prevalent in children. As a result, they represent serious medical, financial and social burdens for society. Low levels of physical activity (PA) are believed to be partially responsible for fueling this dramatic increase in excess body fat. School-based physical activity interventions offer a novel solution to this problem as children spend the greatest portion of their day in school. Furthermore, these interventions provide an opportunity to reach children from diverse socioeconomic and ethnic backgrounds.

Objective: The primary aim of this study was to determine if Action Schools! BC, a school-based physical activity model, could positively affect change in percent (%) body fat in elementary school (Grades 4-6) children. The secondary objective was to determine if Action Schools! BC could have a positive effect on change in % body fat in children considered overweight or obese at baseline.

Methods: This was a 29-month randomized controlled trial. Students were randomized by school to the intervention (INT, 7 schools, n=235) or control (CONT, 3 schools, n=111) condition. The AS! BC model was a school-based model specifically designed to deliver 150 minutes of physical activity per week through physical education class and classroom-based activities. Percent fat was measured using Dual-energy X-ray Absorptiometry. Group means were compared for age, race, body composition (height, weight, BMI, fat mass, % fat, lean mass, % lean) and lifestyle variables (general physical activity score (1-5), min / day of physical activity). Differences in maturity status and number of menarcheal girls were also evaluated. Physical activity delivered in schools (minutes/week) was assessed using activity logs filled out by teachers. Students with \geq 33% body fat at baseline (n=73) were considered overweight or obese and included in a subgroup analysis. Sex-specific multi-level models were used to compare change in percent fat between INT and CONT groups. Covariates included baseline % fat and change in height. In the secondary analysis, change in menarcheal status was also added to the model.

Results: At baseline, students were 10.2 (± 0.6) years and INT and CONT groups were of similar racial background (>50% Asian, 30-40% Caucasian, 10-15% Other ethnicities). Students were mainly pre-pubertal (53% Tanner 1) although girls tended to be mature than boys. Teachers delivered an average of 152 minutes/week of physical activity (adjusted for school) in the INT schools compared with 94 minutes/week in CONT schools. After adjusting for covariates, girls in the INT group lost slightly less % body fat (-0.9%) compared with girls in the CONT group (-1.0%) (95% CI: -1.0-1.2). Boys in the INT group lost slightly more % body fat (-1.9%) compared with boys in the CONT group (-1.8%) (95% CI: -1.7-1.5). In the subgroup analysis, INT girls lost more % body fat than CONT girls (-3.6% vs. -3.0%, 95% CI: -3.8 to 2.7) and INT boys lost more % body fat than CONT boys (-3.5% vs. -2.3%, 95% CI: -4.5-2.2). **Conclusions:** Action Schools! BC was a feasible, school-based model that led to an increased delivery of physical activity opportunities in schools. However, a greater dose of physical activity over a longer timeframe may be required to win the fight against childhood obesity.

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% BF	Percent body fat or relative fatness		
AS! BC	Action Schools! BC		
Action	A service, program, intervention, strategy, policy change or other activity that is implemented with the intent of preventing chronic disease and/or promoting healthy living.		
Adipose tissue	Connective tissue that stores fat. Measured using the skinfold technique.		
Adiposity	The quality or state of being fat.		
Adolescence	The period of physiological, sexual and psychological development from the onset of puberty to maturity.		
Anthropometry	Measurement of height, weight and other aspects of human form and structure.		
'At-risk'	A term used in the present thesis to describe all children with \geq 33% body fat at baseline. Typically, the term 'at-risk of overweight' is used by the Centre for Disease Control to classify children whose BMI-for-age is \geq 85 th percentile and <95 th percentile.		
BIA	Bioelectrical Impedance Analysis. An indirect measure of body fatness that is based on electrical conductance and the greater electrical conductivity of fat-free mass.		
BMI	Body Mass Index. A measure of body fatness that is obtained by dividing body weight (kg) by the square of height (m ²).		
CDC	(American) Centre for Disease Control		
Chronic disease	 Diseases that have one or more of the following characteristics: Are prolonged or permanent Leave residual disability Can be treated but rarely cured completely Require special training of the patient for rehabilitation, or Can require long periods of supervision, care or observation. 		
CVD	Cardiovascular disease		
DXA	Dual energy x-ray Absorptiometry. An imaging technique.		
Intervention	A program designed to alter the physical characteristics, environment or behaviors of a group.		
Fat mass (FM)	Triglyceride (lipid). Stored in adipose tissue. DXA identifies fat mass by its R value of \sim 1.2.		
Heritability	The proportion of total variance in a trait that is attributable to genetic factors.		

IOTF	International Obesity Task Force
Lean mass (LM)	Composed of water, glycogen, protein and minerals. Also referred to as muscle. DXA identifies lean mass by its R value of ~ 1.36-1.37.
MVPA	Moderate-to-vigorous physical activity
NIDDM	Non-insulin dependent diabetes mellitus (Type II Diabetes)
NS	Non-significant difference. Statistically, this refers to p>0.05.
Obesity / overweight	A state characterized by abnormal or excessive fat accumulation to the extent that health may be impaired. Health risk is greater with obesity than overweight. Different classification systems exist for children and adults.
"Obesogenic" Environment	An environment that promotes the development of obesity. For example, an environment that is rich in energy-dense foods and which involves little physical labour could be term 'obesogenic'.
Physical activity (PA)	Any bodily movement produced by the skeletal muscles that results in an expenditure of energy. A <i>process</i> measure.
Physical education (PE)	An educational process which uses physical activity to help people acquire skills, knowledge, attitudes and fitness, with the objective of achieving optimal health and well-being. In British Columbia, all schools are required to allocate at least 10% of instructional time to PE class.
Physical inactivity	Not engaging in any regular pattern of physical activity beyond daily functioning.
Puberty	 The first stage of adolescence during which an individual becomes capable of sexual reproduction. Puberty is characterized by: the onset of secondary sexual characteristics secretion of hormones a growth spurt
RCT	Randomized controlled trial. A study where individuals are randomly assigned to a treatment or control condition. RCTs provide the highest level of scientific evidence.
Risk Factor	Any attribute, characteristic or exposure of an individual, which increases the likelihood of developing a disease or injury.
Soft tissue	Composed of lean and fat mass.
SES	Socio-economic status. A measure of a relative economic or social ranking within society.
Stata	A statistical analysis program (Stata Statistical Software: Release 9).
Tracking	The stability or maintenance of one's rank or position over time.
UBC	University of British Columbia

Vancouver General Hospital

Weight

VGH

Composed of lean mass, fat mass, bone mass and residual tissue mass (ie. visceral mass). Measured in kg.

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1.0 INTRODUCTION

1.1 Childhood Obesity – a Global Problem

Western society has witnessed a dramatic shift in illness over the years- a shift away from communicable disease and towards chronic illness. Now, chronic diseases such as cardiovascular disease and diabetes are the hallmarks of modern illness and are clearly associated with obesity, a condition defined by an unhealthy, excess amount of fat (8, 83). Today, obesity is a global epidemic- attributed ultimately to industrialization, urbanization and immobility of the modern world (8).

Unlike many communicable diseases which western medicine has sufficiently curbed, chronic conditions such as childhood obesity are on the rise. Paradoxically, obesity coexists with under-nutrition and is now prevalent in countries where it was previously unseen, such as China and Taiwan (233). The World Health Organization (WHO) International Obesity Task Force estimates that 30-45 million children worldwide are obese while another 155 million children are overweight (123). In Canada alone, since 1981, the prevalence of obesity in children aged 7-13 years has nearly tripled since 1981- a 25 year span (225). This has created serious medical, financial and social burdens. Furthermore, as the current generation of overweight or obese children transition into adulthood, the long-term ramifications of this disease have the potential to truly overwhelm the health care system. This represents a significant public health concern.

1.2 Physical Activity in Children

An important contributor to the accrual of body fat is physical activity. Numerous empirical studies support the notion that physical activity provides protection from overweight and obesity (112, 224). Further, physical activity is associated with a plethora of other health benefits (83). However in Canada, more than half of all children and youth are currently not active enough for optimal growth and development (1).

Although we do not know how much physical activity is necessary to entirely prevent overweight or obesity, we do know that for most children, exercise is essential for healthy growth and development. Therefore, any truly sustainable intervention designed to curb the rising trend in childhood obesity must have physical activity woven into its very fabric.

1.3 Comprehensive, School-based Interventions – a Potential Solution

In the past, approaches aimed at promoting physical activity and healthy body weights in children focused primarily on the individual determinants of behavior, not accounting for environmental factors (211). However, the environment exerts a powerful influence on children and in a media-rich world that promotes sedentary activity, individual attempts

Introduction

to change unhealthy behaviors may not be enough. Considering that previous interventions have been largely unsuccessful, it is thought that an ecological approach that incorporates environmental, social and individual elements is the only way to create long-lasting change (211). For young people, the school is a critical environment of influence and has the potential to affect children from diverse ethnic and socio-economic backgrounds. Furthermore, schools provide a venue for prospectively tracking children as they progress through into adolescence.

Action Schools! BC (AS! BC) was a comprehensive, school health-based model that used a socioecological framework to consider children in the context of their environment. Aside from engaging students, AS! BC challenged multiple stakeholders in the school, community and provincial government to take action and improve the lives of children in British Columbia. AS! BC was developed as a means to enhance physical activity in elementary schools and aimed to provide <u>150 minutes</u> of physical activity per week for children. The AS! BC model was unique as it was geared for implementation by generalist teachers as opposed to PE specialists solely in PE class. In addition, it provided opportunities for every child, regardless of skill level, to be physically active on a daily basis. The innovative aspect of the AS! BC evaluation was the direct assessment of body fat using Dual Energy X-Ray Absorptiometry (DXA).

Therefore, the primary aim of this thesis is to assess the effect of AS! BC on change in the percent (%) body fat in children over 29 months. The secondary aim of this thesis is to assess the effect of AS! BC on change in % body fat in children who are overweight or obese at baseline. Should AS! BC be effective, it would support provincial efforts to improve child health through physical activity and temper the rise in childhood obesity.

2.0 LITERATURE REVIEW

In this chapter I conduct a review of the literature. In the first section, I explore the determinants and consequences of obesity in children. In the second section, I discuss the various methods of assessment and classification of childhood obesity. Following, in the third section, I discuss the importance of physical activity in children, including the determinants of and opportunities for physical activity currently. I then describe the variety of methods for quantifying physical activity in children in the fourth section. Finally, in the last section, I explore the rationale for school-based physical activity interventions and review previous interventions that have attempted to target childhood obesity through physical activity.

2.1 Understanding Childhood Obesity

2.1.1 Defining overweight and obesity

Obesity is defined as a "condition of abnormal or excessive fat accumulation in adipose tissue, to the extent that health may be impaired" (3). It is best described using the first law of thermodynamics which states that the energy of a system is determined by the difference between the energy (or heat) that enters the system and the energy (or heat) that leaves (35). In the case of obesity, increased energy intake relative to decreased energy expenditure results in deposition of fat and ultimately, weight gain. Internationally, the most commonly used method to assess the degree of fatness is the Body Mass Index (BMI = weight (kg) / height² (m²)). The BMI classification schemes used for children will be explored in detail later in this chapter (Section 2.2).

2.1.2 Prevalence of obesity

Although the prevalence of obesity varies substantially between countries, it is undoubtedly the highest in North America and some European countries (Figure 1) (123). Rates also differ based on the classification system used and for this reason it is often difficult to compare rates across countries. **Figure 1.** Prevalence of overweight and obesity (based on IOTF definitions) among children ages 5-17 years. Survey data from various years after 1990. Reproduced from the IOTF (123).



Most of the established rates for childhood obesity in Canada stem from the work of Tremblay et al. (222, 225, 237). They used the International Obesity Task Force (IOTF) classification system (48) to define overweight and obesity (Section 2.2.2.2). From 1981-1996, the prevalence of obesity in Canadian children ages 7-13 years nearly tripled (5% to 14%) (225, 237). The prevalence of overweight almost doubled, from 15% to 29% in boys and from 15% to 24% in girls (225). Prevalence was also much greater in the Atlantic provinces than in the western provinces (237).

In the past, the United Kingdom and Australia have also identified children as overweight or obese using the IOTF classifications. In 1996, the prevalence of obesity in England ranged from 11% to 17% in children 6 to 15 years of age (176). Similar to Canadian trends, rates of overweight in Australia doubled and rates of obesity tripled among children from 1985 to 1995 (133).

The United States uses the American CDC percentiles to classify children as overweight or obese (Section 2.2.2.1). This country has witnessed the percentage of overweight ($\geq 95^{th}$ percentile) young people (6-19 years) triple since 1980. Currently, more than 9 million young people (16%) in the US are overweight (94).

In countries where the prevalence of overweight and obesity were previously rare, incident cases of obesity are now increasing. For example, from 1982 to 1997 Bangladesh experienced a rise in the prevalence of obesity among preschool children from 0.1% to 1.1% (54). Although these percentages are seemingly small, they represent a 100-fold increase in a country where this problem was previously non-existent. Other countries undergoing a 'nutrition

transition' are also experiencing similar changes (Section 2.1.3.2). However, in most countries around the world a lack of survey data makes it difficult to monitor this problem (123). Still, it is clear that the prevalence of global obesity is on the rise.

2.1.3 Determinants of overweight and obesity

When energy intake and energy expenditure are unbalanced, physiological homeostasis is disrupted. In times of food shortage, the body employs excellent defense mechanisms to slow metabolism and conserve energy. This evolutionary adaptation has ensured survival in times of famine. However, in developed nations, there is an abundance of food and little demand for physical work. Using a plethora of strategic messages, the popular media also prompts individuals to consume more energy than is required to meet physical demands. Coupled with energy saving technology and sedentary leisure pastimes such as TV and video- this disrupted energy balance leads to weight gain.

In this next section, I introduce the many determinants of overweight and obesity. For the purpose of this thesis, only those determinants that are most prevalent in the literature and of the greatest relevance to this study are reviewed. However, it is still important to be cognizant of the other determinants of obesity. A recent paper by Reilly et al. (175) identifies 31 potential risk factors for obesity including such factors as low birth weight and earlier age of menarche.

I have created two overarching classifications for the determinants of obesity: biological and environmental. Biological factors, such as genetics and age are referred to as 'non-modifiable' factors; environmental factors, such as diet and physical activity levels are said to be 'modifiable'. Modifiable factors are the prime targets for intervention.

2.1.3.1 Biological determinants

Genetics plays an important role in weight gain. Although the search for the obesity-causing genes is ongoing, defective genes have already been identified in severe obesity. Leptin, the product of the obese *(ob)* gene, is a hormone that increases energy expenditure and induces satiation. In mice that did not produce functional leptin, administration of leptin decreased appetite and increased energy expenditure, leading to weight loss (41). Two studies, both published in the late 1990's in the journal Nature, reported mutations affecting leptin production in obese children. The first found a deletion mutation in the leptin gene that was associated with morbid obesity (149), the second found that a truncated leptin receptor gene (*LEPR*) led to severe early-onset obesity and disruption of multiple endocrine functions *(46)*. Clearly, genetic mutations can play a substantial role in the development of obesity.

Tying into genetics is the fact that parental obesity has consistently been found to place a child at risk for subsequent weight gain (43, 117, 156, 175, 235). Studies of monozygotic twins tended to provide higher estimates of heritability

than adoption or nuclear family studies. To illustrate, the National Heart, Lung and Blood Institute Twin Study was a longitudinal, multi-centre study of 514 Caucasian male twins over a 43-year period. Heritability for BMI was 71%, indicating substantial genetic influence (71). In the literature, the reported heritability of obesity in monozygotic twins has been as high as 85%, whereas adoption and family studies generally report a heritability range of 25-50% (17, 32). Children with two obese parents are believed to be especially at risk, with decreasing risk if only one or neither parent is obese (117, 235). Thus, familial genetics also contributes greatly to a child's likelihood of becoming obese

Developmental stage also plays a critical role in the probability of becoming obese. Body weight generally increases during the 1st year of life and then declines thereafter to a minimum at age 4 years. It then increases after ages 4-6 years (termed the *adiposity rebound*) and then again around the time of adolescence (14, 59). These 3 critical periods of life when body weight is increasing mark the stages of elevated susceptibility to obesity (57, 241). BMI follows a similar pattern to body weight (as seen in Appendices 1& 2) (114). In terms of body composition, from ages 5 or 6 on, girls have a greater % body fat than boys (135). Puberty represents the hallmark period of development, characterized by an intense growth spurt, as well as increased levels of circulating estrogen, growth hormone and testosterone (18, 180). Both sexes experience an increase in total body fat and lean mass. However, the increased fat mass in boys is substantially slower due to the more rapid and greater increase in fat-free mass, thus explaining the large decline in relative fatness (% fat) (135, 199). Approximately 50% of adult body weight is amassed during peri-puberty (180). There is evidence that adolescent obesity is the single best predictor of adult obesity; it has a stronger predictive value than childhood obesity alone (235).

2.1.3.2 Environmental determinants

Since the prevalence of obesity has changed considerably in a relatively short time, it is believed that the driving factor must be an environmental one since genetic changes could not occur at this rapid rate (59, 97, 181). Furthermore, genes related to obesity are best expressed in environments which are conducive to weight gain. As Hill writes, "*Obesity can be viewed not as a result of defective physiology, but as the natural response to the environment*" (97). The extensively studied Pima Indian population provides one of the best examples of this concept. Ravussin et al. (174) compared two different groups of Pimas, one group living in Mexico that had maintained its traditional lifestyle (comprised of heavy physical labour and a diet rich in fiber and complex carbohydrate) to another group living in Arizona that had adopted Westernized practices. Results showed that not only did Mexican Pima Indians have significantly lower BMIs, but only 11% of females and 6% of men had Type II Diabetes as compared with 37% and 54% in the Arizona cohort. This study is one of many to provide strong evidence of the effect of societal change on body weight.

Over the course of time, the 'natural' environment has come to mean convenience and technological mobility. Ironically, transportation involves minimal movement and leisure time is often spent in sedentary pursuits. With

globalization, urbanization and the mass production of inexpensive, energy-dense foods, an 'obesogenic' environment has been created (97). Our genes cannot adapt to these toxic surroundings.

A balanced energy intake also plays an important role in weight maintenance. When considering the dramatic increase in obesity rates, the evidence regarding a change in dietary intakes among children must also be considered. However, it is difficult to pinpoint which part of childrens' diets has contributed most to this increase in body size. The central questions remain; Are children eating more than they did 50 years ago? Or, are diets simply higher in energy density but lower in nutrient density than they were in the past? Definitive answers to these questions remain largely unknown.

Society has seen portion sizes and access to inexpensive foods increase substantially (206). Therefore, children who 'finish their plates' nowadays consume larger quantities than children of past. In addition, there is a large price gap between healthy and unhealthy foods that influences people to choose lower-cost, lower-quality foods (62). Socioeconomic status also plays an important role in food choice as the inability to afford fresh, nutritious foods can often be the main determinant of dietary intake (62).

However, diets have also changed in a very specific way which is often referred to as the '*nutrition transition*' (61, 170). Simple carbohydrates and vegetable oils are the cheapest ingredients in the world and are highly prevalent in almost all processed foods (61). Because of the transition, diets that were once high in whole grains, complex carbohydrates and fiber are now filled with fat and refined carbohydrate (61, 170). Westernized, fast-foods have replaced ethnic cuisine just as carbonated beverages have replaced traditional natural fruit drinks and water (61). Children are not necessarily eating more than they did the past; rather, the composition of consumed foods has changed. Winburn et al. (215) confirmed that children are consuming a greater number of calories from fat and energy-dense foods. Frequency of snacking (22, 206), as well as the energy density of snacks has also increased. This is especially true in adolescence when individuals are able to establish independent eating patterns away from home (242).

Consumption of carbonated beverages has also more than tripled in the past 3 decades and this has been coupled with a decline in milk consumption (226). In a 19-month study by Ludwig et al. (125), the odds ratio of becoming obese increased by 1.6 for each sugary beverage consumed daily. It is believed that high-fructose corn syrup (HFCS) plays a crucial role in the rising rates of obesity associated with beverage intake. HFCS was introduced into the food supply in the United States just before 1970. Today, it constitutes >40% of the sweeteners used in beverages. Bray and colleagues (36) analyzed the food consumption patterns of Americans using the national health statistics surveys. They found that the prevalence of obesity began to rise just after the introduction of HFCS into the market. Taken together, these findings suggest that dietary changes play a role in the development of obesity.

In the United States, it is estimated that over the course of a year, children spend as much time watching television as they do attending school (60). Media usage requires no energy expenditure above resting and food is advertised more than any other product on television (60). Television viewing and computer/video game usage are thought to contribute to obesity in two ways: (1) through a displacement of physical activity, and (2) through an increase in energy consumption (either during media usage or through the influence of advertising on television) (111, 179). Children who spend a great deal of time viewing television may in fact have different eating and snacking patterns than other children (172). Although there are studies that find no relationship between media viewing and overweight/obesity (64), longitudinal studies by Dietz et al. (60) and others (91) provide guality evidence that media usage is a risk factor for weight gain. In a population-based study by Proctor et al. (172), children with the greatest number of hours spent viewing television and playing video/computer games (>3 hours/day) experienced the greatest increases in body fat over 7-years. The lowa Bone Development study also found positive relationships between body fatness and time spent viewing media (102). Although the lowa study used a cross-sectional design, both body fatness and physical activity were measured directly using objective techniques - DXA and accelerometry Gortmaker et al. (87) examined this relationship over four years in a sample of 746 US youth. Results showed a 4.6 times greater relative risk of obesity for adolescents that watched > 5 hrs/day of television as compared to those who watched ≤ 2 hrs/day. This association remained stable even after controlling for confounding variables, such as ethnicity and baseline maternal overweight. Recently, in 2003, Tremblay and Willms (224) asked the guestion "Is the Canadian childhood obesity epidemic related to physical inactivity?" In their cross-sectional study of a representative sample of 7,216 Canadian children ages 7-11 years, researchers found strong support for the link between physical inactivity and obesity. Again, TV watching and video game usage emerged as significant risk factors for overweight or obesity.

To my knowledge, only one study has explored the relationship between body fatness and media usage in a randomized controlled trial (179). The aim of this study was to reduce television viewing and media usage and thereby, decrease fatness. This intervention was tested in 192 Grades 3 & 4 children 2 elementary schools. After 7 months of intervention and after controlling for baseline values, age and gender, students who received the intervention exhibited significantly greater decreases in BMI as well as time spent viewing television (ß=-0.45, 95% Cl: -0.73: -0.17).

Thus, even with very limited longitudinal, randomized controlled trial (RCT) data to highly support this relationshipthere is mounting evidence that media usage, as a component of *physical inactivity*, has a marked impact on body weight. However, larger, broader, RCTs are still needed to determine if these relationships are simply correlative or causative (102).

The dramatic increase in obesity in westernized nations can be attributed to many additional factors, including economic prosperity (8). Wealthier, industrialized countries generally have greater rates of obesity than poorer

countries, and urban populations have a greater prevalence of this problem than rural ones (123). At the individual level, there is a clear inverse relationship between socioeconomic status and prevalence of obesity or overweight (172, 237).

Finally, obesity rates vary strikingly by ethnicity, with marked impacts on minority groups (83, 115). Prevalence rates of overweight and obesity in the United States are especially pronounced among Hispanic, African-American and Native American children (73). In Canada, a study by Hanley et al. (91) found a significantly higher prevalence of overweight among First Nations children and youth as compared to NHANES III (American) reference data. A recent study by Tremblay et al. (223) used the 2000/01 and 2003 Statistics Canada cross-sectional Community Health Surveys to evaluate differences in adult BMI by ethnicity. Similar to the trends in children, aboriginal men and women again had the highest prevalence of overweight and obesity. The prevalence was lowest among East/Southeast Asians. It is postulated that minority groups such as the Aboriginals may secrete and use insulin in a different manner which places them at risk (83). However, these ethnic differences could also reflect social changes that affect minorities the most (75, 83, 160). In previous studies done in the Bone Health Lab at UBC, Caucasian girls were heavier and had more fat and lean mass than Asian girls (130). However, Asian pre-pubertal boys had more fat mass and a greater BMI than Caucasian pre-pubertal boys (131).

2.1.4 Biology (gene) – environment interactions

Although there are a whole host of reasons on which to apportion the blame for the obesity epidemic on environmental triggers, the truth is that it is the complex interaction between our genes and the environment that mediates weight gain. Although the genes for obesity might be present, an environment that stimulates overconsumption or restricts energy expenditure is generally necessary for the phenotypic expression of this disease. For this reason, it is difficult to ascertain the proportion of obesity attributable to genetic or environmental factors. Children and parents share the same physical environments and this may cause certain traits to 'run' in the family for reasons unrelated to genes. Bouchard et al. (33) showed that after 100 days of controlled overfeeding monozygotic (MZ) twins there was more variance between pairs than within. Furthermore, weight gain responsiveness tended to aggregate within families. The same researchers (34) reached the same conclusions again after 93 days of increased energy expenditure in a controlled environment with MZ twins. Cumulatively, these findings suggest that susceptibility to obesity is determined in part by genetic factors, but also by immersion in an obesogenic environment.

2.1.5 Tracking of unhealthy body weights from childhood to adulthood

Childhood is a vulnerable period when children are particularly susceptible to environmental, parental and societal influence. Unhealthy behaviors that are acquired during this stage of life can be carried forward into adolescence and adulthood (17). A wealth of longitudinal cohort studies have shown that BMI tracks throughout these periods. In the Bogalusa Heart Study, 841 participants were 9-11 years of age at baseline and 19-35 at follow-up. Baseline BMI was found to be strongly correlated with final BMI (r=0.7) (55). Similarly, in a Finnish study of 100 people followed at 6-

months, 7-years and 15-years, BMI at 7-years of age and 15-years had the highest correlation (r=0.7, p<0.001). Children in the highest tertile for BMI at 7 years of age had a 3.6 times greater risk (CI: 2.0-6.3) of being in the same tertile at 15-years. Guo et al. (89) pooled data from four major American studies (Fels Longitudinal Study, Harvard Growth Study, Oakland Study and Guidance Study) to predict overweight status at age 35 from younger ages. Prediction was excellent at age 18 (r=0.7 in women, r=0.6 in men), good at age 13 (r=0.6 in girls, r=0.5 in boys) but then moderate at younger ages. The Child and Adolescent Trial for Cardiovascular Health Cohort Study (CATCH) was a shorter study, but a randomized controlled trial. In the CATCH follow-up study, 90% of students stayed within \pm 1 quintile of their BMI from third through eighth grade (108). Tracking for fat mass is similar to tracking for BMI. In the Amsterdam Growth & Health Longitudinal Study, 500 participants were followed from ages 13 to 32. The tracking coefficient for fat mass was fairly high (r=0.63, CI: 0.56-0.71) (110). Essentially, the theme from these studies in addition to others (116, 204) is that an unhealthy body weight, BMI or an excess amount of fat mass tracks from childhood on. However, the correlation improves if follow-up periods are close together or if tracking is examined post-adolescence. Children who become obese during or after puberty show the strongest tracking of BMI into adulthood (199). Thus, healthy eating and activity behaviors must be instilled beforehand and sustained throughout adolescence.

2.1.6 Consequences of childhood obesity

The psychological, medical and economic ramifications of obesity are evident in all facets of society. Furthermore, as the current generation of obese or overweight children transition into adulthood, the morbidity and mortality that stems from this disease has the potential to override the health care system.

2.1.6.1 Psychological

Children dealing with overweight or obesity experience negative psychological outcomes (58). They are more prone to depression and poor body image (58). In a longitudinal study by Lee et al. (119), the greatest concerns about body image and thinness were expressed by overweight children or children who had experienced an increase in BMI over a 6-year period. Issues of social acceptance and stigmatization are also greater among overweight or obese children as their weight status is wrongly associated with a variety of negative attributes, such as laziness and sloppiness (207). This makes it critical that methods for diagnosing obesity are highly specific and as unobtrusive as possible.

2.1.6.2 Medical

There is a significant relationship between overweight / obesity and cardiovascular disease. Some of the initial evidence for this came from the Framingham Heart Study. The study began in 1948 with 5,209 people aged 30-62 years. After 26 years of follow-up, each SD increment in relative body weight was associated with a 15% increase in the risk of cardiovascular events in men and a 22% rise in women (95). In children, the same trends exist as overweight / obese children are at high risk for subsequent coronary heart disease (78) and hypertension (198). In the Bogalusa Heart Study, 61% of overweight children 5- to 10- years of age had \geq 1 risk factor for CVD (77). Furthermore, overweight children in that study represented 80% of students with \geq 3 risk factors for CVD. Overweight

children were approximately 10 times more likely to have 2 risk factors and 43 times more likely to have 3 risk factors than children of normal weight (77). Further, the Bogalusa Heart Study (follow-up time of 22 years from childhood to adulthood) also showed that childhood fatness was a significant predictor of cardiac mass in adulthood (120). Increased cardiac mass, or left ventricular hypertrophy, can be caused by increased fatness and increased blood pressure, both of which are predictive of cardiovascular morbidity and mortality. Similar associations between poor cardiovascular profiles and weight were reported in The Fels Longitudinal Study (200). The Fels study examined 414 men and women ages 18 to 72 years. Average follow-up time ranged from four to 20 years. Findings from Fels showed that both men and women who had become overweight or maintained overweight (BMI>25 kg/m²) had higher blood pressure and poorer lipoprotein profiles than those who had maintained healthy weights. Moreover, in both sexes, the deterioration of the atherogenic profile was twice that of participants who had never been overweight. Although to my knowledge, no study has ever tracked participants from childhood into old age, there is mounting evidence that the relationship between excess body fat and CVD exists at all ages.

