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The increase of childhood obesity in a limited sample of Canadian children between 1979 and 1998.

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Abstract

Overweight and obesity are important public health concerns associated with a variety of negative physiological and psychological consequences in children[1], youth[1] as well as in adults[2,3]. The objective of this study was to evaluate the increase in childhood overweight and obesity in a Canadian sample of 7 to 12 year olds between 1979 and 1998 using the BMI as the indicator of obesity. Analyses of variance were performed on the data between the different study cohorts. The 85th and 95th age and gender specific percentile of BMI of the 1979 CAHPERD study respectively defined overweight and obesity cut-off points. Results support previous studies and clearly show a significant increase in the prevalence of overweight and obesity in today's children. They also show a higher increase of overweight and obesity in girls than in boys. Since childhood obesity is an increasingly important predictor of adult obesity[26,27,28,29] and obesity in adults is associated with a number of health consequences[2,3], regular screening of children for overweight and obesity should be put in place and preventive measures taken when children are at risk.

Résumé

L'embonpoint et l'obésité sont des problèmes de santé public importants reliés à une variété de problèmes physiologiques et psychologiques tant chez les enfants[1], les adolescents[1] que chez les adultes[2,3]. Cette étude avait comme but d'évaluer l'augmentation du taux d'embonpoint et d'obésité chez un échantillon d'enfants canadiens âgés de 7 à 12 ans utilisant l'IMC comme indicateur d'obésité. Des analyses de variance ont été effectuées. L'embonpoint et l'obésité ont respectivement été définis par le 85ème et 95ème percentile de l'IMC de l'étude de l'ACSEPRD de 1979 selon l'âge et le sexe. Les résultats supportent les études antérieures et démontrent clairement une augmentation du taux d'embonpoint et d'obésité chez les enfants

d'aujourd'hui. Ils démontrent également que l'augmentation de l'embonpoint et de l'obésité est plus élevée chez les filles que chez les garçons. Puisque l'augmentation du taux d'obésité chez les enfants prédit une augmentation du taux d'obésité chez les futurs adultes[26,27,28,29] et que l'obésité chez les adultes est reliée à une panoplie de conséquences négatives[2,3], le dépistage de l'embonpoint et de l'obésité chez les enfants devrait être effectué régulièrement et des mesures préventives devraient être initiées chez les enfants à risque.

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Finally, this thesis would never have been possible without the endless opportunities given to me by my family. I am forever grateful to my father for his endless assistance, to my mother for her encouragement and to my brother for his inspiration.

Over the course of this project and in the process of working with my advisor, colleagues and friends I have learned and have grown a great deal.

Table of Content

Chapter 1

General Introduction

Being overweight or obese is a common disturbance in children and adolescents and is becoming a major concern for health professionals (Troiano, Flegal, Kuczmarski, Campbell, & Johnson, 1995). It seems that childhood is a critical period for the initiation of obesity and its associated health problems (Power, Lake, & Cole, 1997). The increase of body fat and the eventual development of obesity is the result of the energy intake being greater than the energy expenditure over a long period of time (Leibel, Rosenbaum, & Hirsch, 1995). The factors causing a positive energy balance are of a genetic, behavioural, and environmental nature (Bouchard et al., 1990; Warden & Fisler, 1994). These include such things as a high-fat diet (Heitmann, Lissner, Sorensen, & Bengtsson, 1995), a low level of habitual physical activity, a low resting metabolic rate for a given body mass and body composition (Ravussin & Swinburn, 1993). Unlike what many people think, there is no evidence that the current prevalence of overweight and obesity is due to an increase in energy intake (Bouchard, 1997). Overweight and obesity are important public health concerns associated with a variety of negative physiological, psychological, social and economic consequences in children and youth (Must, 1996) as well as in adults (USDHHS, 1996).

Because obese youth tend to become obese adults, and obesity in adulthood is associated with increased risks of adverse health outcomes, pediatric obesity is gaining increasing recognition as an important public health concern (Troiano et al., 1995). In fact, an increase in childhood obesity now may predict an increase in morbidity as adults later. This concern has been heightened by findings of several recent European and American epidemiological studies indicating a definite increase in obesity in youth as well as in adults

(Boreham, Savage, Primrose, Cran, & Strain, 1993; Gortmaker, Dietz, Sobol, & Wehler, 1987; Jonides, 1990).

Canada has many studies describing anthropometric data from national samples of children. Recently in 1979 (Gauthier, Quinney, Massicotte, & Conger, 1980), 1983 (Gauthier, Massicotte, Hermiston, & Macnab, 1983) and 1989 (Massicotte, 1990) the Canadian Association for Health, Physical Education, Recreation and Dance gathered anthropometric data from national samples of children aged 7 to 17. Unfortunately, no recent studies exist that describe the prevalence of overweight and obesity in Canadian children. It is thus the purpose of this thesis to assess the prevalence and the increase of overweight and obesity in a limited sample of Canadian children 7 to 12 years old between 1979 and 1998.

The present study will contribute to the body of knowledge related to the prevalence and the increase of childhood overweight and obesity as depicted in a number of studies. With respect to the Canadian youth population, very little (if not none) research has been conducted on the prevalence and increase in childhood overweight and obesity. Tracking of obesity during childhood and from childhood into adulthood suggests that the increase in childhood obesity foreshadows increased morbidity in future Canadian adults. It is thus of great importance to assess the increase in childhood overweight and obesity in Canada over the past several years.

A lack of Canadian norms has resulted in Canadian studies using United States (US) norms to compare anthropometric data (Evers & Hooper, 1995; Shephard & Rode, 1995). This practice may lead to erroneously labelling a nonobese child as obese which may lead to negative psychological sequela, or the initiation of harmful weight reduction attempts (Robinson, 1993).

This study begins with an up-dated version of the review of the literature and methodology section of the thesis proposal meeting. An article prepared for publication in a

refereed scholarly journal following the requirements of the selected journal follows. A general discussion and conclusion provides a global summary and discussion of the work. Finally a statement of contributions of collaborators is presented.

Chapter 2

Review of the Literature

The Physiological Consequences of being Overweight or Obese

Overweight and obesity are associated with a number of health consequences in youth (Must, 1996) as well as in adults (Kissebah, Freedman, & Peiris, 1989; Pi-Sunyer, 1993; USDHHS, 1996).

Serious physical health complications associated with obesity rarely occur during childhood (Must, 1996) and are primarily demonstrated in very obese children. These include Pickwickian syndrome (obstructive apnea), cardiomyopathy, and pancreatitis (Dietz & Robinson, 1993; Taitz, 1983).

A less serious but more common condition related to obesity at a young age is high blood pressure. Studies have shown that the Body Mass Index (BMI) in children is strongly correlated with blood pressure (Gutin et al., 1990; Moussa, Skaik, Selwanes, Yaghy, & Bin-Othman, 1994). In a recent study, Verma, Chhatwal, and George (1994) found a much higher prevalence of hypertension in obese as compared to nonobese children (13.7% vs 0.4%) and a highly significant ($p < 0.01$) correlation was noted. In their study, Gupta and Ahmad (1990) reported that the prevalence of sustained hypertension in obese children was 20 times greater than in controls. Research has shown that overweight children are significantly more likely to have elevated systolic blood pressure and total blood cholesterol levels (Resnicow, Futterman, & Vaughan, 1993; Resnicow & Morabia, 1990; Williams et al., 1992) and pediatric blood pressure levels, particularly systolic, are predictive of adult levels (Webber, Srinivasan, Wattigney, & Berenson, 1991).

Evidence also exists to support an association between obesity and cardiovascular

disease in children (Boreham et al., 1993; Sangi et al., 1992). Other studies have linked juvenile obesity with respiratory disease (Bray, 1985; Simpser, Strieder, Wohl, Rosenthal, & Rockenmaker, 1977; Tracey, De NC, & Harper, 1971) and several orthopaedic conditions (Bray, 1985; Dietz, Gross, & Kirkpatrick, 1982).

Children with persistent increased adiposity carry associated risk factors with them into adulthood (Aristimuno, Foster, Voors, Srinivasan, & Berenson, 1984). Overweight or obesity during childhood and adolescence predicts a number of adverse health consequences later in life, including increased morbidity and mortality (DiPietro, Mossberg, & Stunkard, 1994; Must, Jacques, Dallal, Bajema, & Dietz, 1992; Nieto, Szklo, & Comstock, 1992).

