STATURE, MASS, AND BODY MASS INDEX OF CANADIAN CHILDREN

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Abstract

This study examines changes in the anthropometric measurements of stature, mass and the Body Mass Index (BMI) among Burlington, Ontario children during the last half of the 20th century. Few studies have investigated changes in these variables within a Canadian context; fewer still have examined them using a large mixed longitudinal sample of children conducted over a 20-year period (The Burlington Growth Study, 1952-1972). When the Burlington Growth Study profile (n=1380) is compared to that for a contemporary sample of Burlington children (n=252), it is evident that stature, mass and BMI have risen among children growing up in the 1990s compared to those who matured in the 1950s to 1970s. These increases, albeit small, are statistically significant ($p<0.001$). The prevalence of overweight children has grown substantially as well, with a particularly striking two-fold increase in overweight girls ($p<0.001$). These findings indicate that Canadian children are participating in the global rise in these variables, including an epidemic of children at risk for and already overweight.

Tracking of BMI values for 220 children in the Burlington Growth Study over a nine-year period revealed significant associations for inter-age comparisons and BMI at age 14 compared to younger ages ($p<0.001$). Further study of the "tracking" phenomenon may lead to the identification of a critical age for the onset of obesity and, in turn, to the

development of appropriate age-specific public health interventions.

KEY WORDS: Secular trend, overweight, longitudinal, tracking

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Chapter 1
Introduction

1.1: Introduction

There has been a global trend toward increased stature, mass and the body mass index (BMI) during this century (Blockstra and Kromhout 1991; Korkeila et al. 1991; Kuskowska-Wolk and Rossner 1990; Shah et al. 1991; Magbool 1994; Troiano et al. 1995; Gordon-Larsen et al. 1997). Recent evidence suggests that secular increases in stature have slowed down and may have ceased altogether (Eveleth and Tanner 1990). On the other hand, mass and the resulting BMI, have continued to increase to a point where there is now a worldwide public health concern about the prevalence of overweight and obese individuals and those "at risk for overweight" (Ajlouni et al. 1998; Al-Isa et al. 1998; Campaigne et al. 1994; Flegal et al. 1998; Gordon-Larsen et al. 1997; Kuczmarski et al. 1994; Martorell et al. 1998; Melnik 1998; Popkin and Udry 1998; Power et al. 1997b). Increases in body mass and the BMI, especially among children, have alarmingly high correlations with acute and chronic diseases of later adulthood including, but not limited to: non-insulin-dependant diabetes mellitus (NIDDM), cardiovascular disease, respiratory dysfunction and certain site specific cancers (Armstrong et al. 1951; Bray 1992; Gasser 1996; Guo et al. 1994; Holbrook et al. 1990; Janghorbani and Parvin 1998; Lopez and Mâsse 1992; Micozzi et al. 1986; Must et al. 1992; Pi-Sunyer 1993; Sichieri et al. 1991; Troiano et al. 1995).

1.2: Purpose and Goals

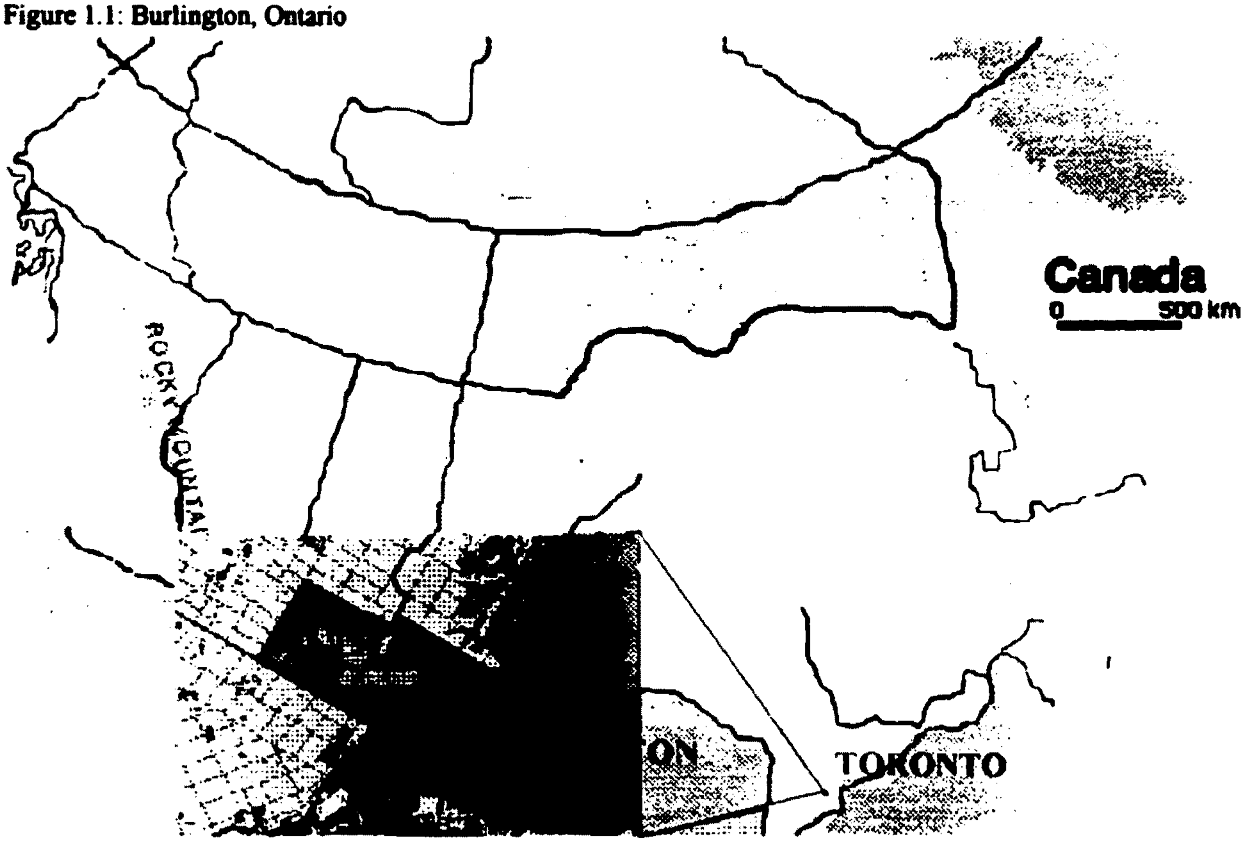
Clearly, overweight and obesity among children is a serious health issue. Despite this, few studies incorporate historical growth data to evaluate long term secular changes in growth and the prevalence of obesity among Canadian children (see for example Farkas and Wood 1982; Hoppa and Garlie 1998; Keyfitz 1942). In order to help rectify this deficiency, a 50-year study of growth and development among children in Burlington, Ontario was undertaken. The first phase of the project involved extracting information on stature, mass and the Body Mass Index (BMI) from a well-known mixed longitudinal growth study conducted in the region some 50 years ago (hereafter referred to as the Burlington Growth Study (BGS), 1952-1972). The second phase required that comparable data be collected from a contemporary sample of children attending school in Burlington, Ontario (hereafter referred to as the Burlington School Study (BSS), 1998-99). The last phase of the research entailed comparing stature, mass and BMI results from the two studies to determine whether patterns of growth and the prevalence of obesity changed in Burlington during the last half of the twentieth century.

Five primary questions are considered in this study: 1) What is the distribution of stature, mass and the BMI for the BGS and BSS? 2) How do these distributions compare to national reference standards of Canadian and American children? 3) Are there secular trends present for stature, mass or BMI between the time of the two studies? 4) What is the prevalence of "at risk for overweight" and overweight in the two studies, and what, if any are the differences within and between the two studies? and 5) How does BMI "track" in individual children from year to year?

1.3: Burlington, Ontario in Context

The location for this study is Burlington, Ontario, Canada (see Figure 1.1). Burlington was the site of an orthodontic growth study during the 1950s, selected because it was said to represent a "...typical Ontario suburban community" (Popovich and Grainger 1959:192). Initiated in 1952, the BGS collected data on children who were born at the end of the 1940s, a time of extensive post-war economic growth in Burlington and Canada (Emory and Ford 1967:162; Loverseed 1988:97-98). The economic growth rate for Burlington between the years 1947 and

Figure 1.1: Burlington, Ontario



1960, for example, was 228 percent compared to 33 percent for the rest of Ontario (Emory and Ford 1967:246).

Burlington is ideally situated at the head of Lake Ontario between the cities of Toronto and Hamilton, enabling it to take advantage of the extensive growth in technology, industry and communication that occurred in the area around Lake Ontario known as the "The Golden Horseshoe" (Loverseed 1988:9). The Burlington vicinity or the "Garden of Canada", as it has often been referred to, has long been recognized for its excellent soils and quality produce grown there (Canadian Council of Churches (C.C.C.) 1967:5; Emory and Ford 1967:142; Turcotte 1992:13). From the 1950's to present, however, the farms and farmland have been disappearing and replaced by extensive residential and industrial development (Emory and Ford 1967:142; Loverseed 1988:98; Turcotte 1992:13). In 1973, the town of Burlington officially became a city with extensive commercial development, and highway and housing construction that have, by and large, buried much of its early history (For a detailed account of the development of Burlington from its pioneer beginnings to the present day see Dorothy Turcotte's (1989) Burlington: Memories of Pioneer Days and (1992) Burlington: The Growing Years).

Economic growth was not limited to Burlington, as Canada in the 1950s was experiencing an economic boom with the discovery of oil in the west and deposits of iron-ore in the Northeast. Technology and hydroelectric power were becoming more accessible across many parts of Canada with the result that the nation's GNP rose significantly between the years of 1946 and

1957, with a large percentage of the resources invested in the health and welfare of the country (C.C.C. 1967). Many Canadians, including the inhabitants of Burlington, were experiencing a rise in their standard of living, although working longer hours to achieve this level, and holding larger debt loads. Burlington's residents, in fact, enjoyed a standard of living that was on average slightly higher than that of the average Canadian (C.C.C 1967:54; Nikiforuk 1977:1).

The fifty-four years between 1945 and 1999 finds Burlington, Ontario growing from a small town of about five thousand people to a large multifaceted city of more than 150,000 people. With the massive construction of highways linking Burlington with Toronto, Hamilton and the rest of the "Golden Horseshoe", the population of Burlington experienced a massive population explosion, increasing as much as 10% in the succeeding years 1958, 1959 and 1966 (C.C.C. 1967:6). In 1952 the population of Burlington reached 6700 people. This number increased to approximately 33,000 individuals in 1958 and to almost 66,000 individuals by the start of 1967 (C.C.C. 1967:52; Statistics Canada 1961). As of 1996, Statistics Canada lists the population of Burlington at 136,976 people, up from 129,575 people in 1991 (Statistics Canada 1999).

The population of Burlington during the 1950's and 1960's was largely comprised of persons claiming British ancestry (C.C.C 1967:53; Nikiforuk 1977:1; Popovich 1969:1; Statistics Canada 1961). The 1961 census revealed that 70% of Burlington's population was of British origin and that 27% was of European origin other than British (see table 1.1). According to the

1996 census, persons living in Burlington that classed themselves as belonging to a visible minority, included but were not limited to, Chinese, South Asian, Black, Arab and West Asian, and comprised approximately 5% of the population. The other 95% of people in Burlington included those that the census classed as all Others, including British and Other Europeans (see Table 1.2). Although direct comparison of the two periods is difficult because of changes in census classifications, it is clear that the population of Burlington has increased substantially over the last forty years, but that the composition of its population origins remains quite stable.

Table 1.1: Population Origins for Burlington, Ontario
(Statistics Canada 1961)

Ethnic Groups	**Males**	**%**	**Females**	**%**	**Totals**	**%**
British Isles*	16543	49.94	16586	35.28	33129	**70.48**
European**	6517	19.67	6299	13.40	12816	**27.26**
Asiatic***	99	.30	52	.11	151	.32
Other****	488	1.47	424	.90	912	1.94
Totals	23647	50.30	23361	49.70	47008	100

* Includes: English, Irish, Scottish and Welsh
** Includes: French, Austrian, Czeck Slovak, Finnish, German, Hungarian, Italian, Jewish, Netherlands, Polish, Russian, other
***Includes: Chinese, Japanese, Other
**** Includes: African Canadian, native Aboriginal, Inuit and others not stated

Table 1.2: Population Origins for Burlington, Ontario
(Statistics Canada 1996)

Ethnic Groups	Males	%	Females	%	Totals	%
All Others*	62835	46.01	66205	48.48	129045	94.49
Visible Minorities**	2735	2	2930	2.15	5665	4.15
Aboriginal and Black	935	.68	920	.67	1855	1.36
Totals	66505	48.70	70055	51.30	136565	100

* Includes: All Others
** Includes: Chinese, South Asian, Arab and West Asian, Filipino, Southeast Asian, Latin American, Japanese, Korean, and others

The BGS and relative ethnic homogeneity of the population of Burlington provide an excellent opportunity to examine changes in stature, mass and the BMI in Canadian children during the post World War II era, a phenomenon that has been overlooked to date. The BGS is an exceptional source of data that covers a twenty-year window during which the city of Burlington was growing and prospering. Stature and mass measurements collected during the winter of 1999 on children attending two Burlington, Ontario schools provide comparative data from which to address questions of secular change in stature, mass and the BMI, as well as changes in the prevalence of "at risk for overweight" and overweight in children from a single community.

1.4: Outline of the Study

This study begins with a historical synthesis of the development of the field of anthropometry from the 1800s onward, highlighting key issues regarding the evolution of knowledge about human growth and development (Chapter 2). Improvements in the methods for assessing growth and development in children, and the validity of using the anthropometric measures of stature, mass and the composite BMI as gauges for monitoring child growth and development are presented. This is followed by a discussion of the information extracted from the BGS (1952-1972) and the measurements collected for the new BSS (1998-1999), including methods used to collect the data and the statistical analysis used to interpret them (Chapter 3). Chapter four outlines the results of a reliability study performed to ensure that observer and measurement error was absent from the BSS. Chapter five presents the results of the statistical analysis for both the BGS and the BSS.

Chapter six discusses the results of this study relative to three central themes. First, the role that anthropometry can play in public health assessments is highlighted. Stature, mass and the Body Mass Index (BMI) are important measurements for assessing various aspects of growth and development and for investigating overall health and well being because they are extremely sensitive to environmental and genetic influences (Bock 1995:29; Bogin 1999; Eveleth and Tanner 1990: Krogman 1970:61; Lasker 1994:6). The second major theme addresses methodological problems in anthropometric research that came to the fore during this study.

These problems include the terminology employed to describe increased adipose tissue (i.e. fat, fatness, overweight and obesity), measurements used to collect data, and appropriateness of reference standards used to interpret growth data. The final theme addressed in this chapter is the importance of historic anthropometric data. Information on stature, mass and the BMI has been collected in many locations worldwide for a long period of time. The availability of such studies provides the opportunity to compare growth patterns, past and present, and to examine the health of populations both diachronically and synchronically.

The final chapter (Chapter 7) considers the contributions made by this study to the literature on child growth and development. These include identification of an increase in Canadian children "at risk for overweight" and already overweight during the last 50 years, as well as the potential for BMI "tracking" to identify a critical age when children are "at risk for overweight" and hence, the possibility of developing age-specific intervention strategies.

Chapter 2

Background to Study

2.1: Introduction

Chapter 1 introduced the current study and illustrated that the anthropometric variables of stature and mass and the resulting BMI provide important insight into growth, maturation, health and nutrition of individuals and populations in a regional and global context (Ajlouni et al. 1998; Al-Isa et al. 1998; Campaigne et al. 1994; Flegal et al. 1998; Gordon-Larsen et al. 1997; Kuczmarski et al. 1994; Martorell et al. 1998; Melnik 1998; Popkin and Udry 1998; Power et al. 1997a). This chapter investigates three primary issues important for understanding the context of the current study. First, the study of anthropometry/human auxology and its significance for investigating changes in growth and development of the human population or the individual is outlined. Second, a brief historical synthesis regarding the development of modern anthropometry is presented, highlighting several key themes in its evolution, including: aesthetic vs. social constructs, cross-sectional vs. longitudinal investigations, heredity vs. environmental theories, and improvements and changes in equipment used for measurement. The final section presents a review of anthropometric methodology and answers the question: Why use stature, mass and the BMI to investigate growth and development?

2.2: Sizing up Anthropometry: What is it and Why Study it?

Anthropometry is "the study and technique of taking human body measurements, especially for use on a comparative or classification basis" (Bender and Remancus 1999:1). The application of such measurements for monitoring biological growth and development in the human population is known as "human auxology" (Borms et al. 1984; Bogin 1986:7; Bogin 1988:5). The terms growth and development, although representing different processes, are often confused. Bogin (1988:7) clarifies these terms by defining growth as "... a quantitative increase in size or mass.", while development can be thought of, "... as a progression of changes, either quantitative or qualitative, that lead from an undifferentiated or immature state to a highly organized, specialized, and mature state." As Bogin (1988:7) argues, "... this definition allows one to consider the development of organs (e.g., the kidney), systems (e.g. the reproductive system), and the person."

The significance of examining changes in human growth and development rests on the premise that such research provides a window to the health and nutrition of the population or individual under study (Bogin 1988:3). Growth studies are employed to monitor social conditions and identify groups of children who are disadvantaged or neglected, and changes in anthropometric variables can provide information on a population's health. For example, Bowditch (1881) argues that there is "... value in [anthropometric] measurement in two directions, [1] in the comparative health of populations and large scale identification of deprived areas and [2] in the recognition of growth problems of individuals" (cf. Buckler 1989) The current study compares stature, mass and the BMI from a recent historical growth study to a contemporary growth study in order to assess changes in these variables over the past fifty years.

2.3: Anthropometry Grows Up: 1800s to present

The following synthesis of the development of theory and methods of anthropometry is drawn primarily from Boyd (1981), Tanner (1981), Lowery (1986) and Bogin (1988) and is not intended to be a detailed historical review but rather an overview of key developments in anthropometry and auxology during the last two hundred years. Readers should consult the above authors, especially Boyd (1981) and Tanner (1981), for interesting and exhaustive examinations of the historical development of anthropometry.

Understanding the history of anthropometry is critical as it illustrates what types of information have been recorded in the past, and allows for improvements to be made in the collection and analysis of such information. The late 18th and early 19th century, for example, marks the point at which the importance of collecting longitudinal information versus cross-sectional information was realized. A historical perspective also identifies problems that require further research, such as how to: 1) accurately assess body composition and compare it within and between populations 2) how to determine appropriate standards with which to compare anthropometrical variables and 3) how to best gain access to reliable data for analysis (Bogin 1988:7).

The last 200 years have witnessed an explosion in the investigation of growth and development of the human form. The entrenchment of scientific empiricism into almost every aspect of inquiry put the focus of growth and development studies, for the first time, on understanding the state of health for groups of children (Bogin 1988:12). This era has often been labeled as the era of public health reform, auxological epidemiology and educational auxology (Tanner 1981:142). At the forefront of these investigations are researchers like Henry Bowditch, Charles Roberts and Franz Boas (often considered the father of anthropometry), who signify the beginning of modern anthropometrical studies and its embedding in the larger field of human biology. Earlier investigations, including those of Quetelet (1796-1874) and Villermé (1782-1863), set important groundwork for advances in anthropometry and the study of the human form. It is this groundwork, which followed from the small amount of research during the 18th century, that begins the ensuing discussion, followed by a review of the key developments at the turn of the 20th century.

Interest in growth investigations in the early 19th century primarily resulted from humanitarian efforts to change the deplorable conditions of the poor and their children (Tanner 1981:142). Tanner (1981:145) suggests that between the years 1830 and 1870 the growth of children, especially in the United Kingdom, was appalling, arguing that British children at this time were shorter than the children of plantation slaves for the same time period and even shorter than the children of many present day third world nations. Governments at this time were concerned with the decrease in manpower and human resources that had resulted from famine, disease and war. In a sense, Tanner (1981:142) argues, there were too many undersized and sick people, mostly male. The collection of growth data at this time then was a product, in part, of the passing of Factory Legislation Laws, Poor Law Commissions, Sanitation and Housing Acts to help the poor, but also represented a governmental investigation of the state of health of the nation (Tanner 1981:142; Buckler 1989:3).

The first large scale surveys of children in the United Kingdom began in 1833 with the *Report of the Commissioners on the Employment of Children* (Tanner 1981:147). The primary goal of these surveys was to detect differences in age and/or sex between children reared in a factory environment and those not associated with factory living (Tanner 1981:147-148; Buckler 1989:3). Two of these surveys, Stanway and Cowell's (1833) and Horner's (1837) suggested that the factory children were small, and in fact, Stanway and Cowell's results illustrated that the small size of the children studied was permanent and not a result of a temporary growth delay (Tanner 1981:158; Buckler 1989:3). Similar data presented by Gandevia (1977a,b) on young convicts sent to

Australia from the United Kingdom during the 1840s also suggest the prevalence of environmentally induced small stature during this period. Tanner (1981:159) argues that these results should not be surprising as the boys in the study hailed from the most deprived areas of London and lived in conditions that were worse than those of the children who worked in factories.