Diabetes is similar to cardiovascular disease in that they share many of the same risk factors. Until recently, Non-Insulin Dependent Diabetes Mellitus (NIDDM) was considered to be an adult disease. Now, for the first time ever, there is an emerging epidemic of NIDDM among youth (18, 168, 182). The phenomenon of NIDDM in youth was first noticed in Pima Indians 15-24 years of age when obese youth presented with Type II Diabetes and other obesityrelated chronic illnesses (195). Today, it is well established that apart from age, obesity is the greatest risk factor for diabetes (83, 104, 198). Furthermore, NIDDM appears to be especially pronounced among minority groups, including Hispanic American, Native American and African American children and adolescents (83). In another analysis of Bogulasa Heart Study data, subjects were tracked from adolescence to adulthood (mean follow-up time of 12-14 years). Subjects with adolescent-onset overweight were 5.4 times more likely to have elevated insulin levels compared to their leaner counterparts (205).

Perhaps the greatest cause for concern is the fact that risk factors for NIDDM and CVD in obese children tend to surface in clusters, creating a constellation of risk factors referred to as the Metabolic Syndrome, or Syndrome X. This syndrome includes the development of insulin resistance, hyperinsulinimea, dyslipidemia, and hypertension (18, 40). Physiological variables that are associated with the Metabolic Syndrome show stability over time. In the Aerobics Centre Longitudinal Study in Dallas, Texas, 48 individuals measured in adolescence were followed for approximately 11 years (66). Tracking was consistent over time for indicators of metabolic syndrome, including total cholesterol (r=0.62), triglycerides (r=0.54), mean arterial pressure (r=0.41), BMI (r=0.64) and waist circumference (r=0.79) (p<0.05 for all). Tracking of these indicators was also seen in the Quebec Family Study where adolescents were followed for 12 years (107) but fatness was measured by skinfold assessment (r=0.5-0.7). Both studies controlled for length of follow-up and the Quebec Family Study controlled for initial age. These findings were alarming as the presence of Metabolic Syndrome placed children at extreme risk for a plethora of future chronic diseases.

Jung states, "Obesity is not just a health risk but a disease" (104). It is associated with a host of other illnesses aside from CVD, NIDDM and Metabolic Syndrome. Obesity can lead to respiratory difficulties, including sleep apnea and hypoventilation (22). Risk of colorectal cancer in men and endometrial cancer in women are also increased in obese persons (104). A comprehensive list of risk factors and health consequences of obesity is provided (Table 1).

2.1.6.3 Economic

Lastly, obesity must be considered from an economic perspective. The direct costs of obesity stem primarily from health-care expenditures on diabetes, hypertension and cardiovascular disease. Indirect costs are far greater and are attributable to lost productivity, premature mortality, physician/hospital visits, and other intangible items (215). Birmingham et al. (27) estimated that in 1997, the direct cost of obesity in Canada was over \$1.8 billion. This represented 2.4% of all health care expenditures, the majority of which were attributable to hypertension, NIDDM and coronary heart disease.

Table 1.	Risk factors and health	outcomes related to	o obesity in youth.	Reproduced from Ball et al. ((18).
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Cardiovascular	 Dyslipidemia (increased total cholesterol, low-density lipoprotein-cholesterol, and triglycerides) Elevated systolic and diastolic blood pressure
Endocrine	 Insulin resistance Abnormal glucose metabolism Polycystic ovary syndrome
Gastroenterological	 Gallstone formation Hepatic steatosis
Lifestyle	 Low fitness and low physical activity Low movement competence High fruit juice/pop intake High television viewing Low socioeconomic status
Orthopedic	Accelerated growthBlount's Disease
Psychosocial	 Low self esteem and poor body-image Barophobia Low socioeconomic status
Pulmonary	 Asthma Sleep apnea Pickwickian syndrome
Persistence into adulthood	 The longer obesity is present in youth, the greater the probability that it will track later in to life.

2.2.1 Assessing body fatness

Monitoring child and adolescent development is imperative as it ensures that parents or health practitioners can identify (and intervene) when a child deviates from a healthy weight trajectory. In the following section, I will explore various methods of assessing and classifying 'healthy trajectories' of body fatness in children.

2.2.1.1 Body mass index (BMI)

Body Mass Index (weight / height²) has been globally applied as a tool for estimating overweight and obesity in both child and adult populations. Determining BMI is practical, inexpensive, non-intrusive and easy to ascertain. For these reasons, it is the most commonly used proxy measure of body fatness obtained in clinical practice or epidemiological studies (177). BMI has been validated with DXA in children (ages 4-11 years) and correlates well with percent body fat in biracial samples (r=0.71-0.87) (84, 90). Correlations in these studies and others (52) are typically higher in girls than in boys. Still, there are a number of limitations to adopting and applying this index.

Firstly, although BMI accounts for weight relative to height, excess weight does not always imply excess fat. Body weight is dependent on the composition of fat mass, fat-free mass and bone and BMI does not take capture these individual components (52, 177). Many studies have found that BMI is better correlated with fat mass in relatively fatter children (80, 196). In thinner children, differences in BMI are largely due to differences in fat-free mass. Relationships between body composition and BMI are then further complicated by the differences that exist between individuals of different sex, age and ethnicity (196). Ellis et al. (68) found that the relationship between BMI and % fat was sex- and ethnicity-dependent. At any given BMI, the BMI-% fat relationship was higher among women. Furthermore, within sex, at a given BMI, African-Americans had lower % fat than Caucasians while Hispanics had greater % fat. Schaefer et al. (196) showed that the relationship between BMI and % fat in pubertal boys deteriorated when maturity status was not controlled for.

2.2.1.2 Dual-energy x-ray absorptiometry (DXA)

Dual-energy X-ray Absorptiometry (DXA) is considered to be one of the best direct measurements of assessing adiposity (72). As DXA passes over the whole body, each pixel's R-value is captured and then used to build three compartments; bone, fat mass (FM) and lean mass (LM) (Figure 2) (165). Percent fat mass is determined using the following equation (217): % Fat mass = [fat mass / (fat mass + bone-free lean tissue mass + bone mineral content)] * 100.

Although some studies estimated the reproducibility of % fat in children, comparisons with this thesis are difficult due to differences in DXA systems and software, age ranges and ethnicities. Three main studies emerge as the most

relevant to the present thesis. Gutin et al. (90) examined reproducibility in 43 African-American or Caucasian children (ages 9-11 years). Using the Hologic QDR-2000, the intracluster correlation (ICC) was 0.998. Litaker et al. (121) used the Hologic QDR-4500 and found an ICC of 0.998 for percent body fat in children (ages 13-18 years) receiving 3 scans in one morning. Most recently, investigators using the Lunar-Prodigy DXA machine found high precision in 49 children ages 5-17 years (ICC=0.997, CV=1.82%) (138). The Bone Health Research Lab at Vancouver General Hospital houses a Hologic QDR-4500W. The reproducibility of % fat in this machine in 15 adults (ages 27-50) was 1.9% (unpublished data). In all cases, it is evident that DXA's provides very precise estimates of % body fat. DXA accuracy has been determined in pig-carcass studies (169), as well as pediatric studies (45, 69). It is a safe, non-invasive instrument with an effective radiation dose of no more than 9.6 µSv per whole body scan, an extremely low dose (29). Regional assessments are also available.

In the past, different concerns over DXA's ability to handle tissue hydration and attenuation have been expressed. Infants and younger children tend to have high and rapidly changing hydration levels. However, DXA assumes a constant tissue hydration of 73% (118). Regardless, the magnitude of this error is small and does not represent a significant limitation to the DXA technique (167). Further, tissue attenuation in subjects with greater tissue depth, such as obese subjects, is believed to be a source of error as at tissue depths greater than 20 - 25 cm, the amount of fat can be overestimated due to increased attenuation. However, newer software has been able to sufficiently overcome these challenges (118).



Figure 2. DXA 3-compartment model. Reproduced from Pietrobelli et al. (165).

DXA has not been used in many pediatric intervention studies due to its considerable cost and the expertise that is required to obtain and analyze scans (72). DXA has evolved from pencil to fan-beam technology. Although the fanbeam has improved image resolution and decreased scan time, it is more difficult to compare results between studies due to the differences in system design. Systematic errors can also occur due to differences between manufacturer, model, phantom and software algorithm (28, 79).

2.2.2 Classifying adiposity

Unlike adults, children are continually growing in a pattern that varies by sex and maturity. This creates a unique situation where pediatric researchers are constantly measuring a "moving" target. In epidemiological studies that measure change in BMI over time, finding the best way to quantify this change is essential. Growth charts produced by the CDC and the classification system developed by the International Obesity Task Force are two ways that researchers have attempted to classify children. I describe these approaches in detail in the following sections.

2.2.2.1 CDC standards

In adults, a BMI between 18.5 kg/m² and 25 kg/m² is considered healthy and represents a weight that is at low risk for chronic disease. A BMI equal to or greater than 25 kg/m² is classified as *overweight* and a BMI greater than or equal to 30 kg/m² is classified as *obesity*. *Extreme* or *morbid* obesity refers to a BMI of 40 kg/m² or more (94). These cut-offs are based on evidence of increased mortality with a BMI greater than 25 kg/m². The increase in risk is modest until a BMI of 30 kg/m² is reached, at which point all-cause mortality rates, especially from cardiovascular disease are substantially elevated (12, 137, 227).

In children, BMI must be used differently as children experience periods of rapid growth and change that are ageand sex-specific (114). Thus, BMI is referred to as 'BMI-for-age' in children. In order to interpret BMI scores in children, individual values for BMI are plotted on age- and sex-specific growth charts. The growth charts that dominate pediatrics are supplied by the American Centre for Disease Control (CDC) and are based on five national data sets collected from 1963 to 1994 (114) (Appendices 1 and 2). Data from recent NHANES surveys in the United States have been excluded from these charts because the increase in childhood BMI-for-age would shift the curve upwards, establishing a new, higher 'norm' for overweight compared to years past.

BMI-for-age classifications from these charts are then interpreted based on percentiles that track body size throughout childhood and adolescence. The CDC classifies children at or above the 85th percentile as *at risk of overweight* compared to norms and *overweight* as at or above the 95th percentile compared to norms (Table 2). These categories were chosen based on recommendations made by an expert committee that aimed to increase specificity as much as possible when classifying children (22). Furthermore, a BMI \geq 95th percentile corresponds to

an adult BMI of 30 in late adolescence, and a BMI \geq 30 kg/m² is linked to adverse health profiles (98, 103). A child with a BMI-for age that is \geq 95th percentile should be red-flagged for medical attention, as this excess weight could pose serious health risks. A child with a BMI-for-age between the 85th and 95th percentiles should be investigated for risk factors of obesity and then closely monitored. For children under 2 years of age, there are no BMI-for-age references and thus overweight is defined as at or above the 95th percentile of weight-for-length (160).

Despite their broad usage, the CDC curves have drawn considerable criticism. The threshold cut-offs of the 85th and 95th percentiles are believed to be somewhat arbitrary as there is not sufficient evidence to link these classifications to an increased risk of child or adult chronic disease (48). Furthermore, by the very nature of percentiles, the prevalence of overweight is set- 5% of the population will always be overweight if the 95th percentile is used as the definition. Lastly, it is difficult to justify using these normative US-based curves for comparison as pediatric populations from other countries may have a different tempo and timing of growth in body size (171).

Table 2.	Classification of body s	size according to BN	/II-for-age location	on centile curve.	Reproduced from	the CDC
(9).						

Classification	Interpretation
Underweight	BMI-for-age < 5 th percentile
Normal	BMI-for-age between 5th and 85th percentile
At risk of overweight	BMI-for-age between 85 th and 95 th percentile
Overweight	BMI-for-age ≥ 95 th percentile

2.2.2.2 International obesity task force approach

In 1999, the International Obesity Task Force (IOTF) held a workshop to discuss classification of BMI in children. The IOTF proposed linking the adult cut-off points for overweight (BMI=25 kg/m²) and obesity (BMI=30 kg/m²) to BMI centiles for children. Children tend to retain the same percentile rankings as they age and BMI of 25 kg/m² and 30 kg/m² correspond to the 80th and 95th percentiles respectively, in 18-year olds (26). Cole et al. (48) proposed age-and sex-specific cut-offs by combining cross-sectional data from six countries (Brazil, Great Britain, USA, Hong Kong, Netherlands and Singapore). The purpose was to create international standards that could be used to compare obesity prevalence between countries. Ideally, they would be of greater value because they were linked to adult BMI that signified health risks, as opposed to arbitrary cut-offs, such as the 85th percentile in the CDC's classification (14, 48). The approach was more holistic, with the goal of uniting the adult and child definitions (15) (Table 3). Furthermore, this approach was easier to use and understand than growth charts and percentiles.

	Body Mass Index 25 kg/m ²		Body Mass Index 30 kg/m ²	
Age (years)	Male	Female	Male	Female
2	18.41	18.02	20.09	19.81
4	17.55	17.28	19.29	19.15
6	17.55	17.34	19.78	19.65
8	18.44	18.35	21.60	21.57
10	19.84	19.86	24.00	24.11
12	21.22	21.68	26.02	26.67
14	22.62	23.34	27.63	28.57
16	23.90	24.37	28.88	29.43
18	25	25	30	30

Table 3. IOTF cut-offs for children ages 2-18, corresponding to adult BMIs of 25/30 kg/m2. Actual cut-offs are available in 6-month intervals. Reproduced from Cole et al. (48).

Although the idea was novel and practical for epidemiological purposes, numerous studies found that the prevalence rate of obesity when using the IOTF definitions was consistently lower when compared to other definitions. A study by Reilly et al. (177) classified all children (age 7) within the top 5% of the distribution of % body fat (by BIA) as having excess body fat. Then, they compared the sensitivity and specificity of the IOTF approach to this definition. The IOTF approach showed a sensitivity of 46% in boys and 72% in girls (p<0.001). A study in Singaporean Chinese children (ages 6-11 years) found the IOTF classifications had a sensitivity of 83% in boys in 67% in girls when compared to similar definitions for obesity using Bioelectrical Impedance Analysis (BIA) (NS) (81). Poor sensitivity has tremendous impact on screening and surveillance as overweight/obese children may not be properly identified, leaving them susceptible to the long-term consequences of early obesity. Furthermore, the prevalence of overweight/obesity will be underestimated.

In addition to these limitations, body composition varies greatly between countries and ethnic groups (Section 2.1.3.2) (56). Although the IOTF approach is somewhat representative of an international sample, it fails to adequately represent populations from Asia and other non-western parts of the world (81). Lastly, although a BMI of 25 and 30 kg/m² is related to health risk in adulthood, in children these extrapolated cut-offs may not represent the same health consequences (48).

2.2.2.3 A comparison of CDC with IOTF

Choosing the most appropriate method of classification and assessment of overweight/obesity depends on a variety of factors. Janssen et al. (100) examined the ability of the IOTF and CDC classification systems to predict adult

disease from childhood overweight. Both methods had low sensitivity and high specificity for predicting metabolic disorders in young adulthood. There appears to be an emerging consensus in the literature that for clinical use, as a screening tool, population-specific curves such as those produced by the CDC are recommended. A 2004 Canadian public policy statement recommended that the CDC charts be used as reference curves in clinical practice to enable comparison of all of a child's anthropometric measures (ie. height, weight, BMI-for-age) to a norm (14). However, to compare prevalence rates between countries in epidemiological studies, the IOTF approach is preferred (14).

2.2.2.4 Population-specific growth curves

Numerous countries, including Singapore, Japan, and Australia have developed their own population-specific BMI growth curves. Cut-off points used to define obesity vary between countries. Rather than the 95th percentile (used in the United States), other countries use the 90th or 97th percentiles to distinguish overweight/obese children from normal weight children (99). However, the basis for establishing these curves and cut-off values will not be explored in this thesis.

2.2.2.5 % Body fat by DXA

There is a clear lack of research on % body fat cut-offs (by DXA) to classify overweight and obesity in children. Furthermore, to my knowledge, only one study has determined DXA-based cut-offs that are associated with cardiovascular risk. Higgins et al. (96) found that a DXA cut-off of \geq 33% body fat in pre-pubertal children demonstrated good sensitivity and specificity and was indicative of cardiovascular risk. Children (aged 4-11 years) with \geq 33% body fat were ~15 times more likely to have cardiovascular risk factors (ie. elevated cholesterol, triglycerides, blood pressure) than other children. This study also showed that children with <20% body fat were at low risk for cardiovascular disease. However, to my knowledge, similar studies have not been conducted at other maturational time points.

Others have attempted to create % body fat reference ranges for estimating overweight and obesity in children. Using this approach, children with a % body fat between the 85th and 95th percentiles (based on the study cohort) were classified as having 'excess body fat', and above the 95th percentile classified as 'obese' (68). Actual % body fat values were sex, age and ethnic dependent and so are not discussed here. Ellis et al. (67) used similar DXA cut-offs; % body fat of >25% but <35% indicated 'overweight' and \geq 35% indicated 'obesity.' Two other studies established similar cut-offs but used prediction equations developed from skinfold techniques rather than DXA measures of fat mass (65, 236).

2.2.3 Clinical diagnosis of the obese child

Methodological issues aside, clinical diagnosis of an obese child encompasses far more than knowledge of BMI. For epidemiological purposes, these classification schemas are sufficient and can be used to guide public health efforts and policy. However, they are not diagnostic tools. In clinical evaluations these classification techniques are simply

preliminary steps that must be taken, and which provide a framework for further investigation. Family history, comorbidity, health history and skinfold thickness are just a few of the areas which would also merit extensive evaluation by a trained clinician (14).

2.3 Physical Activity in Children

In nearly every animal species, the young are the most active population. Humans are no different. While adults can stimulate their central nervous system (CNS) through non-locomotor activities such as reading and problem solving, children require physical activity to stimulate their CNS and provide it with important information related to daily living (234). Thus, children have an inherent need to be active. In the next section I will explore the concept of physical activity and the many determinants, correlates and outcomes of a physically active lifestyle.

2.3.1 Defining physical activity, exercise and physical fitness

According to the CDC in the United States (10), physical activity is defined as 'any bodily movement produced by skeletal muscles that results in an expenditure of energy'. Further to this, exercise is a sub-category of physical activity that involves 'planned, structured and repetitive movements done to improve or maintain one or more components of physical fitness' (44). Physical fitness, however, refers to a 'multi-component trait related to the ability to perform physical activity' (4). Physical fitness is an *outcome*, whereas physical activity is a *process*. This thesis focuses on physical activity.

2.3.2 Distinguishing physical activity from physical inactivity

Physical activity is not simply the opposite of physical *inactivity*. Simply stated, the definition of physical inactivity is 'not engaging in any regular pattern of physical activity beyond daily functioning'(10). This refers to all things done while sedentary. Therefore, television viewing, video game playing and computer usage all constitute physically inactive choices.

2.3.3 Physical activity among children

Low levels of physical activity are prevalent among children (112). In fact, society has reached a point where children can now easily lead an entirely sedentary lifestyle (221). Instead of walking to school, children get rides from parents or take the bus. Instead of playing outside during leisure-time, children are more likely to play computer games or watch television (224). Due to reduced budgets and less resources combined with a greater emphasis on academics, there is less time devoted to physical education (127). In a unique Canadian study by Tremblay et al. (221), activity behaviors and physical fitness of Old Order Mennonites (OOMs) who had maintained a traditional way of living were compared to Canadian children leading a contemporary, modern lifestyle. As hypothesized by the researchers and as shown in the findings, the OOMs were fitter and more physically active. This result suggested that social change and westernization were contributors to declining levels of physical activity. An Australian study found that from 1985-2001, the frequency of walking or cycling to and from school, as well as the frequency of PE class declined (p<0.001 for all) for students 9-13 years within high and low socioeconomic areas (194). Numerous other studies, both cross-

sectional (231) and longitudinal (112), also demonstrated declining levels of physical activity. Since 1981, the Canada Fitness and Lifestyle Research Institute (CFLRI) has conducted survey monitors of self-reported (or parental reported) physical activity. Based on these surveys, children that are 'active enough' expend at least 8 kilocalories per kilogram of body weight per day. From the 2000 monitor, over one half (57%) of Canadian children and youth ages 5-17 were not considered 'active enough' for optimal health (11). Thus, these children are not receiving the health benefits and protection from disease that are afforded by physical activity.

2.3.4 Determinants of physical activity

Before we can design effective interventions to increase physical activity, it is important to clearly understand the determinants of physical activity in children. Many of these determinants are similar to the determinants of obesity and I will discuss them in the following section.

2.3.4.1 Non-modifiable determinants

One of the few consistent findings in the literature relates to the differences in physical activity levels between boys and girls. Boys are continuously more active than girls (193, 212). The CFLRI physical activity monitors have also consistently found boys to more active than girls, with only 38% of girls being 'active enough' in 2000, compared to 48% of boys (11). The PATHWAYS study of children aged 7-8 years at baseline was one of many longitudinal studies that found that boys were significantly more active than girls both at baseline and follow-up (3 years later) (82).

That said, it is difficult to compare sexes as girls mature earlier than boys, and so the confounds of puberty must be disentangled when comparing across sexes. In a study by Thompson et al. (219), sex differences were evident when physical activity levels among children (aged 9-18 years) were compared on the basis of chronological age, but disappeared when biological age (maturity level) was taken into account. Thus, the cultural and behavioral factors associated with puberty and adolescence may be more telling than age alone.

Tying in to the discussion of maturity is the concept of age-related decline in physical activity. As children grow, they experience a decline in habitual levels of physical activity that persists into adulthood (11, 159, 187). To illustrate, in the Bogalusa Heart Study (children aged 5-8 years), there was a decrease in total physical activity (assessed by 24-hour recall) with increasing grade level in school (p<0.0001) (151). This noticeable decline, specifically around the time of adolescence, can be explained by a myriad of developmental, psychological and social factors. Aside from the physical changes that occur during adolescence, children also experience changing interests in leisure-time pursuits (away from physical activity and sports), increased peer influence, greater time away from home and reduced parental involvement in their leisure-time affairs (135).

Children of ethnic minorities appear to face additional barriers that prevent them from becoming physically active. O'Loughlin et al. (159) conducted a large study in multi-ethnic, inner-city, low income neighborhoods in Montreal, Canada. Results showed that Asian children were consistently less active than non-Asian children. In a subsequent study, one-year predictors of decline in physical activity of boys included being of Asian origin (OR=1.81) and being born outside of Canada (OR=2.13) (23). Children and adolescents from ethnic minorities, specifically American Indians (213), African Americans (151) and Hispanics (38) are consistently less active. This was also evident in two major cross-sectional studies of the correlates of physical activity (37, 193).

2.3.4.2 Modifiable determinants

The environmental determinants of physical activity are numerous and include such correlates as sedentary activities, media usage and lack of resources or safe places to play in the physical environment. Currently, advances in technology and transportation have obliterated the need for physical activity (97). The effects of other determinants on childhood health, such as sedentary activities were explored in Section 2.1.3.2. Other modifiable determinants of physical activity, such as leisure-time correlates and PE class are discussed later on in this section.

2.3.5 Importance of an active lifestyle

2.3.5.1 Healthy weights

Although the etiology of childhood obesity is complex, many studies found support for the inverse association between body fatness and physical activity (112, 150, 190). Kimm et al. (112) followed African-American and Caucasian girls (ages 9 and 10 years) enrolled in the National Heart, Lung, and Blood Institute's Growth and Health Study (NGHS) for 10 years. Results from this prospective bi-racial, multi-centre study, published in *Lancet*, showed that with each reduction in 10-MET-times / week, there was an associated increase in BMI of 0.14 kg/m² (after controlling for race). Similarly, the 8-year follow-up of the Framingham Children's Study found that children in the highest tertile of average daily activity from ages 4-11 years had substantially less body fat by early adolescence (150). Although there is a great deal of research on this topic, it is nevertheless difficult to compare studies as physical activity, overweight and obesity were often assessed and classified differently. Additionally, confounding around the pubertal years was often not controlled in the analysis.

However, some compelling evidence exists for the relationship between physical *inactivity* and body fatness. This was discussed at length in Section 2.1.3.2.

2.3.5.2 Prevention of disease

In addition to having a positive effect on body weight, physical activity also has many other positive health benefits. Aside from the more obvious benefits of increased energy and strength, physical activity offers protection from cardiovascular disease and can improve lipid levels, blood pressure and glucose tolerance (17, 83, 127). The Cardiovascular Risk in Young Finns Study followed adolescents (aged 12, 15 and 18 years) for six years and

assessed physical activity by questionnaire (173). Serum triglycerides in both sexes and serum insulin in men were significantly lower in participants who had remained active throughout the entire time compared with those who had not. Results from the Quebec Family Study also showed inverse relationships between the levels of habitual physical activity and risk factors for CVD (including mean arterial pressure, triglycerides, cholesterol and glucose levels) (106). Physical activity can decrease insulin resistance, reduce risk of NIDDM and CVD, potentially through a decrease in fat or an increase in fitness (83). Even without a change in body fat, physical activity can still improve insulin efficacy (109).

2.3.6 Current recommendations and guidelines

Numerous agencies provide guidelines for recommended amounts of physical activity. In Canada, the Physical Activity Guides for Children provide national guidelines for children and youth (1). The guide for children recommends increasing current physical activity levels by 30 minutes more each day *as well* as reducing current physical inactivity by 30 minutes less daily. The total amount of time depends on the intensity- 60 minutes of low intensity physical activity/day or 20-30 minutes of vigorous physical activity/day (1). Further to this, they suggest accumulating bouts of activity in 5-10 minute periods throughout the day.

In the United States, the 2005 Dietary Guidelines for Americans state that all children should be physically active for at least 60 minutes on most, if not all days of the week (4). These 60 minutes should include moderate-to-vigorous physical activity and can be attained through intermittent bouts of activity throughout the day.

The guidelines stated above are recommended for health benefits. However, no prospective, randomized controlled study has yet determined a precise quantity of physical activity that is sufficient to provide maximal health benefits and curb weight gain in children and adolescents.

2.3.7 Current opportunities for physical activity in children

2.3.7.1 Physical education class

Physical education (PE) classes do not provide enough opportunities for moderate-to-vigorous physical activity (74). Simons-Morton et al. (202) found that 68.1% of time in a fifth grade physical education class was spent in sedentary activity. Furthermore, it was a substantial concern because for many students, PE represented the only opportunity throughout the week for physical activity. In 2000, the American Centre for Disease Control published the most recent School Health Policies and Program Study (SHPPS) report (13). According to SHPPS, only 8% of elementary schools and 6% of middle/junior high schools provided daily PE (or its equivalent). Furthermore, elementary school children only spent about 6% of their PE class time engaging in aerobic activity (127). In British Columbia, the numbers were slightly better but still a cause for concern. Only 25% of elementary schools devoted the recommended 10% of curriculum time to physical education (6). Approximately 80 minutes/week of physical
education were delivered and 30 minutes of that time was spent in class management (providing no physical activity time). Only three BC school districts employed PE specialists.

2.3.7.2 Leisure-time physical activity

Leisure-time physical activity opportunities for children exist outside of classroom time and PE class. Children's choices are influenced by access to community/school programs and equipment, availability of before- and after-school sports as well as safe and supervised environments and facilities. In a study of the environmental determinants of physical activity in middle school, fewer than 2% of girls and 6% of boys chose to be active during their free time (189). This was associated with an absence of supports such as adequate recreational equipment and adult supervision. Another observational study in 24 middle schools found only 1/5 of the student population visited activity areas during lunch time (143). It was concluded that changes in school and student environment were necessary to increase participation in leisure-time physical activity. More equipment, supervision and structured programs were posited as tools to engage more children in physical activity (143)

2.3.8 Tracking of physical activity from childhood through to adulthood

Unlike body fatness, physical activity does not track strongly throughout life. Extensive reviews by Livingstone et al. (122) and Malina (134) have confirmed that physical activity-related behaviors do not track strongly into adolescence and adulthood. Pate et al. (162) examined the tracking of physical activity in 47 children (ages 3-4 years) over a 3-year period and found that physical activity tracked well in early childhood as Spearman rank order correlations were above moderate (r=0.57-0.66). However, from childhood to adulthood, tracking studies have shown weak to moderate correlations at best. Data from the 1958 British Cohort Study (31-year follow-up) (161) and the Cardiovascular Risk in Young Finns Study (21-year follow-up) (218) both showed tracking coefficients that ranged from r=0.31-0.44 in men and r=0.14-0.26 in women. Participants were all ages 9-11 at baseline. In the 21-year Trois-Rivieres Study, participants were 10-12 years of age at baseline. At follow-up, the correlation between child and adult physical activity levels was also low (r=0.2). The Muscatine Study was a 5-year study of 147 boys and girls between 10 and 11 years old at baseline (101). Correlations for vigorous physical activity were low to moderate (r=0.32-0.43 in boys and girls) and were higher with decreased follow-up time. However, boys who were classified as sedentary at baseline (based on tv/video recall) were 2.2 times more likely to be classified as sedentary at follow-up. Thirty-six percent of 'active' boys and 42% of 'active' girls maintained their positions in the highest tertile for vigorous physical activity throughout the study.