The Psychological, Social and Economic Consequences of being Overweight or Obese

Obesity affects a variety of psychosocial functions in youth (Wadden & Stunkard, 1985). Early studies viewed emotional disturbances as an antecedent of obesity, but recent evidence suggest that these disturbances are more likely to be consequences of increased adiposity (Stunkard, 1985). The social prejudice and discrimination directed at individuals that are overweight or obese and the effects of dieting lead to the disturbances (Wadden & Stunkard, 1985). This strong prejudice against people who are obese exists regardless of gender and age (Allon, 1979). In fact, children as young as six years old describe silhouettes of obese children as "lazy", "dirty", "stupid", "ugly", "cheats", and "lies" (Staffieri, 1967). Feldman, Feldman, and Goodman (1988) found that when young children are shown pictures of children of various builds they choose chubby children as least "likeable". Several studies have found that when shown line drawings of a child of normal weight, an obese child, and children with various disabilities, children as well as adults rate the obese child as the least "likeable" (Goodman, Dornbusch, Richardson, & Hastorf, 1963; Maddox, Back, & Liederman, 1968; Richardson,

Goodman, Hastorf, & Dornbusch, 1961). In their study, Wright and Whitehead (1987) noted that adults also ranked obese children as least "likeable" when choosing between pictures of children with various disabilities. Health care providers also share this prejudice, in fact, in one study a group of physicians described their obese patients as "weak-willed, ugly, and awkward" (Maddox & Liederman, 1969).

Studies have shown that obese children tend to have higher rates of depression and lower self-concept (Strauss, Smith, Frame, & Forehand, 1985), are more dissatisfied with their body (Wadden, Foster, Stunkard, & Linowitz, 1989; Wardle & Marsland, 1990) and have lower self-esteem than nonobese children (Drake, 1988; Kolody & Sallis, 1995). Overweight adolescents frequently refer to weight as an exclusive focus in social interactions (Allon, 1979) and social isolation has been related to lower self-esteem (Connolly, White, Stevens, & Burstein, 1987) which may explain some of the lower self-esteem and other psychosocial problems in obese youth (Behrman, Vaughan, & Nelson, 1987).

Overweight during adolescence affects high-school performance (Canning & Mayer, 1967) and psychosocial functioning (Monello & Mayer, 1972). Canning and Mayer (1966) found lower acceptance rates into high-ranking colleges for obese high school students than for normal-weight students, even though the two groups did not differ in high school performance, academic qualifications, or application rates to college.

Being overweight or obese during adolescence has been linked to important social and economic consequences that are often greater than those associated with many other chronic physical health conditions (Gortmaker, Must, Perrin, Sobol, & Dietz, 1993). In a seven-year follow-up study, Gortmaker et al. (1993) found that women who were overweight during adolescence completed fewer years of school, were less likely to be married, had lower

household incomes and had higher rates of household poverty than the women who had not been overweight. Men who had been overweight during adolescence were also less likely to be married. These results are independent of baseline socio-economic status and aptitude-test scores.

Stereotypes associated with obesity are extremely negative (Harris, Walters, & Waschull, 1991) which may explain why people who are obese are discriminated against in the work force (Allon, 1982). Larkin and Pines (1979) found that overweight individuals are thought to make less desirable employees than persons of normal weight, even when the two groups are believed to have the same abilities.

The Relationship between Child, Adolescent and Adult Adiposity

In the past, health professionals have shown little interest in childhood obesity. It was thought to be a temporary phase that bore no relation to adult adiposity and its associated mortality and morbidity (Hawk & Brook, 1979). Today, a great public health concern is, the risk that childhood and adolescent obesity will persist into adulthood, since a number of recent studies (Dietz, 1994; Guo, Roche, Chumlea, Gardner, & Siervogel, 1994; Power et al., 1997) have associated overweight in youth with overweight in adulthood. In fact, Serdula et al. (1993) reviewed a number of prospective studies and found that about one third (26 to 41%) of obese preschool children and about half (42 to 63%) of obese school-age children were obese as adults. Overall the risk of obesity in adulthood was 2 to 6.5 times higher for obese children as for nonobese children. In a detailed study of a French cohort of children, Rolland-Cachera et al. (1984) found 41% of obese adults had been obese children.

In addition, the severity of obesity as well as the age at onset affect the likelihood of the persistence into adulthood (Dietz, 1994). Serdula et al. (1993) found that the risk of adult obesity was much greater for children who had higher levels of adiposity and for children who were

obese at older ages. In their study, Guo et al. (1994) found that the risks for being overweight at age 35 were about 2 to 4 times higher for those who were overweight during childhood and adolescence. The risks were consistently higher for the subjects who were very obese (95^{th} percentile) when young, about 3 to 10 times higher for those who were very obese during childhood, and 5 to more than 20 times for those who were very obese during adolescence. These results confirm that among older children, obesity is an increasingly important predictor of adult obesity (Whitaker et al., 1997).

Unfortunately, obesity in adults is associated with increased mortality, coronary heart disease, hypertension, dyslipidemia, osteoarthritis, a number of cancers, and especially diabetes (Pi-Sunyer, 1993; USDHHS, 1996). As well, a number of studies (Mossberg, 1989; Must et al., 1992) have shown an increase in morbidity and mortality in adults who were obese as children. More recent studies (Lee et al., 1993; Manson et al., 1995) have shown a positive relationship between BMI and mortality.

BMI as a Measure of Overweight and Obesity in Children

Accurate identification of obesity in children and in youth is of great concern. Many laboratory methods are available to assess body composition, all with their own advantages and limitations (Bandini & Dietz, 1987; Lukaski, 1987). These include densiometry, magnetic resonance imaging, and dual photon absorptiometry from isotopic or X-ray sources. Because these methods require expensive equipment that is not portable, not practicable for large-scale field work and are technically difficult to apply to children, anthropometric measures have been widely used to measure body fat in clinics and field studies.

According to Flegal (1993), the ideal measure of obesity would have three properties: (1) it would estimate body fat content accurately; (2) appropriate reference values would be

available; and, (3) the measurement would be easily made. Currently, weight for height indices, specifically BMI, comes closest to meeting these criterias for Canadian children. In fact, BMI is widely used to assess adiposity in children (Hall, 1995) and weight divided by height-squared, also known as Quetelet's Index (Quetelet, 1942) or body mass index (BMI), is commonly found in the epidemiology literature concerning risk factors in childhood and adolescence.

BMI as an accurate estimate of body fat content

Studies have shown that BMI in children is correlated with direct measures of adiposity (Roche, Siervogel, Chumlea, & Webb, 1981; Smalley, Knerr, Kendrick, Colliver, & Owen, 1990). Hannan, Wrate, Cowen, and Freeman (1995) found a highly significant relationship between BMI and percentage of body fat measured by dual-energy x-ray absorptiometry (DEXA) in adolescent girls. Another study (Daniels, Khoury, & Morrison, 1997) found correlation coefficients in the order of 0.94 and 0.96 for black and white girls and 0.85 and 0.86 for black and white boys respectively between BMI and fat mass measured by DEXA.

McLean and Skinner (1992) found correlation coefficients of 0.79 and 0.78 between hydrostatic or underwater weighing (UWW) and BMI for males and females respectively. Another study showed significant correlations in the order of 0.89 for women and 0.62 for men between BMI and body fat percentage from UWW (Williams, Going, Milliken, Hall, & Lohman, 1995). Deurenberg, Weststrate, and Seidell (1991), also found significant correlations between BMI and UWW for boys and girls .

Significant correlations were found between BMI and skinfold thickness (TSF) for males (0.71 to 0.85) and for girls (0.78 to 0.85) depending on age (Lazarus, Baur, Webb, & Blyth, 1996). Other studies of both children and adults demonstrated strong correlations between TSF and BMI (Dietz, Bandini, Schoeller, & Gortmaker, 1988; Michielutte, Disker, Corbett,

Schey, & Ureda, 1984; Revicki & Israel, 1986; Spyckerelle, Gueguen, Guillemot, Tosi, & Deschamps, 1988).

Appropriate available reference values

The statistical approach to childhood obesity defines obesity relative to a selected percentile of a reference group, defined in terms of age, gender or other characteristics (Flegal, 1993). However, definitions of obesity in children are not standardized because of the lack of population reference data on children, and the extreme variability of growth ranges in children (Keller & Stevens, 1996). In fact, an expert committee recently published a set of guidelines for the design of routine screening programs for overweight in adolescent (Himes & Dietz, 1994). Their choice of an appropriate reference population was the data provided by Must, Dallal and Dietz (1991). Unfortunately, Canadian clinicians might uncritically adopt these recommendations which could lead to systematic misclassification as found by Lazarus, Baur, Webb, Blyth, & Gliksman (1995) in an Australian sample of children and adolescents. They suggest that screening programs should use BMI cut-offs appropriately derived from local measurements.

Fortunately, a number of studies have been conducted in Canada on anthropometric data in children from which BMI cut-offs may be derived. The 1979 CAHPER (Gauthier et al., 1980) study has one of the largest national sample of randomly selected children from which weight and height have been collected. This would be an ideal reference population in studies measuring growth in Canadian children.