American slaves were among the largest sample of individuals ever to be measured. Unfortunately, this information was collected (between 1820 and 1860) for economic reasons rather than as an investigation of the social ills surrounding slavery. Steckel (1979) stresses that after 1807, laws were enacted requiring the collection of names, sex, ages, colour and heights of American slaves in order to prevent the addition of new slaves from outside the country (cf. Tanner 1981:165). Steckel's studies conclude that American slaves were larger than both the British children who worked in factories during the same period and the children of the labouring classes studied by Charles Roberts in 1872-73. The only sample of children that were larger than Steckel's (1979) study of 1840 slave manifests was Henry Bowditch's sample of American born children residing in Boston during the year 1875 (cf. Tanner 1981:168).

One of the main controversies during this time, and still present, is the debate between environmentalists and hereditarians regarding the specific factors regulating growth and development. Until the turn of the 19th century genetic predisposition was considered to be the primary drive behind the growth and development of children, and in fact the primary drive in almost every aspect of human biology. Under the influence of scientific empiricism and in concert with the growing public health reform movement at this time, many people started to promote environmental factors as having a significant influence on human growth and development. However, it is not until the work of Franz Boas at the end of the 1800s that environmental theories begin to overshadow genetic predisposition theories. These environmental theories, however, can be traced to the turn of the 19th century and the work of Villermé and Quetelet.

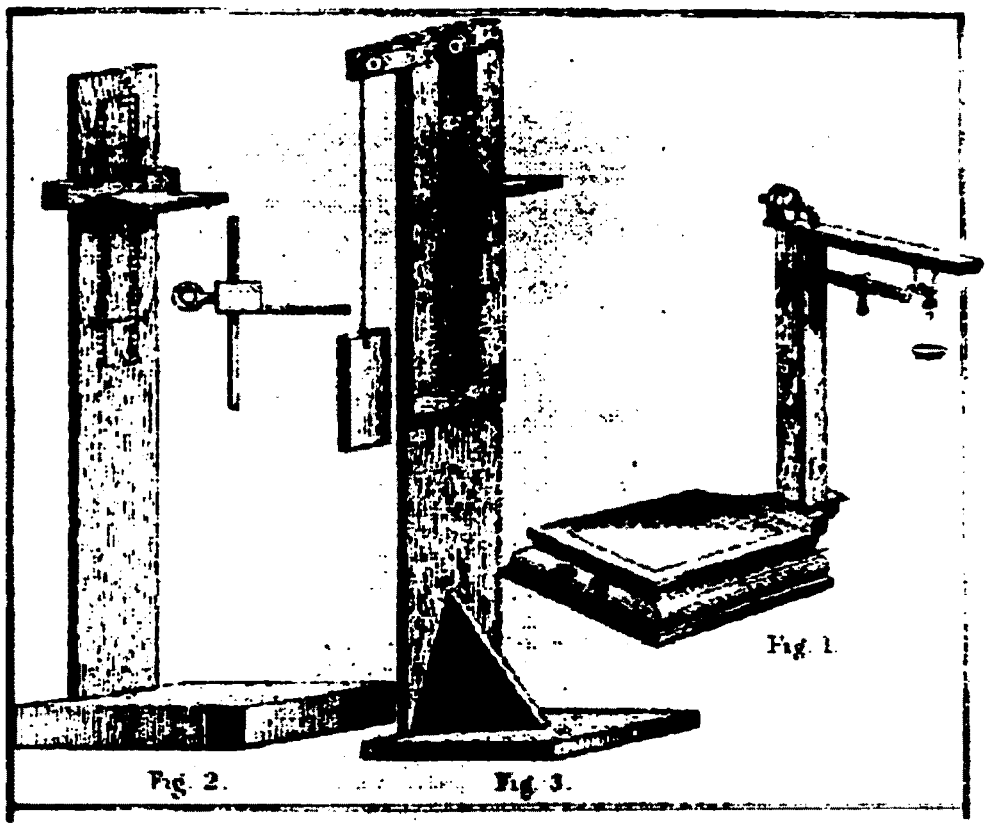
In 1828, L. Villerme, who was working in France, published data from a governmental inquiry on the heights of male conscripts from 1812 - 13. His results suggested that poverty was a more important influence on growth than climate (Tanner 1981:162).

Adolphe Quetelet (1796-1874), sometimes referred to incorrectly as the father of modern growth studies, carried out extensive studies of height and weight on males and females of all ages, which he published in 1835 (Lowrey 1986:3; Tanner 1981:122). This study is considered the first cross-sectional population survey of children to be carried out and the first to have growth data fit to a mathematical expression (Tanner 1981:125,135). With the eye of an artist, Quetelet focused his growth investigations on finding absolute beauty in the average [male] (*l'homme moyen*) (Tanner 1981:123,126,129). This led him to see a fixity in the human form, resulting in the view that variations were oddities around the mean. Although his work was extensive and provided a basis for the significant advancement of anthropometry later in the century, Quetelet's data and explanations are problematic. He failed to recognize family resemblance in stature (Tanner 1981:129) or the greater stature of female children who reach their adolescent growth spurt before males (Tanner 1981:132). In fact, it transpired that Quetelet had smoothed his growth curves to adhere to his vision of *l'homme moyen*, and therefore he failed to recognize the adolescent growth spurt. According to Tanner (1981:138), Quetelet believed that the average male should have a growth curve of perfect regularity and impeccable form, hence no disturbances of growth regularity at adolescence. This smoothing confounded researchers until much later in the century when they continually found the presence of a growth spurt in height along with almost every other physiological process, refuting Quetelet's earlier results (Buckler 1989:2; Lowrey 1986:3; Tanner 1981:133, 135, 136). The BGS shows similar growth spurts for stature, mass and the BMI, with females entering their growth phase about two years earlier than males, a common finding among other growth studies (Eveleth and Tanner 1990).

Lehmann (1800 - 1863) was the first to identifiy several of the problems with Quetelet's interpretations. He refitted serial data collected from the door jambs of peoples' homes and compared them to Quetelet's growth curves. Lehmann discovered, for the first time, a double hyperbola that had one curve riding on the back of the other, clearly showing the adolescent growth spurt (cf. Tanner 1981:139).

In 1873 Francis Galton provided a significant transformation to the study of growth in England through a program of collecting body measurements from children in schools. He also developed a stadiometer that was still in use in the 1950s (see Figure 2.1)(Tanner 1981:181). Galton highlighted familial factors in growth and was the first to present his data in terms of centiles (Tanner 1981:183); he also stressed the necessity for collecting longitudinal growth data because cross sectional data present a misleading picture during pubertal growth (Buckler 1989:3; Tanner 1981:181).

Figure 2.1: Galton's stadiometer



Adapted from Boyd (1981:348)

In 1872-73 Charles Roberts, one of five doctors on a British Parliamentary Commission, measured 10,000 children in the North of England. His results demonstrated that differences existed between the heights of children for manual and non-manual workers. His work also noted that there is a great deal of variation occurring around the means, highlighting again the problems associated with averaging growth velocity data in cross-sectional studies (Buckler 1989:3; Tanner 1981:172-180). Roberts argued that the primary factor affecting growth and development in children was the social environment in which they lived. While life in factory towns produced few differences in growth, working in the factory environment resulted in significant differences in stature between children (Tanner 1981:172). In two key papers published by Roberts between 1874 and 1876, based on the measurements of 1872-73, he argued that the age of a child could not be identified to within two and often three years of their birthdays. This led to the suggestion that the use of birth certificates and physical exams be enforced to ensure that a child was of legal age to work in the factory, therefore reducing the effects of factory life on growth and development (Tanner 1981:173).

At about the same time as Charles Roberts was conducting his investigations in the United Kingdom, Henry Bowditch's work on Bostonian state and private school children yielded similar results. His 1872 paper is often considered the beginning of the study of growth in North America (Tanner 1981:185). Bowditch's investigations showed a different pattern of growth between the children of the laboring and non-laboring classes, with smaller children found more often in the former. He argued that these patterns of growth resulted from a variety of different environmental factors experienced by the two classes, rather than any differences in their genetic makeup (Tanner 1981:195). As a result of Bowditch's efforts there was an explosion of growth studies that began under the auspices of school surveys, in North America and abroad, to determine if educational stress was a factor affecting child growth, especially in female children, as they were considered "the weaker sex" during this period and at higher risk of being affected.

Luigi Pagliani's school survey in Italy in the 1880s and 1890s is often cited as a model study. Because his main interests were outside the field of growth and development, his name and research have receded from the literature. During the 1870s he conducted a school survey in Italy demonstrating that the adolescent growth spurt occurred after the slowest period of growth (Buckler 1989:6; Tanner 1981:199-200). Pagliani was also the first to recognize the importance of the different timing of the adolescent growth spurt, a phenomenon often obscured through the used of composite means (Buckler 1989:6; Tanner 1981:201). His investigations highlighted the differences in growth patterns between social classes, where the children of higher social status were taller, heavier and had larger vital capacities than children who grew up in poverty. Pagliani's ideas suggested that the adolescent growth spurt and puberty were part of the same process (Tanner 1981:201). He was interested in how a change in a child's circumstances influenced growth and hence became a strong proponent of the longitudinal study design (Tanner 1981:198).

Several other school surveys followed Pagliani's lead in both Europe and North America, resulting in the creation of standard growth curves for many countries after the turn of the 20th century (see Tanner 1981:205-233 for an exhaustive list of school surveys completed during this period). The primary reason for undertaking these studies was in order to investigate how stress affected child growth and development, especially in female children, and what differences in growth occur between various groups of individuals. Researchers during this period were also interested in how children's health and sickness were related to general growth and development (Tanner 1981:202). In keeping with similar aims, the BGS was initiated in the 1950s to better understand dental health and facial growth while at the same time collecting significant information on other growth variables, including stature and mass.

The moving force behind the entrenchment of growth studies into the field of human biology and anthropology is often identified as Franz Boas, whose work generally marks the beginning of the modern era of growth measurement and analysis. His primary theoretical premise, and one held strongly and steadfastly, was that the environment produced significantly greater effects on growth and development than does genetic predisposition. Boas published several influential papers around 1895 in which he described variability in growth and rate of development between populations of people, especially migrants to the United States (Tanner 1981:242-243). He was also the first to recognize the significance of the difference between individual and composite growth patterns and in 1898 began the first large longitudinal study in North America, consisting of 90,000 children. The results of this study became the first reference standards for children's growth. Boas further argued that the longitudinal study of children constitutes the best way to understand the nature of growth and development. Boas' ideas were largely ignored by the scientific community until he revived them in the 1930s, along with the work of Charles Davenport (1931) and Frank Shuttleworth (1937) (cf. Tanner 1981:309, 340). The most significant of this work was Boas' studies of migrants which suggested that children growing up in America were developing and growing to a much better degree than children who did not migrate from the populations from which they were drawn. His research rocked the foundations of physical anthropology, for one of its central tenets was the fixity of human races. Boas promoted the idea that certain biophysiological features and processes, including growth, were not genetically fixed and that environmental factors significantly influenced their expression (Tanner 1981:250).

In the first half of the 20th century a great many large scale growth studies were implemented in the U.S.A. and Europe. Many of these were descriptive in nature and outlined how children grew, primarily between birth and age 14, although there was also a significant increase in the literature concerning the growth and development of the fetus between 1900 and 1930 (see Scammon and Boyd in Tanner 1981:266). In the early 1900s several research centers for the study of child growth and development in a longitudinal setting were instituted in the United States, stimulated by the child welfare movement and a changing view of child health that promoted preventive medicine. These include the University of Iowa Child Welfare Research Station (1917), The Harvard Growth Study (1922), The Child Research Council at the University of Colorado (1923), The Brush Foundation at Western Reserve University (1930), The Berkeley Growth Study (1928), and The Fels Research Institute at Yellow Springs, Ohio, (1929) (see Tanner 1981:299 for a detailed description of these and others). A similar development only occurred in the United Kingdom after the second World War, where most studies were oriented toward understanding the medical implications of differences in growth. In the United States, the majority of the investigations at this time attempted to include an analysis of the "whole" child by conducting physical, psychological and behavioural tests and presenting the results in journals specifically developed for this purpose (i.e. Child Development, initiated in 1930). As these types of growth studies matured, it became difficult to maintain them financially, with the result that specific groups of researchers went their own way. By the 1950s, for example, most of the studies on physical growth were published in the anthropological journal, Human Biology. At the same time it seems that interest in growth and development was waning, as funding for the very expensive and long term studies were cut, forcing several growth studies to shut down. With the exception of the Fels Longitudinal Study (1929 - present), American growth studies were shut down because of lack of funding and justification to collect data for its own sake, with the result that interest in the "whole child" philosophy disappeared (Bogin 1999:38).

During the past thirty years a number of researchers have re-examined and re-analyzed various sections of such historic longitudinal studies to elicit new information (for example, Baumgartner and Roche 1988; Cronk et al. 1988; Guo et al. 1994; Must et al. 1992). Consequently, there is a great deal of information locked away in these unpublished studies, data amenable to analysis with modern computers and statistical programs. Further, much of the information collected on children during these studies (i.e., secondary sexual characteristics and x-rays) would be unacceptable in today's research sphere. One of the drawbacks to these data is that they are several decades old and it may be misleading or inappropriate to present them as representative of contemporary patterns of growth; however, they are an important resource for comparative studies. This was one of the considerations for using data from the BGS to compare to recent measurements collected from the same area of southern Ontario.

Many other studies in the past two or three decades have examined cross-sectional data or smaller longitudinal samples where children are followed for only a few years. (For example, Troiano 1995; Schey et al. 1984; Henneberg and Louw 1998). Many of these studies attempt to correlate various anthropometric measurements and indices with risk outcomes later in adult life to assess and prevent mortality and morbidity by recommending preventative measures in the growing child (Must et al. 1992; Must 1996).

Rigorous scientific inquiry regarding the growth and development of the human population and individual has had a rather late start, dating to the last two hundred years. During this period, knowledge about growth and development has steadily grown, exemplified by the increasing number of published studies and number of growth centers since the 1920s, one of which is still conducting growth research. Data from the BGS is still actively being used, primarily in the field of dentistry, however, recent anthropological studies have begun to access this important database in a variety of different ways (see De Vito 1988; Garlie 1995; Garlie and Saunders 1999; Mcveigh 1999)

Today, several investigations have arisen from data that was collected as part of these earlier studies, in part because a number of the variables that interest researchers are difficult to collect at present and the cost, in money and time, is difficult to obtain and maintain over long periods. This is one of the advantages of the BGS, for it is a large, well archived database spanning twenty years and is accessible to researchers. Stature and mass are among the most common variables currently collected in growth studies, owing to ease of collection. There has been little change in the way that this information is obtained, except for the introduction of digital equipment in the late 1950s. In fact, Krogman in 1970 argued that stature and mass have long been universally accepted as excellent measures of physical growth. In recent years there has been growing concern regarding the prevalence of overweight and what effects the presence of increased fat mass might have on the human body. A number of methods are available to researchers for testing and analyzing the amount of body fat present and how it might affect the human body. The following section highlights some of these methods for the anthropometrical inquiry regarding body fat. It also explains why the BMI was chosen for estimating the amount of overweight in the current study.

2.4: Measuring Up: Methods of Anthropometrical inquiry

Stature and Mass

The anthropometrical variables of stature and mass have long been considered important for the understanding of human physical growth and development (Krogman 1970:iii; Prince 1995:388) because they can be used to calculate other ratios of body measurement and to help in the assessment of nutrition of individuals and populations.

Stature is considered a strong indicator of overall body size and bone length and is employed in the screening of people for disease, malnutrition or over nutrition (Bogin

1988:115; Byard et al. 1985:62; Macfarlane 1996:421; Malina et al. 1987:518,519; Mascie-Taylor 1991:56,5; Micozzi 1986:725; Prince 1995:388,398). Stature is generally measured with the subject in a vertical position unless there is difficulty in obtaining the measurement, as in children under the age of three, the elderly or the handicapped. In such cases measurement of recumbent length and arm span or knee height is often substituted (Lohman et al. 1988:4). Various equipment is available to measure stature, but generally the use of a stadiometer is preferred (Lohman et al. 1988:3). The sample of children from the BGS and the new BSS were all measured in a vertical position employing a portable stature rod.

Weight, or mass, is the most commonly recorded anthropometrical variable and has the advantage of being collected with a high degree of accuracy, while being fairly simple to obtain. This measure is also very important in the assessment of unusual growth patterns, obesity and undernutrition (Anderson et al. 1975:453; Gerver 1996; Lohman et al. 1988:7-8; Lowrey 1986:91,113; Mueller 1982:191). A variety of scales are available for the collection of mass and it is critical that they be operated on a level surface and calibrated to zero, using an object of known weight. Adaptation of these tools is often necessary when measuring handicapped individuals, for whom a regular scale is inadequate (Lohman et al. 1988:8). In the current study, a Tanita digital scale (model 551) was used to record body weight.

BMI: Why use this ratio?

The BMI is a ratio between stature and mass that produces a measure indicative of overall body fat (Himes and Dietz 1994). This ratio is calculated by dividing mass in kilograms by stature in meters squared (m/s^2). Although this is among the most common methods employed to assess underweight, overweight and obesity in people, and the method chosen for this study, other methods exist and are presented below.

Researchers have a battery of methods available to assess overall body fat and regional body fat with a high degree of accuracy. Overall body fat can be determined using methods of underwater weighing, water or air displacement, inert gas absorption, photogrammetry, electrical impedance or conductivity. Regional body fat can be ascertained by using skinfold measurements, circumferences, ultrasound, magnetic resonance imaging, soft tissue radiography, computerized tomography and dual photon absorptiometry (Roche 1992 199-207; Shephard 1991; 35-80). The unfortunate reality is that the majority of these methods involve a high degree of technical knowledge, are quite invasive, and are very costly to carry out and result in the drastic and almost necessary reduction in sample sizes. As a result, many researchers including this one, have adopted the use of the BMI or Quetelet's index as a particularly effective method for assessing underweight, "at risk for overweight", overweight, and obesity. Other ratios (i.e. m/s, m/s^3, and m/s^p, where p is age dependent) have been developed and tested against the BMI to assess their accuracy in determining overall body fat (see for example, Gasser et al., 1994). The BMI has been observed however to be an extremely useful and reliable method for determining relative fatness and providing insight into questions surrounding changes in body mass, persons at risk for health problems due to obesity and for predicting adult obesity from childhood measures of fatness (Ballew et al. 1990; Bray 1992; Cole et al. 1981; Davies and Lucas 1989; Davies and Lucas 1990; Gasser et al. 1994; Gasser 1996; Gordon-Larsen et al. 1997; Guo et al. 1994; Kuczmarski 1992; Lopez and Mâsse 1992; Micozzi et al. 1986; Sichieri et al. 1991; Troiano 1995; Zannolli and Morgese 1995).

The use of the BMI as a measure of fatness has been investigated by a number researchers (see for example Gasser et al. 1994; Micozzi et al. 1986; Schey et al. 1984). Several have argued that the BMI is problematic as a measure of fatness (see Davies and Lucas 1989; Davies and Lucas 1990; Gasser 1996; Roche 1992;). Gasser (1996:341) maintains that the BMI is highly correlated with body width and only moderately correlated with relative fat, and although the BMI is useful as a measure of overweight, questions remain as to its utility for determining excess fat or percentage of overall fat in people. Lohman (1992) argues that the BMI also does not distinguish between areas of lean mass and fat mass in the body and hence limits its use. In a 1993 article, Kuczmarski also argued that the adolescent growth phase has different maturation processes and the

BMI therefore cannot provide a reliable measure of excess fat. In their ***Guidelines for overweight in adolescent preventive services***, Himes and Dietz (1994:308) argue however that the BMI is a useful tool for screening for adults and children "at risk for overweight" and overweight. Gasser and colleagues (1994:111) demonstrated that the BMI is generally as effective as other weight-for-height indices used to detect over and underweight individuals. Furthermore, Rolland-Cachera and colleagues (1982:181) made similar observations in their investigation of fatness in children. Guo and colleagues (1994:810) also championed the BMI as the most widely used measurement for conducting health surveys in their study investigating the prediction of adult obesity from childhood measurements. Micozzi and his team (1986:730) found that BMI values were highly correlated with subscapular skinfold measurements, the latter being related to measurement and identification of centripetal fat patterning. Centripetal fat has been linked to an increased risk of developing certain chronic diseases in adulthood (Micozzi et al. 1986:730; Mueller 1982:191) and thus BMI has value for making inferences about health and nutrition based on these high correlations. In their 1985 study, Garrow and Webster argue that the BMI is useful and reliable as a measurement for determining overweight in adults.