If the objective of a physical activity intervention is to give children the skills they need to be active throughout life, then it is important to examine the reasons why physical activity may not track well over time. Several factors will attenuate tracking coefficients over time. As children mature, levels of habitual physical activity tend to decline with age (83, 162). Patterns of activity change dramatically during adolescence when marked physiological changes occur and between ages 18 and 24 when many individuals become independent (228). Lengthy time intervals between

measurement periods can also weaken the correlation. Finally, the stability of physical activity as a trait is poor (134, 209). More specifically, the words 'mild, moderate and intense exercise' mean different things to people at different ages throughout their life.

Thus, the combination of unhealthy weight that tracks into adulthood (112) and physical activity levels that tend to decline with age supports the greater likelihood of adult obesity and morbidity. Ideally, health-related behaviors should be well-established prior to adolescence and then stand the test of time. Early intervention has emerged consistently in the literature as childhood may be the opportune time to promote healthy living.

2.3.9 Economic costs of physical inactivity

The economic burden of physical inactivity is large. Katzmarzyk and Janssen (105) estimated that the combined direct and indirect cost of physical inactivity in Canada in 2001 was approximately \$5.3 billion. This amounted to 2.6% of total health care costs. A recent study in the United States found that approximately 9.2 million incident cases of cardiovascular disease were associated with physical inactivity. This translated to 23.7 billions dollars (US) of direct health care expenditure (232).

2.4 Quantifying Physical Activity in Children

Quantifying physical activity in children is a challenging task. Unlike adults, children are more likely to accumulate physical activity in intermittent bouts rather than single bouts throughout the day. In addition, elementary school children are generally concrete thinkers, making it difficult to rely on self-report (234). Thus, finding the best way to measure this variable can be difficult.

Criterion measures, secondary measures and subjective measures have all been used to assess physical activity in children (Figure 3). However, the 'accuracy-practicality' tradeoff must always be taken into account as in general, the more accurate measures are less feasible (and vice-versa). In the following section I will outline various methods of quantifying physical activity as well as some key issues associated with utilizing these techniques.



Figure 3. Validation of physical activity schema, including the "accuracy – practicality" tradeoff (234). Dash arrows from left to right imply a decreasing accuracy gradient for assessment of physical activity. Curved arrows from right to left refer to order of validation (eg. Subjective measures can only be validated with more accurate measures). Schema adapted from Sirard et al. (203).

2.4.1 Criterion standards

The term 'criterion standard' or 'gold standard' refers to those techniques that provide the most accurate assessments of physical activity. These methods include direct observation, doubly labeled water (DLW) and indirect calorimetry. Since most large-scale, school-based interventions do not employ DLW or indirect calorimetry, I will not discuss these techniques in this thesis.

2.4.1.1 Direct observation

The instrument that is most commonly used in the literature to directly observe physical activity in children is the System for Observing Fitness Instruction Time (SOFIT). The SOFIT was developed by McKenzie et al. (146) and correlates highly with heart rate monitors (183) and CALTRAC accelerometry (145). The SOFIT method involves 10-

second momentary time sampling in PE class by a trained observer. Activity periods are then coded using five mutually exclusive categories that distinguish sedentary from active behaviors. Although highly accurate, direct observation is impractical for large-scale surveillance (197). Direct observation is also susceptible to subject reactivity as children see the measurers present. Lastly, it represents a significant burden for the observer as accuracy and consistency of recordings depends solely on one person (203).

2.4.2 Secondary / Objective measures

Heart rate monitors and motion sensors are the most commonly used objective measures of physical activity. Motion sensors include pedometers, uniaxial and triaxial accelerometers. Although they do provide objective evidence, these instruments cannot be worn in water or in contact sports, are subject to mechanical failure, and are dependent on subjects remembering to wear them (50).

2.4.2.1 Heart rate monitors

Heart rate monitors rely on the assumption that a linear relationship exists between heart rate and oxygen consumption (V0₂). The monitors can be used to assess patterns of activity and are cost-effective and unobtrusive (203). However, during low intensity exercise, the HR - V0₂ relationship is not as robust as heart rate can be affected by physiological factors (such as stress) or environmental factors (such as caffeine) that are unrelated to movement. Furthermore, changes in heart rate lag behind changes in movement. This is relevant because children's physical activity patterns are typically intermittent (184).

2.4.2.2 Pedometers

Pedometers are springs that measure vertical oscillations and provide a total step count for a given time period. Output is then displayed in steps/day or total steps taken. Pedometers are designed to be worn on the hip and are ideal due to the low-cost and lack of expertise that is required in using them. For these reasons, they offer an attractive approach in large-scale epidemiological studies. Newer models have also improved accuracy and precision considerably. Scruggs et al. (197) validated Yamax Digi-walker pedometers using direct observation (C-SOFIT) in 410 1st and 2nd grade students. The pedometer was found to be a good indicator of MVPA (r=0.74-0.86). Bassett et al. (25) also found the Yamax Digiwalker to be accurate, recording 100.7% and 100.6% of steps taken on the left and right sides, respectively. (70). Nevertheless, pedometry does have its limitations. Because of its two-dimensionality, pedometers are not ideal for distinguishing between intensity levels or patterns of activity (eg. moderate versus intense, daytime versus evening) (203). They also cannot assess activity done in the horizontal plane, such as cycling or throwing (234).

2.4.2.3 Accelerometers

Accelerometers measure accelerations produced by ambulatory movement. They use piezo-electric transducers to detect movement and microprocessors to convert the accelerations into 'counts' (203). The development of triaxial accelerometers marked a significant advance as it allowed for the assessment of movement in three dimensions, or

volume of movement. Furthermore, when biodata such as height and weight are provided, energy expenditure can be estimated.

Sirard and Pate (203) did a review of accelerometer validation studies and found that across all age groups, both the CSA uniaxial (Computer Science and Applications, Inc., Shalimar, FL) and Tritrac-R3D® triaxial (Professional Products, Reining International, Madison, WI) accelerometers showed moderate to high reliability (r= 0.69 - 0.94) with criterion measures (oxygen consumption (V0₂) and direct observation). Eston et al. (70) found that when comparing the accuracy of heart rate monitoring, pedometry, uniaxial and triaxial accelerometry in thirty children doing daily activities (such as playing hopscotch, in addition to running and walking on a treadmill), triaxial accelerometers accounted for more variance (82.5%) in V0₂ than any other measure. Interestingly, both heart rate monitors and hip pedometers accounted for 80.2% of the variance, making this alternative only *slightly* less accurate but much more practical from an economic and epidemiological perspective.

2.4.3 Subjective measures

Secondary measures of physical activity include interviews, questionnaires and diaries. As only self-report questionnaires are relevant to thesis, they alone will be discussed below.

2.4.3.1 Self-report questionnaires

Self-report questionnaires are the most common subjective techniques used to quantify physical activity in children. They are inexpensive, require little expertise to administer, and are a feasible way to collect information on large numbers of children in short periods of time. Previous-day recall instruments are generally preferred so as to increase the likelihood that child will accurately recall information. However, the questionnaire must then be administered on multiple days in order to account for intra-individual variability (234). Further to this, self-report instruments are often associated with an overestimation of activity. For example, a child may indicate that he/she played a soccer game yesterday, when in fact they were only active for a quarter of the game. Children may not perceive time and effort in the same manner as adults. This misperception may be attributed to the fact that children think more concretely than adults or that children's activity levels are typically intermittent in nature (234).

The Physical Activity Questionnaire for Children (PAQ-C), a self-report questionnaire, was developed by Crocker et al. (49) to measure habitual moderate-to-vigorous physical activity (MVPA) through 7-day recall. It provides timerelated memory cues (eg. recess, lunch, evening) to help children in Grades 4 and above recall information. The PAQ-C is geared for administration 3 times / year (3 seasons / year) to account for variability in seasons. The original questionnaire consisted of 10 items but the Bone Health Research Group has modified it to consist of 12 items, 9 of which are marked on a five-point scale and form composites of a summary activity score (1=low active, 5= high active). MVPA is defined as 'sports, games, or dance that make you breathe hard, make your legs feel tired or make you sweat.' Question 1 on the PAQ-C provides information on the minutes/day of physical activity.

The PAQ-C has acceptable 1-week reliability (r=0.75 for boys, r=0.82 for girls) (49) and has been validated against other self-administered and interview-administered physical activity measures, as well as Caltrac accelerometers (50, 113). However, it does not provide an estimate of energy expenditure, nor does it discriminate between moderate and vigorous physical activity (50). Lastly, the use of a weighted (1-5) scoring system means that all activities are given the same weight, regardless of the time of day or type of activity undertaken.

2.5.1 Rationale for school-based intervention

Previous approaches to promoting physical activity and healthy body weights have often not accounted for the plethora of environmental factors that affect behavior. The school is an integral component of a child's environment and offers an excellent venue for reaching the greatest number of children from the most diverse ethnic and socioeconomic backgrounds. School-based approaches can intervene formally through curriculum, but also informally through school meals, snacks, classroom and after-school opportunities (185). Children are in school for 10 months of every year and are engaged in a variety of activities throughout this time, making the school an obvious institution in which to combat childhood obesity (188).

Nevertheless, it is important to understand that school-based models are not meant to create dramatic change in children who are morbidly obese. This population requires clinical intervention that is much more intensive than can be provided by a school-based health intervention.

2.5.2 Social theories underlying this approach

2.5.2.1 Ecological Systems Theory

To truly understand behaviors, individuals must be considered in terms of the *context*, or 'ecological niche', within which they exist (53). This niche includes many layers. For a child, it refers not only to the school and family, but also to the greater community and society in which the school and family are embedded (211). Interactions occur between and within layers. Characteristics, such as sex and age play important roles and are intertwined with and influenced by societal and communal events. Therefore, risk factors for overweight are shaped by individual attributes, people and events on many different levels. Relationships are bi-directional. The foundation of Ecological Systems Theory (EST) is built upon the notion that interactions between and within these contexts guide development in all facets of life (Figure 4).

It takes many years to change a gene pool. The fact that the epidemic of childhood obesity has arisen so quickly implicates the environment, more than genetics, as a causal factor. This means that interventions that change the *environment* must be an integral component of any strategy for change. Large-scale, ecological approaches that are manifested in every layer of society are essential if we are to properly treat or reduce obesity (178).



Figure 4. The many contexts of the ecological systems which are posited to be predictors of overweight during childhood. Modifiable childhood characteristics are shown in uppercase and non-modifiable characteristics are shown in italics. Reproduced from Davison et al. (53).

2.5.2.2 Social Cognitive Theory

Albert Bandura, one of the patriarchs of modern psychology, conceived the Social Cognitive Theory (SCT) in 1986 (21). SCT is based on the concept that human behavior is influenced by a dynamic interaction between environmental, behavioral and individual factors (20). In SCT, behavioral outcomes are largely mediated by cognitive processes – processes which change as humans mature and develop (21). In the context of health promotion, SCT involves examining a set of determinants (as well as the ways in which they operate), and translating them into effective health practices. These core determinants include *knowledge of health risks and benefits, perceived self-efficacy, outcome expectations, health goals and perceived facilitators* (19). Therefore, according to SCT, to be successful, an intervention must take into account these critical determinants.

Although both theories consider the various factors which affect behavior, the key difference between SCT and EST is the central focal point from which behaviors stem. In EST, behaviors are a result of the 'ecological niche' within which a person is immersed. However, SCT attributes behaviors to cognitive processes which form the construct of each individual's reality.

2.5.3 Comprehensive school health

Since the beginning of the 20th century, the school health program has consisted of three main components: school health education, environment and services. Extending this concept further captures the essence of a model which evolved in the late eighties and which is referred to as 'comprehensive school health'. Comprehensive school health includes the three traditional components mentioned above. However, it builds upon them to incorporate school food services, counseling, physical education, coordinated school and community efforts, and lastly, faculty/staff health promotion (16). These eight components are critical for health promotion within schools. To illustrate, when schools have safe, quality equipment for physical activity that is accessible to students more often, physical education becomes far more beneficial to students. Therefore, these components are synergistic and complementary. Together they provide more opportunities for students to be active than each component alone.

2.5.4 School-based interventions: reducing obesity through an increase in physical activity

Preventing or decreasing overweight or obesity is a difficult task. Recidivism related to diet or exercise regimens can occur during summer months and efforts to decrease body fat through physical activity can be negated if an increase in energy consumption occurs. In this last section, I will evaluate the various types of school-based interventions that have been employed in the past to reduce obesity / overweight through an increase in physical activity. All studies were randomized or cluster-randomized controlled trials (although a limited amount was quasi-experimental). All studies also took place in the general student population and were not restricted to overweight or obese students. Lastly, all studies involved students in elementary or middle school (Grades 3-8) at baseline. Details of the trials are presented (Table 4).

The Child and Adolescent Trial for Cardiovascular Health (CATCH) study merits the most in-depth discussion as it was the broadest, most comprehensive and generalizable study of its kind (126). At baseline, 5106 ethnically and geographically diverse third grade students (from 96 schools across 4 states) were randomized to either intervention or control status. Schools participating in CATCH were committed to offering 90-minutes (3, 30 minute classes) a week of physical education over 3 years. In addition, schools had to provide 20 extra hours per year of class time of health education that was related to CATCH goals and outcomes. The aim of the intervention was to increase the amount of time that students spent engaging in moderate-to-vigorous physical activity (MVPA) in PE class to 40% of class time. After 3 years, results showed a significant increase in intensity of physical activity in PE classes. CATCH schools were engaging in MVPA for 52% of PE class and had met the national objective of engaging students in MVPA for 50% of PE class. The CATCH study demonstrated the successfulness of a school-based health intervention that was designed to meet the specific needs and structures of schools. Furthermore, policies and practices of schools were altered without major changes to the school infrastructure. The CATCH team provided basic training to school staff and modest follow-up support (126, 144). However, despite all these positive changes, there was no difference in BMI between groups at follow-up.

Similar to CATCH, the PATHWAYS study was also a 3-year trial that involved 1,704 students from 41 schools across 7 American-Indian communities (39). PATHWAYS targeted the school environment, physical activity, family and food service industry in the school. Opportunities for PA were delivered through PE class and classroom lectures were provided in addition to the PE component. There was a trend for increased physical activity in intervention schools compared with control schools. However, there were still no significant differences in BMI or percent body fat (as measured by BIA) between groups. After two years, SPARK was able to increase the provision of moderate-to-vigorous physical activity to students (40 min/week and 33 min/week in intervention conditions compared with 18 min/week in the control condition, p<0.001) but again did not lead to a significant decrease in BMI in intervention students (relative to controls) (190).

It is difficult to compare studies because of differences in ethnicity, developmental stage and socioeconomic status among participants. These variables can have a significant impact on fatness. Furthermore, studies assess program fidelity in different ways, making it hard to determine if the lack of an effect is due to the intervention itself or poor implementation. Differences in methodology and instrumentation can also confound any true differences between studies. Regardless, it is important to understand as best as possible the reasons why so many interventions were not successful in reducing fatness. CATCH (128) was able to increase physical activity in PE class- but PE class represented a small window in a child's day. This may not have been enough to affect fatness and this approach was taken in both PATHWAYS (39) and SPARK (190). The PATHWAYS cohort was entirely American-Indian. Thus, there could have been a host of cultural factors that were affecting obesity in these communities that would have been less evident in an assimilated environment. However, the underlying cause for the lack of an effect may in fact be quite simple- body fat is resilient and difficult to change (39). Two or three years could simply not have been enough time for an effect to occur, especially because increases in physical activity were targeted only in PE class and were not accompanied by reductions in energy intake. BMI could also not have been a sensitive enough instrument to capture changes in body fatness. In addition, all three trials invoked either Social Cognitive or Social Learning Theory. Thus, the focus was on changing childhood the childhood behaviors that were requisite of increasing physical activity.

2.5.4.3 Gaps in the literature

Although much research has been done in this area, it seems that long-term studies with significant, positive outcomes related to body fat are rare. The majority of studies have used BMI as an outcome measure when % fat is a stronger indicator of fatness. Many interventions have been geared towards implementation by a PE specialist in PE class, when as discussed earlier, PE class represents a very small portion of a child's day. Consequently, some interventions have designed health lectures for generalist teachers. However, these lectures have been taught intermittently throughout the year and do not provide students with opportunities for physical activity on a daily basis. Lastly, most studies have been founded in social cognitive theory, without taking into account the social ecology of children.

Therefore, the literature points to the need for a school-based health intervention that aims to reduce childhood obesity through *daily* physical activity. The intervention needs to be built upon a socio-ecologic foundation that targets all children, regardless of skill level or background. Since the objective is to affect obesity, body fat should be measured with a highly accurate instrument that provides information on changes in body composition (specifically % fat) as opposed to changes in relative weight. Lastly, the theoretical framework indicates that all teachers should be given the tools and skill sets that are necessary for providing students with opportunities to be physically active. This would permit evaluation of a broad, all-encompassing approach to altering childhood obesity.

Table 4. School-based physical activity enhancement and obesity prevention trials. Only those outcomes relevant to this thesis are reported.

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Key: INT = intervention schools/students, CONT = control schools/students, CV= covariate, NS = non-significant, PA = physical activity, MVPA = moderate-to-vigorous physical activity, PE = physical education class, RCT= randomized controlled trial, QE= quasi-experimental, ECT= ecological systems theory, SCT= social cognitive theory, % BF= % body fat

First Author Project Country	Methods	Intervention	Statistical Approach	Results	Other
Gortmaker (1999) (88) Planet Health United States	 Design: RCT, 5 INT and 5 CONT schools, 2 year duration Subjects: 1,295 ethnically diverse students in Grades 6 & 7 at baseline Outcome(s): obesity prevalence/remission (defined by BMI (kg/m²) and a triceps skin-fold value (mm) greater than or equal to the age- and sex- specific 85th percentile) Outcome measures: BMI, triceps skinfold thickness (TST) 	 Theory/Concept: Behavioral Choice & Social Cognitive Theory Aim: to reduce the prevalence of obesity and increase remission Intervention: 16 lessons each year had to incorporate one of the major themes (such as increasing physical activity through setting behavioral objectives or decreasing time spent viewing television) Lessons were taught by classroom teachers in 4 major subjects and physical education. Sessions consisted of teacher or student resources, homework, setting behavioral objectives, classroom activities, or handouts. Thitu 5 min teacher or student 	 linear regression (separate for each sex) was used to predict obesity at follow- up (with CVs obesity, age, ethnicity, TSF and BMI at baseline) adjusted for school effect using generalized estimating equations 	Prevalence of obesity Female data: INT < CONT: (p = 0.03) Male data: NS Remission of obesity (using same definitions, adjusted for incidence): Female data: INT > CONT (p = 0.04) Male data: NS	Participation Rate: 65% of eligible students consented Follow-up: 83% Program Fidelity: Teacher reports showed that teachers provided approximately 3.5 lessons/ year. PE teachers completed 8.2 microunits / yr.

held in PE focusing on activity

First Author Project Country	Methods	Intervention	Statistical Approach	Results	Other
		and inactivity as well as self- assessment and goal setting. Control: Continued with usual practice.			
Vandongen (1995)(229) Australia	 Design: RCT, 9-months, 30 schools, 6 groups, 5 schools / group Subjects: 1,147 students, mean age = 11 years Outcome(s): Change in laps run, Change in run time (min), % body fat Outcome Measures: Leger shuttle run, 1.6 km run, skinfold measurements 	 Theory/Concept: unknown Aim: reduction of cardiovascular risk factors, including obesity/overweight, physical inactivity and poor nutrition Intervention: 6 groups: 1) fitness (FIT), 2) fitness + school nutrition (FIT + SN), 3) school nutrition (SN), 4) school + home nutrition (SN + HN), 5) home nutrition (SN + HN), 5) home nutrition (HN), and 6) control Fitness program was implemented for 15 min daily (in pre-planned lessons) and included interval training and slow intensity progression (eg. skipping, relays, running). Fitness component also included 6, 30-min classroom sessions about the importance of PA. 	 Regression (separate for sexes) for all outcome measures Adjusted for baseline measures on all outcomes 	Run time (min): FIT < CONT, FIT + SN < CONT (p < 0.05) for girls and boys Leger Score (laps): FIT < CONT, FIT + SN < CONT for girls and boys % Body Fat: NS BMI: NS TRICEPS SKINFOLD THICKNESS: FIT + SN < CONT (p < 0.05) SUBSCAPULAR SKINFOLD THICKNESS: NS	Participation Rate: 93% Follow-up: 92% Program Fidelity: none mentioned

First Author Project Country	Methods	Intervention	Statistical Approach	Results	Other
		Control: continued with usual school practice.			
Gortmaker (1999) (86) Eat Well and Keep Moving United States	 Design: QE, 2-yr, 6 intervention and 8 control schools Subjects: 479 children in 4th and 5th grade at baseline, 91% African American Outcome(s): dietary intake, hours/day of vigorous physical activity Outcome Measures: 24- hour food recall, Youth Physical Activity Questionnaire (YAQ) 	 Theory/Concept: SCT Aim: 1) to decrease intake of high-fat foods and increase fruit and vegetable intake 2) to reduce tv viewing to less than 2 hrs/ day, and 3) to increase MVPA Intervention: taught by generalist teachers 13 lessons / year on healthy living (3 of which involved physical activity) 5 PE lessons school campaigns were developed to reinforce the program themes (such as healthy eating, reducing tv time, increasing walking, etc) Control: continued with usual school practice. 	 Regression models (that accounted for clusters) with the variable of interest as the dependent variable Covariates included baseline value, sex, ethnicity, baseline energy intake. 	Vigorous Physical Activity: NS	 Participation Rate: 90% (absence from school (61%) and parent refusal (15%) listed as reasons for refusal). Follow-up: 66% Program Fidelity: 22/31 (71%) of lessons were completed. Other: Safety concerns, lack of facilities and minimal PE time may explain the NS result.
Yin (2005) (238)	Design: RCT, 3-year study but only 1 st 8 months are	Theory / Concept: ECT	 Mixed model ANCOVA with 	Change in % fat: NS	Participation Rate: 52%
MCG FitKid Project	reported,18 schools (9 INT, 9 CONT)	Aim: to increase MVPA during the 2-hr block of time after school	school as the random effect, change in % fat	However, significant differences were seen between groups when only	Follow-up: 92%

First Author Project Country	Methods	Intervention	Statistical Approach	Results	Other
United States	Subjects: 3 rd grade at baseline, 601 students, 61% African American, 31% Caucasian Outcome(s): change in % body fat Outcome measures: DXA	 Intervention: 2-hours / session Each session started with a 40-min "academic enrichment" period where students did homework and other academic endeavors 80-minute period then followed that included a 20-min warm-up followed by a 40-min MVPA session (tag and ball games) and 10-min of cool-down. different activity theme each month (ie. soccer, basketball) implemented by FitKid instructors Control: received free health screenings and diet/ PA information 	as the dependent variable • Covariates included baseline % fat, age, ethnicity, sex and whether the child received a free or reduced lunch were entered as covariates.	those students who attended ≥ 40% of the sessions were included in the analysis.	Program Fidelity: -program implemented for 128 days over the 8-mos -average program attendance= 49%
Story (2003) (214) Minnesota GEMS (Girls health Enrichment Multi-site Studies) United States	Design: RCT, 3 schools 12-week after-school program Subjects: 53 girls, all African-American, mean age = 9.3 years, majority of households were low- income, 92% of parents were overweight or obese	Theory/Concept: Social Cognitive Theory Aim: 1) increase frequency of MVPA, 2) decrease time spent sedentary, and 3) increase positive feelings towards PA. Another aim was to help families create home environments conducive to PA and healthy eating.	 ANCOVA with baseline value as covariate. Poisson regressions were used for "count" measures (ie. number of servings of beverage). 	BMI (kg/m ²): NS Waist Circumference (cm): NS % Body Fat: not reported as it was only measured at baseline CSA counts/min: NS	 Participation Rate: not mentioned Follow-up: 98% Program Fidelity: girls attended 21/24 of the KEEPS sessions Other: Authors note that inadequate power

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Methods

Intervention

Statistical Approach

Outcome(s):

% body fat, kg/m², average CSA counts/minute minutes of MVPA, GAQ Metadjusted usually score, waist circumference (cm)

Outcome Measures: DXA, BMI, CSA Accelerometer, GEMS Activity Questionnaire (GAQ), waist circumference

Dietary intake information and psychosocial variables of parents were also collected but not included here. **Intervention:** called "Girlfriends for KEEPS (Keys to Eating, Exercising, Playing and Sharing).

- Sessions held 2x/week afterschool at each of the 3 schools (1 hr/session)
- Emphasized skill building and practice of that session's health behavior (ie. increasing PA, choosing fruits and veggies, etc)
- Included a variety of activities such as ethnic dance, aerobic dance, etc.
- Family component included educational family packets and family nights in the 2nd and 9th weeks of the program where families participated in activities and set goals for themselves.

Control: "Active Placebo".

- Met three times over 12-week
 period
- Sessions promoted selfesteem and cultural enhancement (through arts and crafts and cultural activities) but without the nutrition/PA component.