Easily made measurement

For the assessment of body composition in epidemiological studies, a weight-height index (BMI being one of them) is the most simple method. A minimum of (inexpensive)

equipment is needed, i.e. only a balance and a stadiometer, and the errors in measurement due to intra- or inter-observer variations are small (Deurenberg et al., 1991). Although BMI is an indirect index of adiposity, it is easy to calculate from two anthropometric measures (weight/height^2) that are inexpensive, convenient, harmless to the subject and reliable in screening settings (Lazarus et al., 1995).

Reference Population and Cut-off Points in the Present Study

In this study childhood overweight and obesity is defined in terms of the BMI, because it is the best and most widely used measure of adiposity among indexes derived from height and weight measurements (Kraemer, Berkowitz, & Hammer, 1990; Rolland-Cachera et al., 1982). It has been widely adopted as the least complicated and reliable epidemiological indicator of body fat (James, Ferro-Luzzi, & Waterlow, 1988).

An expert committee recently published a set of guidelines for the design of routine screening programs for overweight in adolescent and recommends that adolescents whose BMI>85th percentile, but <90th percentile or equal to 30 (whichever is smaller) be considered at "risk of overweight" (Himes & Dietz, 1994). The guidelines suggest that subjects be classified as "at risk of overweight" or "overweight" by using BMI cut-off points (85th and 95th percentiles for age and gender, respectively). More recent studies (Troiano et al., 1995; Whitaker et al., 1997) used the 85th percentile as the criteria for "overweight" and the 95th percentile as the criteria for "obesity". It is important to note that choosing the 85th percentile as the criterion value entails an arbitrary initial assumption that the prevalence of overweight is 15%; it should not be interpreted as an independent finding that the prevalence of obesity is 15%.

As discussed before, the determination of obesity is usually made using population-based criteria, such as body mass index established from a reference population (Must, Dallal, &

Dietz, 1991). For the present study, the 1979 CAHPERD study (Gauthier et al., 1980) will be used as the reference population since it is one of the largest and most representative sample of Canadian children ever collected from which BMI may be derived.

Increasing Childhood Obesity

Because obese youth tend to become obese adults, and obesity in adulthood is associated with increased risks of adverse health outcomes, pediatric obesity is gaining increasing recognition as an important public health concern (Troiano et al., 1995). In fact, an increase in childhood obesity now may predict an increase in morbidity as adults later. This concern has been heightened by findings of several recent European and American epidemiological studies indicating a definite increase in obesity in youth as well as in adults (Boreham et al., 1993; Gortmaker et al., 1987; Jonides, 1990).

Cernerud (1993), in a study of Swedish children, found an increase in the BMI of boys and girls during the period 1970-90. In an other study, a significant mean increase of 0.45 kg/m^2 in the BMI was found for the entire Swedish male population aged 16 to 84 between 1980 and 1989 (Kuskowska-Wolk & Bergström, 1993). A study of a clinical sample of approximately 800 obese children and adolescents from all over Germany found a significant ($p<0.0001$) BMI-increase from 1985 to 1995 for constant gender and age (Barth et al., 1997). Increments over the ten-year period largely correlated with the quartiles analysed and were maximal at the 9th decile for males in whom the increase between 1985 and 1995 averaged approximately 5 kg/m^2. In females the corresponding increase was more than 2.5 kg/m^2.

Mean BMI for US adult men and women aged 20 through 74 increased from 25.3 to 26.3 kg/m^2 between 1976 and 1991 and mean body weight increased 3.6 kg (Kuczmarski, Flegal, Campbell, & Johnson, 1994). Between the National Health Examination Survey (NHES)

(Cycles II and III; 1963-1965 and 1966-1970) and the National Health and Nutrition Examination III (1988-1991), overweight defined by the NHES 85th percentile of BMI increased approximately 7% for 6 through to 11 year olds and for 12 through to 17 year olds. When overweight was defined by the NHES 95th percentile of BMI the increase was approximately 5% for 6 through to 11 year olds and 6% for 12 through to 17 year olds (Troiano et al., 1995). These increments translate into relative increases of 40% using the 85th percentile as a cut-off and 100% upon use of the 95th percentile.

Canada has many studies describing anthropometric data from national samples of children. In 1957, "The report on Canadian average weights, heights, and skinfolds" (Pett & Ogilvie, 1957) described data collected from a Canadian sample of children in 1953. In 1982, Jetté published a report describing the anthropometric characteristics of Canadian children based on data collected during the 1970-72 Nutrition Canada National Survey. More recently in 1979, 1983 and in 1989 the Canadian Association for Health, Physical Education, Recreation and Dance gathered anthropometric data from national samples of children aged 7 to 17.

Unfortunately no recent studies exist that describe the prevalence of obesity in Canadian children. It is thus the purpose of this research to assess the prevalence and the increase of overweight and obesity in a Canadian sample of 7 to 12 year olds from 1979 to 1998.

Research hypothesis

In relation with previous studies it is hypothesised that there will be a significant constant increase in childhood overweight and obesity for constant age and gender in Canadian children aged 7 through 12 from 1979, 1983, 1989 and 1998.

Significance of the present study

The present study is of importance for a number of reasons. First, this study will

contribute to the body of knowledge related to the prevalence and the increase in childhood overweight and obesity as depicted in a number of studies. With respect to the Canadian youth population, very little (if not none) research has been conducted on the prevalence and increase in childhood overweight and obesity. Tracking of obesity during childhood and from childhood into adulthood suggests that the increase in pediatric obesity foreshadow increased morbidity in future Canadian adults. It is thus of great importance to assess the increase in childhood overweight and obesity in Canada over the past several years.

Second, it proposes specific cut-off points defining overweight and obesity (85^{th} and 95^{th} percentile respectively) for Canadian children using a Canadian study as a reference population. A lack of Canadian norms has resulted in Canadian studies using US norms to compare anthropometric data (e.g. Evers & Hooper, 1995; Shephard & Rode, 1995). This practice may lead erroneously labelling a nonobese child as obese which may lead to negative psychological sequela, or the initiation of harmful weight reduction attempts (Robinson, 1993).

In summary, the present study is of theoretical significance in the area of exercise science since it will add to the body of literature on obesity and on the growing body of knowledge related to pediatric obesity. This study will also be of significance in the context of applied settings where recent efforts to assess and prevent any more increases in childhood obesity have started to receive increasing attention in recent times.

Chapter 3

Methodology

The 1979 CAHPERD Study

In 1979, the opportunity to gather height and weight data from a large random sample of Canadian school children presented itself with the revision of the CAHPER Fitness Performance Test.

The sample of schools

The sample of 140 schools from the ten provinces and two territories of Canada was an unbiased, representative sample of the population. The population was defined as all school children and youth, aged 6 to 17 years at the time of measurement, in grades 1 to 12, except in Quebec, where grades covered were 1 to 11. Exclusions to the population included schools specifically for the education of disabled children, and Department of National Defence schools outside of Canada. The population from which the sample was selected was the 1977-78 Statistics Canada ERL File and the 1978-1979 File from the "Service de l'informatique, Gouvernement du Québec" (Gauthier et al., 1980).

The sample of schools selected was proportional to enrolment but stratified by province and territory to ensure representation from all areas of the country. It was assumed that the number of individuals per school was independent of province and territory. Therefore, the number of schools selected was proportional to the total enrolment of that province or territory and was ordered by grade level groups. A systematic probability was then selected according to the latest enrolment data (Gauthier et al., 1980).

The sample of participants

For elementary schools, each school selected was divided into class units that were both

comprehensive and non-overlapping. For each class unit, the number of individuals was listed by gender and age of the majority of the students. The classes were then selected with equal opportunity within each school. Selection of classes was balanced across groups of schools to ensure that each group would have an approximately equal sample size. In each school approximately 90 students were selected, usually by selection of three class units (Gauthier et al., 1980).

The procedure for selecting the grades in secondary schools was the same as described for the elementary schools. Within each grade though, subjects were selected using a table of random numbers. A total of ninety students were selected from each secondary school (Gauthier et al., 1980). In all, 8 428 participants were selected from the total Canadian school population between the ages of 6 to 17.

The 1983 CAHPERD Study

The purpose of the 1983 study was threefold. The first objective was to determine the level of physical fitness in young Canadians aged 7 to 17 as measured by the physical work capacity test. The second objective was to develop new norms of physical work capacity for young Canadians aged 7 to 17. The last objective was to compare the fitness levels of young Canadians aged 7 to 17 in 1983 with those of 1968 (Gauthier et al., 1983).