Employing the BMI as a measure of fatness, numerous studies have found recent increases in the prevalence of overweight and obesity in adults and children. Although researchers have suggested that secular increases in stature have decreased or ceased altogether during recent decades (see Eveleth and Tanner 1990; Tobias 1985), the trend for increased body mass appears to be in the opposite direction, and is the prediction for this current study (Gordon-Larsen et al. 1997; Kuczmarski et al. 1994; Shah et al. 1991; Troiano et al. 1995). Gordon-Larsen and colleagues (1997) found that African-American children show positive secular trends for increased body mass from the mid-1950's to the mid-1990's. Kuczmarski and colleagues (1994) also identified an increasing prevalence for overweight in adults living in the United States, using NHANES survey data from 1960 to 1991. Similarly, Shah and colleagues (1991) observed secular increases in body mass for adults from three communities in The Minnesota Heart Health Program. Secular increases in body mass were also found by Campaigne and colleagues (1994) when they examined adolescent African American and Euro-American girls aged 9 and 10. Sugarman and researchers (1990) produced similar results when they investigated body mass among Navajo schoolchildren.

Along with this apparent increase in adiposity in recent decades, it appears that increased obesity has important links to a myriad of health problems among adults, such as high blood pressure, cardiovascular disease, diabetes and certain forms of cancer. (Bray 1992; Lopez and Mâsse 1992; Must et al. 1992; Pi-Sunyer 1993; Troiano et al. 1995). The link between adiposity and greater risks of chronic diseases during adulthood has been hypothesized to originate during childhood and adolescence (Abraham and Nordsieck 1960; Bandini and Dietz 1992; Guo et al. 1994; Johnston 1985; Must et al. 1992; Must 1996; Stark et al. 1981). Guo and colleagues (1994) found that being overweight during childhood was a significant predictor for being overweight at 35 years. They further suggest that the predictive value of their results might increase if there were data on parental body mass measurements. Must's (1996) analysis of increased morbidity and mortality from overweight led to the observation that health problems in adulthood were highest for individuals who were obese during adolescence. Stark and colleagues (1981) also suggest that adult obesity has its origins in adolescence.

Although interpretations regarding health risks of overweight and obesity from the BMI are limited, general trends may be suggested. Individuals who are above the 95th percentile for BMI are considered overweight and at a greater risk for ill-health consequences. Individuals who are at the 85th percentile but less than the 95th percentile are at a significant risk for becoming overweight and should be monitored (Himes and Dietz 1994:307).

From this brief review of the literature it is clear that debate surrounds the usefulness of the BMI as a measure to assess overweight and obesity. Many researchers insist on the use of complex technological methodologies to measure body fat reliably. Others maintain, however, that these methods are of little value for collecting data in field situations due to the high cost, technical knowledge and amount of equipment needed. The collection of body fat data on children using such complex methods raises a number of important ethical questions as well (i.e. assessing secondary sexual characteristics and invasive aspects of the methodology). Given that the collection of measurements required to calculate the BMI is less costly, easier to obtain and does not involve stringent ethical issues, many researchers have adopted it as the method of choice. Early studies of growth during this century and the last moreover, often incorporated only stature and body mass as growth data; as such, complex techniques have limited application for historical comparative analysis.

2.5: Summary

It is clear from this chapter that an interest in the growth and development of the human form has only recently been scrutinized under the meticulous eye of scientific empiricism. Stature and mass have been employed as key measures during this period of time and continue to be essential variables in the anthropometrical assessment of individual and population growth and of interest to public health officials. Although a variety of methods exist for discerning the amount of body fat, the majority of them are far too invasive, costly and complex to carry out in field situations or on a large scale. Consequently, the BMI is adopted in this study as a proxy for estimating overweight and

Chapter 3

Materials and Methods

3.1: Introduction

The previous chapter made the point that many growth studies employ cross-sectional or semi-longitudinal samples for the practical reasons of lower cost and shorter time for completion. True longitudinal studies are very costly and involve time frames that often exceed research careers (Mueller 1982). The study presented here uses anthropometric measurements gathered from a mixed longitudinal data set, *The Burlington Growth Study (1952-1972)*. The BGS also includes a large number of individuals (m, n=117; f, n=103) who are represented in true longitudinal form. For comparative purposes, I collected a new set of anthropometric measures from children aged 6-14 years, *The Burlington School Study (1998-1999)*. These two samples constitute the data upon which this study is based.

This chapter is divided into four sections. The first section provides a description of *The Burlington Growth Study*, including the materials and methods used to collect the original data from 1952 to 1972 and the data selected for this project. The second section is devoted to a description of the materials and methods used to collect comparative data from children attending two Burlington schools during the 1998/99 school year. In the third section, the national reference standards employed for comparison with data from this study are briefly discussed. The last section describes the statistical methods used for data analysis and interpretation.

3.2: The Burlington Growth Study (1952-1972)

Materials

The Burlington Growth Study was initiated in 1952 to evaluate the provision of early orthodontic treatment in children and to collect growth records from a representative population in order to better understand dental and facial growth and provide an early diagnosis of malocclusion (Popovich 1969:6). The original mixed longitudinal study produced a data set for 1380 children, including a serial cohort measured annually from age 3-20 (m=163, f=111) and several control cohorts measured annually from ages 6 (m=167, f=136), 8 (m=96, f=126), 10 (m=112, f=107) and 12 (m=116, f=102) until age 20. Owing to attrition or no shows, sample numbers vary from year to year. Table 3.1 presents the overall number of children and parents who participated in *The Burlington Growth Study*. A total of 1367 children were included in the analysis presented here (m=714; f=653). A smaller sample of children (m=117; f=103), ages 6 - 14, whose growth was monitored over a consecutive nine year period, is also investigated.

Table 3.1: Composition of the Burlington Growth Study

3-Year - Serial Experimental Group(Records Taken to August 31, 1971)

AGE	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
MALES	132	167	161	154	149	144	141	141	136	127	125	122	35	116	86	101	32	68			
FEMALES	100	136	132	130	126	122	121	117	116	115	113	109	0	103	47	86	31	57	1		
TOTAL	232	303	293	284	275	266	262	258	252	242	238	231	35	219	133	187	63	125	1		
C-6 SERIAL CONTROL																					
MALES				168	2		138	3	3	133	3	91	3	105	1			53	4		
FEMALES				129	1		107	1	1	101	1	70		76	2			49	2	1	
TOTAL				297	3		245	4	4	234	4	161	3	181	3			102	6	1	
C-8 SERIAL CONTROL																					
MALES						96				1	4	12	1	20				24	2		
FEMALES					1	123	3	1		6	3	17	2	25				21	8		
TOTAL					1	219	3	1		7	7	29	3	45				45	10		
C-10 SERIAL CONTROL																					
MALES								111		1				19	3			4			
FEMALES								106	2			1	2	12				1	1		
TOTAL								217	2	1		1	2	31	3			5	1		
C-12 SERIAL CONTROL																					
MALES									1	113	1			1	2	1		56	8		
FEMALES									1	99	1			1	2			37	4	1	1
TOTAL									2	212	2			2	4	1		93	12	1	1
FAMILY STUDY SIBS (These figures do not include those from above)																					
MALES		2	4	19	8	28	29	31	7	35	5	36	1	33	1	3	3	3	1		
FEMALES	1	3	4	25	11	37	43	45	3	44	8	43	3	43	1		1	3	1		
TOTAL	1	5	8	44	19	65	72	76	10	79	13	79	4	76	2	3	4	6	2		

PARENTS
MALES 151 FEMALES 161 TOTAL 312

CHILDREN
TOTAL 1380

Modified from Burlington Growth Study

Participants in *The Burlington Growth Study* represent approximately 90% of the children living in Burlington, Ontario at the time the study began in 1952. Each year of the 20-year duration of the study, children's stature and mass were measured, radiographs taken, and dental casts made, on or near their birthdays. In 1964, additional anthropometric data began to be collected, including measures of skinfold thickness and a variety of other measures of body size and shape (Nikiforuk 1977; Popovich 1969). Unfortunately, these were only collected for male children and are not included in this study. A sample of parents for some of these children was also measured, allowing for comparisons to be made with the children's data (males = 151; females = 161). Parental measurements are not discussed in this study, as they too are beyond the scope of this project.

This large data source makes it possible to assess individual and group growth patterns over a 20-year period in a relatively homogeneous children of northwestern European descent (primarily of English, Scottish and Irish origins).

Methods

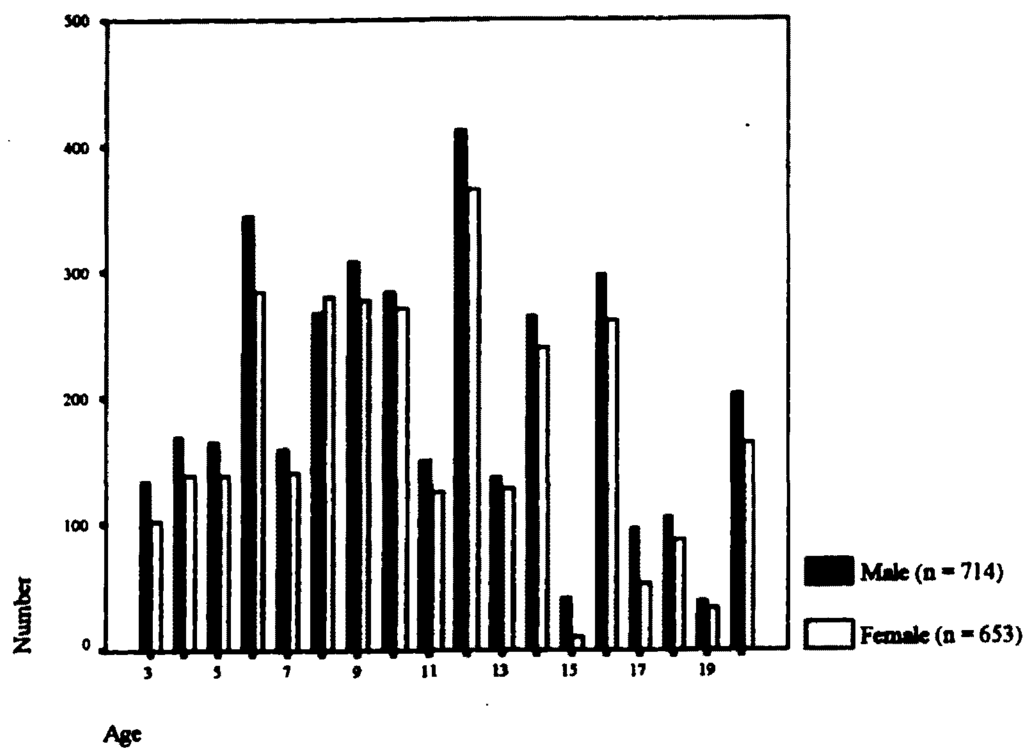
Stature and body mass measurements were made available for this project with the kind permission of Dr. F. Rousseau of The Burlington Growth Center at the Faculty of Dentistry, University of Toronto. These measurements, originally collected using a

Fairbanks-Morris sliding weight scale with attached stature rod, were reported in inches and pounds but were subsequently converted to centimeters and kilograms (Jorgenson per. comm.).

For the current study, stature measured in centimeters and mass in kilograms was collected from the archived BGS records. Data records were copied and scanned into a personal computer using a HP6100 scanner, then saved as text files. The files were then converted to Quattro Pro 7.0 for cleaning and error checking. Each record was checked for errors by comparing the new files to the original data. This step revealed only 80 typographical errors out of 6604 entries for the 1380 children. These errors were corrected. The record files were transferred to SPSS 9.0 (Statistical Program for the Social Sciences) for analysis. Preliminary descriptive statistics revealed thirteen entries that appeared biologically implausible. These were deleted from the file and from further analysis. Figure 3.1 presents the age and sex distribution of the final sample of 1367 children from *The Burlington Growth Study* discussed here. In addition, 117 male children and 103 female children who are present every year from age 6 to 14 were extracted from the original database for longitudinal analysis. Further, a sample of children was extracted from this group in order to match the composition of children in the BSS. This sample was derived by calculating the proportion of the longitudinal BGS sample necessary to match the children in the BSS sample by age and sex. A random number generator from SPSS 9.0 was then used to extract the necessary samples by sex for each age group. The children from this sample were then compared to those from the BSS.

Stature and mass measurements are compared to the 5th, 50th, and 95th centiles from American and Canadian reference standards (Hamill et al. 1977; Canada Fitness 1985). BMI categories were calculated for the children in the BGS data based on reference standards from the United States and Canada (Must et al. 1991b; Canada Fitness 1985) and focus on the 5th, 50th, 85th and 95th centiles. To investigate the prevalence of "at risk for overweight" and overweight in this sample, a recommended cut-off between the 85th and 95th centiles and greater than the 95th centile has been followed (Himes and Dietz 1994).

Figure 3.1: Age and sex of participants in the BGS (1952 - 1972), (n = 1367)



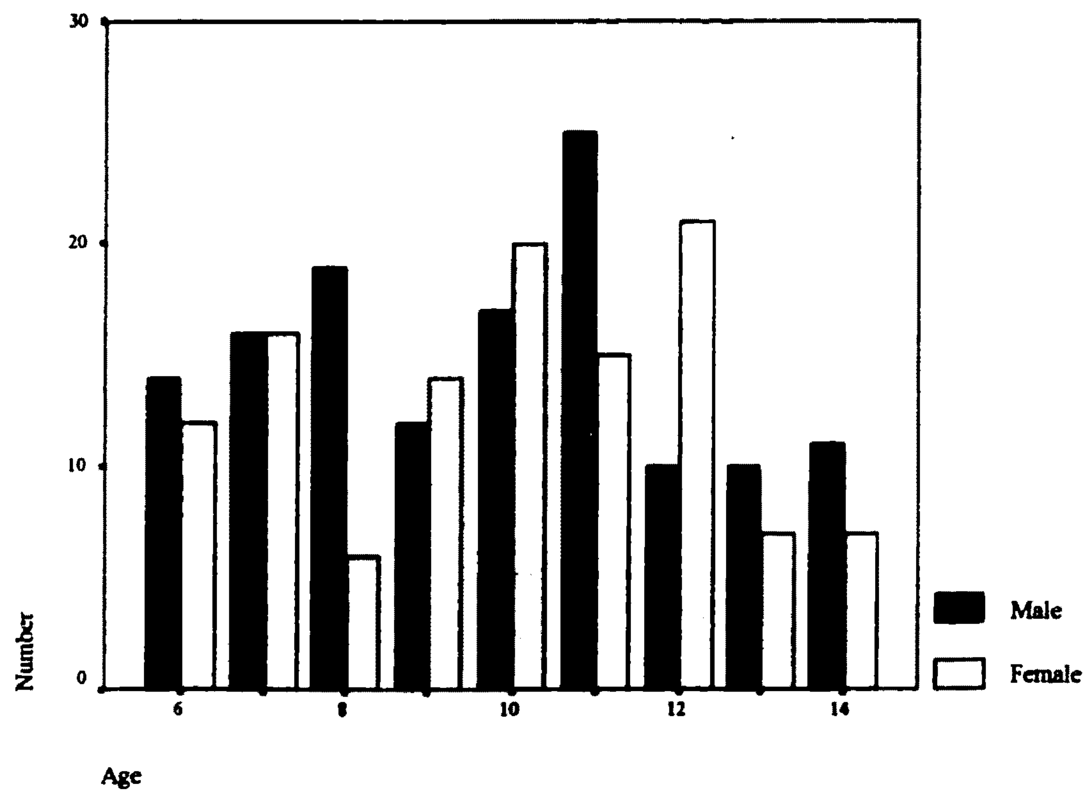
3.3: Burlington School Study (1998/1999)

Materials

Stature and mass measurements were collected on children from two Burlington schools during January and February of 1999. The process for collecting measurements from children in these schools began in the Spring of 1998 when on May 8, 1998 an application for permission to conduct research on children in Burlington area schools was submitted to the Research Advisory Board for the Halton District School Board. An application to conduct research on human subjects was also submitted to the Ethics Committee at McMaster University at this time. Approval for these applications was received in July, 1998. With the approval of the Halton School Board, consent to conduct research within the schools was sought from the principals of two Burlington area schools, Duncan Elementary (kindergarten to grade eight) and Sycamore High (grade nine through twelve)[1] . Owing to ongoing labour disputes during the summer and fall of 1998, consent was not granted until early November, 1998. With the approval of the principals in place, parental permission forms were sent home with the 1200+ students attending these two schools on January, 6, 1999, asking for a response within one week. The letter briefly outlined the research design and my interest in including these children in the study (see Appendix A for copy of letter). Owing to winter storm delays, the letters were not returned until the week of January 18, 1999. Of the 600 letters sent out to Duncan Elementary, 300 were returned with permission granted for 282 children. Of the almost 700 letters sent out with the Sycamore High students, only a disappointing 37 were returned with permission granted for 29 students, of which 12 fell into the age 14 category. For this reason, only the anthropometric data on children from Duncan

[1] Names are pseudonyms to protect the anonymity of the schools as mandated in the contract to conduct research in the Halton region.

Figure 3.2: Age and sex distribution of participants in the BSS (n = 252)



Elementary and the 12 students from Sycamore High were used for this study.

Methods

During the month of February, I was assisted by Sylvia Abonyi and June Archer in measuring the children from Duncan Elementary and Sycamore High. Two grade six students (names withheld as mandated by the school board) also assisted by bringing the children to the measurement area. Figure 3.2 presents the distribution of the participating children by age and sex. A total number of 252 (m, n=134; f, n =118) were measured[2]. The ethnic origins of the children is not known due to the sensitivity surrounding any questions on this issue and at the request of the school board and schools.

Stature, mass, age and sex were collected using standard equipment and methods (Lohman et al. 1988; Roche 1992:68-70). Stature was measured using a portable adult/infant stature rod, while body mass was collected using a Tanita digital floor scale (model 521) calibrated throughout using a standard weight. Students were measured wearing light indoor clothing without shoes. The data were entered into Quattro Pro 7.0 and transferred to SPSS 9.0 (Statistical Package for the Social Sciences) for analysis and comparison with the results from *The Burlington Growth Study*. Results of this analysis are discussed in Chapter 5. Intra-observer error for *The Burlington School Study* (BSS) was tested by re-measuring a random sample of students to collect a 10% sub-sample. Results of this error study are presented in chapter 4.

3.4: Reference Standards

In order to make the measurements of the children in *The Burlington Growth Study* and *The Burlington School Study* meaningful, the data are compared with national

[2]The total number of students measured is smaller than the total number of students with permission because on the day of measuring some students did not show up and others decided they did not want to be measured.

reference standards for children in the United States and Canada. Reference standards for stature and mass of American children of western European ancestry were obtained from the National Center for Health Statistics (NCHS) data on children from birth to 18 years of age (Hamill et al. 1977). These reference standards were developed at the urging of the National Academy of Sciences and other agencies to create new growth charts for children. These new growth charts were derived from a combination of cross-sectional data drawn from the Fels Growth Study (1929-75) (see Roche 1992 for an excellent description of the Fels data) and from the Health Examination Surveys (HES) of the National Center for Health Statistics (NCHS) (1963-74)(Hamill et al. 1977:2-3).

Canadian reference standards were drawn from the 1981 Canada Fitness Survey. This investigation was launched as part of a federal government initiative to collect reliable statistics, acquire baseline data in order to monitor trends, and provide data on lifestyle, physical activity and fitness to develop programs in the fitness field. The data are available to the public but were collected primarily for those interested in improving and implementing fitness programs (Fitness Canada 1985). The Canada Fitness Survey (CFS) collected data on a large representative sample of the Canadian population aged 7 to 69 years (n=15,000). In addition, approximately 22,000 individuals filled out detailed questionnaires. Information was collected for six different categories: 1) performance measures, 2) anthropometric measures, 3) activity patterns, 4) motives, values and knowledge of physical activity, 5) health and lifestyle, and 6) demographic and household information (Fitness Canada 1985). Category two, anthropometric measures, is used for comparative purposes in this study.

3.5: Statistical Analysis

The Statistical Package for Social Sciences 9.0 (SPSS) was used to generate and interpret the anthropometric data in this study. Statistical results from the Burlington Growth Study and the Burlington School Study are discussed in Chapter 5. Analysis of Variance (ANOVA) tests were incorporated into the study to test for statistical variations between sex and age categories on the variables stature, mass and BMI. The ANOVA is the statistical test of choice for this study as it enables the analysis of more than two groups of variables and the ability to determine differences between and within groups of variables. ANOVA is a statistical method for testing the null hypothesis that several group means are equal in the population (i.e. that no differences exist between the groups of means). Further, ANOVA is commonly used for the analysis of growth data in other studies, allowing the results from this study to be compared to those of other studies (for example, Gordon-Larsen et al. 1998; Blockstra and Kromhout 1991; Rolland-Cachera et al. 1987). Post hoc tests using Tamhane's t^2 are employed to examine statistical differences for individual means assuming unequal variances. Tamhane's t^2 is a conservative pairwise comparison based on a t-test that performs statistics based on the fact that growth data is generally skewed (i.e. not distributed in a normal bell curve).