Min MVPA: NS

GAQ met-adjusted usually score: NS

Results

All physical activity measures showed positive trends among intervention girls as opposed to controls. However, all were NS. may have prevented them from detecting differences in BMI between groups

Other

First Author Project Country	Methods	Intervention	Statistical Approach	Results	Other
Sallis et al. (1997) (190) Sports, Play and Active Recreation for Kids (SPARK) United States	Design: QE, 2 years, 7 schools Subjects: Grade 4 students, 82% Caucasian, 7 schools Outcomes: out-of school PA, min/wk of MVPA during PE class, kg/m ² Outcome Measures: self- report PA, SOFIT, BMI, (used accelerometers but only at follow-up)	 Theory / Concept: SCT Aim: to increase PA throughout the school day in children Intervention: 2 conditions: 1) specialist-led (taught by certified PE teachers), 2) trained classroom-teacher led designed to encourage high levels of activity, teach skills, self-management and be fun activity units included dance, aerobics, jumping rope classes held 3 times / week for 30 minutes self-management skills were taught weekly in 30-minute of class time Control: usual PE class. 	 ANCOVA with outcome of interest as the dependent variable adjusted for baseline value and baseline age. analyses also accounted for clustering of schools. 	Min/week of activity: Specialist-led > teacher- trained > control (p<0.001) PA out of school: NS BMI: Boys: NS Girls: Cont < specialist-led or teacher-trained (p<0.001)	Participation Rate: 98% Follow-up: 62% Program Fidelity: videotapes of classes and teachers
Goran & Reynolds (2005) (85)	Design: RCT, four schools (2 INT, 2 CONT), 8-week duration	Theory/concept: SCT Aim: to improve physical activity	• General linear models with post-intervention	% Body Fat: girls in intervention < girls in control group (p = 0.009). NS	Participation Rate: 68%
Interactive Media for Promoting	Subjects: 209 students in 4 th grade, 58% Hispanic, mean age = 9.5 years	levels and decrease obesity using interactive computer games	values as the dependent variable and treatment and	amerences for boys. BMI z-score: girls in intervention < girls in control	Follow-up: 58% for acclerometers, 96% for everything else
Physical Activity	Outcome(s):	Intervention: Interactive multimedia 	sex as main effects	group (p = 0.016). NS differences for boys.	Program Fidelity: none mentioned

First Author Project Country	Méthods	Intervention	Statistical Approach	Results	Other
(IMPACT) in Children United States	BMI z-score, % body fat, counts per minute and % of time spent in light, mod, vigorous, very vigorous and MVPA. Outcome Measures: BMI, BIA, CSA accelerometry	 component consisting of 8 interactive CD-ROM sessions, 4 classroom assignments and 4 family-based assignments. Total of 12 contact hours with children through these devices Lessons incorporated SCT (eg. goal setting, increasing self- efficacy) and were designed to be interactive and fun. Control: received educational CD-ROMS that were not related to health topics 	• baseline value of the dependent variable, baseline age and BMI z- score were entered as covariates.	% of Time spent in Light, Moderate, Vigorous, Very Vigorous and MVPA: Light: INT girls > CONT girls INT boys < CONT boys (p = 0.052) Moderate: INT < CONT (p =0.03) Vigorous and Very Vigorous: NS	n (karako ek us en en en en en en en en en en en en en
Going (82) Caballero (39)	Design: RCT, 41 schools (20 CONT, 21 INT) across 7 American-Indian	Theory/Concept: Social Learning Theory	 Mixed linear model with % body fat as 	Average vector magnitude/min: NS	Participation rate: 85%
Pathways	communities, 3-yr duration	Aim: 1) to increase physical	dependent	Questionnaire (activity	Follow-up: 83%
United States	Subjects: 580 American- Indian students evaluated for PA, 1,704 students evaluated overall, 3 rd to 5 th grade, mean age = 7.6 at baseline Outcome(s): school mean % body fat, kg/m ² , average vector magnitude (AVM) from a 24-hour period	in school, 2) to promote positive attitudes towards PA, and 3) to enhance motor skills that are necessary for lifelong activity. Intervention: Four areas were targeted: classroom curriculum, food service, physical activity and family involvement.	 baseline % BF was entered as a fixed effect, field site and schools within sites were entered as random effects. 	cost): NS % Body Fat: NS BMI: NS Skinfold thickness (mm): NS Intervention schools were significantly more active then control schools at ³ / ₄ study	Program Fidelity: - 94% of lessons were completed - 81% of school provided at least 3 PE sessions/ week in Year 1 - 100% of schools provided at least 3 PE sessions/ week in Years 2 & 3.
	activity index for 24-hour	• PE component:		sites, but overall difference	- surveys, attendance

First Author Project Country	Methods	Intervention	Statistical Approach	Results	Other
	period (translated into energy costs), skinfold thickness (mm) Outcome measures: BIA, BMI, TriTrac-R3D accelerometry, self-reported physical activity questionnaire, triceps and subscapular skinfold thickness (mm)	 Encouraged PE class ≥ 3 times/week (30 min/class) plus recess (≥15 min) Also included simple classroom exercises of 2-10 minutes (1-2/day) <u>Classroom component</u>: 2, 45-min lessons were delivered each week by teachers for 12-weeks during 3rd and 4th grades and for 8- weeks during 5th grade. Cultural relevance was incorporated in to the PE curriculum by adding an American Indian games module. Control: Nothing mentioned. 		was NS.	logs for training sessions, PE calendars, student and parent evaluation forms Limitations:, large variation in AVN across time and between study sites.
Sahota (2001) Active Programme Promoting Lifestyle in Schools (APPLES) United Kingdom	 Design: RCT, 10 schools (5 INT, 5 CONT), 1-year duration Subjects: 634 students, 7- 11 years (Grades 4 & 5), slight bias towards more advantaged children, 1-42% from ethnic minorities Outcome(s): frequency of 	 Theory/Concept: Health Promoting Schools Aim: to reduce risk factors for obesity Intervention: schools received teacher training, school meal assessment and modification, development of school action 	 Multi-level model was built to assess change in BMI or PA while accounting for clusters. Covariates included age, sex, baseline BMI or baseline PA. 	BMI: NS. Physical activity: NS	 Participation Rate: 63-97%, depending on measurement Follow-up: 63-94%, depending on measurement Program Fidelity: - 89% of "points" in Action plans were

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First Author Project Country	Methods	Intervention	Statistical Approach	Results	Other
	physical activity and sport over the last week, frequency of sedentary behavior over the last week, kg/m ² Outcome measures: Physical activity questionnaire, BMI	plans based on their own needs, modifications to PE class, tuck shops and playground activities. <i>Nutrition component also included.</i> Control: continued with usual practice.			successfully implemented
McKenzie (1996) (144) Luepker (1996) (126)	Design: RCT, 3-year duration, 96 schools (56 INT, 40 CONT) across 4 states	Theory/Concept: Social Cognitive Theory Aim: 1) to increase enjoyment of	School level: • mixed-model repeated measures	<u>School-level:</u> MVPA : INT > CONT (p=0.002) Energy Expenditure: INT	Participation Rate: 60% Follow-up Rate:
Child and Adolescent Trial for Cardiovascular Health (CATCH) United States	Subjects: 5,106 children in 3rd grade at baseline, diverse ethnic background Outcome(s): School-level: MVPA and estimated energy expenditure (EEE) Student-level: SAPAC scores, kg/m ² , skinfold thickness (mm) Outcome Measures: SOFIT, PA questionnaire (SAPAC), BMI, skinfold measurements	 PA, and 2) to Improve MVPA done by children during PE class and outside of school. Intervention: 2 conditions: 1) school-based intervention, or 2) school-based plus family intervention. Provided 90 min of PE/week, split into at least 3 different sessions. 40% of PE time was supposed to be dedicated to MVPA. CATCH PE curriculum and materials were provided, teachers were trained and on- site consultation was also 	 Site was a fixed effect and school (nested within site and group) was a random effect. MVPA and EEE were adjusted for location and teacher specialty. <u>Student level:</u> same ANCOVA but race, sex, season and interaction terms 	<pre>>CONT (p = 0.002) Student-level: SAPAC scores: General PA minutes: NS MET-weighted PA minutes: NS Vigorous PA minutes/day: INT > CONT (p = 0.003) MET-weighted vigorous PA minutes/day: INT > CONT (p = 0.003) Boys were also significantly</pre>	Program Fidelity: debriefing forms for teachers, checklists for teachers to record the frequency and duration and PE classes - trained PE observers also completed checklists while observing PE classes.

First Author Project Country	Methods	Intervention	Statistical Approach	Results	Other
		provided. Control: Continued with regular PE class. <i>CATCH also included a</i>	were also included as covariates.	more active than girls in all four areas. BMI: NS Skinfold thickness: NS	
		cardiovascular health & tobacco curriculum, food industry intervention, and a home/family intervention as well.			
Sallis et al. (2003)(192) McKenzie et al. (2004) (147) Middle Schools Physical Activity and Nutrition study (M-SPAN) United States	Design: RCT, 24 schools (12 INT, 12 CONT), duration of 2 years Subjects: Grades 6 at baseline, mean enrollment across 24 schools was 1109 students, with approximately 45% non-white students. Outcome(s): kcal/child/day/school expended in MVPA, kg/m ² Outcome Measures: Direct observation- SOFIT and SOPLAY, BMI	 Theory/Concept: Structural Ecological Model (47). Aim: 1) to increase the total energy expenditure from physical activity, and 2) to reduce the grams of saturated and total dietary fat bought at or brought to school by pupils. Intervention. no classroom education study aimed to increase physical activity in PE classes (staff development, on-site follow-up and curricular materials) and in leisure time (ie. PE staff gave credit for leisure time PA) Health policy meetings were 	 Regression models examined change in outcomes at the school-level by condition. For PA, analyses were then split by sex. 	Kcal/child/day/school expended in MVPA: INT > CONT for total group and for males (p < 0.009). Female differences between groups were NS. BMI: INT < CONT for boys (p = 0.044)	 Participation Rate: 1st 24 of 48 schools to sign up were accepted (50%). Follow-up: 24/24 schools. Program Fidelity: None mentioned Other: M-SPAN significantly increased student moderate-to- vigorous physical activity in PE class by 3 minutes (without increasing class frequency or duration). By year 2, the effects

First Author Project Country	Methods	Intervention	Statistical Approach	- Results	Other
		held • Student health committees were formed and parental education was undertaken. Control. Continued with usual practice.			increased substantially more.
Simon et al. (2004) (201)	Design: RCT, 6-month duration, 8 schools (4 INT & 4 CONT)	Theory/Concept: Ecological Theory	 Generalized estimating equations (with 	LOPA: INT > CONT (p < 0.01 for girls and boys)	Participation Rate: 91%
Intervention centred on adolescents' physical activity and sodontary	Subjects: 954 students, 65% from medium SES, mean age = 11.7 yrs	Aim: to reduce weight gain through an increase in physical activity	schools nested within groups) were used to predict change in dispotements	BMI and % body fat not yet reported.	Follow-up: 90% (loss due to school absence or transfer)
behavior (ICAPS)	Outcome(s): 1) change in kg/m ² , change in % body fat,, 2) change in % of physical activity time spent	 educational component (debates, classes) focused on increasing PA and decreasing sedentary behavior 	outcomes (such as participation in LOPA). • Linear mixed		Program Fidelity: - recorded number of activities held on each site (as well as
France	in leisure-organized physical activity (LOPA)	 offered new opportunities for PA during and after school no competitive aspects 	models were used for other outcomes		attendance), number of school hours devoted to curriculum
	Outcome Measures: BMI, BIA, Modifiable Activity Questionnaire for Adolescents (MAQ)	 no competitive aspects organized active transport to and from school Control: continued with usual health curriculum 	 Models adjusted for school effect. Covariates included baseline age, overweight and parent SES. 		components - 10-12 activities/week were held, 50% of students participated in at least one
			F		

First Author Project Country	Methods	Intervention	Statistical Approach	Results	Other
Harrell et al. (1996) (93) The Cardiovascular Health in Children (CHIC) Study United States	Design: RCT, 12 schools (6 INT, 6 CONT), 8-week duration Subjects: 1,274 children in 3 rd and 4 th grade. Mean age = 8.9 years. 74.3% of cohort was Caucasian, 20.4% African-American. Outcome(s): skin thickness (mm), kg/m ² , physical activity score Outcome measures: skinfolds, BMI, self-reported physical activity (Know Your Body Health Habits Survey),	 Theory/Concept: not provided Aim: to reduce cardiovascular disease risk factors in children. Intervention: Lessons on smoking, exercise, and other lifestyle factors were taught twice / week for 8 weeks in a classroom setting. "elementary educator" provided guidance, consultation and training for teachers. Physical activity intervention was held 3 times / week. Lesson plans involved non-competitive aerobic activities and other athletic games. Control: Continued with usual practice. 	 Analyses were first done at the school level followed by the individual level. ANCOVA was used with change in variable of interest as dependent variable. Baseline values of dependent variables as well as sex, race, grade and parental education were included as covariates. 	Change in BMI: NS Change in Physical Activity Score: NS Change in Skinfold thickness: INT < CONT	Participation Rate: 58.1% Follow-up Rate: 100% Program Fidelity: none mentioned Other: Physical activity questionnaire was not validated externally and did not have a specific outcome in units (such as METs).
McMurray et al. (2002) (148) The Cardiovascular Health in Children (CHIC	Design: RCT, 8-week duration, five rural schools (2 of which were very small and treated as 1 school) Subjects: 1,140 youth (approximately 2/3	 Theory/Concept: not given Aim: to reduce cardiovascular disease risk factors in children. Intervention: 1. <u>Exercise only.</u> 30 min of consistent aerobic exercise, 	 For each dependent variable, ANCOVA adjusting for sex, age, ethnicity, SES and 	Change in BMI: NS Change in Sum of Skinfold thickness: Exercise only group < education only group & control group (p = 0.001) ??? RESULTS FOR COMBO	Participation Rate: 38% Follow-up Rate: not mentioned, most likely not that different since the intervention

First Author Project Country	Methods	Intervention	Statistical Approach		Results	Other
II) Study United States	Caucasian, ½ African- American), mean age = 12 years Outcome(s): kg/m ² , mm skinfold thickness, VO2 _{max} Outcome Measures: BMI, Skinfold Thickness, VO2 _{max}	 3 days/ week (provided in PE class and taught by PE teacher) 2. <u>Education only.</u> 'Knowledge program' included information on nutrition, smoking and exercise. -taught by regular classroom teacher 3. <u>Exercise & Education</u> (combo) -received both programs 	baseline values was used.	GRP?		was only 8-weeks Program Fidelity: none mentioned
		Control: Continued with usual				

practice.

3.0 RESEARCH QUESTIONS

In the following chapter I outline the rationale and research questions which provided the framework for this thesis. I also outline the objectives and hypotheses of my research.

3.1 Rationale

Childhood obesity has reached epidemic proportions in Canada. Studies have shown that childhood obesity tracks strongly into adolescence and adulthood, having serious medical, psychosocial, financial and societal ramifications. Physical activity is a well-known mediator of body weight, and if targeted, can help to prevent obesity. AS! BC was a school-based health intervention that was developed to promote physical activity among elementary school children in BC. DXA was used to obtain direct measures of body composition, thereby providing a more accurate assessment of body fatness than BMI alone. At this time, it is unknown if AS! BC had an effect on percent (%) body fat in children. If AS! BC was successful in its endeavors then it would provide additional evidence of the effectiveness of school-based physical activity models in the reduction of childhood obesity. Furthermore, it could be used to build future school-based models that address this problem.

3.2 Research Questions

The primary research questions I will address are:

1. Is Action Schools! BC an effective means to positively affect % body fat in elementary school children?

The secondary research question I will address is:

2. Is Action Schools! BC an effective model to positively affect % body fat in children with \geq 33% body fat at baseline?

3.3 Research Objective

1. To determine if AS! BC is an effective means to positively affect body fat in children.

3.4 Specific Hypotheses

The specific hypotheses I will address (for both objectives) are:

1. Girls in the intervention group will exhibit a smaller increase in % body fat than girls in the control group over 29 months.

2. Boys in the intervention group will exhibit a greater decrease in % body fat than boys in the control group over 29 months.

4.0 METHODS

In this chapter I discuss the development and structure of the Action Schools! BC model. I review group allocation and study design followed by participant recruitment strategies and required program components. I then discuss program fidelity and the various tools that were used for assessment of compliance and measurement of participants. Lastly, I discuss the statistical approach that was undertaken in the analysis.

4.1 Action Schools! BC Model

Action Schools! BC was a school-based physical activity intervention that targeted improved health in seven different domains (Figure 5). AS! BC challenged and encouraged schools to take action in improving the health of students, thereby decreasing student risk factors for future chronic disease.

Figure 5. The seven outcome areas of AS! BC.



4.1.1 Program development

AS! BC was developed based on other models of school health that had been implemented both nationally and internationally. Specific best-practice program components were determined after a comprehensive search of the literature, internet, and media and through prolonged interaction with a principal/teacher advisory group to determine contextual appropriateness.

4.1.2 Action Schools! BC organizational structure

AS! BC was unique because it represented a partnership between government, educators, researchers and the health, recreation and sport sectors. The Support Team, Evaluation Team, Advisory Committee and Technical Team were comprised of individuals from across sectors, disciplines and institutions (Figure 6).



Figure 6. AS! BC organizational structure.

The AS! BC **Advisory Committee** represented an alliance between members of the government, community and educational sectors. This committee guided the growth and development of the AS! BC 'best practices' model and helped to identify facilitators and barriers to the long-term implementation of AS! BC. Examples of stakeholders included 2010 Legacies Now, the Ministry of Health Services and the BC Confederation of Parent Advisory Councils. A complete list of partners is provided (Appendix 3).

The **Support Team** (JW Sporta) was responsible for the facilitation of AS! BC within the schools. JW Sporta had experience overseeing the province-wide delivery of a technical-skills program (the Premier's Sport Award Program) in elementary schools and so had previously established relationships with schools and school administrators. The Support Team seconded two Grade 5 physical education specialists (AS! BC Liaisons) to liaise with the School Action Team was comprised of the principal or 'Champion' teacher(s). 'Champions' referred to teachers or others that were responsible for designing the customized Action Plan and actively promoting AS! BC within schools. Ultimately, the sustainability of the program depended on its uptake by the school community. The AS! BC Liaisons assisted the School Action Team in creating action plans for their school that addressed all 6 zones of the AS! BC model.

The **Technical Team** was comprised of university professors, sports administrators, principals, teachers and PE specialists. The team met during the developmental stage to help design the intervention model and to identify barriers and facilitators to its success. They then met intermittently during program implementation to provide feedback for course correction.

Finally, the **Evaluation Team** was responsible for the research study design and the selection of appropriate outcomes, tools and instruments. The AS! BC Research Coordinator, along with the relevant graduate students was responsible for hiring and training the measurement team (staff and students) as well as participant recruitment and day-to-day operations of the research project. The Research Administrator was responsible for the administrative aspects of the study. Lastly, the Measurement Team measured all students and acquired all relevant data during the in-school and Bone Health Research Laboratory visits (at Vancouver General Hospital).

4.1.3 Action Schools! BC delivery

The AS! BC model provided a framework for change. This model was comprised of six zones for action: *School Environment, Extracurricular, Family and Community, School Spirit, Scheduled Physical Education* and *Classroom Action* (Figure 7). The overall target was to provide students with a total of <u>150 minutes</u> of physical activity per week across these zones.



Figure 7. AS! BC six action zones. Zones in boxes involved a measured physical activity component.

For the purpose of this thesis, I will only review the Scheduled Physical Education and Classroom Action zones as they were the key physical activity components of the model. In the **Scheduled Physical Education** Zone, the goal was to encourage teachers to provide a minimum of two or three 30-minute sessions of physical education class each week (with the ultimate goal of 5 PE sessions/week). Schools currently provide two 40-minute PE classes per week, on average. In the **Classroom Action** Zone, generalist teachers were encouraged to build physical activity opportunities into the fabric of their classes for 15 minutes each day, 5 times per week (for a total of 60-75 minutes/week). Classrooms were provided with *Action Bins* (Section 4.2) that were equipped with a plethora of resources for quick and easy classroom activities.

4.1.4 Group assignment

At baseline, schools were randomly assigned to one of two intervention (AS! BC) arms (Liaison/Champion) or control. It is important to note that both levels of the intervention employed the same AS! BC model and teachers undertook the same kinds of activities. Thus, the only difference lay in amount of program facilitation by the AS! BC Support Team. Details are provided below.

Level 1 of the intervention involved external facilitation by AS! BC Liaisons. Level 1 schools were provided the greatest direct contact and support from the AS! BC Liaisons. Schools were asked to identify 'Champion' teachers that would work with the AS! BC Liaisons to provide initial training and resources for teachers. Together, they also conducted a school inventory of space, equipment and policy. AS! BC Liaisons assisted in designing Action Plans for the schools and provided workshops and resources that were essential for complete program implementation. The Support Team and Liaison also worked with school principals, parent groups and community members to determine how best to successfully implement AS! BC. They sought to identify areas for change within school health policy. Total contact time between the AS! BC Liaison and the school ranged from 2 - 4 hours per week.

Level 2 of the intervention was slightly different as facilitation for the model was provided from within the school rather than externally. In this arm of the intervention a principal, teacher, parent or community 'Champion' adopted the roles and tasks of the Liaison (in the Level 1 intervention). Contact with an AS! BC Liaison was limited to 0.5 - 1

hour per school per week. Other forms of communication (ie. telephone, email) with the Support Team were provided.

The control group represented the third condition. Schools randomized to this condition continued with their usual practice without intervention.

In September 2004, all control schools were offered intervention training resources and supplies. However, aside from start-up workshops provided for the schools, neither the AS! BC Support Team or school Liaisons were involved in program implementation. In addition, both Liaison and Champion schools adopted the Level 2, Champion model.

For the remainder of this thesis, the period of intervention from February to June 2003 will be referred to as 'Phase I', September to June 2004 as 'Phase II', and September to June 2005 as 'Phase III'. Levels 1 and 2 are collectively referred to as the intervention group as they both delivered the same AS! BC model.

4.2 Action Schools! BC Resources and Supplies

Individualized action plans were created for Grades 4, 5 and 6 classes as well as for the whole school by the AS! BC Support and School Action teams. Action Ideas in each of the 6 Action Zones were chosen from a list of 'best practices' activities and resources. The Action Plan also served as a reference tool as it further clarified the AS! BC model for teachers (Appendix 8).

All Grades 4, 5 and 6 classrooms in AS! BC received a customized Action Bin that was meant to supplement their uniquely tailored Action Plans. These bins contained equipment such as exercise bands and hand grippers, as well as teaching resources (such as activity manuals). Bins also contained motivational Energy Blast activity videos.

4.3 Study Design

This was a 29-month prospective, cluster randomized, controlled school-based trial within the Vancouver and Richmond school districts of British Columbia. Schools were randomly assigned by remote site allocation to the Liaison, Champion or Usual Practice group. Stratification occurred based on geographical location (Richmond or Vancouver), school size (> 300 students) and ethnicity. Children were in Grades 4 and 5 at baseline. All variables of relevance to this thesis, including age, height, weight, BMI, maturity status, % body fat, % lean mass, physical activity and dietary intake were assessed multiple times, as outlined below in Figure 8 and Table 5. The baseline measurements of % body fat were acquired from Feb-Apr 2003 when the study began. However, teachers did not begin logging their classroom activity until early April 2003. For this reason, I consider 'baseline' to be the time from February to April 2003 and the study to have officially begun in April 2003.

Figure 8. Timeline of AS! BC evaluation. A complete list of measurements acquired at each time point is provided below (Table 5).



Table 5. Measurements acquired at each time period.

Measurement.	Time Period
Height, weight, BMI	All time periods
Physical activity	All time periods
Dietary intake	All time periods (except 24-hr recall was not done
	at T1)
Maturity status	Times 1, 5 and 8
DXA (body composition)	Times 1, 5 and 8

Although there were seven time periods (after baseline) during which students were measured, in the present thesis, only data from Time 8 is included. Thus, Time 8 (T8) is referred to as the 'follow-up' period.

4.4 Participant Recruitment

AS! BC recruitment began in October 2002 after a formal partnership with the Vancouver and Richmond school districts was established. From October to November 2002, the AS! BC Evaluation Team made presentations in Richmond and Vancouver at meetings attended by school Principals and Vice-principals. Principals/Vice-Principals that were interested in participating in the evaluation were encouraged to contact the AS! BC Evaluation Team for further information.

During the same year, the BC Ministry of Education Satisfaction Survey was administered to principals in order to ascertain how satisfied they were with the amount of physical activity provided for students during school. Responses were based on a 5-point scale from 1, not very satisfied, to 5, very satisfied. To differentiate those who were not already undertaking a school-based physical activity program, only schools with scores between 1 and 3 were invited to participate in the study.

Once eligible schools were identified, the AS! BC Support and Evaluation Teams met with Principals, Vice-Principals and teachers (November 2002 - January 2003) to further describe the objectives of AS! BC as well as review the study timeline and staff responsibilities. Lastly, in January 2003, presentations were made to teachers and their students in school to answer questions and distribute information packets, consent forms and Health History Questionnaires (Appendix 4) for children to take home for parental signature. Based on the language spoken at home, forms were sent home in one of four languages: English, Chinese, Punjabi or Vietnamese.

Figure 9. Flowchart of **school** (and student) recruitment and allocation, including final number of participants included in analysis. Bracketed values (that are not bolded) indicate number of Grade 4 & 5 students.



4.5 Study Participants

All children who returned signed consent forms and were in Grades 4 and 5 (9-11 years old) were eligible to participate in the study (Figure 9).

Ethnicity was determined from information provided in the Health History Questionnaire (Appendix 4). Children were asked where they were born, where each of their parents (and parent's parents) were born, and to categorize their family by ethnicity. The following racial classifications were applied if both parents or all grandparents were born in a certain country or geographic region:

- 1) Hong Kong, China, Japan, Philippines, Taiwan = Asian
- 2) North America / Western Europe = Caucasian
- 3) Other

No specific socio-economic data were collected in the AS! BC trial. However, information on SES was acquired from the 2001-2002 District Reports (published on the Ministry of Education website). These data were collected by Statistics Canada in the 2001 Canadian census (7).

The Health History Questionnaire was designed to identify potential medical conditions that could preclude a student from participating in the study (Appendix 4). Children who had experienced sustained bed rest or immobilization for longer than 3 months were excluded, as were students who could not participate in physical education. Any children with diseases that could affect body composition / fat mass were also excluded from the analysis conducted for this thesis.

4.6 Required Program Components

Although teachers were encouraged to implement AS! BC as widely as possible, there were two required components within the **Classroom Action** Zone: *Bounce at the Bell* and *Classroom Action 15 x 5*.

Classroom Action 15 x 5 referred to the classroom goal of 15 minutes of physical activity per day, five days per week, for a combined 75 minutes of physical activity each week. These minutes were in addition to the physical activity opportunities afforded by PE class. Activities were meant to be moderate-to-vigorous in intensity and included such activities as skipping and working with 'exercise bands'. Action Bins were provided to supplement these exercises.

AS! BC required 'Bounce at the Bell' to be implemented a minimum of four times per week. The aim of this component was to provide short, frequent and high impact bouts of loading at various strain rates. This particular drill

was done primarily to affect bone status and was evaluated in the "Healthy Bones" component of the program. For this reason, it will not be discussed thoroughly in this thesis.

4.7 Program Fidelity

Teacher logs (Appendix 5) were distributed in order to monitor program dose and fidelity. During Phases I and II, teachers were required to record in their log book the type, frequency and duration of each activity that was undertaken by the class each week. The minutes/week of physical activity delivered was determined from these logs. Levels of physical activity prior to the study were determined from Question 2.1 on the School Health Inventory that indicated amounts of physical activity provided by schools (Appendix 6).

During Phases I and II, logs were picked up bi-monthly and teachers in both intervention and control schools were reminded at those times to log all their activity. However, in Phase III teachers did not routinely complete activity logs. During Phase III, teachers faxed their activity logs to the AS! BC office or activity logs were given to the measurement team when they were present in schools.

4.8 Data Collection

Prior to the commencement of each measurement period, a group of 8-12 measurers underwent a 4-5 hour training session by an experienced measurement team. Measurers were instructed on how to administer questionnaires, conduct performance tests and acquire anthropometric measurements. Facilitated practice was also a part of each training session. To standardize measurements and to maintain reliability between measurement periods, the same measurer obtained anthropometric data during each measurement period whenever possible. Between years, although training was standardized different measurers collected anthropometric data.

Data collection took place eight times over the 29-month measurement period. At each period, the AS! BC Research Coordinator scheduled times for consenting students to be released from class for measurement. Figure 10 depicts participant flow-through during a typical Bone Health Research Laboratory visit (Times 1, 5 and 8). Students were always supervised by members of the Measurement Team.

During the in-school measurement sessions (Times 2, 3, 4, 6, 7) students were released from class in groups of 5-7 for approximately one hour at a time (Figure 10). Measurement usually took place in the multi-purpose room, library or an unused classroom. Measurers administered questionnaires, obtained performance measures and acquired student height and weight.



Figure 10. Typical schedule for data collection at Bone Health Research Laboratory. Stations shown in white were part of the schedule but not included in this thesis.

4.8.1 Measurements

I discuss in detail only those measurements relevant to the research questions posed in this thesis.

4.8.1.1 DXA

The Bone Health Research Laboratory is home to a Hologic QDR-4500W bone densitometer (Hologic Inc, Waltham, MA). DXA is safe and has an effective dose of 9.6 µSv per whole body scan, an extremely low dose. A spine phantom was scanned daily to ensure quality control. During Phases I and II, the same technologist acquired all DXA
scans. During Phase III, two different technologists were involved. If ever a technologist was unable to attend a scanning session, there were two other technologists (during all phases) who were able to substitute. Thus, throughout the 29-month period, DXA measurements were acquired by five different highly trained and qualified individuals. For the total body scan, we utilized standard positioning and acquisition procedures (5). Children were asked to lie down on the padded table for positioning (Figure 11). The technician ensured proper alignment of the body within the scan limit border lines. Arms were placed at the side of the body with palms down and separated from the thighs. Feet were pointed up and rotated inward until the toes touched. The body was positioned straight on the table pad (using the centre lines at the head and feet as markers) (5).

Figure 11. Photograph of DXA scanner and positioning of the child at the Bone Health Research Laboratory.



Measurement time was approximately 5 minutes. The same research assistant analyzed all scans for T1 and T5 and another research assistant analyzed all T8 scans.

Analysis procedures adopted are outlined in the Hologic Users Guide (5) and a sample total body DXA scan is provided (Figure 12). From these scans, % total body fat mass, total body fat mass, % total body lean mass and total body lean mass were determined. DXA has been used extensively in the Bone Health Research Lab in previous studies (132, 141). Although precision for total body fat for children has never been estimated in the Bone Health Lab, in adults the precision is 1.9% (unpublished data).



Figure 12. Printout of a whole body scan of an 11-year old boy.

4.8.1.2 Anthropometry

During the Bone Health Research Laboratory visits (Times 1, 5 and 8), stretch stature was measured without shoes to the nearest millimeter using a wall-mounted stadiometer (Seca Model 242, Hanover, MD). The head was placed in the Frankfort plane and measurers applied mild upward traction from the base of the mastoid process. Weight was measured on a calibrated electronic scale (Tanita BWB-800) to the nearest 0.1 kg. During schools visits, measurements were taken using a portable stadiometer (Invicta, Inc) and electronic scale (Seca Model 840). Measurements were taken twice for both height and weight. If measurements differed by \pm 0.4 cm for height or \pm 0.2 kg for weight, a third measurement was taken. For both, the average of 2 values or the median of 3 values were used for analysis.