The sample of schools

The selection of schools was done by Statistics Canada and by the "Service de l'information du Gouvernement du Québec". The National Defence schools outside Canada, schools for the education of disabled children and schools in the Yukon and North West Territories were excluded. The random selection of 150 schools within the five regions of Canada: Atlantic, Québec, Ontario, Prairies and British Columbia, was made proportional to the

square root of the total regional enrolment, based on the census of 1979-1980. Within a region, allocation to each province was made proportional to provincial enrolment. Schools in each province were ordered by grade level. This procedure was done to ensure that all age-gender groups were included in the sample. The schools were then randomly selected within each province according to a systematic probability proportional to enrolment (Gauthier et al., 1983).

The sample of participants

The participants were systematically selected from the class lists provided by each school. In order to ensure that a minimum of 24 subjects was tested, the total number of students between the ages of 7 to 17 was divided by 30. A random number "X" between 1 and the result obtained by dividing the total number of students by 30 was determined from a table of random numbers. Every "X" participant was then selected. This procedure respected the selection process in the basis of age and gender (Gauthier et al., 1983). A total of 3 360 participants between the ages of 7 and 17 were selected to take part in the study.

The 1989 CAHPERD Study

The objectives of the 1989 study were threefold as well. The first was to add an endurance test that could be performed inside on a shorter distance. The second objective was to make proper changes in the execution of the partial sit-up. The last objective was to modify the norms for push-ups since the old norms were made on a restricted sample (Massicotte, 1990).

The sample of schools

Due to budget restrictions the sample of schools was restricted to 150 kilometres around urban centres in 8 Canadian provinces. Statistics Canada randomly selected a total of 125 schools proportionally to the population of each province. Tests were performed in 104 of the selected schools (Massicotte, 1990).

The sample of participants

Each selected school was divided into class units, which were both comprehensive and non-overlapping. For each class unit, the participants were listed by gender and age of the majority of the students. The classes were then selected with equal opportunity within each school. Selection of classes was balanced to ensure that each group would have an approximately equal sample size by age and gender. Approximately 65 students were selected in each school, usually by selection of two class units (Massicotte, 1990). In all 6, 064 participants between the ages of 7 and 17 were selected from the total Canadian school population.

Data Collection in 1998

The sample of schools

A total of 13 primary schools from two school boards of a large urban centre in Canada, were randomly selected using a table of random numbers. Although the sample is quite large it is not representative of the Canadian population of school children. The school boards and/or principals were contacted to get approval for the study and to inform them of the procedures.

The sample of participants

Within each school class units were recruited. Measurements of height and weight were taken from approximately 40% of the students in each school. Selection of participants was balanced to ensure of an equal number of participants by age and gender. Measurements were taken within the participants physical education class by an experimenter following standardised test protocols. A total of 1, 195, 7 to 12 year olds were recruited to participate in this study.

The distribution by age and by gender of the participants for the four previous studies is depicted in table 1.

Table 1.

The Anthropometric Measurements

The anthropometric measurements (described below) were taken using the same procedures in all four previous studies (1979, 1983, 1989 and 1998).

Standing height

Standing height was measured using a metric measuring tape and a plastic 90 degree square. The subject who is in bare stocking feet stood with his-her back to the measuring tape, heels together, and feet pointing comfortably out. The subject's back was as straight as possible, which was achieved by rounding or relaxing the shoulders and manipulating the posture. The subject stretched upward to the fullest extent, aided by gentle traction by the measurer on the mastoid processes. With the participant in this position, he/she was instructed to "take a deep breath and stand tall". He/she was then told to "relax" and the measurement was taken by placing the triangle against the tape and resting on the subject's head. The measurement was recorded to the nearest 0.5 cm (Gauthier et al., 1980).

Body weight

The body weight was measured using a calibrated balance or spring scale. Calibration was done by the experimenters themselves using standardised techniques The subject who was in light gymnasium dress without shoes was asked to stand in the middle of the scale platform and to be as still as possible. Weight was evenly distributed on both feet. The weight was measured and recorded to the nearest 0.1 kg (Gauthier et al., 1980).

Statistical Analyses

The present study used the age and gender specific 85th and 95th BMI percentile of the 1979 CAHPERD study as a cut-off point for defining overweight and obesity respectively. The values of the 85th and 95th percentile was then compared with the data from the three other studies (the 1983 and 1989 CAHPERD studies and the data collected in 1998) to evaluate at which percentile the values of the 85th and 95th percentile of the 1979 study corresponded. Choosing the 85th and 95th percentile as the criterion values entails an arbitrary initial assumption that the prevalence of overweight is 15% and the prevalence of obesity is 5%; it should not be interpreted as an independent finding that the prevalence of overweight and obesity is 15% and 5%.

A number of descriptive statistics (e.g. mean height, mean weight and mean BMI) are presented for each study by age and gender. As well, analyses of variance test (ANOVA) were performed for all anthropometric variables between the different study cohorts to evaluate any significant mean increases or decreases over the past years. Finally, the assesment of body fat percentage (BF%) from using BMI age- and gender- specific prediction formulas derived from the relationship between densitometrically-determined body fat percentage and BMI was made. Deurenberg et al. (1991) found that in children aged 15 years and younger the BF% could best be predicted (Se=4.4% BF) by the formula BF%= 1.51 X BMI - 0.70 X age - 3.6 X gender + 1.4 (males=1, females=0).

Chapter 4

The Article that will be submitted to a Refereed Scholarly Journal

The increase of childhood obesity in a limited sample of Canadian children 7 to 12 years old between 1979 and 1998.

Running title: The increase of childhood obesity

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C/O Canadian Journal of Public Health
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August 30, 1998

Ms. Craven

It is with pleasure that I submit this manuscript for review to the Canadian Journal of Public Health. Let me assure you that this work has not been reported in a published paper nor has it been submitted or accepted for publication elsewhere.

Both authors agree to publication and are awaiting a response.

Thank you very much for your consideration,

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Overweight and obesity are associated with a number of health consequences in youth[1] as well as in adults[2,3]. Evidence exists to support an association between obesity and cardiovascular disease in children[4,5]. A less serious but more common condition related to obesity at a young age is high blood pressure. Studies have shown that the Body Mass Index (BMI) in children is strongly correlated with blood pressure[6,7,8]. Research has also shown that overweight children are significantly more likely to have elevated systolic blood pressure and total blood cholesterol levels[9,10,11]. Other studies have linked juvenile obesity with respiratory disease[12] and several orthopaedic conditions[12,13].

Obesity also affects a variety of psychosocial functions in youth[14,15]. Early studies viewed emotional disturbances as an antecedent of obesity, but recent evidence suggest that these disturbances are more likely to be consequences of increased adiposity[16]. Studies have shown that obese children tend to have higher rates of depression and lower self-concept[17], are more dissatisfied with their body[18,19] and have lower self-esteem than nonobese children[20,21]. Overweight or obesity during childhood and adolescence predicts a number of adverse health consequences later in life, including increased morbidity and mortality[22,23,24].

In the past, health professionals have shown little interest in childhood obesity. It was thought to be a temporary phase that bore no relation to adult adiposity and its associated mortality and morbidity[25]. Today, a great public health concern is the risk that childhood and adolescent obesity will persist into adulthood, since a number of recent studies[26,27,28,29] have associated overweight in youth with overweight in adulthood. In fact, studies[27,28,29,30] have shown that the risk of adult obesity was much greater for children who had higher levels of adiposity and for children who were obese at older ages. Unfortunately, obesity in adults is associated with a number of health consequences including increased mortality, coronary heart

disease, hypertension, and a number of cancers[2,3].

Increasing Childhood Obesity

Recent European and American epidemiological studies indicate a definite increase in obesity in youth as well as in adults[4,31,32,33,34]. Unfortunately very few studies exist that describe the prevalence of obesity in Canadian children. It is thus, the purpose of this research to assess the prevalence and the increase of overweight and obesity in a Canadian sample of 7 to 12 year olds between 1979 to 1998. In relation with previous studies it is hypothesised that there will be a significant increase in childhood overweight and obesity for constant age and gender in a Canadian sample of children aged 7 through 12 from 1979, 1983, 1989 and 1998.

Methodology

BMI as a Measure of Overweight and Obesity in Children

According to Flegal[35], the ideal measure of obesity would have three properties: (1) it would estimate body fat content accurately; (2) appropriate reference values would be available; and, (3) the measurement would be easily made. Currently, weight for height indices, specifically body mass index (BMI), comes closest to meeting these criteria. In fact, BMI is widely used to assess adiposity in children[36] and weight divided by height-squared, also known as Quetelet's Index[37] or BMI, is commonly found in the epidemiology literature concerning risk factors in childhood and adolescence. Studies have shown that BMI in children is correlated with direct measures of adiposity[38,39,40,41,42,43]. BMI is the best and most widely used measure of adiposity among indexes derived from height and weight measurements[44].