Chi-square analysis is used in this study to examine the prevalence of children "at risk for overweight" and already overweight within the BGS, the BSS and between the two studies. The chi-square is a test of the association between two variables. The larger the chi-square value the more the numbers in the table differ from expected if there were no association (Norman and Streiner 1986:80; 1994:151-152). Employing the 85th centile as a cut-off for determining individuals "at risk for overweight" and the 95th centile for establishing individuals who are overweight, chi-square analysis determines if the same proportion of males or females are overweight in either study or whether the same proportion of overweight individuals occur in the BSS when compared to the BGS. The chi-square is also one of the most common statistical tests performed and thus allows for the comparison of results from this study with other growth studies (for example, Al-Isa 1998; Ajlouni et al. 1998; Janghorbani and Parvin 1998; Kasmini et al. 1997).

Pearson's inter-age correlation analysis is employed to investigate the tracking of BMI over a nine year period. This statistical procedure tests for the strength of a linear relationship between two variables. Results show values ranging from -1 to 1. The sign of the value indicates the direction of the association and the absolute value indicates the strength of the relationship, with larger numbers indicating stronger relationships (Norman and Streiner (1986:80; 1994:151-152). Again, this is one of the preferred statistical tests for investigating the tracking of the BMI and allows for inter-study comparisons (for example, Katzmarzyk et al. 1999; Micozzi et al. 1986; Serdula et al. 1993).

Chapter 4

Reliability Study

4.1: Introduction

It has been argued by several researchers that a suitable standard for measuring error among and between studies be implemented in order to increase the strength of such studies (Cameron 1984; Malina et al. 1974:65; Mueller and Martorell 1988:84). The use of the Technical Error of Measurement (TEM) on a minimum of a 10% sample of the overall measured population, a Coefficient of Variation (CV) and a Reliability Coefficient (R) to estimate the amount of measurement error/variation in a study of growth and development are suggested (see Cameron 1984; Malina et al. 1974:61-62; Marks et al. 1989:579,580; Mueller and Martorell 1988:84; Ulijaszek and Lourie 1994:30). This chapter describes the analysis and results of an intra-observer error study conducted to test the reliability of repeat measurements collected from thirty of the 252 children in *The Burlington School Study* (1998-99).

4.2: Why Conduct An Intra-Observer Error Study?

When conducting a study that involves measuring specific variables (i.e. stature and mass), measurement error/variability can occur that influences the interpretations of the resulting data. In any such study it is critical to identify potential errors and address them prior to the onset of the study as this minimizes mistakes and maximizes useful data for analysis (Krogman 1970; Tanner 1986, cf. Ulijaszek and Lourie 1994:30; Cameron 1984).

Error is often introduced into a study through a combination of observer error, instrument error and natural variation in the variable under study (Malina et al. 1974:52,66; Cameron 1984:10). Error can be divided into either systematic or observer error (Hunter and Priest 1960, cf. De Vito 1988:25). Systematic error occurs when the instruments of measure provide precise but inaccurate results due to a mechanical fault. In the *Burlington School Study* systematic error was kept to a minimum by using only two measurement tools. The adult-infant stature rod was in excellent working order with no apparent damage. The Tanita electronic scale was new and included the use of fresh batteries and repeated calibration, using an object of known weight, during the period of investigation to maintain accuracy.

Observer error can be introduced when trying to maintain accurate measurement techniques, read the measurements and record the data (Malina et al. 1974:52,66; DeVito 1988:25). In this study, errors may have been introduced in the process of reading measurements from the electronic scale and stature rod. All measurements were collected by the author in order to eliminate inter-observer error. Measurements were read aloud and the recorder repeated the value as it was entered onto the data sheet. Only two research assistants recorded the data, thereby minimizing reading and recording errors. Mistakes can also be introduced when the information is entered into the computer database. For this study, the data were checked against the original recording forms to eliminate data entry errors.

Cameron (1984:101) and Malina et al. (1974:66) suggest that natural variation can also result in measurement differences. For example, if an individual is measured once and then measured again later, there are likely to be positional differences in the short term which are difficult to control for. Positional differences refer to the fact that it is impossible for the subject to strike the exact stance that was held during the first measurement episode. The effect of positional differences however can introduce substantial measurement changes for several variables, especially stature and mass. For example, the shifting of body weight from one leg to the other, or the different position of the head can alter measurements between two consecutive time periods. Further, the longer the time between repeated measurements the greater the chance of introducing error because changes in stature and mass can occur between the two episodes of measurement (Malina et al. 1974:66).

In order to assess measurement error, a test-retest study was completed on 30 individuals, approximately 10% of the total sample of children in the BSS. Every tenth individual was chosen during the initial measuring session and measured a second time later in the visit.

Table 4.1 presents the raw data for this intra-observer error study, and shows minor measurement difference for stature, mass and the BMI. The electronic scale ensured mass was measured consistently both times. The mean difference between the two mass measurements was .03 kg with a range of -.10 kg to .20 kg. This suggests that mass was a little higher during the second round of measurements for the majority of the children, resulting in a slight overestimation of mass. This is likely caused by a positional difference on the scale, which can affect the outcome of the measurement. Stature measurements show a mean difference of .00 cm with a range of -1.10 cm to .80 cm.

There does not appear to be any systematic over- or underestimation of stature measures as approximately half the second measurements underestimated and half the measurements overestimated it. The larger range of measurements for this variable is related to slight differences in the children's positions during the second session or to a parallax effect when I read the stadiometer. BMI also shows a small mean difference of .016 kg/m^2 with a range of -.2 kg/m^2 to .3 kg/m^2. Again, measurement differences for

Table 4.1: Intra-observer error analysis for the Burlington School Study[3]

Number	Mass	Mass1	Diff	$Diff^2$	Stature	Stature1	Diff	$Diff^2$	BMI	BMI1	Diff	$Diff^2$
1	22.30	22.30	0.00	0.00	124.10	124.00	0.10	0.01	14.48	14.50	-0.02	0.00
2	18.80	18.70	0.10	0.01	115.50	115.70	-0.20	0.04	14.09	13.97	0.12	0.02
3	28.90	28.90	0.00	0.00	121.80	121.90	-0.10	0.01	19.48	19.45	0.03	0.00
4	19.20	19.20	0.00	0.00	116.60	116.40	0.20	0.04	14.12	14.17	-0.05	0.00
5	27.50	27.50	0.00	0.00	125.50	126.60	-1.10	1.21	17.46	17.16	0.30	0.09
6	30.40	30.40	0.00	0.00	133.50	134.10	-0.60	0.36	17.06	16.91	0.15	0.02
7	25.80	25.90	-0.10	0.01	124.20	123.80	0.40	0.16	16.73	16.90	-0.17	0.03
8	36.10	36.10	0.00	0.00	137.90	137.50	0.40	0.16	18.98	19.09	-0.11	0.01
9	46.50	46.30	0.20	0.04	147.40	146.90	0.50	0.25	21.40	21.46	-0.05	0.00
10	39.10	39.10	0.00	0.00	143.90	143.10	0.80	0.64	18.88	19.09	-0.21	0.04
11	27.20	27.20	0.00	0.00	141.20	140.60	0.60	0.36	13.64	13.76	-0.12	0.01
12	41.80	41.80	0.00	0.00	150.60	150.10	0.50	0.25	18.43	18.55	-0.12	0.02
13	46.70	46.60	0.10	0.01	144.70	144.80	-0.10	0.01	22.30	22.23	0.08	0.01
14	57.40	57.50	-0.10	0.01	161.70	161.60	0.10	0.01	21.95	22.02	-0.07	0.00
15	39.30	39.20	0.10	0.01	148.10	148.10	0.00	0.00	17.92	17.87	0.05	0.00
16	61.50	61.50	0.00	0.00	156.00	156.60	-0.60	0.36	25.27	25.08	0.19	0.04
17	56.00	55.90	0.10	0.01	168.50	169.30	-0.80	0.64	19.72	19.50	0.22	0.05
18	35.30	35.20	0.10	0.01	145.30	144.50	0.80	0.64	16.72	16.86	-0.14	0.02
19	25.20	25.20	0.00	0.00	131.10	131.40	-0.30	0.09	14.66	14.60	0.07	0.00
20	49.80	49.70	0.10	0.01	157.30	157.10	0.20	0.04	20.13	20.14	-0.01	0.00
21	61.10	61.10	0.00	0.00	177.00	177.00	0.00	0.00	19.50	19.50	0.00	0.00
22	62.90	62.80	0.10	0.01	176.10	176.10	0.00	0.00	20.28	20.25	0.03	0.00
23	86.00	86.00	0.00	0.00	169.10	169.80	-0.70	0.49	30.08	29.83	0.25	0.06
24	61.00	61.00	0.00	0.00	165.00	164.40	0.60	0.36	22.41	22.57	-0.16	0.03
25	43.70	43.60	0.10	0.01	158.90	159.40	-0.50	0.25	17.31	17.16	0.15	0.02
26	57.80	57.80	0.00	0.00	183.20	183.20	0.00	0.00	17.22	17.22	0.00	0.00
27	66.20	66.10	0.10	0.01	174.90	174.70	0.20	0.04	21.64	21.66	-0.02	0.00
28	75.00	75.00	0.00	0.00	174.30	173.60	0.70	0.49	24.69	24.89	-0.20	0.04
29	56.60	56.60	0.00	0.00	165.40	166.20	-0.80	0.64	20.69	20.49	0.20	0.04
30	51.00	50.90	0.10	0.01	169.90	170.20	-0.30	0.09	17.67	17.57	0.10	0.01

[3] Mass, Stature and BMI represents the first measurement and Mass1, Stature1 and BMI1 represents the second measurement. Diff represents the differences between the first and second measurement and $Diff^2$ represents the measurement difference squared.

$\bar{x}$	**45.20**	**45.17**	**0.03**	**0.01**	**150.29**	**150.29**	**0.00**	**0.25**	**19.16**	**19.15**	**0.02**	**0.02**
Sample $\bar{x}$	**45.19**				**150.29**				**19.16**			
$\sum$ of diff.				**0.16**				**7.64**				**0.57**
Variance	**296.53**				**392.93**				**13.01**			

Table 4.1: Continued

the BMI show no preference for overestimation or underestimation as approximately half the differences are above and half are below zero. The range of measurements for BMI however is a result of combining any measurement errors present for stature and mass. Referring to the last two columns in Table 4.1(Diff and Diff^2) it is evident that measurement differences were quite small.

In order to assess how much measurement error/variation is present in a study, and to standardize the reporting of such margins of error for comparative purposes, it is recommended that the Technical Error of Measurement (TEM), Coefficient of Variation (CV) and the Reliability Coefficient (R) be calculated (see Bouchard 1985; Cameron 1984; Malina et al. 1974:61-62; Marks et al. 1989:579,580; Mueller and Martorell 1988:84; Ulijaszek and Lourie 1994:30).

The Technical Error of Measurement (TEM) is calculated by taking the square root of the summed differences for each measurement (mass, stature and BMI) divided by twice the sample size:

Equation 1: $$\mathbf{TEM\ (r) = \sqrt{\sum d^2/2N},}$$

where d^2 is equal to the square of the summed differences and N is equal to the number of individuals in the test-retest study. This value, reported in the same units as the measured variable, indicates the level of measurement error/variation for a single observer. The equation becomes more complex when evaluating two different observers (see Cameron 1984; Ulijaszek and Lourie 1994:30). The values derived from this equation are then compared to reference values from national samples to determine the magnitude of the error. For this study, the reference values calculated by Malina et al. (1974:61) are used in this study to evaluate the TEM in stature and mass (Table 4.2). TEM of BMI is compared to Bouchard (1985) (Table 4.2).

The Coefficient of Variation (CV) is calculated by dividing the Technical Error of Measurement by the overall mean of the test-retest sample, not the mean of the differences and is multiplied by 100 in order to report the value as a percent:

Equation 2: $CV = TEM/\bar{x}_o * 100$

This value, also reported in the same units as the original variable, measures variation in the replicability of the measurement relative to the overall magnitude of the measure. This shows that replicability is better for a variable of small rather than large magnitude. For example, the comparison of standing height and knee breadth, where standing height presents a much larger magnitude compared to knee breadth, introduces a greater margin of error for the larger measurement (Malina et al. 1974:63) Again, the computed value is compared to reference standards (Bouchard 1985; Malina et al. 1974) (Table 4.2).

The Reliability Coefficient is calculated here as the square of the Technical Error of Measurement divided by the square of the total sample variance subtracted from 1:

Equation 3: $R = 1 - [(TEM)^2/(SD)^2]$

This equation calculates a number between zero and 1 and is an indication of how reliable/precise the measurements are. For example, a value of R=.95 suggests that 95% of the variation is due to factors other than measurement error. Therefore, as the value approaches 1 there is greater confidence that variance does not stem from measurement error. Reliability coefficients for this study approach 1 (.999) (see Table 4.2).

Table 4.2 presents the means, mean differences, TEM, CV and R values for stature, mass and the BMI for this intra-observer error study in relation to reference standards presented by Malina et al. (1974:61) and Bouchard (1985). National standards are presented in bold along side the results from the Burlington study.

Table 4.2: Results for intra-observer error study, BSS

Measurement	$\bar{x}$	$\bar{x}_d$	TEM	CV	R
Stature (cm)	150.29	.00 **(.5)***	.357 **(.5)***	.2% **(.3%)***	.999
Mass (kg)	45.19	.03 **(1.3)***	.052 **(1.2)***	.1% **(2.1%)***	.999
BMI (kg/m²)	19.16	.02	.098 **(0.2)****	.5% **(0.8%)****	.999

*Malina et al. (1973:61)
**Bouchard (1985)

The TEM and CV for stature are .357(cm) and .2%(cm) respectively. These are lower than the values reported by Malina et al. (1974:61) from the NCHS reference population. TEM and CV for mass in this study are also lower those reported by Malina et al. (1974:61), .052 and .1%, respectively. Results of the TEM and CV for BMI are again lower than those reported by Bouchard (1985). The reliability coefficients (R) for all three measurements are well above .999. This suggests that more than 99% of the variance is due to factors other than measurement error (Table 4.2).

4.3: Summary

From this evaluation of the TEM, CV, and R for the BSS measurements it is clear that measurement error/variation in this database is very low and reliability is high. Consequently, the ensuing analysis of the BSS database (chapter 5) can be viewed with confidence that the results are meaningful.

Chapter 5

RESULTS

5.1: Introduction

This chapter presents the results of the investigation of *The Burlington Growth Study* (1952-1972) and *The Burlington School Study* (1998-1999). The first section examines the BGS's mixed longitudinal set of measurements on 1367 children and presents the statistical results. The second section investigates the measurements of a smaller longitudinal sample of the same individuals, aged 6 to 14 years, from the BGS. The primary focus of section two is to examine the prevalence of "at risk for overweight" and overweight children aged 6 to 14 years. More importantly, the measurements for these children make it possible to "track" BMI values and investigate inter-age correlations during this nine year period. The third section presents the analysis of the BSS. The results from the BGS and BSS are compared in the final section.

Each section is divided into the subsections of stature, mass and BMI. The data are presented in relation to national reference standards from the United States and Canada in order to place them in a larger North American context of growth and development (NCHS, Hamill et al. 1977; Must et al. 1991b; Fitness Canada 1985). Graphs illustrating stature, mass and BMI are presented in order of appearance at the end of each subsection.

5.2: The Burlington Growth Study (1952-1972)

Figure 3.1 shows the age and sex distribution of the children included in this sample from *The Burlington Growth Study*. It is clear from Figure 3.1 that there are no fewer than one hundred male and female children in each age category except at: ages 3 (f, n=89), 15 (m, n=39; f, n= 8), 17 (m, n=92; f, n=52), 18 (f, n=85), and 19 (m, n=36; f, n=31). The smaller sample of individuals found in these age groups results in larger 95% confidence intervals and as such, interpretations should be made with caution for these ages. The number of children in these age groups nevertheless compares favorably with sample sizes found in other growth related studies, except for females at age 15 (see Gordon-Larsen et al. 1997; Henneberg and Louw 1998; Janghorbani and Parvin 1998; Melnik et al. 1998; Sugarman et al. 1990).

Stature

The age-specific mean stature measurements with 95% confidence intervals for male and female children in *The Burlington Growth Study* are shown in Figure 5.1. Table 5.1 gives the means, standard deviations and sample size for each age and sex category. On average, males tend to be slightly taller than females until the age of 10. Females then become taller, on average, from age 11 through 13. After age 13 males become increasingly taller than their female counterparts and continue to be taller at the age of twenty. Stature continues to increase slightly in males until age twenty but appears to level off in females around the age of 15, increasing only ever so slightly after that. This growth pattern is similar to that found in studies conducted globally (see Eveleth and Tanner 1990). Confidence intervals at ages 15, 17 and 19 are larger than at other ages because of the smaller sample sizes in these age groups.

Table 5.1: Mean stature measurements for the BGS (m = 714; f = 653)

Age	Male (n)	Female (n)	Male Mean	SD	Female Mean	SD
3	133	100	97.28	3.96	96.41	3.83
4	168	137	104.90	4.40	104.40	3.99
5	164	137	110.70	4.35	110.40	4.53
6	343	283	117.10	5.02	116.70	4.94
7	157	139	122.90	4.89	122.50	5.33
8	265	277	129.50	5.34	128.40	5.65
9	306	274	134.70	5.69	133.90	5.65
10	282	268	140.20	5.53	138.90	6.31
11	148	123	144.30	6.49	145.40	7.01
12	409	362	150.20	7.06	152.20	7.25
13	135	125	156.50	8.23	156.80	7.62
14	262	237	164.00	8.67	160.20	5.66
15	39	8	169.10	7.95	161.40	7.25
16	295	259	173.20	6.79	162.30	5.65
17	94	50	174.70	6.96	161.70	6.26
18	104	85	175.60	6.40	162.80	6.39
19	36	31	174.90	7.07	162.00	6.99
20	202	164	177.20	6.35	163.30	5.23

Figures 5.2 and 5.3 present scatterplot distributions of male and female stature measurements from *The Burlington Growth Study*, relative to American and Canadian 95^{th}, 50^{th} and 5^{th} centiles (NCHS, Hamill et al. 1977; CFS, Fitness Canada 1985). Stature measurements are well distributed for each age category, clearly showing the smaller sample sizes at ages 15, 17 and 19. While 88.7% of males are within the 5^{th} and 95^{th} U.S. reference centiles, 97.7% fall between the Canadian 5^{th} and 95^{th} centiles. The percentage of the sample below the U.S. and Canadian 5^{th} centile is much closer, 2.2% and 1.9% respectively. A substantially larger percentage of males is situated above the U.S. 95^{th} centile compared to the Canadian 95^{th} centile, 9.1% versus 0.4%. Female measurements also fit well within the 5^{th} and 95^{th} centiles for American and Canadian reference data, 97.7% and 97.6%, respectively. Almost twice as many females in the BGS fall below the U.S. 5^{th} centile compared to the Canadian 5^{th} centile, 3.0% versus 1.8%, while a much larger number of them are found above the American 95^{th} centile versus the Canadian 95^{th} centile, 6.3% and 0.7%.

The age-specific means for male stature measurements with 95% confidence intervals are presented in Figure 5.4, relative to American and Canadian references standards. This graph suggests that the BGS children follow just above the 50^{th} centile for both American and Canadian standards until age 16, whereafter they fall slightly below the U.S. 50^{th} centile; at age 19 they are below the Canadian 50^{th} centile. A similar pattern is seen in Figure 5.5 which characterizes age-specific mean stature measurements and 95% confidence intervals for females. As is the case for males, females are situated below the American 50^{th} centile at approximately 16 years of age. Unlike the male pattern however, female stature dips below the Canadian 50^{th} centile around age 14 and remains there.

Table 5.2 presents Analysis of Variance (ANOVA) results testing the null hypothesis that there is no difference in stature between male and female children by age and no interaction between age and sex. Results show statistical differences in stature between male and female children ($p<0.001$) and between age categories ($p<0.001$). There is also a statistical interaction between sex and age on stature ($p<0.001$). This suggests that the null hypothesis can be rejected and that differences in stature do exist between the sexes and age groups for the BGS. The null hypothesis for no interaction is also rejected, reflecting the fact that the magnitude of the difference between sex and age increases after age 14. Post-hoc tests, utilizing Tamhanes t^2, testing for contrasts between specific means, when variances are assumed unequal, revealed significant differences between age groups up until age 16 ($p<0.001$). Beyond this age there are no statistical differences between individual means. This indicates that after age 16, increases in growth have become minimal. A glance at Figure 5.1 shows that the line representing stature is horizontal after age 16, indicating the cessation in growth, especially among females. This pattern of growth for children in the BGS is similar to the general pattern found from other growth studies worldwide, and represents a normal pattern of growth (Eveleth and Tanner 1990).