4.8.1.3 Questionnaires

The Health History Questionnaire (HHQ) was sent home to parents to complete in order to assess each student's eligibility to participate in the program. The aim was also to ensure that participating students were free of any comorbid conditions that could affect study outcomes. Modified versions of the questionnaire were administered at T5 and T8 to ascertain any change in childrens' medical status.

The Physical Activity Questionnaire for Children (PAQ-C) was administered at all eight measurement periods (Appendix 7). It was designed to assess habitual levels of physical activity in children in Grades 4 and above. Based on the average of scores from Questions 1- 8 and 10, an average moderate-to-vigorous physical activity score (PA score) was calculated on a 5-point scale (1 = low activity, 5 = high activity). In addition, average leisure time activity (min/day general PA) was calculated from Question 1.

Maturity was assessed at time points 1, 5 and 8 when students were asked to complete a self-assessment of Tanner stage (Appendices 10 & 11) (216). Students were taken to a private room to complete the questionnaire. On the questionnaire, the five stages of development (pubic hair for boys and breast and pubic hair for girls) were depicted using line drawings. Students were asked to place a tick next to the drawing that best represented their current appearance. Tanner stages corresponded to the following levels of development: 1= pre-puberty, 2 & 3 = early puberty, 4 = late / peri-puberty, and 5 = post-puberty. Self-report of Tanner staging is highly correlated with physician rating (63).

Dietary intake was assessed using the Food Frequency Questionnaire (FFQ) (Appendix 12) and 24-hour dietary recall. The FFQ was used to assess dietary intake of calcium and was validated in a study by Barr et al. (24). The measurer read off a list of foods that were high in calcium and asked the children how often they consumed a given food (eg. Daily? Weekly? Monthly? Never?). Empty yogurt containers, bowls, cups and empty snack wrappers were provided so that students could quantify amounts. Students were also asked what type of milk they drank regularly (white, chocolate, rice or soy), if they had any food allergies and if they took any vitamins or minerals.

The 24-hour dietary recall (Appendix 9) was administered to a subset of students who participated in the cardiovascular portion of the study in Times 2-7 and then to the majority of students in Time 8. Students were asked to recall everything they had eaten the day before; from the time they woke up until the time they went to bed. Students were asked to estimate portion sizes using the different measuring cups, measuring spoons, diagrams, empty packages/containers and other tools provided. The 24-hour recall can be used to estimate energy consumption.

Weekly minutes of classroom activity were determined from the teacher activity logs (Appendix 5). This allowed us to determine program adherence.

4.9 Sample Size Consideration

The sample size for AS! BC was originally based on the ability to distinguish differences in bone strength. The aim was to have sufficient power to detect a 4% difference in the primary endpoint, % change in section modulus. Based on a 2:1 randomization, 80% power, a Type 1 error of 5% (2-sided) and a standard deviation of 5%, a total of 60

children were needed in both groups. Because separate comparisons by sex and maturity (pre- vs. early-puberty) were planned, the intent was to randomize 240 children. However, because a 10% attrition rate / year was expected (across 3 years), at least 312 children needed to be randomized. A positive response from volunteer schools led to randomization of 515 children.

4.10 Statistical Analyses

All statistical analyses were completed using StataCorp (Stata Statistical Software: Release 9) (208) and all outcomes were analyzed on an intention-to-treat basis. Group characteristics were compared for age, race, body composition (height, weight, BMI, fat mass, % fat, lean mass, % lean) and lifestyle variables (physical activity score, general physical activity). Differences in maturity status and number of post-menarcheal girls were also examined. Independent t-tests and chi-squared tests were used to compare differences between groups and sexes over time. Results were presented by group and sex in both primary and secondary analyses. In addition, differences between control and intervention schools for min/week of physical activity were assessed using linear mixed models that accounted for the effect of school in the clustered model.

4.10.1 Primary objective

To test my primary objective, I used ANCOVA (analysis of covariance) with change in % fat as the dependent variable. I chose to use this statistical test because I wanted to adjust for any predictors of change in % fat that could confound the effect of the intervention. ANCOVA has the same 3 assumptions of the ANOVA, meaning: 1) data are normally distributed, 2) each observation is independent and 3) homogeneity of variance exists. However, it also has 3 additional assumptions, including: 1) there is a linear relationship between each covariate and the dependent variable, 2) variance for each set of predictors and for both groups is approximately equal, and lastly, 3) slopes for the relationship between the dependent variable and each covariate are approximately equal for each level of the independent variable (157). I checked these assumptions using diagnostics tests to ensure that the residuals were normally distributed and that there was constant variance between the residuals and predicted change in % fat, as well as between the residuals and each covariate.

In the preliminary analysis, I first ignored the effect of school cluster and focused on understanding the relationships between the various predictors, as well as between each predictor and change in % body fat. I wanted to capture baseline body size (and maturity), change in body size (and change in maturity), physical activity and energy intake in my model because of the known relationships between these variables and body fatness. I felt that the most suitable measure of baseline size was height. Change in height was also the best measure of change in body size. I used the PA Score to account for leisure-time physical activity and Tanner Stage to represent maturity. However, as data on dietary intake was not collected on all participants at baseline and follow-up, I could not use this variable as a covariate in my model. These covariates were all identified a-priori as important contributors to change in body fatness.

An evaluation of these covariates provided the final statistical models adopted for this thesis. As both groups were of similar height at baseline, height was not a significant explanatory variable and did not remain in the model. I used baseline % fat to control for regression towards the mean at baseline for this key variable (30, 230). Change in height was used to represent change in body size. Both PA Score and Tanner Staging were not included in the final model as groups were similar at baseline and their inclusion did not explain any additional variance. Baseline maturity and change in maturity changed linearly with the other selected covariates. I conducted an ANCOVA separately for both sexes due to the inherent differences in body composition between boys and girls as they approach or transition through puberty.

Once the simple model was constructed I undertook a multi-level model incorporating school clusters as the final step. This allowed me to account for the fact that students were nested within schools which were nested within groups. From a statistical standpoint, the purpose of this was to adjust the standard error of the mean to account for any correlation between students within schools. Normally, the true number of independent observations is simply the number of students. However in this case, the true number of observations was somewhere between the number of schools and number of students. Thus, clusters were accounted for as observations were not independent.

The equation for my final model was:

Change in % fat_{j(i)} = $T_{(i)}$ + $\beta_1(\text{group})_{j(i)}$ + $\beta_2(\text{baseline \% fat})_{j(i)}$ + $\beta_3(\text{change in height}(\text{cm}))_{j(i)}$ + $\varepsilon_{j(i)}$,

where i represents school₍₁₋₁₀₎, j represents individual_(1-ni), β is the slope or regression coefficient that describes the relationship between the variable and change in % fat, ϵ is the error associated with the student model and T is the random effect of school.

4.10.2 Secondary objective

All children with \geq 33% fat at baseline were defined as being 'at-risk' of subsequent illness due to overweight or obesity. This cut-off was chosen based on previous work that showed an increased cardiovascular risk in children with \geq 33% fat (based on DXA) (96). For this subgroup analysis, I used ANCOVA to determine if change in % fat differed between groups. Baseline % fat and change in height were used as covariates for the reasons I outlined previously. Change in menarcheal status was added to the model as it significantly influenced change in percent fat in this subset of girls.

5.0 RESULTS

In this chapter I present the findings from this study, beginning with the characteristics of the sample. I then provide the results of the amount of physical activity delivered by teachers followed by the effect of AS! BC on change in % body fat in all children. Following, I provide the characteristics of the subgroup of 'at-risk' children and present the findings related to the effectiveness of the model on change in % fat in this subgroup.

5.1 Characteristics of Sample

5.1.1 Participant characteristics at baseline

Baseline measurements (February-April 2003) were obtained from 514 Grades 4 and 5 children. The Liaison and Champion groups were collapsed and described as on intervention group as they received the same intervention. School randomization is shown below (Table 6). Of the 103 eligible schools, 19% (20) volunteered for this study. Attrition is discussed in greater detail later on in this section.

Table 6.	Baseline school ass	ignments of sample s	howing number of	consenting	participants at	each school.	School
assignme	ents of those students	s who completed the	study are shown ir	n italics.			

Intervention	N N	Percentage completing study (%)	Control	N	Percentage completing study
School 1	36 (26)	72	School 8	24 (12)	50
School 2	51 <i>(</i> 33)	65	School 9	53 (41)	77
School 3	37 (22)	59	School 10	78 (58)	73
School 4	64 <i>(40)</i>	63			
School 5	94 (57)	61			
School 6	47 (32)	68			
School 7	30 (25)	83			
Total	359 (235)	65		155 (111)	71

All children from volunteered classrooms who participated in PE also participated in other parts of the intervention. However, on average, 38% of eligible participants volunteered for the evaluation component of AS! BC. Forty-eight percent of those assigned to the intervention arm and 31% of students assigned to the control arm provided written parental consent for measurement.

The socioeconomic data obtained from the Ministry of Education reports showed that the schools in this study were diverse. In the two school districts assessed, the average family incomes were \$52 152, below the provincial and national averages of \$54 840 and \$55 016, respectively. Approximately 26% of families in these two geographical districts reported incomes below \$30 000 per year.

The original cohort (n=513) is described below (Table 7). At baseline, the control and intervention arms of the study consisted of 30% (155) and 70% (359) of students, respectively. Participants in both groups were 10.2 (\pm 0.6) years and of similar racial backgrounds (>50% Asian, 30-40% Caucasian). Both intervention and control groups were approximately 50% boys and 50% girls. Using the CDC classification system as guide, 67% of boys were not at-risk for overweight (<85th percentile), 19% of boys were at-risk for overweight (\geq 85th percentile but <95th percentile) and 14% of boys were overweight (\geq 95th percentile). Seventy-eight percent of girls were not 'at-risk' of overweight while 15% of girls were 'at-risk' of overweight and 7% were considered overweight.

There were differences in body composition between students in intervention and control groups. The control students were 1.5 kg heavier, on average than the intervention students and this was reflected in their body composition data at baseline. Control students had 1.0 kg more body fat and 0.4 kg more lean mass than intervention students. Control students also had 1.6% more body fat but 1.6% less lean mass than intervention students. Control students. Control students also had a 0.7 kg/m² greater BMI. These differences were a result of the control boys who had 3% more fat on average, weighed 2.8 kg more and had a 1.3 kg/m² greater BMI than the intervention boys.

Boys had a 0.8 kg/m² greater BMI than girls and weighed 1.7 kg more, on average. Boys also had 1.6 kg (1.8%) more lean mass. However, boys had 1.8% less body fat than the girls, on average. Boys and girls were of similar height (141.2 cm) and fat mass (10.1 kg).

Leisure-time general PA also differed between intervention and control groups. Control students reported approximately 17 more minutes/day of average leisure-time physical activity than intervention students at baseline. The same trend emerged for the PA score. Boys were consistently more active than girls for general PA as they averaged 14 minutes/day more PA per day than girls and had a greater general PA score as well.

There were no differences in maturity status between intervention and control groups. As expected for children of the same chronological age, girls were more mature than boys. The greatest percentage of girls were in Tanner 2 (49% intervention, 56% in control) whereas the greatest percentage of boys were in Tanner 1 (59% in intervention, 61% in control). Also, 96% of girls in both groups were pre-menarcheal at baseline.

5.1.2 Description of clusters

Although the unit of analysis was the student, the unit of randomization in this study was the school. Further to this, students were exposed to the intervention in classrooms which were run by different teachers who implemented the model to varying degrees. Classroom cluster size ranged from 1 consenting student/class to 19 consenting students/class. The number of consenting teachers providing the program ranged from 2 teachers (and therefore classrooms)/school to seven teachers (and classrooms)/school. Also, ethnicities in schools varied from 15% to 88% Asian students, 6% to 75% Caucasian students and 5% to 27% other/mixed ethnicity students

 Table 7. Baseline characteristics of participants (n=513). All values are means (SD) unless otherwise indicated.

 Values are not adjusted for school clusters.

an an an an an an an an an an an an an a	Action Schools! BC			Usual Practice			
	Girls (n=182)	Boys (n=177)	Overall (n=359)	Girls (n=75)	Boys (n=80)	Overall (n=155)	
Demography:							
Age (years)	10.2 (0.6)	10.2 (0.6)	10.2 (0.5)	10.3 (0.5)	10.3 (0.6)	10.3 (0.5)	
Race (n, %):							
Asian	102 (56%)	97 (55%)	199 (55%)	37 (49%)	42 (53%)	79 (51%)	
Caucasian	54 (30%)	61 (35%)	115 (32%)	30 (40%)	27 (34%)	57 (37%)	
Other	25 (14%)	16 (9%)	41 (11%)	8 (11%)	11 (14%)	19 (12%)	
Maturity Status (n	, %):						
Tanner 1	69 (39%)	105 (59%)	174 (49%)	28 (37%)	49 (61%)	77 (49%)	
Tanner 2	89 (49%)	62 (35%)	151 (42%)	42 (56%)	25 (31%)	67 (43%)	
Tanner 3	21 (12%)	10 (6%)	31 (9%)	5 (7%)	6 (8%)	11 (7%)	
Post-menarche:							
Yes	7 (4%)	n/a	7 (4%)	2 (3%)	n/a	2 (3%)	
No	174 (96%)	n/a	174 (96%)	72 (96%)	n/a	72 (96%)	
Anthropometry ar	nd Body Compo	sition:					
Height (cm)	141.1 (7.4)	141.1 (7.4)	141.1 (7.4)	141.4 (8.0)	141.5 (6.6)	141.4 (7.3)	
Weight (kg)	36.4 (8.2)	37.2 (9.5)	36.8 (8.9)	36.4 (9.0)	39.8 (9.8)	38.2 (9.6)	
BMI (kg/m ²)	18.1 (3.0)	18.4 (3.4)	18.3 (3.2)	18.1 (3.0)	19.7 (3.9)	18.9 (3.6)	
Fat Mass (kg)	10.0 (4.7)	9.6 (5.9)	9.8 (5.3)	10.2 (5.1)	11.2 (6.0)	10.8 (5.6)	
% Fat	27.1 (7.3)	24.5 (8.6)	25.8 (8.0)	27.4 (7.3)	27.4 (8.1)	27.4 (7.7)	
Lean Mass (kg)	24.4 (4.0)	25.6 (4.0)	25.0 (4.0)	24.2 (4.3)	26.5 (4.4)	25.3 (4.4)	
% Lean	70.0 (7.0)	72.5 (8.3)	71.2 (7.7)	69.6 (7.1)	69.7 (7.8)	69.6 (7.4)	
Physical Activity	Status:						
General PA (min/day)	72 (55)	92 (66)	82 (61)	97 (67)	101 (66)	99 (66)	
PA Score (1-5 scale)	2.5 (0.5)	2.6 (0.5)	2.5 (0.5)	2.6 (0.5)	2.7 (0.6)	2.6 (0.5)	

5.1.3 Participant characteristics at follow-up

I provide a detailed flowchart of attrition in this study (overall and by group) below (Figure 13). By sex, approximately 7% (18) girls and 6% (15) boys declined consent during the trial period. Eighteen percent (45) of girls and 10% (25) of boys moved after T5 while thirty-five (14%) girls and 27 (11%) boys moved before T5. Two boys were absent from final measurement and one girl's data was not analyzed due to her medical condition. Therefore, I assessed 67% (346) of the original cohort at final.

Figure 13. Flowchart of students lost to follow-up. Key: INT= intervention students, CON= control students.



There were differences at baseline between those students who were lost to follow-up and those that completed the

study. Students who were lost to follow-up weighed 2 kg more, on average (regardless of maturity stage) and were taller (1.2 cm, on average) than students that completed the study. Students who dropped out had a 0.6 kg/m² greater BMI and 1.3 kg (2.3%) more body fat than those that completed the study. They also had 0.6 kg (2.2%) more lean mass. There were no differences in leisure-time physical activity (general and PA score) or race between students who completed the study and those that did not. However, more girls dropped out than boys (59% vs. 41%). Children that were lost to follow-up were more physically mature at baseline than those that continued on. Forty-two percent of students who dropped out were in Tanner 1 compared to 53% of students who completed the study. In both groups, \geq 95% of the girls were pre-menarcheal.

Table 8. Descriptive characteristics of students who were lost to follow-up (n=167) compared to students who completed the study (n=346). All values are means (SD) unless otherwise indicated. Values are not adjusted for school clusters.

	Students that did not	Students that completed the study
	complete the study (n=167)	(n=346)
Demography:		
Age (years)	10.2 (0.6)	10.2 (0.6)
Race (Asian/Caucasian/Other, %)	92 (55) / 55 (33) / 20 (12)	186 (54) / 117 (34) / 40 (12)
No. Girls/Boys (%)	98 (59) / 69 (41)	158 (46) / 188 (54)
Anthropometry and Body Composition	on:	
Height (cm)	142.0 (7.2)	140.8 (7.4)
Weight (kg)	38.5 (8.8)	36.5 (9.2)
BMI (kg/m²)	. 18.9 (3.2)	18.3 (3.4)
Fat Mass (kg)	11.0 (5.3)	9.7 (5.4)
% Fat	27.8 (7.7)	25.5 (8.0)
Lean Mass (kg)	25.5 (4.0)	24.9 (4.2)
% Lean	69.2 (7.4)	71.5 (7.7)
Maturity Status:		
Tanner Stage (1/2/3, %)	70 (42) / 79 (48) / 17 (10)	181 (52) / 139 (40) / 25 (7)
Menarche (yes/no):	97 / 1	149 / 8
Physical Activity:		
General PA (min/day)	86 (65)	
PA Score (1-5 scale)	2.6 (0.5)	2.6 (0.5)

Six students changed schools throughout the trial period. Three students moved from one intervention school to another intervention school, two students moved from one control school to a non-participating school, and one student moved from an intervention school to a non-participating school. However, these six students were brought back for final measurement in 2005 and analyzed in their original groups. Descriptive data of the children who completed the study is provided (Tables 9 & 10). From herein I am referring only to those children who completed the study (n=346).

The intervention and control groups changed differently over time. The control children grew 0.9 cm more in height (p=0.02) and gained 1.2 kg more weight (p=0.01) compared to intervention children. The control group also gained 1 kg more lean mass than the intervention group (p=0.005). Although their fat mass increased by 0.3 kg more than the intervention group, the control children experienced a 0.5% decrease in fat relative to the intervention children (NS). Change in height and baseline percentage of body fat in intervention and control groups were used as covariates in the model and are presented below for further illustration (Figures 14 and 15).

By follow-up, boys and girls demonstrated similar gains in height and weight. Girls increased their total fat mass by 0.6 kg more than boys (p=0.02). Boys, however, lost 1% more fat than girls (p=0.03) and gained 0.8 kg (1.1%) more lean mass than girls (p<0.01 for both).



Figure 14. Boxplots of baseline % body fat for intervention and control groups (n=346) by sex.



Figure 15. Boxplots of change in height (cm) for intervention and control groups (n=345) by sex.

Levels of physical activity also changed. Control students experienced a decline in general PA by approximately 16 minutes/day while the intervention students increased their general PA by 5 minutes/day (p=0.007). Although the changes in PA scores in both groups were small (\pm 0.1) they reflected the changes in general PA (p=0.003). At follow-up, both groups reported very similar levels of physical activity. Girls demonstrated an 11 minutes/day decrease in general PA while boys demonstrated an increase of 6 minutes/day (p=0.02).

At follow-up, 48% (71) of girls remained pre-menarcheal and 52% (78) were menarcheal. By group, approximately 53% (26) control and 43% (43) intervention girls reached menarche (NS). Overall, maturity status changed similarly between groups. The greatest percentage of students in both groups were in Tanner 3 at follow-up (37% in control, 41% in intervention).

At follow-up girls were still more mature than boys. Forty-six percent of girls were in Tanner 3 whereas 46% of boys were still in Tanner 1 & 2 (p=0.006).

Table 9. Descriptive characteristics of girls at baseline (T1), final (T8) and for change (T8-T1) (n=158). All values are means (SD) unless otherwise indicated. Values are not adjusted for school clusters.

<u>Girls</u>	Intervention (n=101)			Control (n=57)			
	Baseline	Final	Change	Baseline	Final	Change	
Demography:							
Age (years):	10.2 (0.6)	12.3 (0.6)	2.2 (0.04)	10.3 (0.5)	12. 4 (0.5)	2.1 (0.05)	
*Race (A/C/O: n/%):	57 (56) /	29 (29) / 15 (15)		28 (49) / 23	8 (40) / 6 (11)		
Maturity Status (n, %):							
Tanner 1	41(41)	4 (4)		25 (44)	2 (4)		
2	48 (48)	29 (29)		29 (51)	20 (35)		
3	11 (11)	49 (49)		3 (5)	24 (42)		
4	0	19 (19)		0	11 (19)		
5	0	0		0	0		
Post-menarche	7(7) /	50(50) / 40(40)		1(2)/55(06)	28(56) /		
(Y/N: n/%):	94(93)	50(50)7 48(48)		1(2)/33(80)	22(44)		
Anthropometry and B	ody Compos	sition:					
Height (cm)	140.7 (7.9)	153.4 (7.0)	12.7 (3.4)	140.4 (7.3)	154.2 (7.5)	13.9 (2.5)	
Weight (kg)	35.8 (8.6)	46.8 (10.3)	11.0 (4.0)	34.9 (8.0)	46.5 (9.9)	11.6 (4.5)	
BMI (kg/m ²)	17.9 (3.2)	19.7 (3.5)	1.8 (1.3)	17.6 (2.7)	19.4 (3.0)	1.8 (1.5)	
Fat mass (kg)	9.7 (4.8)	12.2 (5.5)	2.5 (2.2)	9.5 (4.8)	11.9 (5.4)	2.4 (2.7)	
% Fat	26.6 (7.3)	25.8 (6.6)	-0.8 (3.5)	26.6 (7.3)	25.4 (7.0)	-1.2 (3.9)	
Lean mass (kg)	24.3 (4.4)	31.8 (5.4)	7.5 (2.6)	23.5 (3.8)	31.8 (5.3)	8.2 (2.5)	
% Lean	70.5 (7.0)	71.0 (6.4)	0.5 (3.4)	70.3 (7.1)	71.3 (6.7)	1.0 (3.7)	
Physical Activity Statu	IS:						
General PA (min/day)	73 (52)	72 (52)	-1 (66)	97 (70)	67 (54)	-30 (74)	
PA Score (1-5 scale)	2.5 (0.5)	2.5 (0.5)	0.01 (0.6)	2.6 (0.5)	2.4 (0.5)	-0.2 (0.7)	

* A=Asian, C=Caucasian, O=other mixed ethnicities

Table 10. Descriptive characteristics of boys at baseline (T1), final (T8) and for change (T8-T1) (n=188). All values are means (SD) unless otherwise indicated. Values are not adjusted for school clusters.

Boys	Intervention (n=134)				Control (n=54)		
	Baseline	Final	Change	Baseline	Final	Change	
Demography:							
Age (years):	10.2 (0.6)	12.3 (0.6)	2.2 (0.04)	10.4 (0.5)	12.5 (0.5)	2.1 (0.06)	
*Race (A/C/O: n/%):	73 (54) / 4	7 (35) / 11 (8)		28 (52) / 18	(33) / 8 (15)		
Maturity Status (n, %):							
Tanner 1	78 (58)	11 (8)		37 (69)	12 (22)		
2	48 (36)	47 (35)		14 (26)	15 (28)		
3	8 (6)	46 (34)		3 (6)	17 (31)		
4	0	22 (16)		0	10 (19)		
5	0	4 (3)		0	0		
Anthropometry and B	ody Compos	ition:					
Height (cm)	140.8 (7.4)	154.0 (9.5)	13.3 (3.8)	141.4 (6.4)	155.3 (8.1)	13.8 (3.7)	
Weight (kg)	36.6 (9.5)	47.4 (12.4)	10.8 (4.6)	37.4 (9.7)	51.9 (12.7)	12.5 (4.2)	
BMI (kg/m²)	18.3 (3.4)	19.7 (3.6)	1.5 (1.3)	19.5 (4.0)	21.4 (4.5)	1.9 (1.3)	
Fat mass (kg)	9.2 (5.8)	10.8 (6.9)	1.7 (3.2)	10.9 (6.3)	13.1 (8.2)	2.2 (3.3)	
% Fat	23.9 (8.4)	22.2 (8.6)	-1.7 (5.6)	26.6 (8.5)	24.2 (9.9)	-2.4 (4.8)	
Lean mass (kg)	25.4 (4.0)	33.7 (6.7)	8.2 (3.7)	26.5 (4.2)	36.0 (6.2)	9.5 (3.3)	
% Lean	73.1 (8.1)	74.6 (8.2)	1.6 (5.4)	70.5 (8.1)	72.9 (9.5)	2.4 (4.7)	
Physical Activity Statu	ıs:						
General PA (min/day)	89 (62)	98 (60)	9 (80)	103 (68)	101 (61)	-2 (72)	
PA Score (1-5 scale)	2.6 (0.5)	2.8 (0.4)	0.2 (0.5)	2.6 (0.6)	2.6 (0.5)	-0.01 (0.6)	

* A=Asian, C=Caucasian, O=other mixed ethnicities

5.2 Physical Activity Delivered by Teachers

The aim of the intervention was to provide students with 150 minutes of in-school physical activity each week. At baseline, all schools except one reported providing less than 90 minutes of physical activity per week. One control school reported providing more than 90 minutes but less than 150 minutes. Average physical activity (minutes/week) delivered by teachers throughout the trial period is provided (Table 11, Figure 16). In Phase II, teachers began logging September 29, 2003 and completed on May 28, 2004. In Phase III, logging began October 4, 2004 and

continued until June 3, 2005. Teachers did not log during the 2-week winter break or the one week spring break. As Phase I was a short time period during which teachers had not begun consistent logging, it was excluded from the analysis.

 Table 11. Minutes/week of physical activity delivered by teachers (mean (range)) during Phases I, II and III and overall. The overall average represents the mean of Phases II & III due to inconsistent logging in Phase I. Values are not adjusted for school clusters.

	Physical activity delivered by teachers (minutes/week)							
	Apr 03 -Jun 03 (Phase I)	Oct 03- Jun 04 (Phase II)	Oct 04 – Jun 05 (Phase III)	Overall Average				
Intervention:								
School ID: 2	174 (77)	200 (95-425)	228 (100-405)	214 (95-425)				
3	120 (75.4)	138 (0-270)	132 (21-480)	135 (0-480)				
4	205 (79.2)	171 (0-370)	160 (15-340)	166 (0-370)				
7	158 (60.4)	127 (40-305)	139 (10-320)	131 (10-320)				
8	196 (97.6)	111 (30-370)	122 (15-295)	115 (15-370)				
9	206 (112.1)	148 (10-335)	148 (50-380)	148 (10-380)				
10	155 117.6)	162 (0-473)	157 (25-462)	160 (0-473)				
Overall:	179 (94.1)	145 (0-473)	151 (10-480)	147 (0-480)				
Control:								
1	126 (69)	92 (30-310)	98 (30-260)	94 (30-310)				
5	241 (173)	83 (0-335)	116 (25-315)	97 (0-335)				
6	133 (62)	96 (15-380)	89 (0-340)	94 (0-380)				
Overall:	158 (112)	91 (0-380)	101 (0-340)	95 (0-380)				

Control schools consistently provided the lowest amounts of physical activity, averaging 95 minutes. After accounting for school clusters, intervention schools delivered 58 more minutes of physical activity each week (152 min/week vs. 94 min/week, Cl: 20.2-94.9, p=0.003). Three (of seven) intervention schools exceeded the goal of 150 minutes/week, and two additional schools were within three minutes/week of meeting this goal. Six intervention schools achieved an overall average > 120 minutes/week, representing >80% compliance with the protocol. None of the control schools provided this amount of physical activity to students. If at baseline schools were providing 80 minutes/week of PE, then average PA delivered at final represents adjusted increases of approximately 72 minutes/week for intervention schools and 14 minutes/week for control schools. This represents a 90% increase for intervention schools and an 18% increase for control schools.

Figure 16. Physical activity delivered by teachers (min/week) across all schools (Phases II & III). Values are unadjusted means (SD).



In Phase III, there was no longer enhanced facilitation within schools, thus Champion and Liaison arms of the intervention adopted the AS! BC 'Champion' model. In addition, control schools were offered the AS! BC model. We provided resources and AS! BC teacher training workshops to those control schools that requested this (n=3). However, no further support from the AS! BC Support Team was provided.

In Phase III, two of the control schools increased general PA by 6 and 33 minutes, respectively, while one control school decreased general PA (7 minutes). Control schools averaged 91 minutes/week of general PA during Phase II and 101 minutes/week during Phase III. After accounting for the clustered model, general PA increased significantly from Phase II to Phase III in the control group (B= 13 min/week, CI: 5.4-19.7, p=0.001).

This study required that all teachers in intervention and control schools log their class's activity (including PE and general activity). The maximum number of logs it was possible to complete in both years was 32. In Phase II, the average number of logs submitted by teachers was 30 (94%) in intervention and 29 in control (91%) groups. In Phase III, compliance with logging decreased. Teachers in the intervention schools submitted 22 (69%) logs and teachers in the control schools submitted 20 (63%) logs, on average.