The statistical approach to childhood obesity defines obesity relative to a selected percentile of a reference group, defined in terms of age, gender or other characteristics[35]. Fortunately, a number of studies have been conducted in Canada on anthropometric data in

children from which BMI cut-offs may be derived. The 1979 CAHPERD study[45] has one of the largest national sample of randomly selected children from which weight and height has been collected. This would be an ideal reference population in studies measuring overweight and obesity in Canadian children and will be used for the present study. As in recent studies[30,34] the 85th and 95th percentile of the variable BMI will be used as the criteria for "overweight" and "obesity" respectively. These cut-off points will then be compared to Canadian data collected in 1983, 1989 and 1998.

The 1979 CAHPERD Study

The sample of 140 schools from the ten provinces and two territories of Canada was an unbiased, representative sample of the population[45]. The sample of schools selected was proportional to enrolment but stratified by province and territory to ensure representation from all areas of the country [45]. Each school selected was divided into class units which were both comprehensive and non-overlapping. The classes were then selected with equal opportunity within each school[45]. In all, 4 670 participants were selected from the total Canadian school population between the ages of 7 to 12.

The 1983 CAHPERD Study

The random selection of 150 schools within the five regions of Canada was made proportional to the square root of the total regional enrolment, based on the census of 1979-1980. The schools were then randomly selected within each province according to a systematic probability proportional to enrolment[46]. The participants were systematically selected from the class lists provided by each school[46]. A total of 1 925 participants between the ages of 7 and 12 were selected to take part in the study.

The 1989 CAHPERD Study

Due to budget restrictions the sample of schools was restricted to 150 kilometres around urban centres in 8 Canadian provinces. Statistics Canada randomly selected a total of 104 schools proportionally to the population of each province[47]. Each selected school was divided into class units that were both comprehensive and non-overlapping. The classes were then selected with equal opportunity within each school[47]. In all 3 296 participants between the ages of 7 and 12 were selected from the total Canadian school population.

Data Collection in 1998

A total of 13 primary schools from two school boards were randomly selected using a table of random numbers from a large urban centre in Canada. Within each school, class units were randomly selected. Selection of participants was balanced to ensure of an equal number of participants by age and gender. In all 1 195 participants between the ages of 7 and 12 were selected. Although the sample is quite large it is not representative of the Canadian population of school children. The distribution of participants by age and gender for the four previous studies is depicted in table 1.

Table 1.

The Anthropometric Measurements

Measurements of height and weight were taken by a trained experimenter following standardised test protocols within the participants physical education class. The anthropometric measurements taken in 1979, 1983, 1989 and 1998 were all taken using the same procedures.

Results

Analyses of variance were performed on the data in order to examine if there were significant increases in mean BMI between the different study cohorts. Table 2 shows the mean and standard deviation for the variable BMI for 7 to 12 year old boys and girls in 1979, 1983, 1989 and 1998. Significant increases ($p < 0.05$) in the male sample between 1979 and 1998 were only found in 9, 11 and 12 year olds. The average BMI increase was 0.9 kg/m^2 with the highest increase being 1.4 kg/m^2 found in 11 year olds. All the female groups had significantly ($p < 0.05$) higher BMI values in 1998 than in 1979. The average BMI increase for the female sample was 1.2 kg/m^2 with the highest increase being 1.8 kg/m^2 also found in the 11 year olds. Results also show that the BMI increases are higher in older children. In fact, the average BMI increase in 7 to 10 year old boys and girls between 1979 and 1998 was 0.8 kg/m^2 while it was 1.5 kg/m^2 in 11 and 12 year olds.

The percentile values in 1983, 1989 and 1998 corresponding to the value of the 85^{th} and 95^{th} BMI percentile of the 1979 CAHPERD study are presented in Table 3. For the male sample, results show that the values of the 85^{th} BMI percentile in 1979 correspond on average to a percentile value 0.9%, 7% and 12.1% below in 1983, 1989 and 1998 respectively. This translates in a 6%, 46.7% and a 80.7% increase in the prevalence of overweight in 7 to 12 year old boys in 1983, 1989 and 1998.

For the female sample, the values of the 85^{th} BMI percentile of the 1979 CAHPERD study correspond on average to a percentile value 0.5% above, 3.6% and 13% below in 1983, 1989 and 1998 respectively. This translates into a 3.3% decrease, 24% and 86.7% increase in the prevalence in overweight in 7 to 12 year old girls in 1983, 1989 and 1998. Using the age and gender specific value of the 85^{th} BMI percentile of the 1979 CAHPERD study as a cut-off point

for defining overweight results show that on average overweight has increased 1.4%, 35.4% and 83.7% in 7 to 12 year olds in 1983, 1989 and 1998 respectively.

For the male sample, results show that the values of the 95th BMI percentile of the 1979 CAHPERD study correspond on average to a percentile value 1.1%, 2.6% and 8% below in 1983, 1989 and 1998 respectively. This translates in a 22%, 52% and a 160% increase in the prevalence of obesity in 7 to 12 year old boys in 1983, 1989 and 1998. For the female sample, the values of the 95th BMI percentile of the 1979 CAHPERD study correspond on average to a percentile value 0.4% above, 1.8% and 9.6% below in 1983, 1989 and 1998 respectively. This translates into a 8% decrease, 45.3% and 192% increase in the prevalence in obesity in 7 to 12 year old girls in 1983, 1989 and 1998. Using the age and gender specific value of the 95th BMI percentile of the 1979 CAHPERD study as a cut-off point for defining obesity results show that on average obesity in 7 to 12 year olds has increased 15%, 48.7% and 176% in 1983, 1989 and 1998.

Table 2 and 3

Discussion

The results partially support the hypothesis. Using the age and gender specific value of the 85th and 95th BMI percentile of the 1979 CAHPERD study as a cut-off point for defining overweight and obesity, it is clear that the prevalence of overweight and obesity in today's 7 to 12 year olds is greater than in 1979. These different relative increases over time suggest that children and adolescents of today are considerably heavier than they were only a few years ago as suggested by previous studies[48,49].

In interpreting these results one must consider the methodological limitations. BMI is an indirect estimate of body fat, since lean soft tissue and bone mineral are included, so against the attractions of simplicity and reproducibility must be set the uncertain accuracy of BMI as an indicator of body fat for nonobese subjects[38]. Young children, depending upon their level of physical fitness or sport selection, may have remarkably different BMIs, even in the same age group[50]. Finally, since data collected in 1998 was not representative of the Canadian population of 7 to 12 year olds one must be careful in generalising the results.

Studies estimate the heritability of human obesity at no more than 33% which has thrown into bold relief the importance of environmental forces in determining the prevalence of human obesity[51]. Unfortunately, the underlying environmental causes can only be speculated upon and include a number of factors. Studies has shown a significant positive relationship between low physical activity, number of hours of television and video watched, intake of saturated fats and increased consumption of snacks[52,53,54]. Obesity in school children has been associated with dietary intake high in fat, mother's educational level, and family history of obesity[7]. Parental neglect predicts a greater risk of obesity in young adulthood, independent of age, body mass index in childhood, gender and social background[55]. There is a clear affect of parental influence on obesity - a major risk factor for obesity in children is parental obesity. A child has an 80% chance of being obese when both parents are obese, and a 40% chance when only one parent is obese. When neither parent is obese, chances of childhood obesity are reduced to 7%[56]. Under the age of 10, parental obesity more than doubles the risk of adult obesity among both obese and nonobese children[30]. Among older children, obesity is an increasingly important predictor of adult obesity, regardless of whether the parents are obese[30].

Therefore, prevention of obesity in childhood and effective treatment of overweight

children is essential[30]. Modification of such a risk factor in childhood can have an enormous potential pay-off. The prevention and treatment of childhood obesity involve changing behaviours responsible for weight gain and maintaining behaviours responsible for weight loss[57]. To achieve long-standing control of overweight, one should combine changes in eating and activity patterns, using behaviour modification techniques[52]. The identification of children who will become obese adults may facilitate early intervention and avoidance of the morbidity and mortality associated with adult obesity[58].

The practical advantages of Quetelet's index as a measure of overweight and obesity are obvious. However, the intent of the current investigation was not to validate the use of the BMI as an indicator of obesity, it was to evaluate the increase in childhood obesity in a limited sample of Canadian children 7 to 12 years old. The potential theoretical and practical contribution of this study are an important beginning due to the gaps existing in the literature regarding the increase in child obesity in Canada. The findings that emerged from this study could be used as a stepping stone in developing prevention programs. It is hoped that the results of the study will help contribute to the body of knowledge related to the prevalence and the increase of overweight and obesity in Canadian children. It is also hoped that this research will be of significance in the context of applied settings where efforts to assess and prevent childhood obesity have started to receive increasing attention. A valuable line of future studies for this issue could be to explore the effectiveness of prevention and weight reduction programs in children that are at risk. Now that there is evidence that there is an epidemic of childhood overweight and obesity in Canadian children something must be done to stop it.