Table 5.2: Analysis of variance (ANOVA) for stature, BGS (n = 1367)

	Sum of Squares	df	Mean Square	F-value
Sex	14656.78	1	14656.78	398.53*
Age	3067789.90	17	180458.23	4906.79*
Sex * Age	39961.75	17	2350.69	63.92 *
Within Subjects	241442.44	6565	36.78	
Total	135000000.00	6601		
Corrected Total	3467563.20	6600		

*(P<0.001)

Figure 5.1: Age-specific mean stature measurements with 95% CI for males and females, BGS (n = 1367)

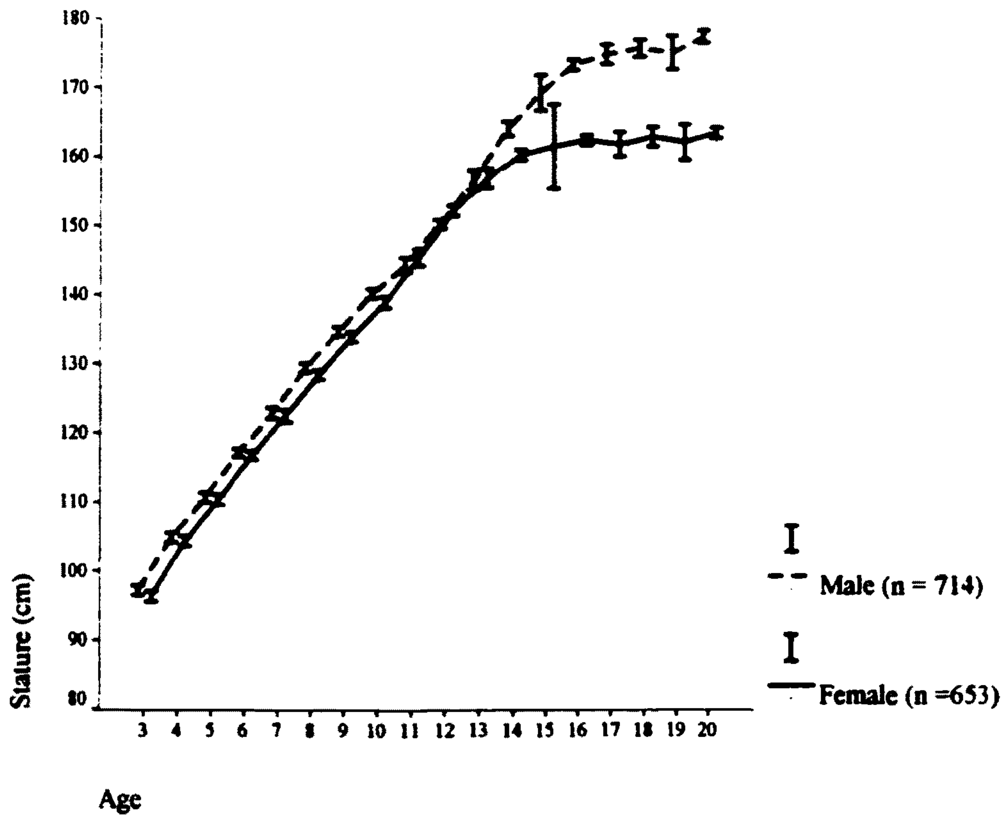


Figure 5.2: **Scatterplot distribution of male stature measurements compared to American and Canadian reference standards, BGS (n= 714)***

*(Dotted lines represent Canadian reference standards for stature (Fitness Canada 1985). Solid lines represent United States reference standards for stature (Hamill et al. 1977). Centiles are presented from top to bottom (i.e. 95th, 50th, 5th).

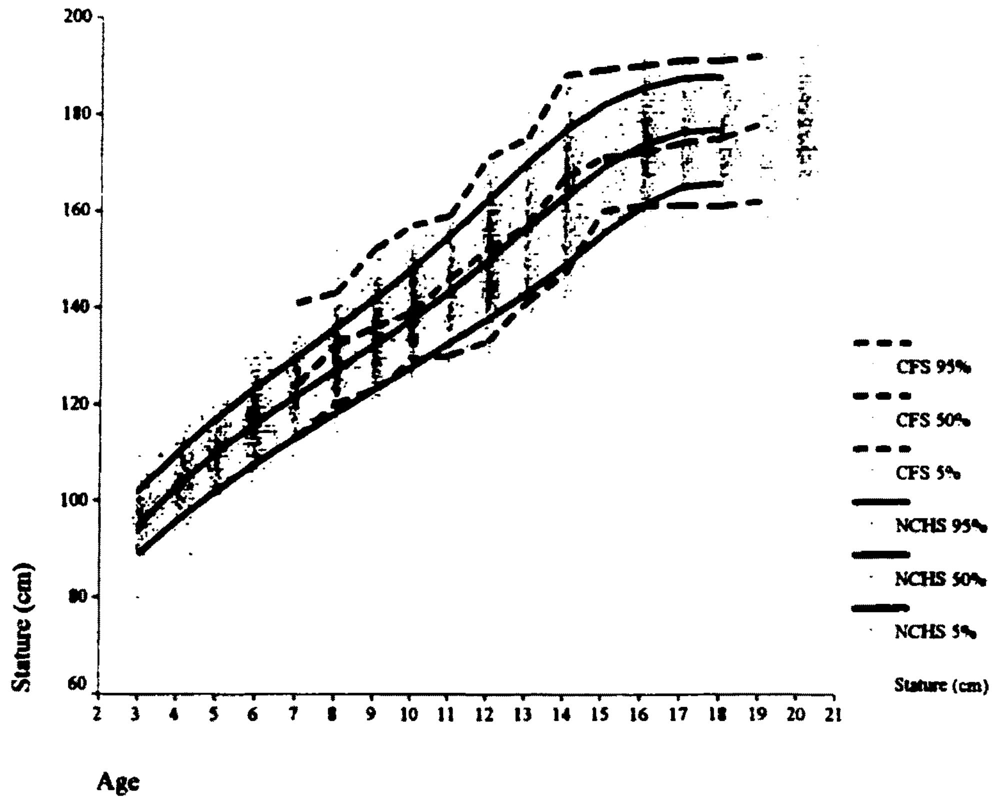


Figure 5.3: **Scatterplot distribution of female stature measurements compared to American and Canadian reference standards, BGS (n = 653)***

*(Dotted lines represent Canadian reference standards for stature (Fitness Canada 1985). Solid lines represent United States reference standards for stature (Hamill et al. 1977). Centiles are presented from top to bottom (i.e. 95th, 50th, 5th).

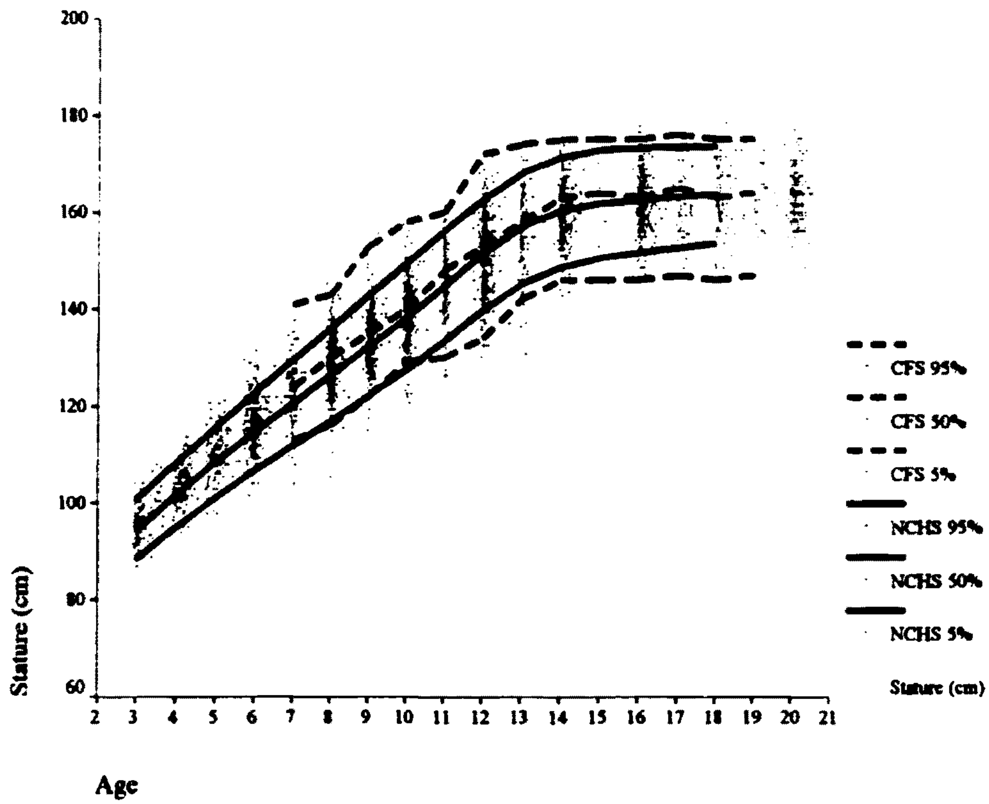


Figure 5.4: **Age-specific mean stature measurements with 95% CI compared to American and Canadian reference standards for males, BGS (n = 714)***

*(Dotted lines represent Canadian reference standards for stature (Fitness Canada 1985). Solid lines represent United States reference standards for stature (Hamill et al. 1977). Centiles are presented from top to bottom (i.e. 95th, 50th, 5th).

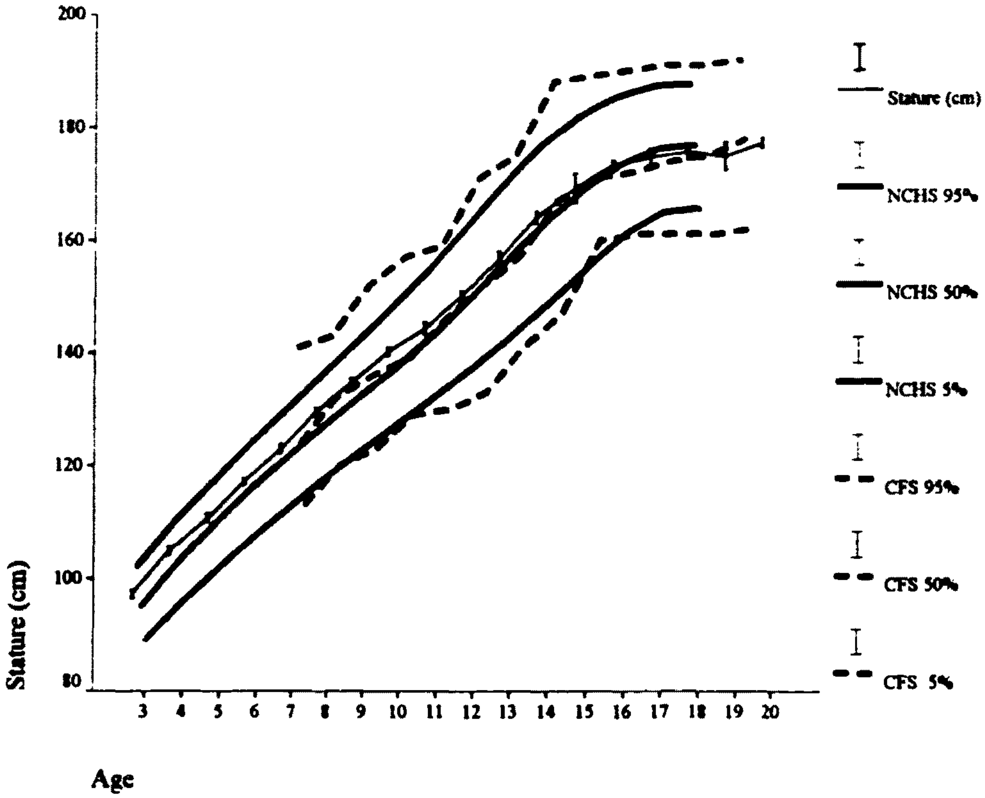
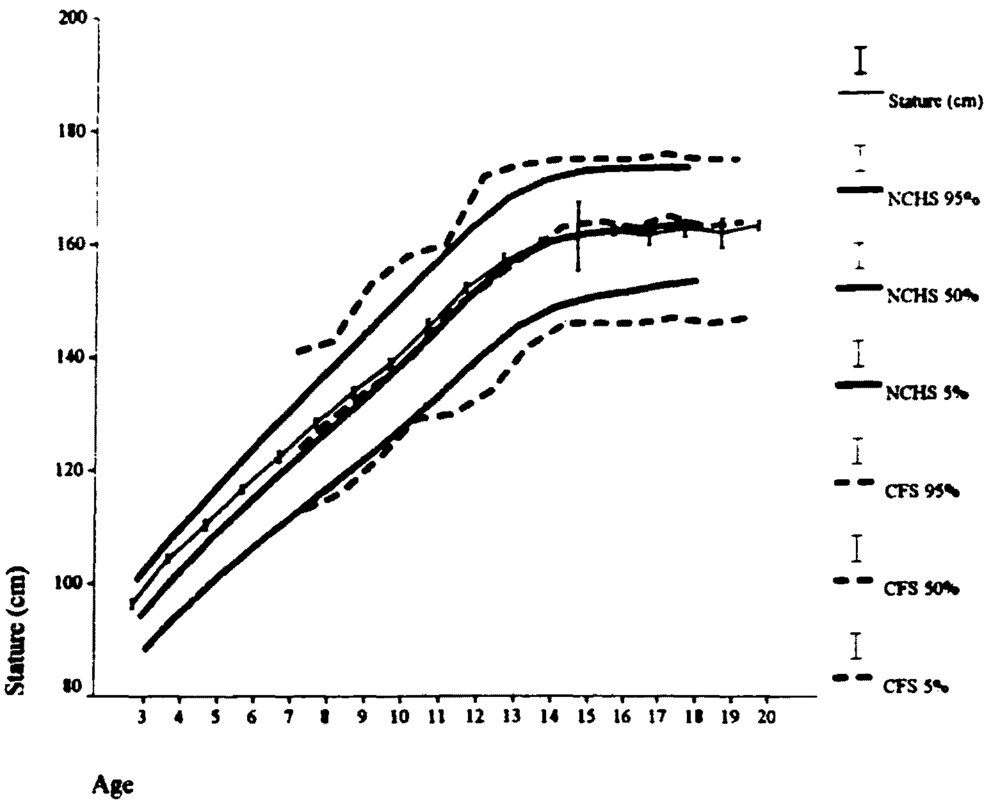


Figure 5.5: Age-specific mean stature measurements with 95% CI compared to American and Canadian reference standards for females, BGS (n = 653)*

*(Dotted lines represent Canadian reference standards for stature (Fitness Canada 1985). Solid lines represent United States reference standards for stature (Hamill et al. 1977). Centiles are presented from top to bottom (i.e. 95th, 50th, 5th).



Mass

Age-specific mean mass measurements with 95% confidence intervals for male and female children in *The Burlington Growth Study* are presented in Figure 5.6. Table 5.3 gives average mass, standard deviations and sample sizes. Males in this study are slightly heavier, on average, than females until the age of 11. Female mass increases and overtakes male mass during the 12th and 13th years of growth. From ages 14 through 20, males continue to add mass and are heavier than their female counterparts. Females also add mass during this period, but to a lesser degree. Again, the wide confidence intervals at ages 15, 17 and 19 reflect the smaller sample sizes at these ages; however, when ages 15, 17 and 19 are excluded there are still large 95% confidence intervals in mass measurements for both groups from ages 13 to twenty, suggesting greater variability in the addition or loss of mass during and after puberty.

Table 5.3: Mean mass measurements, BGS (m = 714; f = 653)

Age	Male (n)	Female (n)	Male Mean	SD	Female Mean	SD
3	133	100	16.17	1.94	15.82	1.74
4	168	137	18.25	2.12	17.62	2.01
5	164	137	20.30	2.55	19.80	2.61
6	343	283	22.27	2.86	21.79	2.80
7	157	139	25.23	3.60	24.60	3.35
8	265	277	28.48	4.59	27.23	4.11
9	306	274	31.40	4.80	30.49	4.85
10	282	268	34.34	5.41	33.82	5.91
11	148	123	37.67	6.50	37.55	6.71
12	409	362	42.11	7.59	43.53	8.36
13	135	125	47.50	9.56	48.18	8.38
14	262	237	54.28	10.60	52.15	7.88
15	39	8	62.32	11.29	52.95	5.92
16	295	259	65.04	10.34	55.97	7.55
17	94	50	68.42	11.45	56.95	7.88
18	104	85	70.15	10.92	56.83	6.62
19	36	31	70.86	10.65	57.25	8.02
20	202	164	73.70	10.17	58.74	7.42

Figures 5.7 and 5.8 are scatterplot distributions of mass for male and female children from *The Burlington Growth Study* in relation to the 5th, 50th and 95th centiles for American and Canadian reference standards (NCHS, Hamill et al. 1977; CFS, Fitness Canada 1985). Mass measurements for males tend to be tightly clustered up to about 8 or 9 years of age. Thereafter, the range of measurements becomes more variable up to twenty years of age. Figure 5.7 illustrates that the majority of the male children falls

within the 5th and 95th centiles for both U.S. and Canadian standards, 92.3% and 92.8% respectively. Almost twice as many males are situated below the Canadian 5th centile compared to the American 5th centile, (3.0% versus 1.2%), while 6.6% of this sample is above the U.S. 95th centile and 4.2% is above the Canadian 95th centile. The pattern for female mass measurements is similar to that of the males except that the data appear less variable over the twenty year age range. While the majority of mass measurements for females are between the 5th and 95th centiles for both American and Canadian reference standards, (92.3% and 92.1%), 3.0% of this sample dips below the U.S. 5th centile and 5.0% below the Canadian 5th centile. Almost twice the number of girls are found above the U.S. 95th centile compared to the Canadian 95th centile, (5.3% and 2.9%).

Age-specific mean mass measurements and 95% confidence intervals for males are presented in Figure 5.9. This graph indicates that males track slightly above the 50th centile for both American and Canadian reference standards throughout the 18-year distribution. Again, the wide confidence intervals at ages 15, 17 and 19 reflect the smaller sample sizes for these age categories. Average female mass shows a similar pattern to that for males except that after age fourteen it follows the 50th centiles for U.S. and Canadian reference standards much more closely than do male mass measurements (see Figure 5.10). In fact, at age fifteen females fall below the Canadian 50th centile, although this is most likely an artifact of sample size.

Analysis of Variance (ANOVA) results testing the null hypothesis of no differences in mass between sex and age and no interaction between these variables are presented in Table 5.4. Results indicate significant differences for sex ($p<0.001$) and age ($p<0.001$). There is also a statistically significant interaction effect between sex and age on mass ($p<0.001$). These findings allow rejection of the null hypothesis and indicate that differences in mass are present for sex and age in the BGS. There is also an interaction present reflecting the increasing magnitude of differences after the age of 15 (see Figure 5.6). Tamhanes t^2 post-hoc tests reveal significant differences between specific means until about the age of 16 ($p<0.001$). As was the case for stature, this illustrates that differences in means between one age and the next are statistically different until age sixteen, whereafter addition of mass decreases until age twenty, especially in females (see Figure 5.6).