5.3 Effect of the Intervention on Change in Percent Body Fat in All Children

As discussed previously, I controlled for baseline % fat and change in height. I observed modest correlations between the dependent variable, change in % fat, and covariates change in height (cm) (r = -0.4, p<0.01) or baseline % fat (r = -0.3, p<0.01) in the whole group. This relationship is presented by sex below (Figures 17 and 18).

Figure 17. Scatterplots showing the relationship between change in height and change in % fat for girls and boys in both groups. Correlations are significant in both sexes (p<0.01).



Figure 18. Scatterplots showing the relationship between baseline % fat and change in % fat for girls and boys in both groups. Correlations are significant in both sexes (p<0.05 in girls, p<0.01 in boys).



First, I provide results of the ANCOVA in Tables 12 and 13, before adjusting for the effect of school. One girl was excluded from the analysis (but included in Section 5.1) as her baseline height was not assessed. The main effect of group was not significant for girls or boys and the confidence intervals were narrow, clustering around zero. Change in height and baseline % fat were significant contributors to change in % fat. In girls, the model explained 19% of the variance in change in percent fat. In boys, the model explained 31% of the variance. At baseline, intracluster correlations (ICCs) approached zero in both sexes (ICC=0.00 in girls, ICC= 0.01 in boys).

	,					
Change in % fat	Coefficient	Std. Error	Z	P> z	[95% Confide	ence Interval]
Group	0.1	0.6	0.2	0.8	-1.0	1.2
Change in Ht	-0.2	0.1	-2.6	0.0	-0.4	-0.1
Baseline % Fat	-0.2	0.0	-5.4	0.0	-0.3	-0.1
Constant	6.7	2.7	2.5	0.0	1.3	12.2

 Table 12. Results of ANCOVA for change in percentage fat by group for girls only (n=157). Covariates are provided.

 Values are not adjusted for school clusters.

 Table 13. Results of ANCOVA for change in percentage fat by group for boys only (n=188). Covariates are provided.

 Values are not adjusted for school clusters.

Change in % fat	Coefficient	Std. Error	Z	P> z	[95% Confide	nce Interval]
Group	-0.1	0.7	-0.1	0.9	-1.5	1.4
Change in Ht	-0.7	0.1	-8.4	0.0	-0.9	-0.6
Baseline % Fat	-0.1	0.0	-3.5	0.0	-0.2	-0.1
Constant	11.5	3.3	3.5	0.0	5.0	18.1

Second, I provide the results of the ANCOVA after adjusting for the effect of school (Tables 14 and 15). In girls, the between-school variance was approximately zero (5.8e-13) and the between-student variance was 10.8 (intracluster correlation, ICC= 5.3×10^{-14}). In boys, the between-school variance was also close to zero.(0.20) and the between-student variance was 19.6 (ICC=0.01). Group means for change in % fat, adjusted for baseline % fat, change in height and school clusters are provided (Table 16).

Table 14. Results of ANCOVA for change in percentage fat by group for girls only (n=157 girls, n=10 schools), after accounting for school clusters. Values for change in height and baseline % fat were presented in Table 12.

Change in % fat	Coefficient	Std. Error	Z	P>[z]	[95% Confide	ence interval] 🏎
Group	0.1	0.6	0.2	0.8	-1.0	1.2
Constant	6.7	2.7	2.5	0.0	1.4	12.0

Table 15. Results of ANCOVA for change in percentage fat by group for boys only (n=188 boys, n=10 schools), after accounting for school clusters. Values for change in height and baseline % fat were presented in Table 13.

Change in % fat	Coefficient	Std. Error	Z	P> z	[95% Confide	nce Interval]
Group	-0.1	0.8	-0.2	0.9	-1.7	1.5
Constant	11.6	3.5	3.3	0.0	4.7	18.5

 Table 16. Group means for change in % body fat for boys and girls. Values are adjusted for covariates and school clusters.

Group	Boys	Girls
Usual Practice	-1.8%	-1.0%
Action Schools! BC	-1.9%	9%

After adjusting for the effect of school, the standard error increased slightly in boys but did not change in girls. Confidence intervals for change in % body fat remained narrow and clustered around zero.

Diagnostic checks of the data showed that residuals were normally distributed. Constant variance and random scatter of the residuals was also noted when plotted against predicted change in % fat or selected covariates. A graph of Cook's Distance identified some outliers. These outliers were checked and values represented children who experienced the most growth in height, weight, bone mass and lean body mass during the trial period. Thus, these children were not excluded from the analysis.

5.4 Effect of the Intervention on Change in Percent Body Fat in 'At-Risk' Children

5.4.1 Descriptive characteristics of 'at-risk' children

In this thesis, children with \geq 33% body fat were referred to as 'at-risk' for obesity. At baseline, 21% (73) of children in this study were classified as 'at-risk'. Although not a subgroup criteria, body fat \geq 33% identified children whose percentage body fat was equal to or greater than the 80th percentile for the larger sample (n=513). Specifically, at

baseline 33.8% body fat represented the 80th percentile, 35.5% fat represented the 85th percentile and 40.6% fat represented the 95th percentile.

Descriptive characteristics of 'at-risk' children at baseline and final, including change is provided (Tables 17 and 18). At baseline, the mean age of kids in these groups was $10.2 (\pm 0.6)$ years. The control group had 46% Asian, 46% Caucasian and 8% Other ethnicity children. The intervention group had 62% Asian, 26% Caucasian, 13% Other ethnicity children. Both intervention and control groups were approximately 50% boys and 50% girls.

At follow-up, 26 'at-risk' children (27% (7) control, 73% (19) intervention) decreased their body fat to <33%. This represented 36% of the 73 children classified as 'at-risk' at baseline. Of these 26 children, the students in the intervention (n= 19) decreased their % body fat by 7.3% (\pm 5.3), on average, while the students in the control (n=7) decreased by 6.6% (\pm 3.0) body fat, on average. Similiarly, 15 children that were not 'at-risk' at baseline became 'at-risk' at follow-up (27% (4) control, 73% (11) intervention). Of these 15 children, the students in the intervention (n=11) increased their % body fat by 6.6% (\pm 3.0), on average, while the students in the control (n=4) increased their % body fat by 3.2% (\pm 2.2), on average.

Table 17. Descriptive characteristics of 'at-risk' girls at baseline (T1), final (T8) and for change (T8-T1) (n=36). All values are means (SD) unless otherwise indicated. Values are not adjusted for school clusters.

<u>Girls</u>	Intervention (n=23)			Control (n=13)		
	Baseline	Final	Change	Baseline	Final	Change
Demography:						
Age (years):	10.1 (0.6)	12.3 (0.6)	2.2 (0.05)	10.3 (0.6)	12.4 (0.6)	2.1 (0.05)
*Race (A/C/O; n/%):	15 (65) / 6 (26) / 2 (9)		4 (31) / 8 (62) / 1 (8)			
Maturity Status (n,%):						
Tanner 1	5 (22)	0		3 (23)	1 (8)	
2	13 (57)	5 (22)		7 (54)	3 (23)	
3	5 (22)	12(52)		3 (23)	5 (38)	
4	0	6 (26)		0	4 (31)	
5	0	0		0	0	
Post-menarche (Y/N; n/%):	2(9) / 21 (91)	14 (61) / 9 (39)		1(8) / 12 (92)	5 (56) / 4(44)	
Anthropometry and B	ody Compositi	on:				
Height (cm)	141.4 (7.4)	154.9 (6.8)	13.4 (2.3)	143.3 (8.1)	156.1 (8.6)	12.9 (8.2)
Weight (kg)	44.8 (7.7)	57.6 (9.2)	12.9 (4.4)	43.9 (8.3)	56.1 (9.9)	12.1 (5.7)
BMI (kg/m²)	22.3 (2.5)	24.0 (3.1)	1.7 (1.8)	21.2 (2.1)	22.8 (2.4)	1.6 (1.9)
Fat mass (kg)	16.5 (3.9)	19.0 (4.6)	2.5 (3.2)	16.2 (4.5)	18.8 (4.8)	2.6 (4.0)
% Fat	37.2 (3.1)	33.5 (4.1)	-3.7 (3.5)	37.2 (3.7)	34.4 (5.4)	-2.9 (5.3)
Lean mass (kg)	26.3 (4.0)	35.5 (5.2)	9.2 (2.1)	25.7 (3.8)	34.1 (6.0)	8.4 (3.2)
% Lean	60.2 (3.0)	63.5 (3.9)	3.3 (3.4)	60.2 (3.6)	62.8 (5.1)	2.6 (5.1)
Physical Activity Status:						
General PA (min/day)	72 (42)	72 (48)	0.6 (59)	91 (54)	93 (72)	3 (85)
PA Score (1-5 scale)	2.4 (1)	2.5 (0.4)	0.1 (0.6)	2.6 (0.6)	2.6 (0.5)	0.01 (0.5)

* A=Asian, C=Caucasian, O=other mixed ethnicities

Boys	Intervention (n=24)			Control (n=13)		
	Baseline	Final	Change	Baseline	Final	Change
Demography:						
Age (years):	10.2 (0.6)	12.3 (0.6)	2.1 (0.04)	10.2 (0.5)	12.3 (0.5)	2.1 (0.06)
*Race (A/C/O; n/%):	14 (58) / 6 (25) / 4 (17)			8 (62) / 4 (31) / 1 (8)		
Maturity Status (n, %):						
Tanner 1	13 (54)	2 (8)		9 (69)	4 (31)	
2	8 (33)	8 (33)		3 (23)	3 (23)	
3	3 (13)	7 (29)		1 (8)	5 (38)	
4	0	5 (21)		0	1 (8)	
5	0	2 (8)		0	0	
Anthropometry and Bo	ody Compositio	n:				
Height (cm)	146.6 (8.0)	160.2 (9.6)	13.6 (3.3)	142.7 (4.3)	155.0 (4.8)	12.3 (1.9)
Weight (kg)	51.4 (9.2)	65.5 (13.8)	14.1 (5.7)	50.8 (10.2)	64.8 (12.6)	14.0 (4.5)
BMI (kg/m²)	23.8 (2.9)	25.3 (3.6)	1.5 (1.7)	24.8 (4.0)	26.9 (4.2)	2.1 (1.5)
Fat mass (kg)	19.1 (5.0)	21.7 (7.4)	2.6 (4.6)	19.2 (6.2)	23.3 (7.4)	4.1 (2.8)
% Fat	37.6 (3.0)	33.7 (6.4)	-3.9 (6.1)	37.8 (4.3)	36.3 (5.4)	-1.5 (3.2)
Lean mass (kg)	30.0 (4.2)	40.3 (7.5)	10.3 (4.0)	29.5 (4.0)	38.4 (5.8)	8.9 (2.9)
% Lean	59.8 (2.8)	63.6 (6.1)	3.8 (5.9)	59.8 (3.9)	61.3 (5.2)	1.5 (3.1)
Physical Activity Status:						
General PA (min/day)	106 (81)	117 (85)	11 (106)	116 (70)	89 (37)	-27 (71)
PA Score (1-5 scale)	2.7 (0.6)	2.8 (0.4)	0.2 (0.6)	2.8 (0.5)	2.6 (0.4)	-0.2 (0.5)

Table 18. Descriptive characteristics of 'at-risk' boys at baseline (T1), final (T8) and for change (T8-T1) (n=37). All values are means (SD) unless otherwise indicated. Values are not adjusted for school clusters.

* A=Asian, C=Caucasian, O=other mixed ethnicities

At baseline, control and intervention groups were of similar height (143.7 cm), weight (47.9 kg) and BMI (23.0 kg/m²). Both control and intervention groups also had approximately 17.8 ± 4.9 kg ($37.5 \pm 3.3\%$) of body fat and 28.0 ± 4.4 kg ($60.0 \pm 3.2\%$) of lean mass. Percentage of fat at baseline and change in height (cm) in intervention and control groups were used as covariates in the model and are presented below for further illustration (Figures 19 and 20).



Figure 19. Boxplots of baseline % body fat for intervention and control 'at-risk' children (n=73) by sex.

Figure 20. Boxplots of change in height (cm) for intervention and control 'at-risk' children (n=73) by sex.



Over the study period, the intervention and control groups changed similarly. Both groups grew approximately 13.0 cm and gained 13.3 kg of weight. BMI increased by approximately 1.7 kg/m², on average. Students in the control

group gained 0.7 kg more fat mass than intervention students and lost 1.6% less body fat (NS). The intervention group gained 1.1 kg (1.5%) more lean mass than the control group (NS).

At baseline, 46% of control students were in Tanner 1 compared with 38% of intervention students. Conversely, 38% of control students were in Tanner 2 compared with 45% of intervention students at baseline. There was no difference in the number of menarcheal girls between groups and approximately 92% of girls were pre-menarcheal. By follow-up, approximately 40% of children in both groups were in Tanner 3. While 19% of children in the control group remained in Tanner 1, only 4% of children in the intervention group were Tanner 1. In both groups, 80–90% of children were early / peri-pubertal (Tanner 2-4) at final. Forty-four percent (4) of girls in the control condition and 52% (12) of girls in the intervention group achieved menarche during the study period (NS). At follow-up, 50-60% of girls in both groups were menarcheal.

At baseline, students in the control group were approximately 14 minutes/day more physically active than students in the intervention group. At follow-up, control students decreased their general PA by 12 minutes while intervention students' general PA increased by 6 minutes (NS). Both groups then reported very similar amounts of general PA (91 minutes/day in control, 95 minutes/day in intervention).

There were important differences between sexes in the 'at-risk' group of children at baseline. Boys weighed 6.7 kg more and were 3.2 cm taller than the girls. BMI in boys was 2.3 kg/m² greater than in girls and boys had 2.8 kg (0.5%) more fat than girls. Boys also had 3.6 kg more lean mass than girls although the percentage of lean mass (59.9%) was similar between sexes.

Over the study period, boys and girls grew approximately 13.2 cm and increased their BMI by 1.7 kg/m², on average. Boys gained 1.5 kg more body weight, 0.6 kg more body fat and 1 kg more lean mass than girls. Girls decreased their relative fatness by 3.4% whereas boys decreased by 3.1%. Both sexes increased their relative leanness by approximately 3%, on average. All differences were non-significant.

As expected, girls were more mature than boys at baseline. The majority of boys were Tanner 1 (59%) while the majority of girls were Tanner 2 (56%) at baseline. At follow-up, the greatest percentage of boys and girls were in Tanner 3 (47% girls, 32% boys).

At baseline, the boys were approximately 27 minutes/day more physically active than the girls. This difference remained largely unchanged throughout the study period.

The covariates used in the analysis were baseline % fat, change in height (cm) and for girls, change in menarcheal status. There were modest correlations between the dependent variable (change in percent body fat) and covariates

change in height (r=-0.4, p=0.001), baseline % fat (r=-0.2, NS) and change in menarcheal status (r=-0.4, p=0.01). These relationships are illustrated in Figures 21 & 22.

Figure 21. Scatterplots showing the relationship between change in height and change in % fat for 'at-risk' girls and boys in both groups. Correlations are non-significant in both sexes.



Figure 22. Scatterplots showing the relationship between change in height and change in % fat for 'at-risk' girls and boys in both groups. Correlation is significant in boys only (p=0.001)



The intervention had no effect on change in % fat in boys and girls (Tables 19 & 20). For girls, the model explained 27% of the variance. For boys, the model explained 30% of the variance in percentage body fat. At baseline, the ICC

approached zero for both sexes (ICC=0.00 for girls, ICC= 0.02 in boys). ANCOVA results (Tables 19 & 20) and group means for change in % fat, adjusted for covariates are provided (Table 21).

 Table 19.
 Results of ANCOVA for change in percentage fat by group for girls only (n=36). Covariates are provided.

 Values are not adjusted for school clusters.

Change in % fat	Coefficient	Std. Error	Z	P> z	[95% Confide	nce Interval]
Group	-0.5	1.6	-0.3	0.7	-3.8	2.7
Baseline % Fat	-0.3	0.2	-1.4	0.2	-0.8	0.2
Change in Height (cm)	-0.3	0.3	-1.0	0.3	-0.9	0.3
Change in menarcheal status	-3.1	1.5	-2.1	0.04	-6.0	-0.09
Constant	16.0	10.4	1.5	0.1	-5.3	37.3

 Table 20.
 Results of ANCOVA for change in percentage fat by group for boys only (n=37). Covariates are provided.

 Values are not adjusted for school clusters.

Change in % fat	Coefficient	Std. Error	and Z	P> z	[95% Confide	nce Interval]
Group	-1.2	1.7	-0.7	0.5	-4.5	2.2
Baseline % Fat	-0.1	0.2	-0.6	0.5	-0.6	0.3
Change in Height (cm)	-0.9	0.3	-3.4	0.002	-1.5	-0.4
Constant	18.3	10.9	1.7	0.1	-3.7	40.4

 Table 21. Group means for change in % body fat for 'at-risk' boys and girls. Values are adjusted for covariates and school clusters.

	Boys	Girls
Usual Practice	-2.3 %	-3.0 %
Action Schools! BC	-3.5 %	-3.6 %

Diagnostic checks of the data showed that the data came from a normally distributed population. Constant variance and random scatter of all residuals was seen.

6.0 DISCUSSION

In this chapter I discuss the findings of this thesis with a focus on a number of key areas: 1) descriptive characteristics of participants; 2) the effectiveness of Action Schools! BC for positively affecting body fat in boys and girls in relation to other, similar studies in the literature; 3) design, statistical and methodologic issues that might explain my findings; 4) limitations of my study; 5) unique aspects and strengths of the study; and 6) future directions.

It has been suggested that there is an epidemic of childhood obesity in Canada (222, 225) and worldwide (8) that is currently costing the Canadian healthcare system \$1.8 billion per year on average (27). There is consensus at all levels that feasible, far-reaching and effective interventions must be designed, implemented and assessed if we are to stay the escalating prevalence and associated economic costs of overweight and obesity.

6.1 Descriptive Characteristics of Participants

Children in this study were generally healthy. In the 1999 Healthy Bones Study (also conducted by the Bone Health Research Lab), 14% of boys were at-risk of overweight and 10% were overweight (unpublished data). In the present study however, the prevalence was increased as 19% of same-age boys were at-risk of overweight and 14% were overweight. Prevalence rates among girls of the same age in Healthy Bones and Action Schools! BC were similar (14% at-risk of overweight, 7% overweight). Compared with Canadian boys measured in a 1996 survey and reported by Tremblay and Willms, (225), boys in the Action Schools! BC trial weighed 2.4 kg more and had a slightly greater BMI (+0.5 kg/m²). There were however, no differences between girls in the current study and girls of the same age assessed in that survey. This reflects the country-wide trend towards increased body fat that has been reported worldwide (8) and which in the present study appears to be exacerbated in boys.

As expected during the normal course of growth, girls were more mature than boys of the same age. After 29months, girls had gained more fat mass than boys and many girls reached reproductive maturity. Conversely, boys gained more lean mass than girls and their percent body fat mass decreased and percent lean mass increased, compared with girls. I was surprised to note, however, that girls' % body fat decreased over the 29 month study as girls typically increase their relative fatness gradually throughout puberty (135, 136). The recent % body fat cut-off values (based on BIA from a sample of 1,985 Caucasian children) proposed by McCarthy et al. (139) showed increases in % body fat in girls from ages 10 to 12 years. However, in Project HeartBeat, a four year study of children 8, 11 or 14 years old at baseline, percent body fat (as measured by BIA) decreased in non-black girl from ages 8 – 12 years and then reached a plateau (51). In the Medical College of Georgia (MCG) FitKid study, relative fatness in girls (ages 8 and 9 years at baseline) decreased from 26.5% to 25.8% after one year (238). For the present study,

this finding suggests that as these girls matured, a greater proportion of their total body weight was comprised of other tissue (lean mass and/or bone mass) compared with fat mass. As this did not reflect increases in physical activity over the study timeframe and a reliable measure of dietary intake was not secured for the whole sample- one can only speculate that this could be a result of dieting habits among young girls. In the CDC Youth Risk Behaviour Surveillance System in 2000, approximately 2/3 (59.4%) of adolescent girls reported trying to lose weight in the past 30 days (2). Although a definitive answer remains unknown, calorie reduced diets could potentially explain these findings.

The physical activity of children in the current study was slightly lower than reported by MacKelvie et al. (129, 132) in the Healthy Bones Study. In that trial, mean PA score for boys was 3.2, higher than for boys in the current study (PA score = 2.6). Tremblay et al. (221) assessed boys aged 8-13 years in urban and rural Saskatchewan using the PAQ-C and reported a physical activity score of 3.1, again higher than boys in this study. MacKelvie et al. (129) reported activity levels for girls in 1999 (PA score = 2.9) who were very similar in age (10.2 years) and maturity (Tanner 2) as girls in the present study. However, the girls in the present study were less active (PA score = 2.5). Tremblay et al. (221) also rated girls' (aged 8-13 years) physical activity in Saskatchewan and reported a similar PA score (2.9) which is again higher than girls in the present study. The difference in baseline activity between studies could be a result of geographical differences, ethnic differences between studies (Action Schools! BC was predominantly non-Caucasian while the other studies had at least as many or more Caucasians as children in other ethnicities or races) or the difference in the socioeconomic status between groups.

Apart from body composition (the grouping criteria), children in the 'at risk' subgroup were unlike the larger cohort in some, but not all, other respects. 'At-risk' boys reported greater amounts of physical activity while 'at-risk' girls' reported similar amounts of physical activity compared with the larger cohort. The 'at risk' girls' rate of growth in height was similar to the larger cohort, but their weight increased more and their fat mass accrual was slightly greater. 'At risk' boys were taller at baseline but their rate of linear growth was less than the larger cohort, although these boys gained 2.5 kg more weight and 1.4 kg more fat mass than boys in the larger cohort. At follow-up, 'at risk' boys still had 10% more body fat than the larger cohort. PA scores in girls (2.5) and boys (2.7) in this subgroup were lower than those previously reported by MacKelvie et al. (129, 132) and Tremblay et al. (221). Effective interventions in this group are particularly relevant as these children appeared to be on an excess weight gain trajectory that may have been mediated by low levels of physical activity.

6.2 Effectiveness of the Action Schools! BC Model in Relation to the Literature

Action Schools! BC builds on previous school-based physical activity interventions by offering a flexible physical activity model for generalist teachers. These results indicate that in this cohort of boys and girls the intervention was not effective for positively influencing body fat. However, results suggest that Action Schools! BC was a model that

was highly acceptable by the generalist teacher, provided increased physical activity opportunities for students within school and opportunities for every child in the class to be physically active, regardless of skill level.

Overall, intervention schools and teachers increased physical activity provided to students by 90% while control schools increased provision of physical activity by 18%. Leisure-time physical activity levels also changed. Girls in the intervention maintained their general PA levels (min/day) compared with a 30% reduction in PA in control girls. Boys in the intervention increased their PA by 10% while boys in the control group maintained their PA levels. Although at baseline girls and boys in the control group were substantially more active than the intervention students, at follow-up, intervention girls were more active than control girls and intervention boys were only marginally less active than control boys. Stone et al. (*212*) wrote, "*Activity participation declines with age during adolescence, although it is not clear at what age the decline commences and if the rate of decline is linear.*" CATCH followed-up 73% of their original cohort three years post-intervention group, intervention children remained significantly more active than CATCH study controls. It may well be that the role of school-based physical activity models is to prevent further decline in physical activity and to set a pattern for physical activity that, hopefully, can be maintained throughout life.

Although this is a notable increase in the provision of PA to students, we were unable to accurately assess the intensity of physical activity undertaken by children. There is a possibility that activities were not intense enough or sustained enough to demonstrate a positive effect on body fatness. We assessed leisure-time physical activity levels of children by questionnaire and in-school physical activity by teacher logs. More objective measures of duration, intensity and timing of physical activity throughout the day using accelerometers would enhance studies of this nature in future.

Classroom Action was a novel aspect of the Action Schools! BC model and opportunities for physical activity were provided throughout the day through PE and general classroom time. All previous long-term elementary schoolbased physical activity studies utilized mainly PE to provide the intervention. After three years in the Pathways study, there was only a trend for change in percent body fat in American-Indian participants (39). The CATCH (128) and APPLES (186) trials also found non-significant differences between groups at follow-up after 3 years (CATCH) and 1 year (APPLES) of follow-up. McKenzie et al. (142) utilized a direct observation tool to assess physical activity levels during PE in Grade 3 students and reported that during a 30 minute PE period, children were moderately to vigorously active for only 11 minutes. This was because a considerable amount of time was utilized for class management. A model such as Action Schools! BC provides additional opportunities for children to be active throughout the school day and may provide an attractive alternative to PE-only based interventions.

Others have implemented alternative models to school-based trials. The only other study to report change in percent fat (by DXA) was the MCG FitKid Study (238). Students were exposed to 40 minutes of MVPA/day for 128 days after-school. An effect was noted only for those students who participated in the intervention for \geq 40% of the time (adjusted change =-0.76, 95% CI: -1.42- -0.09). Analysis based on the intention-to-treat principle, however, showed no effect of the intervention (adjusted change=-0.4, CI: -1.05 – 0.25). Although the intervention had a significant effect in children with the greatest exposure, the magnitude of the effect was small, highlighting the need for a longer time frame or a more intense intervention over a shorter timeframe. Further, it may be that a combination of after-school or classroom- and physical education-based activities may be required to achieve a positive effect for BMI or body fat in school-based models.

Only a few school-based trials have been successful in changing levels of obesity or body fat in children. The 8-week randomized controlled IMPACT study of primarily Hispanic (two-thirds) children, aimed to improve physical activity and reduce obesity through an interactive multimedia approach (85). Girls were measured before and after the intervention. At follow-up, girls in the intervention arm had a significantly lower % body fat (1.6% difference as measured by BIA, p=0.009) than control girls. Given the very short length of the trial, assessment of body fat by BIA and the modest intervention these study results may represent short-term fluctuations in body fat rather than long-term, permanent change.

Two well-designed randomized, controlled school-based trials, Planet Health (88) and M-SPAN (147) both reported significant changes in obesity prevalence. Planet Health incorporated school health lessons and PE micro-units into the Grade 6 and 7 school curriculum across 2 years. The prevalence of obesity in intervention girls was 3.4% less (p=0.03) than control girls at the end of the trial. M-SPAN was undertaken in middle-school (Grade 6 at baseline) and similar to Action Schools! BC, endorsed whole-school environmental changes. At the 2-year follow-up visit, intervention boys had significantly (p=0.04) lower BMI than control boys. The question of whether BMI is an appropriate measure of change in body fat in growing children remains.

It is somewhat difficult to compare outcomes across trials as investigators employed different interventions (type, length) and different methods and tools to assess change in percent fat and different statistical approaches to their data. Both M-SPAN and Planet Health assessed children who were slightly older and thus, more mature at baseline compared to the mostly pre- (52%) and early- (48%) pubertal children in the Action Schools! BC sample. There were also ethnic differences as M-SPAN recruited >55% Caucasian children and Planet Health recruited 60-70% Caucasian children, the remainder of which in both studies was comprised of African American, Hispanic and other ethnicity children. This racial mix of children is very different than the Action Schools! BC cohort. Planet Health undertook a separate analysis by race and found that the largest effect was seen for African American girls, where obesity prevalence was reduced in intervention students compared to control students (p=0.007). M-SPAN did not conduct any further analysis by race. In the present study, I reported 54% Asian, 34% Caucasian and 12% children

of other ethnicities. It is not well known whether children across ethnicities respond similarly to the same intervention as few mixed race trials (with >50% Asian participants) have been undertaken and only one with change in % body fat as the outcome (238). Further, M-SPAN was conducted in San Diego County, where children could be active outdoors year-round as compared to the pursuit of mainly indoor activities during winter months in colder or wetter climates, like Canada. Despite success of these two trials, the optimal level of physical activity that can be administered within the school setting to positively effect and sustain healthy body weight has yet to be conclusively determined.

The framework within which the studies were conducted also differed. Planet Health invoked Social Cognitive Theory to target behavior change directly through goal setting. Similar to Action Schools! BC, M-SPAN utilized an ecological model that targeted social structures, policies and cultural messages within the whole school and directly facilitated these changes within schools. The socio-ecological model utilized for Action Schools! BC has been described in detail elsewhere (153). Simply stated, Action Schools! BC involved stakeholders across sectors and between levels of government and community. Government ministries, community members, parents, school staff and various other members of the city and province were engaged and invested in the success of the program. Students were considered in the context of their environment and everyone was encouraged to take ownership of the program and cultivate the Action Schools! BC vision. Changes in the school environment were assessed separately using focus groups and interviews conducted during a process evaluation. However, these results are also reported elsewhere (154) and are beyond the scope of this thesis. It may be that a combination of approaches is required to elicit significant change in overweight and obesity in children. Stokol et al. (210) suggest that for a program to be successful a combination of changing behaviors (Social Cognitive Theory) and the environment (Social Ecological Theory) might represent the most effective approach.