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Table 1.

Distribution of participants by Age, Gender and Year.

	Boys				Girls			
Age	1979	1983	1989	1998	1979	1983	1989	1998
7	395	171	237	121	366	163	222	100
8	441	187	268	100	391	143	240	96
9	422	161	283	91	377	151	262	109
10	397	175	302	105	381	162	270	113
11	361	173	324	96	352	140	289	98
12	398	156	318	82	389	143	281	84
TOTAL	2414	1023	1732	595	2256	902	1564	600

Table 2.

Means and standard deviations for the variable BMI of 7 to 12 year old Boys and Girls in 1979, 1983, 1989 and 1998.

		1979		1983		1989		1998	
Age	Gender	$\bar{x}$	±Sx	$\bar{x}$	±Sx	$\bar{x}$	±Sx	$\bar{x}$	±Sx
7	Boys	16.2	1.6	16.2	1.7	16.2	2.5	16.5	2.4
8	Boys	16.7	2.1	16.6	2.1	17.0	2.3	17.3	2.9
9	Boys	17.0	2.5	16.9	2.4	17.2	2.5	17.8[79,83]	2.2
10	Boys	17.8	2.9	17.3	2.2	18.1	2.9	18.5[83]	3.2
11	Boys	17.9	2.3	18.5	3.3	18.5	2.8	19.3[79]	2.8
12	Boys	18.6	2.7	19.0	2.9	19.2	2.9	19.9[79]	3.8
7	Girls	16.1	1.8	15.8	2.1	16.2	2.3	16.9[79,83,89]	2.8
8	Girls	16.4	2.0	16.9	2.6	16.8	2.2	17.5[79,89]	2.9
9	Girls	17.2	2.7	17.1	2.7	17.1	2.6	18.3[79,83,89]	3.3
10	Girls	17.8	3.8	17.4	2.7	17.9	3.3	18.8[79,83]	3.7
11	Girls	18.1	2.7	17.9	2.5	18.6	3.1	19.9[79,83,89]	3.7
12	Girls	19.2	2.9	18.6	2.7	19.3	3.3	20.5[79,83,89]	3.4

Note: [79,83] and [89] represent significant differences at the .05 level between 1998 and the year indicated.

Table 3.

The percentile values in 1983, 1989 and 1998 corresponding to the value of the 85th and 95th percentile of the 1979 study for the variable BMI.

			85th Percentile					95th Percentile			
Age	Gender	1979	1979	1983	1989	1998	1979	1979	1983	1989	1998
7	Boys	17.5	85	83.0	79.6	77.7	18.9	95	93.7	89.7	88.4
8	Boys	18.4	85	85.8	80.2	77.0	20.6	95	96.0	93.1	86.5
9	Boys	18.6	85	86.0	77.2	66.7	21.2	95	93.6	94.9	92.1
10	Boys	20.4	85	90.8	79.0	79.9	22.9	95	98.5	95.7	87.7
11	Boys	20.1	85	77.4	75.0	66.7	22.5	95	90.0	91.5	84.8
12	Boys	21.1	85	81.8	76.9	69.2	23.3	95	91.6	89.6	82.2
7	Girls	17.7	85	87.8	80.4	72.5	19.4	95	94.1	91.9	86.5
8	Girls	18.4	85	76.8	80.5	74.0	20.2	95	85.7	93.4	83.1
9	Girls	20.0	85	86.8	84.8	72.5	22.7	95	96.2	95.9	88.5
10	Girls	20.3	85	84.5	80.3	71.3	23.3	95	97.0	93.8	88.7
11	Girls	20.6	85	88.0	78.4	68.9	23.8	95	97.8	92.8	83.7
12	Girls	22.1	85	88.9	84.2	72.7	24.0	95	96.8	91.5	82.0

Chapter 5

General Discussion

The results found in this study partially support the hypothesis. Using the age- and gender- specific values of the 85th and 95th BMI percentile of the 1979 CAHPERD study as cut-off points for defining overweight and obesity, it is clear that the prevalence of overweight and obesity in today's 7 to 12 year olds is much greater than in 1979. These relative increases over time suggest that children and adolescents of today are considerably more overweight and obese than they were only a few years ago as suggested by previous studies (Barth et al., 1997; Limbert, Crawford, & McCargar, 1994). In fact, results show that on average overweight in Canadian children has increased 1.4%, 35.4% and 83.7% in 7 to 12 year olds in 1983, 1989 and 1998 respectively. Obesity, on the other hand, has increased 15%, 48.7% and 176% in 1983, 1989 and 1998. These results are none other than alarming.

Appendix A shows the means and standard deviations for the variable Weight, Height, BMI and percentage of Body Fat (%BF) for 7 to 12 year old boys and girls in 1979, 1983, 1989 and 1998. It also indicates the results of the analyses of variance performed between the four study cohorts.

The results clearly show that Canadian children are getting taller and heavier as years go by. In fact, 7 to 12 year old boys were on average 3.1 kg heavier and 2.7 cm taller in 1998 compared with 1979 while the girls were 3.9 kg heavier and 2.9 cm taller. In fact, when comparing these results with previous Canadian data the increases are even greater. Compared with the data (the 50th percentile) collected during the 1970-72 Nutrition Canada National Survey (Jetté, 1982) 7 to 12 year old boys in 1998 were on

average 7.2 kg heavier and 7 cm taller while the girls were 7.5 kg heavier and 6.9 cm taller in 1998. Similar results are found when the data is compared with Canadian data from 1953 (Ogilvie and Prett, 1957). On average, 7 to 12 year old boys were 6.2 kg heavier and 7.4 cm taller while the girls were 7 kg heavier and 8 cm taller in 1998 compared to 1953.

The results also show that children in 1998 had significantly higher BMIs than in past years. Data from the male sample shows significant ($p < 0.05$) increases in mean BMI in 9, 11 and 12 year olds. Although not statistically significant, increases in 7, 8 and 10 year olds were also found. Results are more striking in females. In fact, mean BMI for all age groups in 1998 were significantly ($p < 0.05$) higher then in 1979. They were also all significantly higher than in 1983 and 1989 with the exception of 8 year olds in 1983 and 10 year olds in 1989. The average BMI increase in the male sample between 1979 and 1998 was 0.9 kg/m^2, with the highest increase being 1.4 kg/m^2 found in 11 year olds. In the female sample, the average BMI increase was 1.2 kg/m^2, with the highest increase being 1.8 kg/m^2 also found in 11 year olds. Estimating mean BMI values using mean weight and height it is possible to compared data from 1998 with previous Canadian studies. Using this technique, results show that the average BMI increase in the male sample between 1953 and 1998 was 1.3 kg/m^2 while it was 1.95 kg/m^2 between 1970-72 and 1998. In the female sample the average BMI increase between 1953 and 1998 was 1.56 kg/m^2 while it was 1.8 kg/m^2 between 1970-72 and 1998.

Using gender- and age- specific prediction formulas it was possible to estimate percentage of body fat. Results indicate that percentage of body fat has increased in all age groups for both female and male between 1979 and 1998. On average males have

1.56% more body fat now than they did in 1979 while female mean BF has increased 1.93%. Analyses of variance show that percentage of body fat in male has significantly increased in 9, 11 and 12 year old boy from 1979 and 1998 while significant increased in girls were found in all age groups between 1979 and 1998.

When interpreting the results found in this study one must consider the methodological limitations. First, since data collected in 1998 was not representative of the Canadian population of 7 to 12 year olds, one must be careful in generalising the results. The data was only collected from 2 large school boards in a large urban centre in Canada. Second, BMI is an indirect estimate of body fat, since lean soft tissue and bone minerals are included. So against the attractions of simplicity and reproducibility must be set the uncertain accuracy of BMI as an indicator of body fat for nonobese subjects (Hannan et al., 1995). Young children, depending upon their level of physical fitness or sport selection, may have remarkably different BMI's, even in the same age group (Keller and Stevens, 1996). For example, the young athlete who is a swimmer, will have more muscle mass than the athlete who is in track, although both children will not have excess body fat, and both will be healthy (Keller & Stevens, 1996). Fortunately, results from this study were examined using the 85^{th} and 95^{th} BMI percentile. BMI as an indicator of overweight and obesity for this population should be an accurate measure.