Table 5.4: Analysis of variance (ANOVA) for mass, BGS (n = 1367)

	Sum of Squares	df	Mean Square	F - value
Sex	14539.45	1	14539.45	321.03*
Age	1609152.70	17	94656.04	2089.97*
Sex * Age	37206.32	17	2188.61	48.32*
Within Subjects	297333.41	6565	45.29	
Total	12054509.00	6601		
Corrected Total	2031226.90	6600		

*(p<0.001)

Figure 5.6: Age-specific mean mass measurements with 95% CI by sex, BGS (n = 1367)

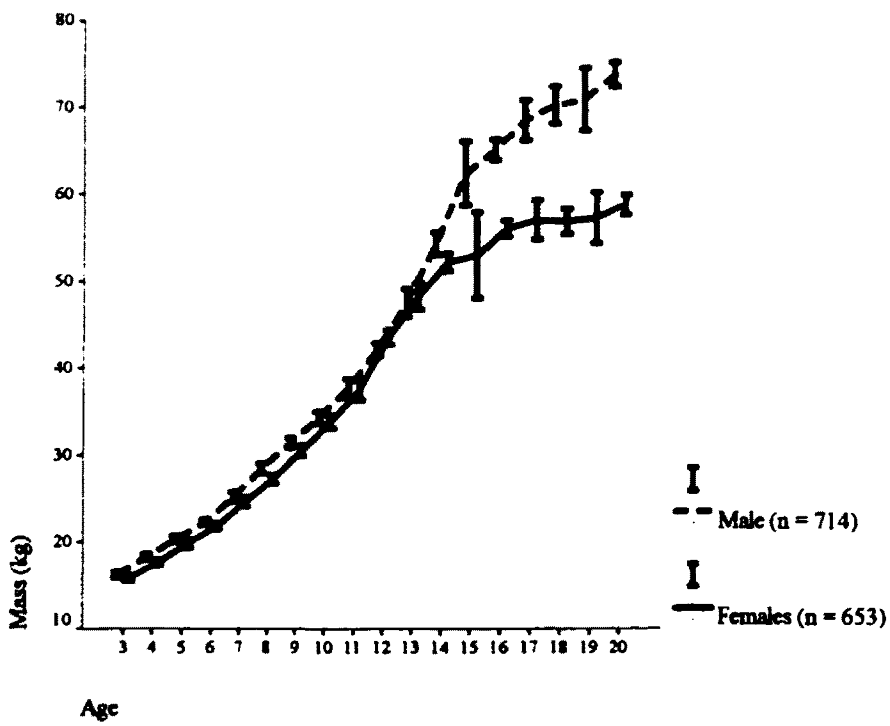


Figure 5.7: **Scatterplot distribution of male mass measurements compared to American and Canadian reference standards, BGS (n= 714)***

***(Dotted lines represent Canadian reference standards for mass (Fitness Canada 1985). Solid lines represent United States reference standards for mass (Hamill et al. 1977). Centiles are presented from top to bottom (i.e. 95th, 50th, 5th).**

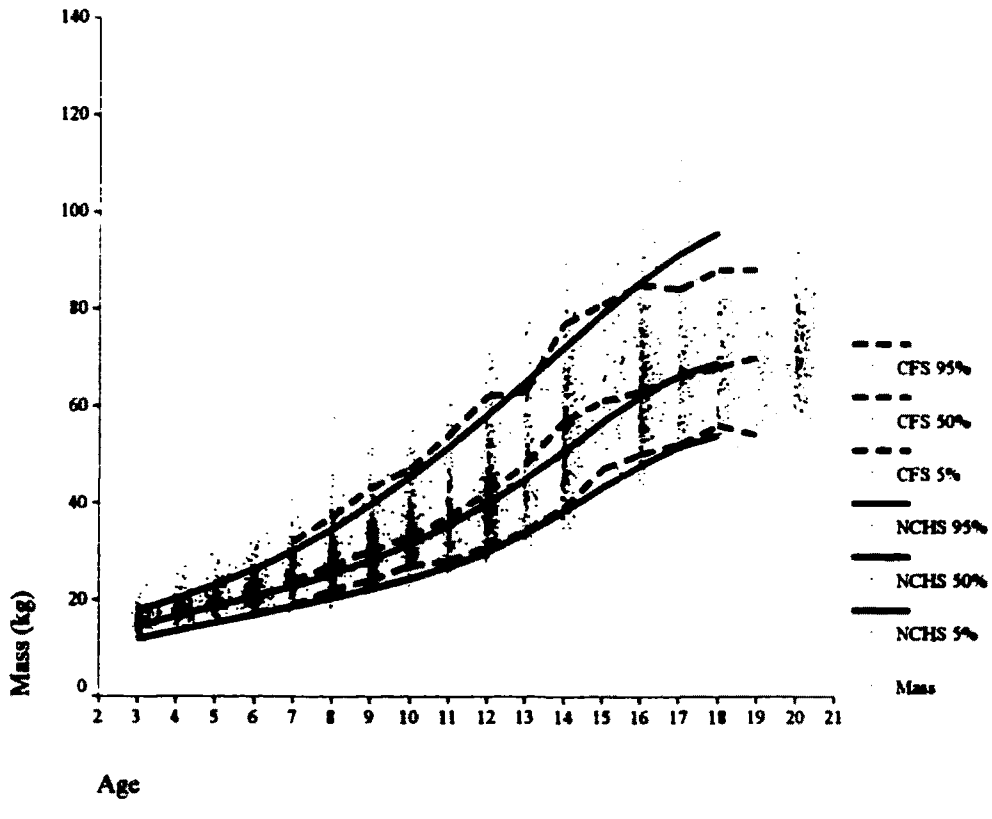


Figure 5.8: **Scatterplot distribution of female mass measurements compared to American and Canadian reference standards, BGS (n = 653)***

*(Dotted lines represent Canadian reference standards for mass (Fitness Canada 1985). Solid lines represent United States reference standards for mass (Hamill et al. 1977). Centiles are presented from top to bottom (i.e. 95th, 50th, 5th).

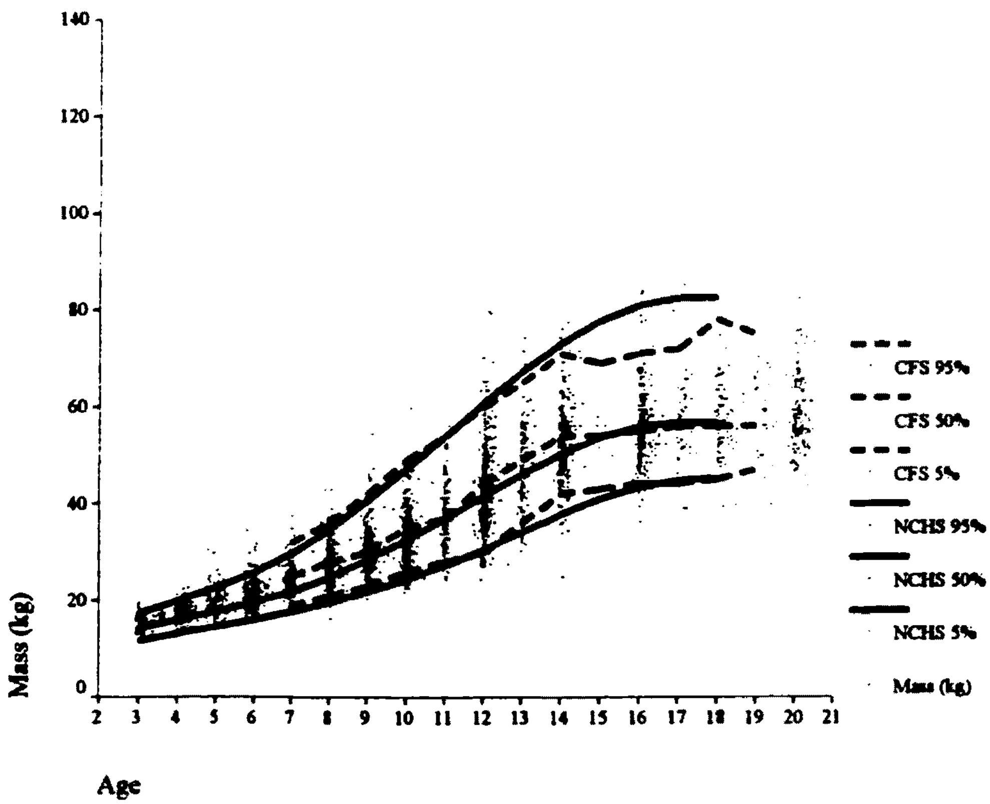


Figure 5.9: **Mean mass measurements with 95% CI compared to American and Canadian reference standards for males, BGS (n = 714)***

*(Dotted lines represent Canadian reference standards for mass (Fitness Canada 1985). Solid lines represent United States reference standards for mass (Hamill et al. 1977). Centiles are presented from top to bottom (i.e. 95th, 50th, 5th).

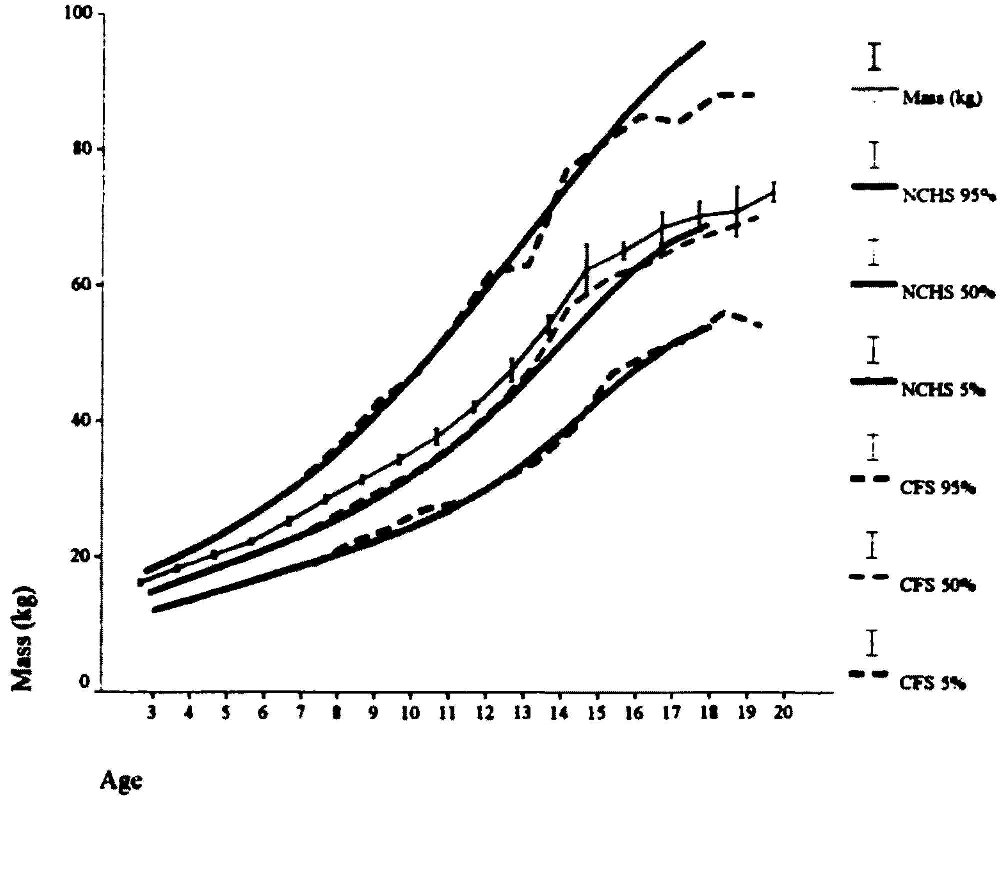
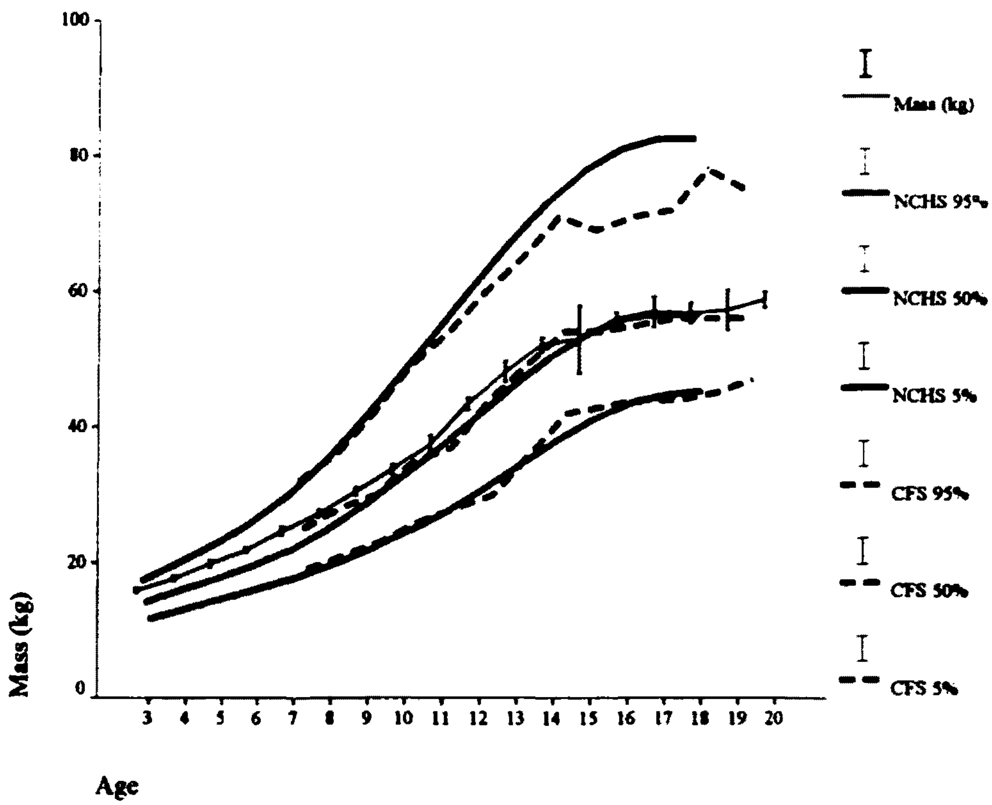


Figure 5.10: **Mean mass measurements with 95% CI compared to American and Canadian reference standards for females, BGS (n = 653)***

*(Dotted lines represent Canadian reference standards for mass (Fitness Canada 1985). Solid lines represent United States reference standards for mass (Hamill et al. 1977). Centiles are presented from top to bottom (i.e. 95th, 50th, 5th).



Body Mass Index (BMI)

Age-specific mean BMI values with 95% confidence intervals for children in *The Burlington Growth Study* are presented in Figure 5.11. Table 5.5 presents the means, standard deviations and sample size for children in this study. The results suggest that males tend to have higher BMI values until age 10, at which time BMI values are approximately equal between the sexes. Males have higher average BMI values at age 11 and from ages 15 through 20. Females have higher average BMI values at ages 12, 13, and 14 years of age. Although males generally have higher BMI values, males and females follow a similar pattern from age 3 through 20. BMI decreases from ages 3 through 6 and then generally increases until the twentieth year. Again, small sample sizes at ages 15, 17 and 19 result in larger 95% confidence intervals. Large confidence intervals are also present for BMI at ages 13 , 14, 16, 18 and 20 reflecting larger variability in the BMI for older children in this sample. Sample size alone does not appear to explain this variability; and other factors, including individual lifestyle choices, may underlie this observation.

Table 5.5: Mean BMI distribution, BGS (m = 714; f = 653)

Age	Male (n)	Female (n)	Male Mean	SD	Female Mean	SD
3	133	100	17.09	1.86	16.99	1.21
4	168	137	16.56	1.39	16.15	1.31
5	164	137	16.53	1.35	16.24	1.89
6	343	283	16.20	1.35	15.95	1.36
7	157	139	16.64	1.61	16.36	1.56
8	265	277	16.92	1.89	16.46	1.79
9	306	274	17.24	1.81	16.94	1.90
10	282	268	17.39	1.99	17.44	2.25
11	148	123	18.00	2.17	17.67	2.28
12	409	362	18.58	2.49	18.70	2.75
13	135	125	19.26	2.72	19.53	2.81
14	262	237	20.06	2.77	20.29	2.66
15	39	8	21.73	3.42	20.30	1.42
16	295	259	21.66	3.01	21.25	2.58
17	94	50	22.40	3.34	21.78	2.72
18	104	85	22.72	3.10	21.47	2.47
19	36	31	23.18	3.39	21.80	2.69
20	202	164	23.46	2.93	22.03	2.64

Figures 5.12 and 5.13 show the distribution of male and female BMI values from *The Burlington Growth Study*. Both distributions show much more variability for BMI values than do the separate measures of stature and mass. This is clearly seen from the spread of the data in both figures. The majority of male data is found within the confines of the 5^{th} and 95^{th} centiles for American and Canadian reference standards, (94.2% and 91.7%) (NCHS, Must et al. 1991b; CFS, Fitness Canada 1985). Only 1.6% and 2.4% of

this sample are situated below the 5th centile for American and Canadian reference standards, while 4.4% and 5.9% are above the 95th centile for American and Canadian reference standards, respectively. A similar pattern is found for females where 94.1% and 92.8% of the individuals are within the 5th and 95th centiles for American and Canadian reference standards. Slightly more females are situated below the 5th centile, (2.9% and 3.8%) than were males, while 3.0% and 3.4% of females in the sample are above the 95th American and Canadian centile.

Age-specific mean BMI values with 95% confidence intervals for males are presented in Figure 5.14. It appears that young males, aged 3 to 6 years old, have BMI values well above the 50th centile for U.S. and Canadian reference standards. Unfortunately there are no reference data for these age groups and it is therefore difficult to presume where the centiles would lie. From age 6 through 20 years of age males tend to track slightly above the 50th centile for both Canadian and American reference standards. Young females, ages 3 to 6 years, also appear to lie above the 50th centiles, but again the reference data are not available for the 3 to 6 year age groups (see Figure 5.15). After age 6 females tend to follow the 50th centiles of the reference standards more closely than males do. In fact, while females are consistently above the U.S. 50th centile during this period they follow very close to the Canadian 50th centile.

Analysis of Variance (ANOVA) results testing the null hypothesis of no differences in BMI between sex and age and no interaction between these variables are presented in Table 5.6. Statistically significant differences are present for sex ($p<0.001$) and age ($p<0.001$). There is also a statistically significant interaction for sex and age on BMI ($p<0.001$). These findings allow rejection of the null hypothesis and indicate that there are actual differences in BMI between the sexes and age groups. There is also interaction between the two variables. This interaction is seen in Figure 5.11 where the magnitude of differences in BMI increases around age 15. Tamhanes's t^2 post-hoc tests reveal that significant differences for age occur primarily between 11 and 15, a pattern that differs from that observed for stature and mass. From ages 4 through 10 and after age 15 there are no significant changes in BMI. This is reflected in Figure 5.11 where an almost horizontal line is observed between ages 4 and 10. After age 15, instead of a horizontal line, BMI increases but wide confidence intervals affect the significance of the measures.

Table 5.6: Analysis of variance (ANOVA) for BMI, BGS (n =1367)

	Sum of Squares	df	Mean Square	F-value
Sex	166.80	1	166.80	32.66*
Age	29991.63	17	1764.21	345.41*
Sex * Age	302.90	17	17.82	3.49*
Within Subjects	33531.68	6565	5.11	
Total	2314290.90	6601		
Corrected Total	64984.17	6600		

*($p<0.001$)

Figure 5.11: Age-specific mean BMI values with 95% CI by sex, BGS (n = 1367)

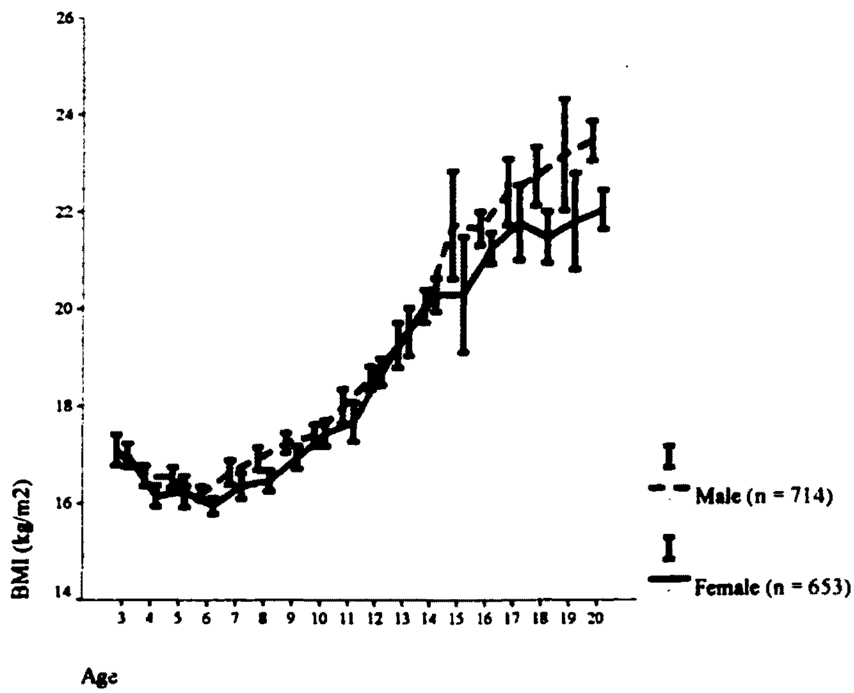


Figure 5.12: Scatterplot distribution of male BMI compared to American and Canadian reference standards, BGS (n= 714)*

*(Dotted lines represent Canadian reference standards for BMI (Fitness Canada 1985). Solid lines represent United States reference standards for BMI (Must et al. 1991b). Centiles are presented from top to bottom (i.e. 95th, 50th, 5th).