I also undertook a subset analysis to determine if those children most at risk for obesity (defined as \geq 33% body fat at baseline) were positively affected by the Action Schools! BC model. Although results were not significant, they showed that children in the intervention group lost 0.8% more body fat (adjusted for covariates) than children in the control group. Differences between groups were greater for boys than girls. Previous trials that have been successful targeted obese children specifically, and were much more intensive. To illustrate, one school-based study recruited students with a BMI-for-age >95th percentile (42). Students were placed in small groups (n=14) and participated in fitness classes that were tailored to the students' skill levels. Activities were undertaken for 42 minutes of a 45-minute gym period, five times every two weeks. Students also received educational handouts on healthy eating. After 9 months, students randomized to the control arm. In another weight loss trial, children met with dieticians, were taught about the importance of weight loss or the battle against childhood obesity, attended health lectures on weight control (often with parents) and participated in rigorous training programs (155). After three months, children in the intervention lost 3.3% (\pm 2.6%) body fat while age- and sex-matched controls gained 1.4% (\pm 4.7%) body fat

(as measured by skinfolds). Action Schools! BC was designed as a physical activity intervention trial for all children, regardless of weight or BMI classification. Also, although we provided an 8-week fruit and vegetable (5-Today) education program we did not modify the diets of these children in any way. It could be argued effectively that in order to affect change in overweight and obesity both an intense program of physical activity and dietary intervention should be provided.

6.3 Design, Statistical and Methodologic Issues that Might Explain my Findings

6.3.1 Study design

Schools house primarily healthy children and based on the nature of schools it is not possible to single out individual children or prevent them from participating in school-based activities. There are also those that argue that schools are a place of learning and health interventions begin in the home environment (158). Thus, the question of whether school-based trials are the appropriate model for healthy weight or obesity trials needs to be addressed. Conversely, researchers argue that based on the diversity of children across races and socioeconomic groups schools may be our best access point to a cross-section of the population (76). My results supported this as children were from diverse ethnic groups (54% Asian, 34% Caucasian and 12% other ethnicities) and socioeconomic strata that reflected the diverse cultural milieu of Vancouver and its regions.

Further, although my baseline results showed that 14% of boys and 7% of girls were overweight, and 19% of boys and 15% of girls were 'at-risk' of overweight, the majority of children had healthy body weights. Group allocation had a small, non-significant effect on change in percent body fat in both sexes and confidence intervals were narrow and clustered around zero. Thus, the small changes I observed in the intervention group may not have been considered clinically relevant. A larger sample size of primarily healthy participants would not have changed this outcome, as the range would have become smaller as the estimate became more precise. To show an effect for an intervention, the study would have to target and be powered for change within the 'at risk' population, and this may not be possible within a school setting.

This is supported by the results from my secondary analysis of "at risk" children. Confidence intervals were much wider and although statistically non-significant, some values could be considered clinically important. To illustrate, 95% confidence intervals for 'at-risk' boys ranged from -4.5% to 2.2%. Thus, in some cases, children in the intervention lost 4.5% more body fat than children in the control group. This could be considered a clinically important finding. With larger numbers of 'at risk' children precision would have increased and an effect of the intervention on this group could have been discerned. This was not possible with the current sample size and within an intent-to-treat analysis.

The clustered-nature of school-based designs continues to be a challenge for researchers. Studies have managed this model by powering for the effect *apriori* in the study design (243) or accounting for this effect in the statistical analysis (88, 191) or both (243). Action Schools! BC (pilot) study was powered to show an effect on its primary outcome – bone health and to serve as a pilot study for the healthy weight question so that a larger trial that specifically addressed the overweight/obesity question could be designed in future. Further, Action Schools! BC was not powered to account for a three-level cluster (students within classrooms, within schools, within groups) but to my knowledge no published study to date has accounted for this level of complexity. However, I adjusted for the clustered effect of students within school in my primary analysis, although I was not able to do so in my secondary analysis due to the small sample size.

To discuss this further, controlling for clustering is based on the rationale that individuals in the same environment will look more similar than individuals in different environments (in this case schools) resulting in greater within, than between school variance. This was not the case in my sample as the ICCs for both boys and girls were very close to zero suggesting little to no relationship between children within schools. Previous studies from the Bone Health Research Lab have shown that the amount of variance between students within the same school was far greater than the amount of variance between students attending different schools (92).

Another consideration in my study was that although *schools* were randomized, participation by children was voluntary. Although 38% of children consented to participate we do not know the characteristics of children who did not volunteer to be part of the evaluation. Recruitment rate was lower than some (128) and higher than other (148) reported school-based studies. The CATCH trial (128) had a participation rate of 60% and CHIC II (148) had a participation rate of 38%, although investigators attributed enrolment numbers to that fact that blood samples were being collected. Eat Well and Keep Moving, a study in Grade 4 and 5 children (similar to AS!BC) had a participation rate of 90%. The major reasons for nonparticipation were absence from school (61%) and parental refusal (15%) (86). There are a number of reasons why children or their parents may not have volunteered for the current study. First, they may simply have been uninterested. Second, parents expressed concerns over their children being exposed to radiation from the DXA scans. This was observed in the MCG FitKid Project (239) which also utilized DXA to study body composition of children in Grade 3 at baseline. Third, some parents were concerned about their children missing school and, finally, consent forms may have not made it home for parents to sign. Facilitators tried to diminish this last effect by checking back with teachers and providing a second (or third) copy of consent forms for those children who lost or did not return them.

We experienced 33% attrition (67% follow-up rate) over 29 months in the trial, which was primarily a function of children moving away (n=132) and a small number of children (n=34) choosing not to participate. Students that were lost to follow-up appeared to be more mature than those that remained in the trial as they were taller and heavier (more lean and fat mass), on average and had higher values for BMI at baseline. This attrition rate is only slightly

higher than other school-based trials. For CATCH, children were Grade 3 at baseline and 79% of students completed the 3 year study (128). For SPARK, students were Grade 4 at baseline and 74% returned for follow-up two years later (190). Students who completed the SPARK study were 0.1 year older and more likely to be minority students than those who did not. This might reflect the fact that both of these NIH funded studies offered families financial incentives to participate. In Planet Health, 83% of students returned for follow-up and of those that did not, 52% transferred schools (88).

Another potential influence on study outcome was the provision of the Action Schools! BC model to control schools in Phase III. The Action Schools! BC pilot was designed as a 16-month active intervention trial and teachers in control schools were promised the intervention at the end of the second school term (June '04). Although Action Schools! BC facilitators provided training for teachers at all three control schools at the start of the 2004-05 academic term, they did not otherwise intervene in the delivery of the Action Schools! BC model. Also, all intervention schools adopted the Champion model and ongoing implementation of the model was driven from within the school by teacher champions who had direct and ongoing access to the Action Schools! BC Support Team. Teacher logs showed that two of the three control schools became more active between Phase II to III (increases of 6 and 33 minutes, respectively) although physical activity provided by teachers varied greatly (between 0 and 315 minutes/week) among these schools. Despite this, adjusted physical activity undertaken by control schools (94 min/wk) was less than for intervention schools (152 min/week), on average. Although the possibility of diluting the effect of the intervention in Phase III was a clear possibility, this did not appear to be the case.

Teacher compliance was determined from the teacher's daily activity logs which were relatively crude instruments. However, activity logs have been used extensively to monitor teacher compliance with interventions in the past (140). Generally in Phase II, the first full year of the intervention, teachers were on average greater than 90% compliant with recording the physical activities provided to their students, however this ranged considerably between teachers (53% to 100%). In Phase III, compliance with tracking program delivery was somewhat lower (60-70%) as teachers were monitored less closely by the Action Schools! BC Support Team. There is the possibility that teachers either over- or under-reported the amount of physical activity provided to their students. Both could have affected study outcomes. Although we had no reason to suspect this, we also had no means to validate physical activity delivered to students as our request to randomly assess delivery through direct observation was denied by school administrators.

Teacher compliance with delivery of the Action Schools! BC model reflected the many demands on teacher time and inconsistent delivery of the model (quantity and quality) could potentially have influenced study outcomes. Teacher compliance varied between intervention schools, however, all but one intervention school provided at least 80% (>120 min/week) of the program goal. Three intervention schools consistently met or exceeded the goal of delivering 150 minutes of physical activity per week.

As suggested previously, the question remains as to whether schools are the appropriate venue to enact intervention trials aimed at health outcomes. Given the nature of an overcrowded curriculum the feasibility of delivering these models within schools remains a challenge. Action Schools! BC strove to overcome this limitation by encouraging teachers to "snack on physical activity" throughout the school day so that physical activity became a part of school culture. The Action Schools! BC model allowed for diversity and skill level of both teachers and students across six action zones by providing resources, training and ideas that were diverse, simple and easily implemented.

Finally, although we conducted a 29-month trial the intervention period was 19 months across three schools years separated by two, two-month summer holiday periods. We were unable to evaluate activity levels of children over the summer months so there was no means to assess whether groups were similarly active. However, this was managed to a large extent by the study design as children were randomly selected and assigned into groups and thus activity levels should have been similar over the summer. The length of trial required to affect sustained change in childhood overweight or obesity is not known as the longest, *randomized controlled* study conducted to date in this age group has been 3 years (128), although results from longer studies, such as the Stockholm Obesity Prevention Project (4 years) (31) are pending. Given the extended period over which excess weight gain occurs, longer studies may be needed to see a significant change in body fat.

6.3.2 Statistics

The statistical approach to the data that I used accounted for intraschool dependence (modeled by the ICC), however, I was unable to construct a three-level model to account for the level of classroom (intraclass dependence) for two reasons. First, there was a large range in the number of students who provided consent in each class and second, teachers (and thus students) in each class changed over the study period. To my knowledge, while many studies incorporated the school effect into their final statistical model, none have incorporated a classroom effect. Despite these limitations, cluster randomized trials currently represent the best approach for effectiveness studies undertaken within schools. Finally, this study provides estimates for ICC at the school and classroom level that can be utilized in a larger trial in the future.

6.3.3 Methods

A novel aspect of my study was that I used DXA to assess percent body fat. DXA is considered the gold standard with which to determine body composition (124). Measuring percent body fat directly with DXA set Action Schools! BC apart from most previous studies that reported BMI as the outcome measure. To my knowledge, only one other published study, MCG FitKid Study, reported *change* in % fat (by DXA) for boys and girls following an intervention (238). The Minnesota GEMS study obtained relative fatness by DXA but only from girls and only at baseline (214)
Although to my knowledge, no study has examined the reproducibility of DXA in Asian/Caucasian children, most pediatric studies reported high ICCs for reproducibility of DXA body fat values (0.0.997- 0.998) (90, 121, 138). A study performed with the Lunar Prodigy system (138) reported a coefficient of variation (CV) of 1.82% between repeated measurements in an ethnically diverse sample of children aged 5-17 years. We used a Hologic 4500 system and results can not be directly applied to the current study as precision varies between systems (220). Given the excellent precision of most DXA systems it is unlikely that DXA precision was responsible for the lack of an effect in the present study.

Although commonly used in clinical settings, BMI is a crude measurement of weight relative to height and its use has been challenged extensively as an appropriate tool to represent overweight or obesity in children (68, 166). It has been recommended that in order to interpret BMI scores in children that individual BMI be plotted on age- and sex-specific growth charts. The growth charts that dominate pediatrics are supplied by the American Centre for Disease Control (CDC) and are based on five national data sets collected from 1963 to 1994 (114). Despite their broad usage, CDC curves have drawn considerable criticism as the threshold cut-offs of the 85th and 95th percentiles are not evidence-based (48). Similarly, although the IOTF approach represents some different ethnicities there are still many races not included in the database (81). Lastly, the IOTF classifications are based on BMI of 25 and 30 kg/m². Although these values have been associated with health risks in adults these values may not represent the same health consequences in children (48). The appropriate means to classify children as overweight or obese remains a challenge in both clinical practice and in research studies.

A few other studies reported percent body fat (as opposed to BMI) derived from skinfold techniques or bioelectrical impedance analysis (BIA) and related prediction equations. The IMPACT (85) and PATHWAYS (39) studies measured % body fat (by BIA or skinfold thickness, respectively) and used post-intervention % body fat as the dependent variable and baseline % fat as a covariate. Both BIA and skinfold thickness have serious limitations, especially for assessing body fat in children. The accuracy of skinfold thickness for estimating % body fat can be compromised by low inter-rater reliability and equations that are population- (and age-) specific (164). BIA also requires age- and sex-specific equations and is highly dependent on positioning, time of day, room temperature are other variables when determining total body water (and fat mass) (166). DXA is now the preferred method as it provides total body as well as regional body composition, has a low radiation exposure and is not dependent on other measurements for accuracy (such as height and weight) (118, 166).

An accurate assessment of physical activity was key to interpreting results from my study. We utilized the Physical Activity Questionnaire for Children (PAQ-C) to assess children's level of physical activity in and outside of school. The PAQ-C is a reliable, validated tool and has performed reasonably well relative to other direct measures of physical activity such as Caltrac accelerometers (r=0.39) (49, 113). However, it would have enhanced my study to

measure physical activity directly (with accelerometers) in order to assess the time of day that physical activity was performed and the intensity of it.

We were unable to obtain measures of the amount of PA delivered to students prior to the start of the study. Based on the School Health Inventories, most schools were providing two, 40 minute PE classes each week. If an error in representing the physical activity levels of schools at baseline was made, this may have influenced the interpretation of our results. However, we had no reason to believe that schools were active outside of PE prior to study commencement. This was reflected by the mean physical activity per week reported by the UP schools in Phase II (89 minutes/ week, on average).

Differences in the tempo and timing of maturity between children must be considered in any pediatric intervention trial. If maturity is left uncontrolled and if an imbalance in maturity exists between groups, there is great potential for findings that may result from the intervention being confounded. Studies conducted in the Bone Health Research Laboratory consistently controlled for Tanner stage within their analysis of the effects of physical activity on bone health and they have previously described their rationale behind selecting variables to account for maturational differences (129, 163). It was, therefore, surprising, that none of the other school-based physical activity interventions that I reviewed for this thesis controlled for maturity status, although many adjusted for age as a surrogate for maturity (148).

I approached maturity in a number of ways in my study. I first evaluated the balance of maturity between intervention and control groups for boys and girls. Girls were in similar stages in both groups however, approximately 10% more boys were in Tanner 1 in the control group compared with the intervention group. I established the relationship between the dependent variable (change in % fat) and the maturity covariates. I then established the relationship between maturity and other covariates to assess their colinearity. As change in height was highly related to maturity and explained more variance than the categorical Tanner stage variable, I used change in height to represent change in maturity between groups. Given the normal course of body fat development, changes in % body fat coincided with changes in maturity status and changes in height (135). Also, there were more early-puberty girls (49%) than prepubertal girls (42%) at baseline. Therefore, I controlled for this difference by including baseline % body fat in my model as the more mature girls had a greater percentage of body fat at baseline. Further, baseline percent fat contributed more to the variance and had a higher correlation with change in percent fat (the dependent variable) than Tanner stage did. Including menarcheal status in the model did not change the results of the primary analysis so it was removed. However, for the secondary analysis for girls with \geq 33% fat, menarcheal status was a strong independent predictor of change in % body fat so menarcheal status was controlled for in this analysis. With the exception of menarcheal status, these relationships were the same for boys.

For my secondary objective, I defined 'at risk' as being those children with \geq 33% body fat. This cut-off was selected based on the work of Higgins et al. (96). To my knowledge, this was the only study to derive cut-offs for % body fat from DXA based on cardiovascular risk. This cut-off corresponded with the 80th percentile amongst the larger group of students (n=513). In general, classification systems for defining 'at-risk' or overweight children begin at around the 80th or 85th percentile. Thus, this cut-off was fairly representative of those children most at risk of subsequent illness from excess body fat.

6.4 Limitations

This study had several limitations. Most have been mentioned previously in the Discussion so I will briefly highlight those most likely to affect study outcomes below.

Action Schools! BC was designed to improve physical activity in school-age children, however, the study was originally powered to detect changes in bone section modulus. Obesity was assessed in order to obtain pilot data to guide the design of a larger trial. Further, the clustered nature of the design was not accounted for *a priori*, although I controlled for the clustered effect of school within statistical analysis. In future, larger, longer term studies powered to detect change in overweight or obesity are needed to assess the effectiveness of school-based models.

There was no formal mechanism in place to determine why non-consenting students did not agree to participate in the study - although I postulated a number of reasons that might explain this in the Discussion. As a result, there was no way to determine if the cohort that declined was different from those children who participated. This may have introduced recruitment bias into the study.

I assumed that prior to the intervention, schools were providing only 80 minutes of physical activity opportunities for children throughout the week which was acquired through 2, 40 minutes PE lessons. In future, direct assessment of pre-trial physical activity delivered by teachers would provide a more accurate assessment of change in these levels over the study period, although data from school health inventories (provided by schools) did support these assumptions.

Activity logs were used to monitor the amount of activity that teachers provided to students. There was however no means to validate how many students within each class participated and to what extent. As previously mentioned, assessing the time of day and the intensity of PA with accelerometers would enhance my ability to determine when PA was undertaken most often and at what intensity. Also, more direct measure of observation, such as the SOFIT (146) (used in CATCH) would have been useful in truly capturing the intensity and duration of physical activity in PE class.

Maturity, if not controlled for represents a confound in any intervention study that evaluates growing children. To account for this we assessed Tanner stage in boys and Tanner stage and menarcheal status in girls. However, the self-assessment of Tanner stage may be considered a limitation as categories are broad and it is not a sensitive tool with which to discern maturation and change in maturation. Age at peak height velocity or hand-wrist X-rays are able to characterize changes in maturity more accurately than Tanner estimates (135). However, classification of students by peak height velocity requires years of longitudinal data and hand-wrist x-rays expose children to ionizing radiation. Although lacking the same level of precision, Tanner staging has performed well against direct ratings of maturity by physicians (63) and may be the only means feasible to assess maturity in trials conducted within schools.

Dietary intake if not controlled for could explain differences in weight or fat gain and loss between groups as homeostasis is a result of a delicate balance between energy intake and energy expenditure. Although we collected food frequencies on all children these instruments were geared towards calcium-rich foods so an accurate assessment of energy intake could not be made. We collected 24-hour dietary recall surveys from a subset of children who were undertaking the cardiovascular assessment (n=244). Thus, it is possible that children in the intervention group were consuming more total calories than the children in the control group, accounting for the non-effect in the current study. However, based on the randomized nature of the study design and preliminary results from the 24-hour dietary recall on the subset of children who completed them in Time 2 (T2), there did not appear to be differences in dietary intake between children (data not provided). Ideally, I would have established a clear baseline for caloric intake and controlled for any differences in my statistical analysis.

6.5 Unique Aspects and Strengths of the Study

Action Schools! BC was unique because it targeted all children, regardless of skill level or background. It was inclusive. Opportunities for physical activity were provided on a daily basis, representing a substantial improvement over previous studies that only targeted PA in PE class. Further, opportunities to be physically active were provided by all teachers intermittently throughout the day.

One of the major strengths of this study was that schools, teachers and parents were an integral part of the planning and development process. The Advisory Committee met twice prior to the beginning of the intervention to guide the development of the AS! BC model. Exchange of ideas and discussion of problems and solutions related to program delivery was facilitated in both directions- from those on the providing and receiving ends of the AS! BC model. Teachers are often inundated with too many students per class, not enough time to cover the basic curriculum and are often too overwhelmed to consider additional tasks. An integral part of any effective intervention is to involve and obtain commitment from schools administrators, teachers, parents and children. At the beginning of the intervention, the support team met with the Action Schools! BC teachers to develop and review the action plans, provide feedback and answer questions. This helped the teachers get started and included them as partners in the process. Future

studies that follow the same protocol when initiating an intervention may achieve better success than prescriptive models of program delivery.

Another strength of Action Schools! BC was that body composition was measured directly using an accurate and precise instrument. In the past, interventions that targeted childhood obesity measured gross changes in weight or BMI. While all children increase their body weight and BMI throughout puberty, changes in fat-mass and fat-free mass vary, especially between sexes. Thus, crude estimates of fatness may not capture the intricacies of body composition whereas DXA provides this advanced capability.

Action Schools! BC represented a partnership between science, education and government. Scientists, school staff and a variety of other community members collaborated with multiple stakeholders across various levels of the government to promote Action Schools! BC in British Columbia. Together, everyone was invested in the success of the program and all partners had a strong desire to lessen the escalating prevalence of obesity in this province. As childhood obesity represents a significant public health concern, the union between individuals, agencies, institutions and ministries marked a major stepping stone in this area.

6.6 Future Directions

This study was a learning experience. Ideas and recommendations for other school-based physical activity trials that target childhood overweight or obesity are described below.

Physical activity if undertaken consistently and at a high enough intensity may be our best weapon against a host of chronic diseases. Not only does physical activity provide protection against a multitude of chronic diseases such as cardiovascular disease and metabolic syndrome, it also assists in the reduction of body fat. Further, it is associated with a plethora of health benefits that cannot be achieved by caloric restriction alone.

Although we can't prevent children from moving from one school to another, in the future, we can develop strategies to increase the number of children who volunteer to participate in school-based trials. Contacting parents directly may be one strategy, although in the current study we were not allowed to do this until formal consent was obtained. The MCG FitKid project contacted parents during school events when parents' presence was mandatory (240). This may be an effective recruitment tool to follow up a letter home that introduces the study. In the future, any process evaluation of an intervention of this nature should include a formal component which documents why parents did not provide informed consent. If parents attend a formal information session, it would be valuable to collect their contact information so that those that decide not to let their children participate could be followed-up.

A formalized tracking system should also be adopted in future studies to explain participant attrition. CATCH investigators tracked all students that left the district within a 100-mile radius (128). Documentation should indicate when students moved, their reason for moving, old and new contact information, and if they will return for follow-up (why or why not).

Based on findings from my study, I also recommend that future interventions incorporate more intense physical activity breaks for students throughout the day in addition to 80 minutes of *quality* PE per week. The physical activity breaks throughout the day are important as they give students a chance to be active on a daily basis. It is possible that 150 minutes of PA per week is not enough to elicit a positive change in overweight and obesity. A higher dose could be incorporated into school routine through structured after-school or lunch-time PA sessions, activity clubs or active transportation to and from school. These activities would not take time away from academics, although they would involve more time, resources and staff supervision. Alternatively, 150 minutes of PA could be sufficient, provided a greater portion of that time is spent in moderate to vigorous physical activity. This could be achieved by increasing the minutes of MVPA in PE class or the intensity of the exercise breaks.

It may be difficult to affect childhood obesity without targeting caloric intake. Thus, future interventions should aim to incorporate a healthy-eating module into their model. Eating nutritious foods is an important part of healthy living, and in the long-run, helping children make better food choices could potentially lead to a reduction in % body fat.

School-based interventions such as Action Schools! BC may not be long enough to demonstrate changes in percent body fat in early- and peri-pubertal children over the short-term. However, over the long-term increased physical activity may translate into positive health habits and benefits including a substantial reduction in percent body fat. Thus, a longer term trial that assesses school-based models where the quality of the intervention is maintained is recommended to determine this.

I also recommend that a more direct measure of physical activity be used in future studies. Although self-report questionnaires are useful, accelerometers provide invaluable data regarding the timing and the intensity of physical activity undertaken in very small intervals throughout the child's waking day. The downside is that accelerometers are also more costly. A direct-observation system such as SOFIT would also be beneficial in quantifying the amount and intensity of physical activity that children are receiving in PE class. However, this would again call for additional funds and resources.

Tanner estimates of maturity are well correlated with physician rating. Even though they introduce bias due to subjectivity, in a school-based intervention that needs to be practical and feasible they are suitable for assessing maturity. If skeletal maturity or peak height velocity cannot be determined, Tanner Staging will suffice and is used most often in pediatric trials.

One of the exciting features of this study for children and parents was that children were sent a copy of their body composition analysis in the mail; they would get to see a 'picture' of their skeletons on paper. Additionally, if children were randomized to the intervention arm of the study, they would have the opportunity to improve their physical activity levels and general well-being, should the program be effective. Many parents reported that their children thoroughly enjoyed getting the mail-outs and seeing their skeletons on paper. Future studies should aim to provide similar feedback and enjoyable incentives for participants. However, for other families it is possible that these incentives were simply not enough- perhaps because they were not necessarily tangible (like money), or perhaps because they were not guaranteed (ie. improved health). Offering monetary compensation is an option that would appeal to most people and which is often done in pharmaceutical trials, but it is not always possible in large-scale trials.

Lastly, the MCG FitKid project had a 'Mobile Lab' that allowed researchers to take the DXA machine to schools (239). Children were excused in groups of four for measurement. This eliminated the need for transportation to and from school and meant that students were missing less class time. Although considerably more expensive than housing the DXA machinery in one location, this is an option that could be more appealing to parents that don't want their children missing class for measurement.

7.1 Summary

Action Schools! BC was a novel school-based physical activity model. It represented a multidisciplinary, collaborative approach to improving childhood health in this province. Body fat was measured directly over a 29-month time period. Findings from this study show that teachers participating in the intervention increased the delivery of physical activity opportunities for students significantly more than teachers in the control. Although this was not effective in reducing % body fat in all children, a definite trend emerged in the children with the greatest % of body fat at baseline. In that subgroup, both boys and girls in the intervention appeared to lose a greater percentage of body fat than children in the control

7.2 Conclusions

School-based trials reach a wide range of children from diverse social, ethnic and socioeconomic backgrounds. The results of this study suggest that school-based ecological models such as Action Schools! BC can be effective for increasing the amount of physical activity provided to children throughout the school day and for maintaining children's physical activity levels. However, to positively affect change in overweight or obesity an intense and more sustained program of physical activity and healthy eating may be required. A model that involves teachers at the outset in the model design and engages multiple sectors and multiple stakeholders is essential for improving the quality and sustainability of the model.

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APPENDICES

Appendix 1. BMI-for-Age Growth Chart (girls). Reproduced from the CDC, 2000.



SAFER . HEALTHIER . PE

2 to 20 years: Boys NAME __ Body mass index-for-age percentiles RECORD # Date Weight Age Stature BMI* Comments BMI 35-34. 31-*To Calculate BMI: Weight (kg) + Stature (cm) + Stature (cm) x 10,000 or Weight (ib) + Stature (in) + Stature (in) x 703 BMI 21. - 14 - 12 kg/m² AGE (YEARS) kg/m² 12 13 16 17

Appendix 2. BMI-for-Age Growth Charts (boys). Reproduced from the CDC, 2000.

Published May 30, 2000 (modified 10/16/00).

SOURCE: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000). http://www.cdc.gov/growthcharts



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Appendix 3. List of Stakeholders in the AS! BC Initiative.

- BC Ministries of Health Services
- Small Business and Economic Development, Education
- 2010 LegaciesNow
- University of British Columbia
- BC Ministry of Education
- Children's and Women's Health Centre of BC
- BC Centre of Excellence for Women's Health
- BC Recreation and Parks Association
- Ministry of Small Business and Economic Development- Sport Branch
- Principals, teachers, students, parents, school boards, superintendents
- Principals' and Vice Principals' Association of British Columbia
- British Columbia Teachers' Federation
- British Columbia Confederation of Parent Advisory Committees
- Physical Education Provincial Specialists Association of British Columbia
- Directorate of Agencies for School Health
- Canadian Association for Health, Physical Education, Recreation and Dance
- Canadian Intramurals Recreation Association
- University professors, PE consultants, Sports administrators

	Fracture 1:
	Fracture 2:
	Fracture 3:
	Please use this space to continue with list if necessary
6. Was	your child sick for longer than one month during the past year?
	If yoe, with whet?
7. Was	your child hospitalized during the past year?
	U YESU NO
	, , , , , , , , , , , , , , , , , , ,
8. Has O Yes	any member of your family been diagnosed with osteoporosis during the past year? O No
	If yes , who?
9. Has	any member of your family been diagnosed with cardiovascular disease or stroke during the past year O Yes O No
	lives who?

|--|

Weekly Activity Leg

Week of:

school/SD#:______Teacher:______Division:______Division:______

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🗌 Head-to-Toe Stretch			🗋 Head-to-Toe Streach			🗋 Head-to-Toe Stretch] Head-to-Toe Stretch] Had-to-Toe Stretch		
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Appendix 5. Teacher Activity Logs.

Appendix 6. School Health Inventory.

School:	
SD#:	
Inventory Takers:	



Action Schools! BC SCHOOL HEALTH INVENTORY

This School Health Inventory is a tool to help school Action Teams assess the school environment to identify areas of improvement to incorporate into the Action Plan!. Each question includes a rating scale that corresponds to the scoring table at the end of the inventory.

The Inventory is a required component of the pilot, and should be completed prior to the creation of the school Action Plan!, and as part of the year-end report. Please contact the AS! BC Support Team at v with any questions or concerns.