A difficulty in identifying obese children is the over diagnosis and under diagnosis of obesity as a result of the particular screening method used. Screening tests for obesity have the ability to detect obesity in children who are truly obese (true positive) and the ability to identify those children in which obesity does not exist (true negative) (Keller & Stevens, 1996). If the screening test under diagnoses obesity in the

child, than the test is said to have poor sensitivity and results are missed opportunity for intervention. If the screening test over diagnoses obesity, the test is said to have poor specificity and children who are not obese will be labelled as such. The over diagnosis of obesity is considered to be more hazardous in screening for obesity in children and adolescents than the under diagnosis because of the negative consequences of erroneously labelling a nonobese child as obese (Keller & Stevens, 1996). Inappropriate identification of young people as overweight or obese may lead to negative psychological sequela, or the initiation of harmful weight reduction attempts (Robinson, 1993). Using the 85th BMI percentile as a cut-off point, Lazarus et al. (1996) found sensitivities and 95% CIs of 67% (range: 41-87%) and 75% (range:48-93%) for males and females respectively, from 230 subjects aged 4 to 20 years old. False-positive rates at these cut-off points were 6% (range: 2-12%) for males and 4% (range: 1-10%) for females. Low sensitivity implies that the screening will miss some truly obese subjects. The low rate of false-positive results suggests that the risk of wrongly labelling a child as "overweight" is very small. Results show that the sensitivity and specificity of BMI are acceptable for population screening and offer a reasonable compromise between true-positive and false-positive rates (Lazarus et al., 1996). In order to have better sensitivity and specificity one should use BMI cut-offs appropriately derived from local measurements as suggested by Lazarus et al. (1995). The results of this study could help in defining Canadian measurements that could be used in screening settings.

Studies estimate the heritability of human obesity at no more than 33% which has thrown into bold relief the importance of environmental forces in determining the prevalence of human obesity (Stunkard, 1996). Unfortunately, the underlying

environmental causes can only be speculated upon and include a number of factors. A study has shown a significant positive relationship between low physical activity, number of hours of television and video watched, intake of saturated fats and increased consumption of snacks (Bar-Or et al., 1996 Obarzanek et al., 1994; Kuczmarski et al., 1994). Obesity in school children has been associated with dietary intake high in fat, mother's educational level, and family history of obesity (Moussa et al., 1994). Parental neglect also predicts a greater risk of obesity in young adulthood, independent of age, body mass index in childhood, gender and social background (Lissau & Sorensen, 1994). There is a clear affect of parental influence on obesity - a major risk factor for obesity in children is parental obesity. A child has an 80% chance of being obese when both parents are obese, and a 40% chance when only one parent is obese. When neither parent is obese, chances of childhood obesity are reduced to 7% (Eck, Klesges, Hanson, & Slawson, 1992). A study (Whitaker et al., 1997) has shown that parental obesity more than doubles the risk of adult obesity among both obese and nonobese children under 10 years of age. Among older children, obesity is an increasingly important predictor of adult obesity, regardless of whether the parents are obese (Whitaker et al., 1997). Therefore, prevention of obesity in childhood and effective treatment of overweight children are essential (Whitaker et al., 1997). Modification of such a risk factor in childhood can have an enormous potential pay-off. The prevention and treatment of childhood obesity involve changing behaviours responsible for weight gain and maintaining behaviours responsible for weight loss (Epstein, Wing, Penner, & Kress, 1985). To achieve long-standing control of overweight, one should combine changes in

eating and activity patterns, using behaviour modification techniques (Bar-Or et al., 1998).

General Conclusion

The practical advantages of Quetelet's index as a measure of obesity are obvious. Both weight and height are easily and accurately measured with simple equipment. We have a very much larger weight-height database, than for any other index of obesity, so it is likely that the epidemiological significance of Quetelet's index will be easier to establish than for an index which is more difficult to measure (Garrow & Webster, 1985). However, the intent of the current investigation was not to validate the use of the BMI as an indicator of obesity. This had been accomplished in prior studies. The purpose of this study was to evaluate the increase in childhood overweight and obesity in a Canadian sample of 7 to 12 year olds. The results are stunning and call for immediate intervention. The identification and treatment of children who will become obese adults may facilitate early intervention and avoidance of the morbidity (e.g. diabetes) and mortality associated with adult obesity (White et al., 1995)

The potential theoretical and practical contribution of this study are an important beginning due to the gaps existing in the literature regarding the increase in child obesity in Canada. The findings that emerged from this study could be used as a stepping stone in developing screening and prevention school programs specifically developed for Canadian children.

It is hoped that the results of the study will help contribute to the body of knowledge related to the prevalence and the increase of overweight and obesity in Canadian children. It is also hoped that this research will be of significance in the

context of applied settings where efforts to assess and prevent childhood obesity have started to receive increasing attention. In fact, a valuable line of future studies for this issue could be to explore the effectiveness of screening, prevention and weight reduction programs in children that are at risk.

Specific recommendations

As stated previously, the results found in this study are none other than alarming. Canadian children are strikingly more overweight and obese than they were only a few years ago. This surely foreshadows increased morbidity and mortality in future adults. Steps must be taken now to prevent any future epidemic. The following recommendations should be useful in accomplishing this goal.

(1) Develop school-based yearly screening programs for early detection of at risk children using BMI cut-offs appropriately derived from Canadian data (e.g. the data from this study).

(2) Develop and implement school-based prevention programs through physical education classes and offer adequate training to physical education teachers.

(3) Develop and implement school-based treatment programs that use behaviour modification techniques and incorporate general health and wellness topics.

Statement of Contribution of Collaborators

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Appendix A

Means and standard deviations for the variables Weight, Height, BMI and BF of 7 to 12 year old Boys in 1979, 1983, 1989 and 1998.

		1979		1983		1989		1998	
Age	Variables	$\bar{x}$	±Sx	$\bar{x}$	±Sx	$\bar{x}$	±Sx	$\bar{x}$	±Sx
7	Weight	25.3[89,98]	3.9	25.3[98]	3.5	26.2[79]	4.9	26.6[79,83]	4.9
	Height	124.7[89,98]	5.5	124.9[89,98]	6.4	127.0[79,83]	7.4	126.9[79,83]	5.8
	BMI	16.2	1.6	16.2	1.7	16.2	2.5	16.5	2.4
	BF	17.3	2.5	17.3	2.5	17.4	3.7	17.9	3.8
8	Weight	28.3[98]	5.0	28.3[98]	4.8	29.3	5.7	30.5[79,83]	7.2
	Height	129.9[98]	5.7	130.1[98]	6.1	131.0	6.5	132.3[79,83]	6.2
	BMI	16.7	2.1	16.6	2.1	17.0	2.3	17.3	2.9
	BF	17.4	3.1	17.3	3.1	17.8	3.5	18.3	4.4
9	Weight	30.7[89,98]	5.5	30.9[98]	6.0	32.3[79]	6.1	33.7[79,83]	5.5
	Height	134.3[89,98]	6.7	135.1	6.9	136.9[79]	7.0	137.3[79]	6.1
	BMI	17.0[98]	2.5	16.9[98]	2.4	17.2	2.5	17.8[79,83]	2.2
	BF	17.1[98]	3.7	17.0[98]	3.7	17.4	3.8	18.4[79,83]	3.4
10	Weight	35.5[98]	7.1	33.9[89,98]	6.7	36.8[83]	7.5	37.9[79,83]	8.8
	Height	140.8[89]	7.3	139.5[89,98]	7.6	142.4[79,83]	6.6	142.4[83]	6.7
	BMI	17.8	2.9	17.3[89,98]	2.2	18.1[83]	2.9	18.5[83]	3.2
	BF	17.7	4.3	17.0[89,98]	3.4	18.1[83]	4.4	18.9[83]	4.8

11	Weight	37.9[89,98]	6.7	39.8[98]	8.9	40.6[79]	8.4	42.7[79,83]	8.4
	Height	145.4[89,98]	7.0	146.3	7.5	147.6[79]	8.0	148.5[79]	7.4
	BMI	17.9[89,98]	2.3	18.5	3.3	18.5[79]	2.8	19.3[79]	2.8
	BF	17.1[89,98]	3.4	18.0	5.0	18.1[79,98]	4.2	19.4[79,89]	4.8
12	Weight	43.0[89,98]	8.9	43.3[89,98]	7.8	46.0[79,83]	10.0	47.9[79,83]	12.2
	Height	151.4[89,98]	8.2	150.9[89,98]	7.2	154.1[79,83]	8.4	154.4[79,83]	8.1
	BMI	18.6[89,98]	2.7	19.0	2.9	19.2[79]	2.9	19.9[79]	3.8
	BF	17.5[89,98]	4.1	18.0[98]	4.3	18.4[79,98]	4.4	20.6[79,83,89]	7.3

Note: [79,83,89] and [98] represent significant differences at the .05 level with the year indicated.

Means and standard deviation for the variables Weight, Height, BMI and BF of 7 to 12 year old Girls in 1979, 1983, 1989 and 1998.