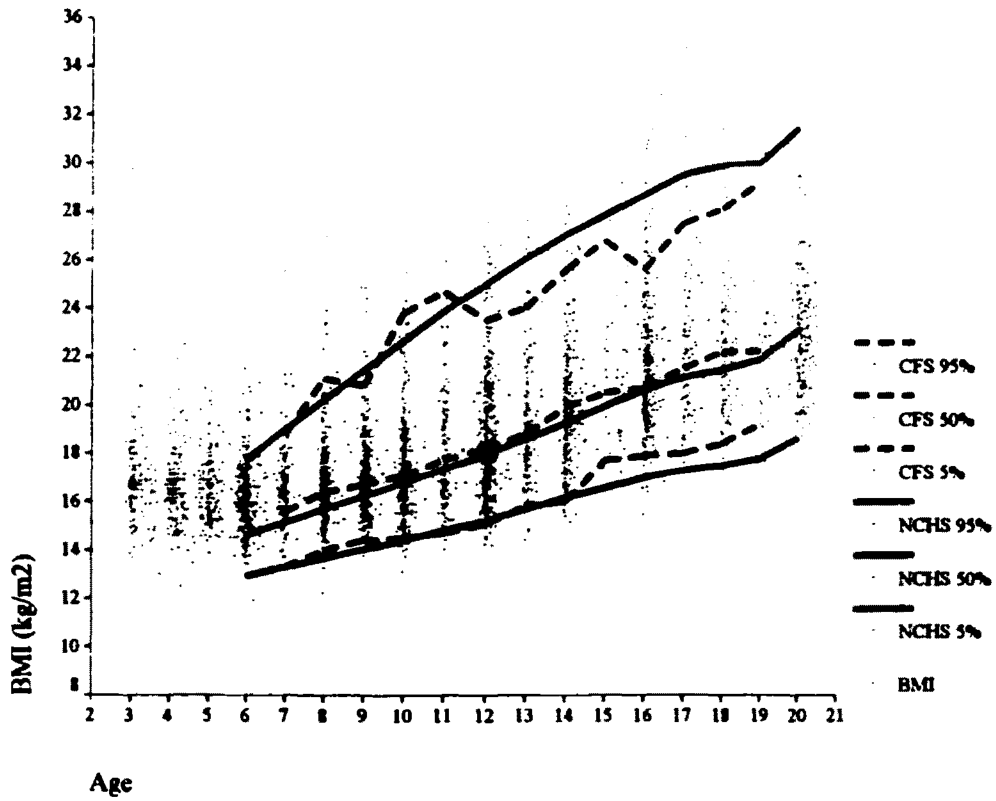


Figure 5.13: **Scatterplot distribution of female BMI compared to American and Canadian reference standards, BGS (n = 653)***

*(Dotted lines represent Canadian reference standards for BMI (Fitness Canada 1985). Solid lines represent United States reference standards for BMI (Must et al. 1991b). Centiles are presented from top to bottom (95^{th}, 50^{th}, 5^{th}).

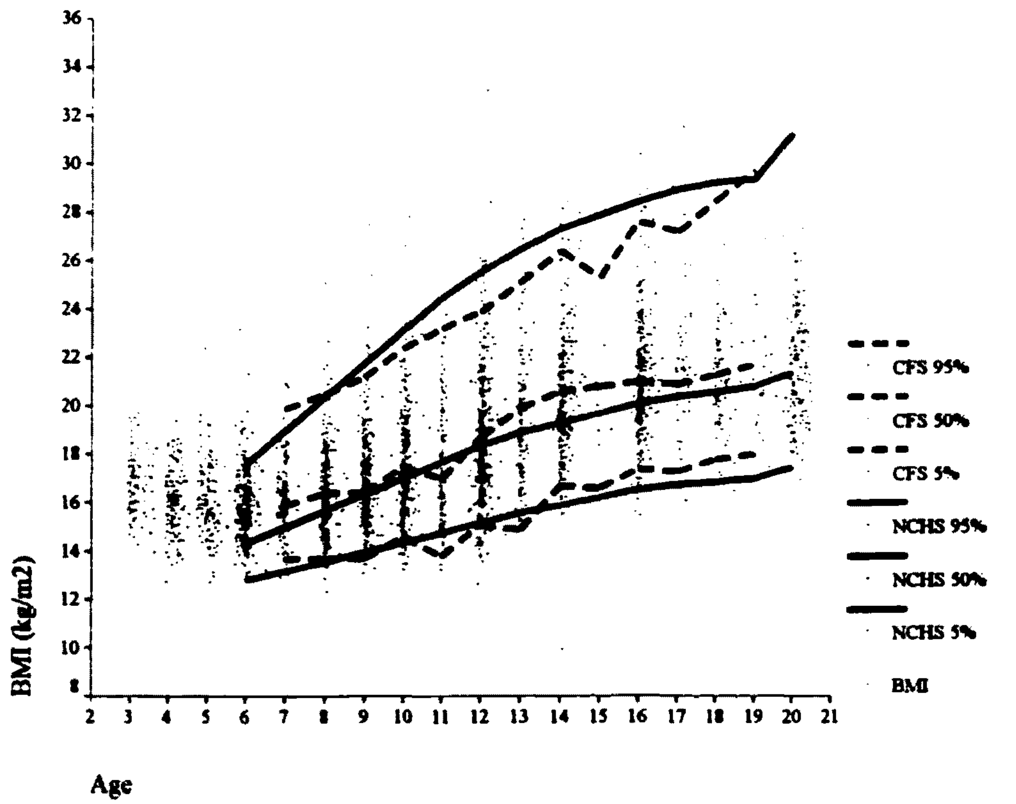


Figure 5.14: **Mean BMI with 95% CI compared to American and Canadian reference standards for males, BGS (n = 714)***

*(Dotted lines represent Canadian reference standards for BMI (Fitness Canada 1985). Solid lines represent United States reference standards for BMI (Must et al. 1991b). Centiles are presented from top to bottom (i.e. 95th, 50th, 5th).

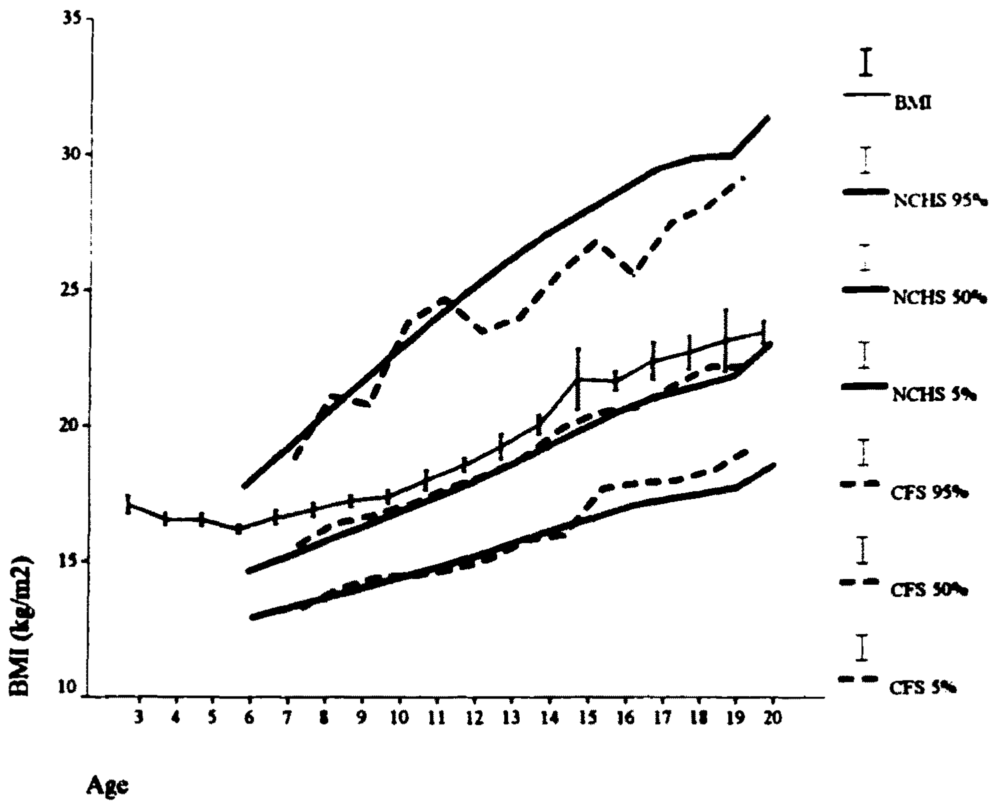
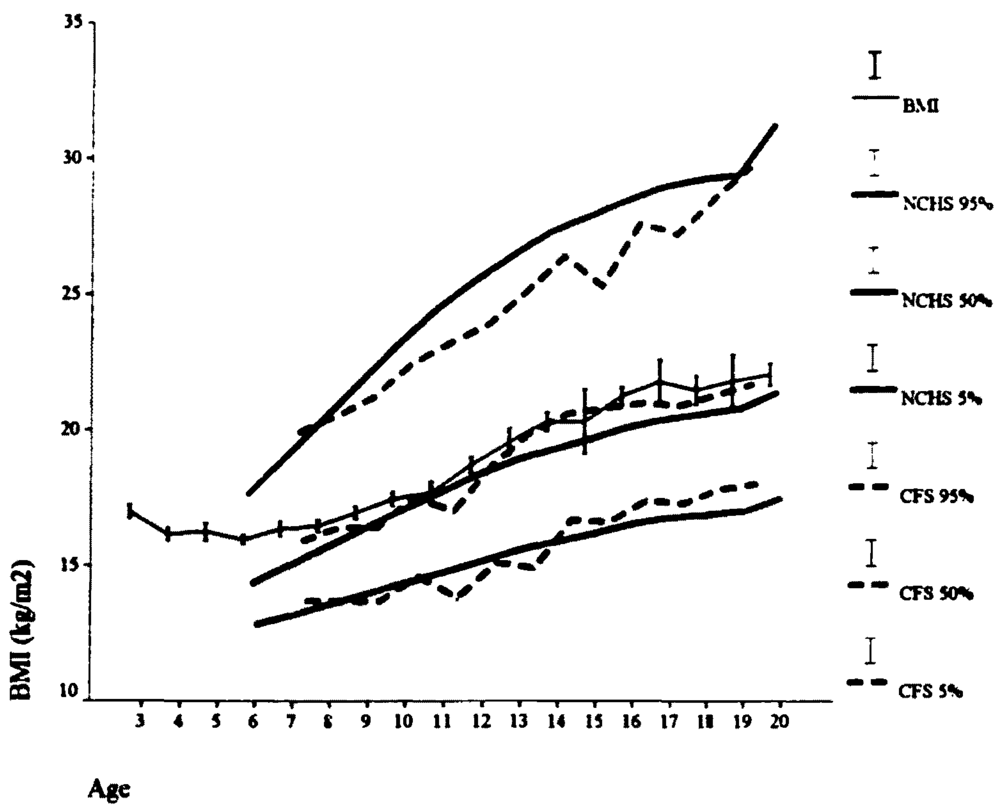


Figure 5.15: **Mean BMI with 95% CI compared to American and Canadian reference standards for females, BGS (n = 653)***

***(Dotted lines represent Canadian reference standards for BMI (Fitness Canada 1985). Solid lines represent United States reference standards for BMI (Must et al. 1991b). Centiles are presented from top to bottom (i.e. 95th, 50th, 5th).**



5.3: The Burlington Growth Study: A nine year longitudinal sample

Due to the mixed-longitudinal nature of the complete BGS, a longitudinal sample of children aged 6 through 14 years was extracted to create a database for investigating stature, mass and BMI in the same children over this nine year period. This new sample comprises 117 males and 103 females. The primary focus of this aspect of the study is to examine the prevalence of "at risk for overweight" and overweight in these children, and to "track" BMI data from ages 6 to 14. Results for the analysis of stature, mass and BMI in this longitudinal sample are similar to the complete sample of children discussed in the previous section and are not discussed here. Any differences occurring between the two samples are the result of this longitudinal sample having been truncated at the age of fourteen in order to maximize the number of individuals followed at yearly intervals. The truncation of the BGS longitudinal sample at age fourteen was also done in order to match the age distribution of the newly collected BSS data.

Prevalence of "at risk for overweight" and overweight

To investigate the prevalence of "at risk for overweight" and overweight in children from the BGS between the ages of 6 and 14, BMI was calculated (see chapter 3) and compared to reference standards for American children published by Must et al.

(1991b) and recommended by *The Expert Committee on Clinical Guidelines for Overweight in Adolescent Preventive Services* (Himes and Dietz 1994). BMI was also compared to Canadian reference standards published by Fitness Canada (1985:32). Sample sizes vary relative to the two reference samples because the Canadian series begins at age seven, instead of age six, as in the American standards. This may affect the interpretation of the results when comparing the two standards. It must also be remembered that the Canadian standards are rounded to the nearest whole age while the American standards use mid-point age groups (i.e. age 4 includes children ages 3.51 to 4.49). This too may have an effect on the interpretation of the results. The Burlington study employs mid-point age categories as recommended by Hamill et al. (1977).

Table 5.7 presents the proportion of children in each centile category relative to American and Canadian reference standards. The majority of children fall between the 5th and 85th centiles (NCHS, m = 82.9%, f = 81.9%; CFS, m = 81.9%, 87.5%). Children between 85th and 95th centiles are considered "at risk for overweight" and account for between 7% and 12 % of the sample data (NCHS, m = 10.07%, f = 12.08%; CFS, m = 11.11%, f = 7.04%) (see Table 5.8). Children above the 95th centile are considered overweight and account for between 2.5% and 6.2% of the sample population (NCHS, m = 5.60%, f = 2.91%; CFS, m = 6.20%, f = 2.55%) (see Table 5.9). Chi-square analysis testing the null hypothesis of no differences in proportion between males and females who are "at risk for overweight" and overweight were conducted. Results indicate that there is no statistical difference in the proportion "at risk for overweight" between males and females based on American reference standards (df 1: $x^2 = 1.47$; p.< 0.225 (see Table 5.8). In contrast, males were more likely to be considered "at risk for overweight" compared to females when using the Canadian reference standards (df 1: $x^2 = 10.29$; p <0.001) (see Table 5.9), resulting in the rejection of the null hypothesis. Employing the 95th centile as a cut-off for establishing overweight individuals illustrates statistical differences in the proportion of overweight males to females when compared to both reference standards (NCHS, df 1: $x^2 = 8.03$, $p < 0.005$) (see Table 5.8); CFS, df 1: $x^2 = 15.18$, $p < 0.000$) (see Table 5.9). In both "at risk for overweight" and overweight cells, males are over-represented and females are under-represented relative to expected values.

Table 5.7: Distribution of BMI relative to national standards, BGS (n=220)

	Male				Female			
	NCHS*		CFS**		NCHS		CFS	
Centiles	%	n	%	n	%	n	%	n
< 5	1.42	15	1.60	15	3.13	29	2.91	24
≥ 5 < 50	31.24	329	44.44	416	34.63	321	48.91	403
≥ 50 < 85	51.66	544	36.65	343	47.25	438	38.59	318
≥ 85 < 95	10.07	106	11.11	104	12.08	112	7.04	58
≥ 95	5.60	59	6.20	58	2.91	27	2.55	21
Totals	100	1053	100	936	100	927	100	824

* United States Reference Standards (Must et al. 1991b)
** Canadian Reference Standards (CFS 1985)
Males (n=117)
Females (n=103)

Table 5.8: **Prevalence for "at risk for overweight" and overweight in males and females based on U.S. reference standards, BGS (n = 220)**
BMI based on NCHS data (Must et al. 1991)

	At risk for overweight				Overweight			
	<85£	≥85<95†			<85	≥95‡		
	n	n	x^2	OR	n	n	x^2	OR
Male	888 (84.3%)	106 (10.07%)	1.47	1.19	888 (84.3%)	59 (5.60%)	8.03*	.52
Female	788 (85%)	112 (12.08%)			788 (85%)	27 (2.91%)		

£ Cut off for children of "normal" weight
† Cut off for children "at risk for overweight"
‡ Cut off for children considered overweight
* ($p < 0.005$)
Males (n=117)
Females (n=103)

Table 5.9: **Prevalence for "at risk for overweight" and overweight in males and females based on Canadian reference standards, BGS (n = 220)**
BMI based on CFS data, Fitness Canada (1985)

	At risk for overweight				Overweight			
	<85£	≥85<95†			<85	≥95‡		
	n	n	x^2	OR	n	n	x^2	OR
Male	774 (82.7%)	104 (11.11%)	10.29*	.58	774 (82.7%)	58 (6.20%)	15.18*	.38
Female	745 (90.4%)	58 (7.04%)			745 (90.4%	21 (2.55%)		

£ Cut off for children of "normal" weight
† Cut off for children "at risk for overweight"
‡ Cut off for children considered overweight
* ($p < 0.001$)
Males (n=117)
Females (n=103)

"Tracking" BMI

Pearson's correlations are calculated to test annual inter-age correlations from ages 6 - 14 years and the association of BMI at age 14 compared to earlier ages. Table 5.10 presents the correlations for males and females in each age group. Results show statistically significant positive inter-age correlations at all ages for both sexes ($p < 0.001$). The correlations remain fairly stable after a peak at age 8 among males ($r = 0.80$), while female correlations decrease steadily from age 6 to 14 (Table 5.10). When BMI at age 14 is correlated to BMI at earlier ages the associations remain significant ($p < 0.001$), ranging from 0.64 to 0.95 for males and 0.64 to 0.92 for females (see Table 5.10, last column). Inter-age correlations and comparisons of BMI at age 14 to younger ages are generally higher for males than for females and increase with age for both sexes (Figure 5.16). Similar correlations and increases have been found for other studies using BMI as an indicator of adiposity (Clarke and Lauer 1993; Guo et al. 1994; Power et al. 1997b). This study failed to detect higher correlations among females as had been the case for other investigations (Guo et al. 1994; Power et al. 1997b).

Table 5.10: Inter-age Pearson correlations for BMI, BGS (n = 220)

males (n = 117)*

Age	6	7	8	9	10	11	12	13	14
6	1	0.664	0.802	0.753	0.776	0.734	0.706	0.744	0.725
7		1	0.73	0.688	0.69	0.647	0.657	0.668	0.636
8			1	0.894	0.897	0.861	0.839	0.87	0.838
9				1	0.904	0.874	0.882	0.891	0.876
10					1	0.925	0.892	0.902	0.885
11						1	0.927	0.924	0.898
12							1	0.951	0.918
13								1	0.945
14									1

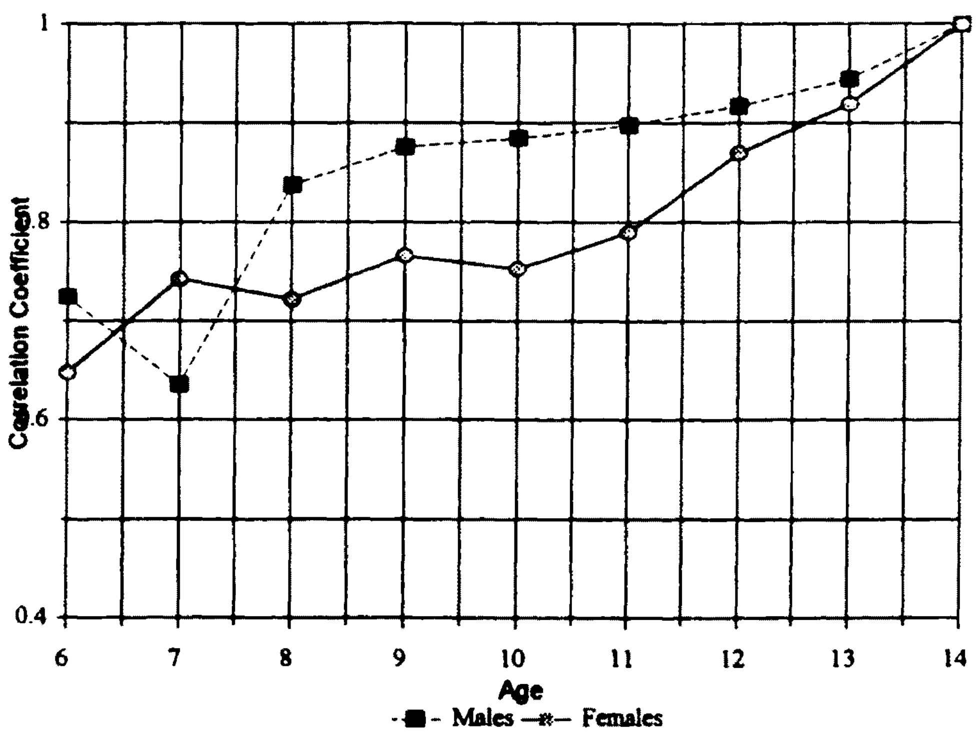
Table 5.10: Inter-age Pearson correlations for BMI, BGS (continued)

females (n = 103)*

Age	6	7	8	9	10	11	12	13	14
6	1	0.803	0.752	0.723	0.679	0.641	0.599	0.566	0.648
7		1	0.81	0.803	0.767	0.772	0.742	0.695	0.743
8			1	0.839	0.817	0.745	0.745	0.699	0.722
9				1	0.89	0.866	0.803	0.742	0.766
10					1	0.905	0.845	0.779	0.753
11						1	0.891	0.809	0.79
12							1	0.909	0.87
13								1	0.92
14									1

*($p < 0.001$)

Figure 5.16: **Pearson's correlation coefficients for assessing "Tracking" of BMI, BGS (m = 117, f = 103)**



5.4: Burlington School Study (1998-1999)

The age and sex composition of the 252 children who participated in *The Burlington School Study* (1999) is presented in Figure 3.2. Sample sizes range from 6 to 25 individuals in each age/sex category (male, n = 134; female, n = 118). Sample sizes for the BSS are smaller than those from the BGS and therefore interpretations from the BSS data should be made with caution.