1. SCHOOL HEALTH POLICIES AND SCHOOL ENVIRONMENT

1.1 Representative committee for school health programs

Does the school have a representative* committee that meets at least twice a year and oversees school health policies and programs concerning physical activity, healthy eating, and tobacco prevention and cessation?

- 3 = Yes, there is a representative committee that meets at least twice a year and oversees school health policies and programs.
- 2 = There is a committee, but it is not representative; or it does not address physical activity, healthy eating, and tobacco prevention and cessation policies and programs; or it meets less than twice a year.
- 1 = There is no committee for school health programs, but there are plans to establish one.
- 0 = There is no committee for school health programs, and there are no plans to establish one.

* Representative means that it includes relevant members of the school community, such as students, school staff (e.g. teachers, administrators, food services and custodial staff), families, community practitioners (e.g. recreation programmers, public health nurses, counselors), and community volunteers (e.g. coaches).

1.2 Written health policies

- a) Does the school or district have written school health policies that commit the school to the following? (check all that apply)
 - Providing a broad range of competitive and noncompetitive physical activities that help students develop the skills needed to participate in lifetime physical activity.
 - Providing foods that are low in fat, sodium, and added sugars wherever food is available inside the school (in the case of schools with cafeterias, this would also apply to food being served in the cafeteria).
 - Providing a 100% tobacco-free environment 24 hours a day.
 - 3 = Yes, for all of the above.
 - 2 = Yes, but for only two of the above.
 - 1 = Yes, but for only one of the above.
 - 0 = No, neither the school nor district have policies on any of the above.

- b) Does the school have written policies about helmet and safety equipment for cyclists and those commuting to school with 'small wheel vehicles' (e.g. rollerblades, skateboards, scooters)?
 - 3= Yes, the school has both helmet and safety equipment policies.
 - 2= The school has policies about helmet and safety equipment for only one of the above.
 - 1= There are no written policies about helmet or safety equipment, but there are plans to develop them in the future.
 - 0= No, there are no written policies about helmet or safety equipment, and there are no plans to develop them in the future.

1.3 Recess

Are students provided with at least 20 minutes of recess* during each school day, and do teachers or recess monitors encourage students to be active?

- 3 = Yes, students are provided with at least 20 minutes of recess each day, and are encouraged to be active.
- 2 = Recess is provided for at least 20 minutes each day, but neither teachers nor recess monitors encourage students to be active.
- 1 = Recess is provided each day, but for less that 20 minutes; or it is provided on some days, but not on all days.
- 0 = Recess is not provided on any day.
- * Recess is an opportunity for unstructured physical activity, and should complement rather than substitute for physical education.

1.4 Adequate physical activity facilities

Are physical activity facilities adequate in the following ways? (check all that apply)

- Both indoor and outdoor facilities are available for physical education, classroom physical activity, and extracurricular physical activity programs.
- Physical education classes do not have to be canceled due to weather extremes (rain, high or low temperatures, etc.).
- In physical education classes, all students can be physically active without overcrowding or safety risks.
- For extracurricular activities, all interested students can sign-up and participate without overcrowding or safety risks.
- 3 = Yes, physical activity facilities are adequate in all four ways described above.
- 2 = Physical activity facilities are adequate in three of the ways described above.
- 1 = Physical activity facilities are adequate in only one or two of the ways described above.
- 0 = Physical activities facilities are adequate in none of the ways described above.

1.5 Access to physical activity facilities outside school hours

Can all students use the school's indoor and outdoor physical activity facilities outside school hours*?

- 3 = Yes, students can use the school's indoor and outdoor physical activity facilities outside school hours.
- 2 = Indoor or outdoor facilities are available, but not both.

1 = Indoor or outdoor facilities are available, but the hours of availability are limited.

- 0 = No, students can not use the school's indoor and outdoor physical activity facilities outside school hours.
- * Outside school hours means before and after school, evenings, weekends, and school vacations.

1.6 Access to facilities and programs that promote safe, active transportation to and from school

Does the School have the following facilities and programs that promote safe, active transportation to and from school? (check all that apply)

- A 'car-free zone' to provide safe walking areas.
- Adequate* facilities available to lock bicycles and small wheel vehicles like skateboards and scooters.
- □ A 'walk-to school' program involving teachers and families.
- □ Programs promoting the use of helmets and safety gear for those who use active transportation to school (bicycles and 'small wheel vehicles).
- 3 = Yes, the school has three or more of the above.
- 2 = Yes, two of the above.
- 1 = Yes, one of the above.
- 0 = No, none of the above.
- * Adequate means that most of the time (80% +) there are spaces available for students to lock up active transportation equipment.

1.7 Fund-raising efforts promote physical activity

Do school fund-raising efforts promote physical activity (e.g. fun runs, family walks, programs like Jump Rope for Heart)?

Please list the school's physically active fund-raisers:

- 3 = Yes, all of the school's fund-raising efforts promote physical activity in some form.
- 2 = Some of the school's fund-raising efforts promote physical activity in some form.
- 1 = The school's fund-raising efforts do not involve or promote physical activity, but there are plans to change in the future.
- 0 = The school's fund-raising efforts do not involve or promote physical activity, and there are not plans to change in the future.

1.8 Fund-raising efforts support healthy eating

Do school fund-raising efforts support healthy eating through the sale of non-food items or foods that are low in fat, sodium, and added sugars (for example, fruits, vegetables, pretzels, or air-popped popcorn) instead of foods that are high in fat, sodium, and added sugars (for example, candy)?

- 3 = Yes, fund-raising efforts support healthy eating through the sale of non-food items or foods low in sodium, and added sugars.
- 2 = Fund-raising efforts rarely support health eating.
- 1 = Fund-raising efforts typically include the sale of foods high in fat, sodium and added sugars, but there are plans to change this practice.
- 0 = Fund-raising efforts typically include the sale of foods high in fat, sodium and added sugars, and there are no plans to change this practice.

1.9 Access to healthy foods

Does the school promote the sale and distribution of healthy foods* and discourage the sale and distribution of foods of minimal and low nutritive value** throughout the school grounds until after the end of the last lunch period?

- 3 = Yes, the school promotes the sale and distribution of healthy foods and discourages the sale and distribution of foods of minimal and low nutritive value.
- 2 = The school prohibits the sale and distribution of foods of minimal nutritional value and other foods of low nutritive value throughout the school grounds, but only during meal service hours.
- 1 = No, but there are plans to do so.
- 0 = No, and there are no plans to do so.
- * Healthy foods are low in fat, sodium, and added sugars (for example, fruits, vegetables, pretzels, air-popped popcorn).
- ** Foods of minimal nutritional value include carbonated soft drinks, chewing gum and certain candies. Foods of low nutritive value provide most calories in the form of fat and/or sugars but contain few vitamin or minerals. Examples include candy, fried chips and juice drinks.

1.10 Staff orientation to school health policies

Are staff oriented to (verbal and/or written orientation) and given copies of the policies on physical activity, healthy eating, and tobacco prevention and cessation that relate to their job responsibilities?

- 3 = Yes, staff are oriented to and given policies about these topics as they relate to their job responsibilities.
- 2 = Staff are oriented to or given copies of the above policies, but not both.
- 1 = No, but there are plans to do so.
- 0 = No, and there are no plans to do so.

1.11 Communication of school health policies

Does the school communicate its policies on physical activity, healthy eating, and tobacco prevention and cessation to students, staff, families and visitors in each of the following ways? (check all that apply)

- □ 'Tobacco-free school' signs
- Student handbook
- □ Staff handbook
- □ Family handbook and/or newsletters
- □ Staff orientation and meetings
- Student orientation
- □ Announcements at school events
- □ Community meetings
- Contracts with outside vendors and organizations that rent school facilities
- □ Other methods? _
- 3 = Yes, 8-10 of the ways are used to communicate school policy.
- 2 = 4-7 of the ways are used to communicate school policy.
- 1 = 1-3 of the ways are used to communicate school policy.
- 0 = School policy is not communicated to students, staff, families or visitors.

2. PHYSICAL EDUCATION AND OTHER PHYSICAL ACTIVITY PROGRAMS

2.1 150 minutes of physical education per week (IRP guidelines)

Do all intermediate grade students receive physical education* for at least 150 minutes per week throughout the school year, spread over at least three days?

3 = Yes, intermediate grade students receive 150 minutes of physical education per week spread over at least three days each week throughout the school year.

- 2 = Students receive 90-149 minutes of physical education over at least three days each week throughout the school year.
- 1 = Students receive 90+ minutes of physical education on one or two days each week throughout the school year.
- 0 = Students receive fewer than 90 minutes of physical education per week.
- * Physical education refers to scheduled instruction-based physical education classes.

2.2 Equitable distribution of gym time

Do all intermediate grade classes receive equal amounts of gym time?

3 = Yes, all intermediate grade classes receive equal amounts of gym time.

0 = No, all intermediate grade classes do not receive equal amounts of gym time.

2.3 Student preparation for physical education (adequate time in clean, safe changing facilities)

Do students have adequate time in clean, safe changing facilities to change before and after physical education class?

2 = Yes, students have adequate time to change, and the changing facilities are clean and safe.

- 1 = Students have only one of the above.
- 0 = Students do not change for physical education.

2.4 Assessment of satisfaction with physical education

Is information collected from students about their satisfaction/enjoyment and participation in physical education?

3 = Yes, information about student satisfaction/enjoyment and participation is collected several times each year.

- 2 = Information is collected annually.
- 1 = Information is collected less than annually.
- 0 = No, information about student satisfaction/enjoyment and participation in physical education is not collected.

2.5 Promotion of community based physical activity

Does the physical education program use three or more promotional methods* to promote student participation in a variety of community-based physical activity**?

- 3 = Yes, the physical education program uses three or more promotional methods to promote student participation in a variety of community based physical activity.
- 2 = The physical education program promotes participation in a variety of community physical activity options, but through only one or two methods.
- 1 = The physical education program promotes only one or two types of community based physical activity.
- 0 = The program does not promote participation in community based physical activity.
- * Promotional methods (check all that apply):
 - □ Class discussions
 - □ Bulletin boards
 - D Public address announcements
 - □ Take-home flyers
 - □ Homework assignments
 - □ Newsletter articles
 - □ Other: _
- ** Examples of community based physical activity include clubs, teams, recreational classes, special events, and use of playgrounds, parks, bike paths, etc.

3. SCHOOL HEALTH SERVICES

Many school health service positions/budgets have been cut recently. Is this the case in your school? What specific programs and/or positions have been removed? Have any alternatives been explored to continue school health services in the absence of government funding?

4

- Our school health service positions/budgets have not been cut.
- Our school health service positions/budget have been cut (please provide additional information below).
- Our school does not have a health service position/budget.

Positions and/or budgets removed:

Alternatives explored:

3.1 Physical activity promotion

Does the school nurse* or other health service practitioner** promote physical activity to students and their families through the following methods? (check all that apply)

- Distribution of educational materials
- □ Individual advice
- □ Small group discussions
- □ Presentations
- □ Other: _____
- 3 = Yes, physical activity is promoted through three or more of the methods listed above.
- 2 = Physical activity is promoted through two of the methods.
- 1 = Physical activity is promoted through one method.
- 0 = Physical activity is not promoted through any of these methods; or the school does not have a school nurse or other health service practitioner.
- * School nurse means a licensed nurse employed by the school or district.
- ** Other health service practitioner refers to a health professional who provides service to the school on either a contracted or a volunteer basis.

3.2 Healthy eating promotion

Does the school nurse or other health service practitioner promote healthy eating to students and their families through the following methods? (check all that apply)

- Distribution of educational materials
- □ Individual advice
- □ Small group discussions
- □ Presentations
- □ Other: _____

- 3 = Yes, healthy eating is promoted through three or more of the methods listed above.
- 2 = Healthy eating is promoted through two of the methods.
- 1 = Healthy eating is promoted through one method.
- 0 = Healthy eating is not promoted through any of these methods; or the school does not have a school nurse or other health service practitioner.

4. HEALTH PROMOTION FOR STAFF

4.1 Staff physical activity/fitness programs

Does the school or district offer* staff members physical activity/fitness programs** that are accessible and free or low-cost?

- 3 = Yes, the school or district offers staff members physical activity or fitness programs that are accessible and free or low-cost.
- 2 = The school or district offers accessible physical activity/fitness programs, but the programs are not low-cost.
- 1 = The school or district offers physical activity/fitness programs, but the programs are not low-cost and not accessible.
- 0 = The school or district does not offer physical activity/fitness programs.
- * Offer means that the school or district has a special arrangement for staff to participate in physical activity/fitness programs either on-site or off-site through a community program.
- ** Physical activity/fitness programs include classes, workshops, facilities and special events.

4.2 Staff healthy eating programs

Does the school or district offer* staff members healthy eating programs that are accessible and free or low-cost?

- 3 = Yes, the school or district offers staff members healthy eating programs that are accessible and free or low-cost.
- 2 = The school or district offers accessible healthy eating programs, but the programs are not low-cost.
- 1 = The school or district offers healthy eating programs, but the programs are not low-cost and not accessible.

0 = The school or district does not offer healthy eating programs.

* Offer means that the school or district has a special arrangement for staff to participate in physical activity/fitness programs either on-site or off-site through a community program.

4.3 Staff participation in health promotion programs

Does the school or district promote and encourage* staff participation in health promotion programs?

- 3 = Yes, the school or district promotes and encourages staff participation in health promotion programs with three or more of the methods listed below.
- 2 = The school or district promotes and encourages staff participation in health promotion programs with two of the methods.
- 1 = The school or district promotes and encourages staff participation in health promotion programs with only one method.
- 0 = No, the school or district does not promote or encourage staff participation in health promotion programs.
- * Participation promotion methods: (check all that apply)
 - □ Information at orientation for new staff
 - □ Information included with pay cheque

- □ Flyers posted on school walls
- □ Letters mailed directly to staff
- Announcements at staff meeting
- Articles in school/staff newsletter
- □ Incentive/reward programs
- Public recognition
- Other methods:

4.4 Staff access to facilities that promote physical activity

Does the school have bike racks, changing facilities and shower facilities for staff who choose to actively commute to work or exercise at the school during breaks?

- 3 = The school has all of the above facilities.
- 2 = The school has two of the above facilities.
- 1 = The school has one of the above facilities.
- 0 = There are no facilities available to the staff.

5. FAMILY AND COMMUNITY INVOLVEMENT

5.1 Family education

Does the school provide families with opportunities to learn about physical activity, healthy eating, and tobacco prevention and cessation, through educational materials* sent home and involvement in school-sponsored activities**?

- 3 = Yes, the school provides families with opportunities to learn about physical activity, healthy eating, and tobacco prevention and cessation through educational materials sent home and involvement in school-sponsored activities.
- 2 = The school provides many opportunities to learn about only two of the three topics.
- 1 = The school provides few opportunities; or provides many opportunities to learn about only one of the three topics.
- 0 = The school does not provide families with opportunities to learn about physical activity, healthy eating, or tobacco prevention and cessation.
- * Examples of educational materials include brochures, newsletter articles, introductions to curricula, and homework assignments that require family participation.
- ** Examples of school-sponsored activities include parent/teacher meetings, health fairs, food tastings, international meals, field days, walkathons, and fun runs.

5.2 Student and family involvement in planning meals

Note: Only for those schools with breakfast/hot lunch programs

Are students and families involved* in planning school meals?

- 3 = Yes, students and parents are involved with planning school meals.
- 2 = Students or parents are involved, but not both.
- 1 = Neither are involved, but there are plans to involve one or both groups.
- 0 = Neither are involved, and there are no plans to involve them.
- * Examples of being involved include giving menu and recipe suggestions, identifying food preferences, and participating in taste-testing activities.

5.3 Family and community involvement in programs

Do families and community members help plan and implement* school physical activity and/or healthy eating programs?

- 3 = Yes, family and community members help in all three areas.
- 2 = Family and community members help in two of the three areas.
- 1 = Family and community members help in one of the three areas.
- 0 = No, family and community members do not help plan and implement school physical activity and/or healthy eating programs.
- * Examples of family and community involvement: (check all that apply)
 - □ Volunteering to help in the classroom, cafeteria, or with special events;
 - Serving on a school planning committee for physical activity or healthy eating programs;
 - Designing or conducting a needs assessment or program evaluation.

5.4 Community access to school facilities

Do community practitioners have access to indoor and outdoor school facilities* outside school hours** to participate in or conduct health promotion programs***?

- 3 = Yes, community practitioners have access to school facilities.
- 2 = Yes, but the hours of access are somewhat limited.
- 1 = Yes, but the hours of access are quite limited; or there is access to indoor or outdoor facilities but not both.
- 0 = Community practitioners do not have access to either indoor or outdoor school facilities.
- * Examples of school facilities include classrooms, gymnasiums, and outdoor areas.
- ** Outside school hours means before and after school, in the evening, on weekends, and during school vacations.
- *** Examples of health promotion programs include physical activity, healthy eating and/or tobacco prevention and cessation programs.
Appendix 7. Physical Activity Questionnaire for Children.



Action Schools! BC

Physical Activity Questionnaire - Spring 2005

We would like to know about the physical activity you have done in the last 7 days. This includes sports or dance that make you sweat or make your legs feel tired, or games that make you huff and puff, like tag, skipping, running, and climbing.

Remember:

A. There are no right or wrong answers - this is not a test.

B. Please answer all questions as honestly and accurately as you can - this is very important.

1. PHYSICAL ACTIVITY IN YOUR SPARE TIME (this does not include P.E classes).

Have you done any of the following activities in the past 7 days? If yes, how many times and for how long? (Remember, recess is 15 minutes long, and lunch is usually ½ an hour (30 minutes)).

Tick only one circle per row	No	1-2	3-4	5-6	7 or more times	time per session
Skipping	0	0	0	0	0	
Four Square	0	0	0	0	0	
Creative Playground	0	0	0	0	0	
Tag	0	0	0	0	0	<u> </u>
Walking for exercise	0	0	0	0	0	<u></u>
Bicycling	0	0	0	0	0	
Jogging or running	0	0	0	0	0	
Swimming	0	0	0	0	0	<u></u>
Baseball, softball	0	0	0	0	0	
Dance	0	0	0	0	0	
Football	0	0	0	0	0	
Badminton	0	0	0	0	0	
Skateboarding/Scooter	0	0	0	0	0	
Soccer	0	0	0	0	0	
Street Hockey	0	0	0	0	0	
Volleyball	0	0	0	0	0	
Floor Hockey	0	0	0	0	0	
Basketball	0	0	0	0	0	
Ice skating	0	0	0	0	0	
Cross-country skiing	0	0	0	0	0	
Ice hockey/ringette	0	0	0	0	0	<u></u>
Martial Arts	0	0	0	0	0	·
Gymnastics	0	0	0	0	0	
Rollerblading	0	0	0	0	0	
Skiing/Snowboarding	0	0	0	0	0	
Other:	0	0	0	0	0	

2. In the last 7 days, during your **PHYSICAL EDUCATION (PE) CLASSES**, how often were you very active (playing hard, running, jumping and throwing)? Check only one.

O I don't do PE

O Hardly ever

O Sometimes

O Quite often

O Always

3. In the last 7 days, what did you do most of the time at **RECESS?** Check only one.

- O Sat down (talking, reading, doing school work)
- O Stood around or walked around.
- O Ran or played a little bit.
- O Ran around and played quite a bit.
- O Ran and played hard most of the time.

4. In the last 7 days, what did you normally do AT LUNCH (besides eating lunch)? Check only one.

- O Sat down (talking, reading, doing school work)
- O Stood around or walked around.
- O Ran or played a little bit.
- O Ran around and played quite a bit.
- O Ran and played hard most of the time.

5. In the last 7 days, on how many days **RIGHT AFTER SCHOOL**, did you do sports, dance, or play games in which you were very active? Check only one.

- O None.
- O 1 time last week.
- O 2 or 3 times.
- O 4 times last week.
- O 5 times last week.

6. In the last 7 days, on how many **EVENINGS** did you do sports, dance, or play games in which you were very active? Check only one.

- O None.
- O 1 time last week.
- O 2 3 times.
- O 4 5 times last week.
- O 6 7 times last week.

7. How many times did you do sports, dance, or play games in which you were very active LAST WEEKEND? Check only one.

- O None.
- O 1 time.
- O 2 3 times.
- O 4 5 times.
- O 6 or more times.

8. Which **ONE** of the following five statements describes you best for the last 7 days? Read all 5 before deciding on the one answer that describes you.

O All or most of my free time was spent doing things that involved **little physical effort** (e.g. watching TV, homework, playing computer games, Nintendo).

O **I sometimes (1-2 times last week) did physical things** in my free time (e.g. played sports went running, swimming, bike riding, did aerobics).

O I often (3-4 times last week) did physical things in my free time.

O I quite often (5-6 times last week) did physical things in my free time.

O I very often (7 or more times last week) did physical things in my free time.

9. How many hours per day did you watch television or play video games (Playstation, X-Box) or computer games last week? (each show is usually a half hour or 30 minutes). Check only one.

- O I watched/played less than 1 hour or have no TV (or no video/computer games).
- O I watched/played more than 1 hour but less than 2.
- O I watched/played more than 2 hours but less than 3.
- O I watched/played more than 3 hours but less than 4.
- O I watched/played more than 4 hours.

10. Were you sick last week, or did anything prevent you from doing your normal physical activities?

O Yes O No

If yes, what prevented you?_____

11. Mark how often you did physical activity (like playing sports, games, doing dance or any other physical activity) for each day last week (this includes P.E, lunch, recess, after school, evenings, spare time, etc). Circle the days that you had P.E. during the last week.

	None	Little Bit	Medium	Often	Very Often
Monday	0	0	0	0	0
Tuesday	0	0	0	0	0
Wednesday	0	0	0	0	0
Thursday	0	0	0	0	0
Friday	0	0	0	0	0
Saturday	0	0	0	0	0
Sunday	0	0	0	0	0

- 12. Do you participate in organized sport (soccer, dance, karate etc.) outside of school?
 - O Yes
 - O No
- 13. Do you participate in other **organized activities** (music lessons, Chinese school tutoring, girl guides, boy scouts) outside of school?
 - O Yes O No
- 14. If you do participate in organized sport or other activities, how many nights during the week do you do these sports and/or activities? (If you have swimming lessons on 2 nights of the week, check the circle beside "2" and write swimming lessons on the line. You can have more than one activity on a line).

SPORTS

OTHER ACTIVITIES



15. During the last 7 days, on how many days did you travel TO SCHOOL by car or by bus?

- O None.
- O 1 time last week.
- O 2 or 3 times last week.
- O 4 times last week.
- O 5 times last week.

16. During the last 7 days, on how many days did you travel HOME FROM SCHOOL by car or by bus?

- O None.
- O 1 time last week.
- O 2 or 3 times last week.
- O 4 times last week.
- O 5 times last week.

17. During the last 7 days, on how many days did you walk or bike TO SCHOOL?

- O None.
- O 1 time last week.
- O 2 or 3 times last week.
- O 4 times last week.
- O 5 times last week.

18. During the last 7 days, on how many days did you walk or bike HOME FROM SCHOOL?

- O None.
- O 1 time last week.
- O 2 or 3 times last week.
- O 4 times last week.
- O 5 times last week.

19. If you walk to and from school, how long does it take you? _____minutes

20. If you *bike* to and from school, how long does it take you? ______minutes

Appendix 8. School Action Plan.



School Action Plan School Year:___

Plan: School Teacher School/SD#:

completed by:

Date completed ... Grade/Div:

Complete this form to develop your School and or Classroom Action Plans. Use the Action Schools! BC Planning Guide nor context the Action Schools! BC Support Team to assist you. Phone 604, 738, 2485 or 1, 800,565,7727 or email info@actionschoolsbc.ca

When completed, please send this form to Action Schools! BC: fax at 604.737.6043 or email info@actionschoolsbc.ca

Goal Statements <i>(see Guide</i>)	Actions (see Guide)	Date(s) or Timing for Action
Action Zone: School Environment – e.g. policies, professional development, facilities/equipment		
Action Zone: Scheduled Physical Education - Gr 4-7 (150 min/wk) - Active Living Movement, Personal & Sc	ctal Asponsibility	PE schedule (e.g. 2x40mm/wk):
Achieve curraculum outocraes		
Action Zone: Classroom Action – e.g. 15x5, health, nut tion		
Provide	Action Schools! BC Action 15x5	All year September-Jane
Action Zone: Family & Community - e.g. active field tips, guest demonstrations, family alghts		
Action Zone: Extra-Curricular – e.g. clubs, intramu in k, team sports		
Action Zone: School Spirk - e.g. s: bool wide events, sports days		



Appendix 9. 24-hr Food Recall

Food/Beverage	Description	Amount	Comments

Do you take any nutritional supplements? Yes o No o
If yes, what type(s)?

Appendix 10. Self-Assessment of Maturity Status (boys).

As you keep growing over the next few years, you will see changes in your body. These changes are a normal part of growth and happen at different ages for different children. You may already be seeing some changes in yourself. Sometimes it is important to know how a person is growing without having a doctor examine them. It can be hard for a person to describe how they grow and develop in words, so doctors have drawings of stages that all children go through. There are 5 drawings of pubic hair on the next page. All you need to do is pick the drawing that looks like you do now. Put a check mark above the drawing that is closest to your stage of development for pubic hair. Put the sheet in the envelope and seal it so your answer will be kept private.

BOYS: After reading the descriptions under each drawing, please place a check mark above the drawing that looks most like your stage of pubic hair development. Seal your response in the envelope provided. Thank you!



There is no pubic hair at all.

There is a small amount of long, lightly coloured hair. This hair may be straight or a little curly.

There is hair that is darker, curlier and thinly spread out to cover a somewhat larger area than in stage 2. The hair is thicker and more spread out, covering a larger area than in stage 3. The hair now is widely spread and covering a large area, like that of an adult male. Appendix 11. Self-Assessment of Maturity Status (girls).

As you keep growing over the next few years, you will see changes in your body. These changes are a normal part of growth and happen at different ages for different children. You may already be seeing some of these changes in yourself. Sometimes it is important to know how a person is growing without having a doctor examine them. It can be hard for a person to describe how they grow and develop in words, so doctors have drawings of stages that all children go through. There are 5 drawings of breast growth, and 5 drawings of pubic hair growth on the next page. All you need to do is pick the drawings that look like you do now. Put one check mark on the line at the drawing that is closest to your stage of development for breast growth, and one check mark at the drawing that is closest to your stage of pubic hair growth. Put the sheet in the envelope and seal it so that your answer will be kept private.

Please put a check mark on the drawing that looks most like (1) your stage of breast development, and (2) your stage of pubic hair development. Seal your response in the envelope provided. Thanks!

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Appendix 12. Food Frequency Questionnaire.

Food	Frequency	Questionnaire
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Name:

_____ Date:_

We would like to know about some of the foods you eat. For each food listed please fill in how often you usually eat a portion of the size stated. If you eat the food:

- every day or more than once a day, fill in how many times you have it per day
- less than once a day but more than one a week, fill in the times per week
- less than once a week, but more than once a month, fill in the times per month
- less often than once a month, or never eat it, put an 'X' under 'do not eat'.

Example: Janice has a glass of orange juice every morning, along with two slices of toast. She usually has two sandwiches at lunch, and eats french fries about 3 times per week. She almost never eats cauliflower.

	Per day	Per week	Per month	Don't eat
Orange Juice, 1 cup French fries, regular serving	·1	3		
Cauliflower, ½ cup (125 ml)		0		X
Bread or toast, 1 slice	2			
NUMBER OF TIMES I EAT THE FOOD				
	Per day	Per week	Per month	Don't eat
Bread or toast, 1 slice or 1 roll				
Muffin, 1 large				
Pizza, 1 medium slice				
Cheeseburger or veggie burger with cheese				
Cheese: 1 slice processed OR 1 piece				
hard cheese (plain or in sandwich)				
Broccoli, ½ cup (125 ml)				
Gai-lan (Chinese broccoli), ½ cup				
Bok- choi (Chinese cabbage), ½ cup				
Ice cream (large scoop)				
Frozen yogurt (large scoop)				
Fast food milkshake				
Cottage cheese, 1/2 cup				
Yogurt, small (174 ml) carton or equivalent				
Canned salmon or sardines with bones,				
1⁄2 small can				
Soft drink, 1 can or large glass				
Tofu, 2 oz (60 gm)				
Milk on cereal				

Orange juice, 1 cup Milk (any type including chocolate), 1 cup Macaroni & cheese, 1 cup (250 ml)

I usually drink (choose milk OF chocola soy mill rice mill	one only) R te milk OR K OR			
Are you allergic to any	foods?			
NO YES: (w	vhat foods?)
Do you use any vitami	n and/or miner	al supplements? (This q	uestion is <u>not</u> about medi	cations)
	Daily	>3x/week	1-3x/week	<1/week
Multivitamin Multivitamin/mineral				
Iron				
Vitamin C				

.....

What is the brand/name of the supplement?_____

THANK YOU!