		1979		1983		1989		1998	
Age	Variables	$\bar{x}$	±Sx	$\bar{x}$	±Sx	$\bar{x}$	±Sx	$\bar{x}$	±Sx
7	Weight	24.7[98]	4.0	24.9[98]	4.1	25.5[98]	4.7	27.1[79,83,89]	5.7
	Height	123.5[83,89,98]	5.9	125.5[79]	7.3	125.3[79]	7.2	126.1[79]	6.1
	BMI	16.1[98]	1.8	15.8[98]	2.1	16.2[98]	2.3	16.9[79,83,89]	2.8
	BF	20.8[98]	2.7	20.3[98]	3.2	21.0[98]	3.4	22.0[79,83,89]	4.2
8	Weight	27.5[83,98]	4.6	29.0[79]	5.5	28.6[98]	5.0	30.6[79,89]	6.9
	Height	129.1[83,98]	5.9	131.0[79]	6.7	130.2	6.1	131.5[79]	5.8
	BMI	16.4[98]	2.0	16.9	2.6	16.8[98]	2.2	17.5[79,89]	2.9
	BF	20.3[98]	3.1	21.3	3.9	21.1[98]	3.3	22.3[79,89]	4.4
9	Weight	31.1[98]	6.1	31.3[98]	5.9	31.8[98]	6.6	34.5[79,83,89]	8.4
	Height	134.2[89,98]	6.8	135.0	6.3	135.9[79]	6.9	136.9[79]	6.7
	BMI	17.2[98]	2.7	17.1[98]	2.7	17.1[98]	2.6	18.3[79,83,89]	3.3
	BF	21.1[98]	4.0	21.0[98]	4.0	21.0[98]	4.0	22.8[79,83,89]	5.1
10	Weight	34.8[89,98]	6.9	34.8[98]	6.5	36.5[79,98]	8.2	39.4[79,83,89]	10.1
	Height	139.8[89,98]	7.6	141.1[98]	7.6	142.4[79]	7.2	143.9[79,83]	7.8
	BMI	17.8[98]	3.8	17.4[98]	2.7	17.9	3.3	18.8[79,83]	3.7
	BF	21.2[98]	4.6	20.7[98]	4.1	21.5	5.0	22.8[79,83]	5.7

11	Weight	38.8[89,98]	7.8	39.1[89,98]	7.5	41.8[79,83,98]	9.3	45.0[79,83,89]	11.0
	Height	146.0[89,98]	7.8	147.5	8.1	149.3[79]	7.7	149.8[79]	8.6
	BMI	18.1[98]	2.7	17.9[98]	2.5	18.6[98]	3.1	19.9[79,83,89]	3.7
	BF	21.0[98]	4.1	20.7[98]	3.7	21.8[98]	4.6	24.2[79,83,89]	6.4
12	Weight	45.4[98]	8.9	43.1[89,98]	7.9	46.4[83]	9.2	49.3[79,83]	9.5
	Height	153.3[89]	7.6	152.1[89,98]	7.7	154.9[79,83]	7.6	155.1[83]	6.7
	BMI	19.2[98]	2.9	18.6[98]	2.7	19.3[98]	3.3	20.5[79,83,89]	3.4
	BF	22.0[98]	4.4	21.1[98]	4.1	22.1[98]	4.9	23.9[79,83,89]	5.3

Note: [79,83,89] and [98] represent significant differences at the .05 level with the year indicated.

Appendix B

Université d'Ottawa • University of Ottawa

Faculté des sciences de la santé
École des sciences de l'activité physique

Faculty of Health Sciences
School of Human Kinetics

le mardi 25 août 1998

Monsieur Marc Grenier
Étudiant de deuxième cycle
École des sciences de l'activité physique
Faculté des sciences de la santé
Université d'ottawa

Monsieur Grenier,

La présente est pour confirmer que votre projet de thèse intitulé *L'évolution de l'obésité en relation avec l'indice de masse corporelle des jeunes canadien-ne-s de 7 à 12 ans entre 1979 et 1997,* ne nécessitait pas l'approbation du Comité d'éthique en recherche chez l'humain de la faculté des sciences de la santé.

Si d'autre informations s'avéraient utiles, n'hésitez pas à communiquer avec moi.

Veuillez recevoir, monsieur Grenier , mes salutations distinguées.

J.Roger Proulx, Ph.D.
Président
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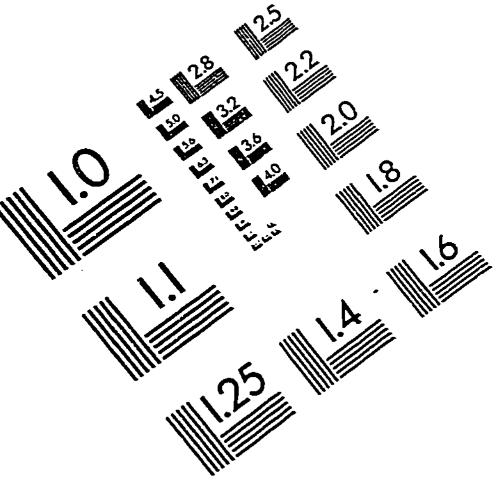
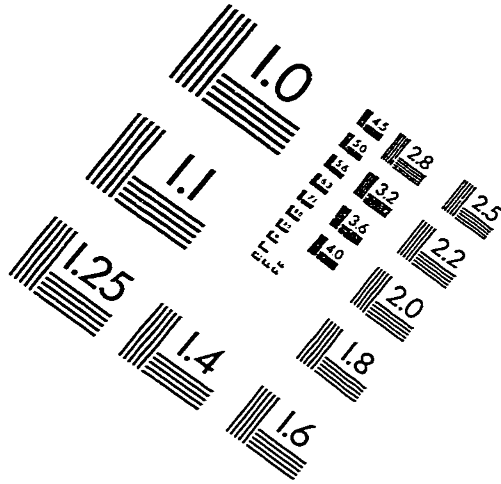
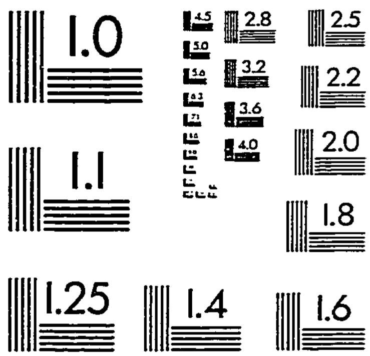
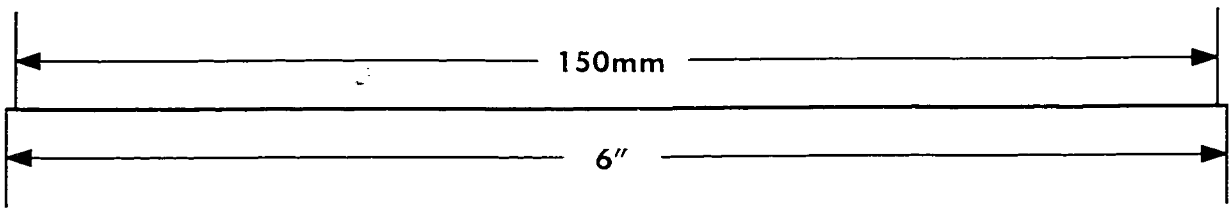
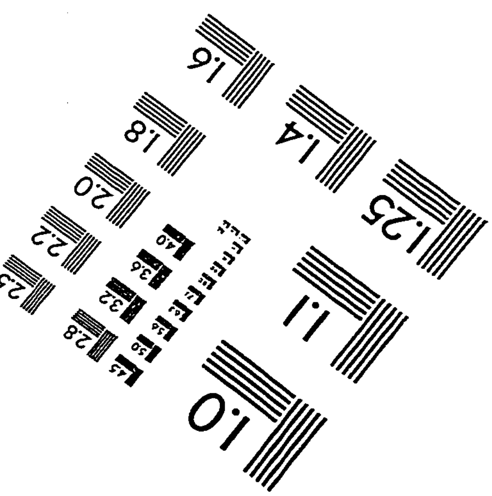
IMAGE EVALUATION TEST TARGET (QA-3)

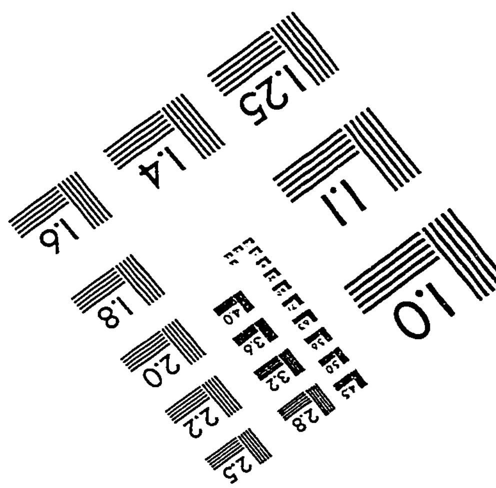












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