Stature

Table 5.11 gives the average stature, standard deviations and sample sizes for the children attending a Burlington Elementary School during the 1998-1999 school year, while Figure 5.17 displays the age-specific mean stature measurements with 95% confidence intervals. Males are generally taller than their female counterparts at all ages except at ages 9, 12 and 14. There is no clear evidence of a female adolescent growth spurt or a divergence in the growth patterns between males and females at age fourteen as was the case for children in the BGS. This is likely the result of a smaller sample size for the BSS and/or because the data are truncated at age fourteen and no growth spurt has yet taken place. The reader will recall that in the BGS a divergence between males and females occurred around 14 years of age.

Table 5.11: Average stature, standard deviations and sample sizes, BSS (n = 252)

Age	Male (n=134)	Female (n=118)	Male Mean	SD	Female Mean	SD
6	14	12	119.45	4.30	115.76	3.23
7	16	16	126.12	7.65	124.40	5.63
8	19	6	129.86	6.67	126.25	4.93
9	12	14	134.18	5.04	134.30	7.21
10	17	20	141.28	4.68	136.71	6.70
11	25	15	147.80	5.84	146.25	6.73
12	10	21	152.57	6.01	154.35	7.22
13	10	7	163.48	6.36	157.57	6.73
14	11	7	161.26	7.70	165.07	6.13

On reviewing the scatterplot distribution of stature measurements for individuals from *The Burlington School Study*, it is evident that the majority of measurements are found within the 5th and 95th centiles for both reference populations, American 87.3% and Canadian 95% (see Figures 5.18 and 5.19). The pattern for males indicates that 11.2% of the BSS sample are situated above the American 95th centile while only 2.5% are above the Canadian 95th centile. Only 1.5% and 2.5% of the sample falls below the U.S. and Canadian 5th centile respectively. A similar pattern is seen among females with 89.9% of the sample being situated between the 5th and 95th centile for American reference data and 97.1% situated between the 5th and 95th centiles for Canadian standards. While 7.6% of the female data for this sample is above the 95th centile for the U.S. standards, none are found above the Canadian 95th centile. A similar percentage of individuals fall below the

5^{th} centile in the U.S. (2.5%) and Canadian reference standards (2.8%).

The comparisons of age-specific mean stature measurements with 95% confidence intervals for male and female children in *The Burlington School Study* to American and Canadian reference standards are presented in Figures 5.20 and 5.21. In general, males follow a similar path relative to both reference standards, close to the 80^{th} centile. Deviations occur only at ages 8 and 9 where males lay close to and on the Canadian 50^{th} centile, and at age 14 where they lie on the 50^{th} centile for both reference standards.

The age-specific mean stature measurements for females varies slightly from the male pattern in that it generally lies closer to the 50^{th} centiles for both reference populations at all ages. Exceptions occur at age 8, when they are located directly on the Canadian 50^{th} centile, and at age 10, when they are found on the 50^{th} centile for both reference populations.

Analysis of Variance (ANOVA) testing the null hypothesis of no differences in stature between sex and age and no interaction between these variables is presented in Table 5.12. There are no significant differences between male and female children for stature measurements ($p.<0.05$), but a strongly significant difference between age categories is observed ($p.<0.001$). No interactions were detected for sex and age on stature ($p.<0.211$). This indicates that the null hypothesis can be accepted for sex and interaction effects. This is not the case for age where significant differences in stature occur with increasing age (Figure 5.17). Tamhanes's t^2 post-hoc tests indicate significant differences between specific means at almost every age.

Table 5.12: Analysis of Variance (ANOVA) results for stature, BSS (n = 252)

	Sum of Squares	df	Mean Square	F-value
Sex	157.45	1	157.45	4.06
Age	46265.76	8	5783.22	149.28*
Sex * Age	424.19	8	5.02	1.37
Within Subjects	9065.39	234	38.74	
Total	4987384.50	252		
Corrected Total	58259.36	251		

*(p<0.001)

Figure 5.17: **Age-specific mean stature measurements with 95% CI for males and females, BSS (n = 252)**

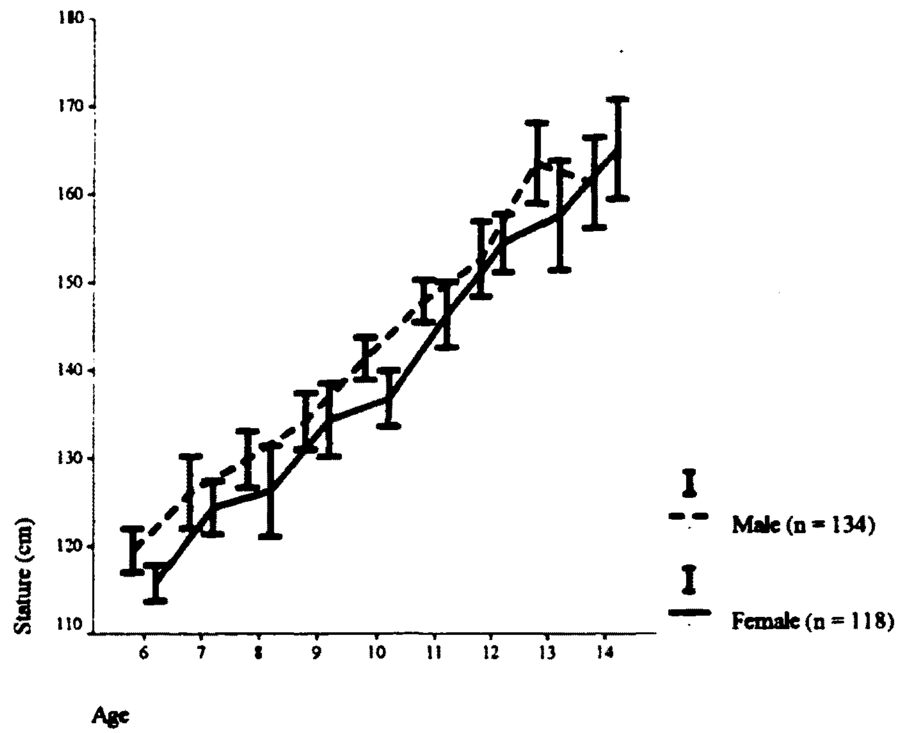


Figure 5.18: Scatterplot distribution of male stature measurements compared to American and Canadian reference standards, BSS (n= 252)*

*(Dotted lines represent Canadian reference standards for stature (Fitness Canada 1985). Solid lines represent United States reference standards for stature (Hamill et al. 1977). Centiles are presented from top to bottom (i.e. 95th, 50th, 5th).

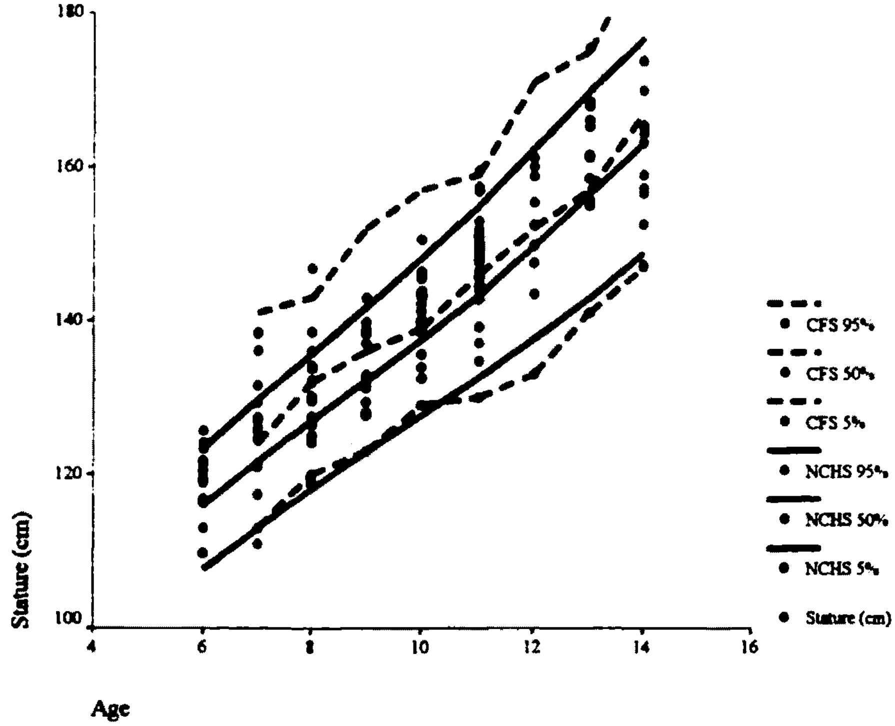


Figure 5.19: **Scatterplot distribution of female stature measurements compared to American and Canadian reference standards, BSS (n = 252)***

*(Dotted lines represent Canadian reference standards for stature (Fitness Canada 1985). Solid lines represent United States reference standards for stature (Hamill et al. 1977). Centiles are presented from top to bottom (i.e. 95th, 50th, 5th).

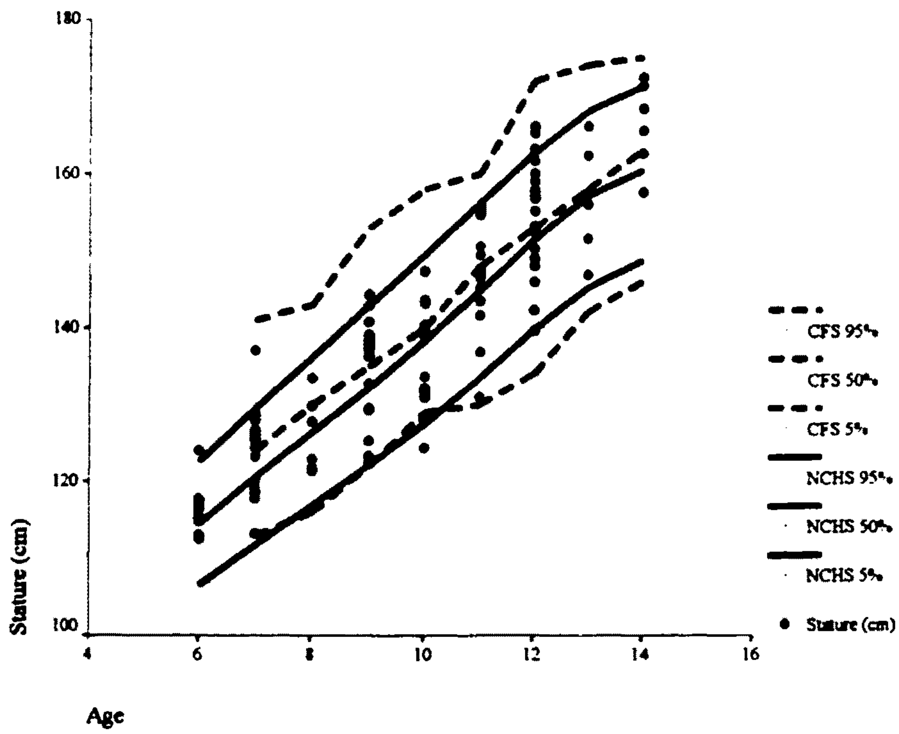


Figure 5.20: **Age-specific mean stature measurements with 95% CI compared to American and Canadian reference standards for males, BSS (n = 252)***

*(Dotted lines represent Canadian reference standards for stature (Fitness Canada 1985). Solid lines represent United States reference standards for stature (Hamill et al. 1977). Centiles are presented from top to bottom (i.e. 95th, 50th, 5th).

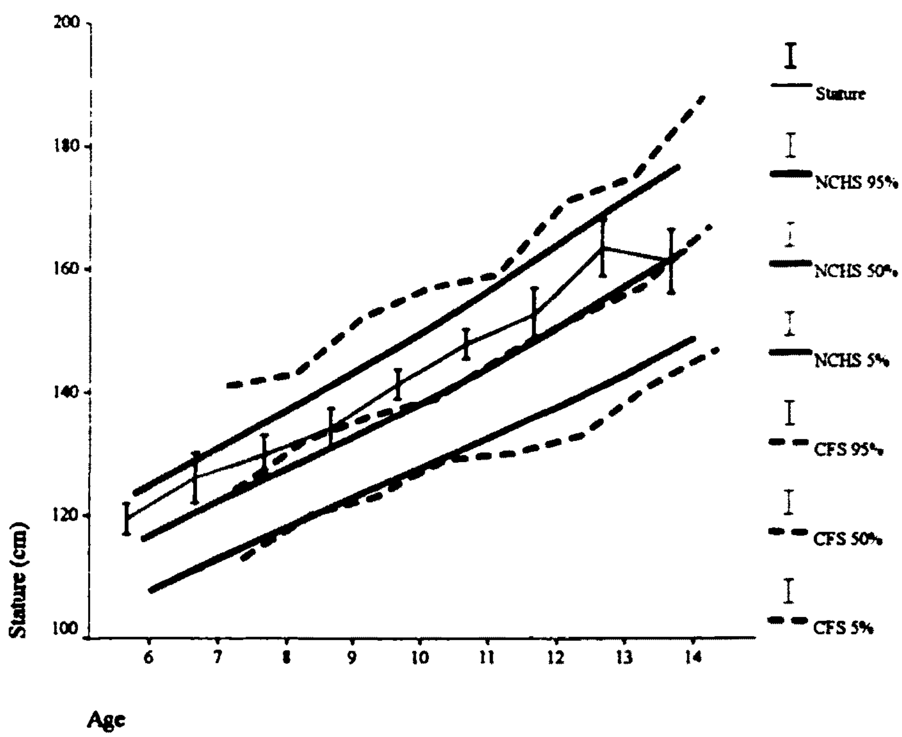
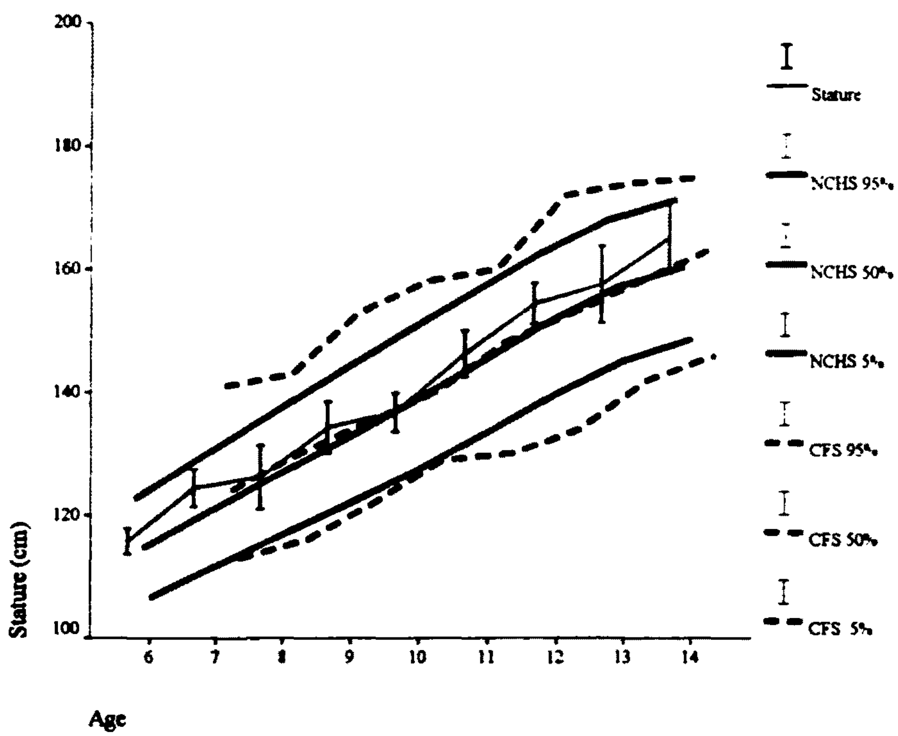


Figure 5.21: **Age-specific mean stature measurements with 95% CI compared to American and Canadian reference standards for females, BSS (n = 252)***

*(Dotted lines represent Canadian reference standards for stature (Fitness Canada 1985). Solid lines represent United States reference standards for stature (Hamill et al. 1977). Centiles are presented from top to bottom (i.e. 95th, 50th, 5th).



Mass

Table 5.13 shows average mass with standard deviations and sample sizes for each age and sex. On average males are heavier than females at ages 6, 8, 11 and 13. Age-specific mean mass with 95% confidence intervals for boys and girls in *The Burlington School Study* are presented in Figure 5.22. Females in this study are heavier than males at ages 10 and 12, while at ages 7, 9 and 14 average mass is almost identical between the sexes. Again, there is no clear evidence of a female adolescent growth spurt or divergence in growth patterns between males and females at age 14. This is likely a reflection of the small sample size in this study and/or the truncation of the data at age 14.

Table 5.13 : Distribution of Mass, BSS (n = 252)

Age	Male (n)	Female (n)	Male Mean	SD	Female Mean	SD
6	14	12	22.80	2.81	20.63	1.30
7	16	16	26.81	4.71	27.32	5.22
8	19	6	30.70	7.49	25.05	3.21
9	12	14	32.14	5.51	31.84	6.70
10	17	20	34.71	4.50	35.98	9.11
11	25	15	44.74	8.02	42.39	8.95
12	10	21	42.52	5.13	52.45	13.59
13	10	7	55.07	12.84	48.36	11.98
14	11	7	56.10	11.31	56.56	6.95

Examination of the distribution of individual values relative to American and Canadian standards indicates that the majority of the boys fall within the 5th and 95th centiles for these reference standards, 88% and 89.2% respectively (Figure 5.23). About 12% and 10% of the boys are found above the American and Canadian 95th centiles respectively, while none are situated below the American 5th centile and only 0.8% are below the Canadian 5th centile. A similar pattern is observed among girls where 88.1% and 84% of the BSS sample are located between the 5th and 95th centiles for American and Canadian reference data respectively (Figure 5.24). Only 1.7% of this sample lies below the U.S. 5th centile while 4.7% lies below the Canadian 5th centile. A similar percentage of this sample exceeds the 95th centile for both reference populations, 10.2% for U.S. reference standards and 11.3% for Canadian reference standards.

The distribution of average mass measurements with 95% confidence intervals for male and female children in *The Burlington School Study* relative to NCHS and CFS reference standards is presented in Figures 5.25 and 5.26 (Hamill et al. 1977; Fitness Canada 1985). Figure 5.25 illustrates that males generally follow close to about the 75th centile of both reference populations. At ages 11 and 13 there is a sudden increase in average mass that peaks around the 80th centile. Girls follow a similar pattern with deviations occurring at ages 7 and 12 where there is a peak along the 80th centiles for both reference standards.

Analysis of Variance (ANOVA) testing the null hypothesis of no difference in mass between sex and age and no interaction between these variables is presented in Table 5.14. Findings indicate that there are no differences in mass between boys and girls ($p<0.61$). There is a strong statistical difference between age groups ($p.<0.001$) and a marginally significant interaction found for sex and age ($p.<0.05$). The null hypothesis for no difference in mass between males and females can be accepted. The null hypothesis of no difference in mass by age is rejected. Age differences in mass with increasing age are clearly seen in Figure 5.22. The significant interaction effect between age and sex is less clear and likely reflects the slightly steeper increase in mass among females between ages 9 through 12 than that seen for males. Tamhanes's t^2 post-hoc tests reveal significant differences between age-specific means at almost every age.

Table 5.14 : Analysis of variance (ANOVA) for mass, BSS

	Sum of Squares	df	Mean Square	F-value
Sex	16.881	1	16.88	0.26
Age	26011.76	8	3251.47	49.89*
Sex * Age	1098.51	8	137.31	2.11**
Within Subjects	15250.75	234	65.17	
Total	402265.92	252		
Corrected Total	44824.31	251		

*($p<0.001$)
**($p<0.05$)

Figure 5.22: **Age-specific mean mass measurements with 95% CI for males and females, BSS (n = 252)**

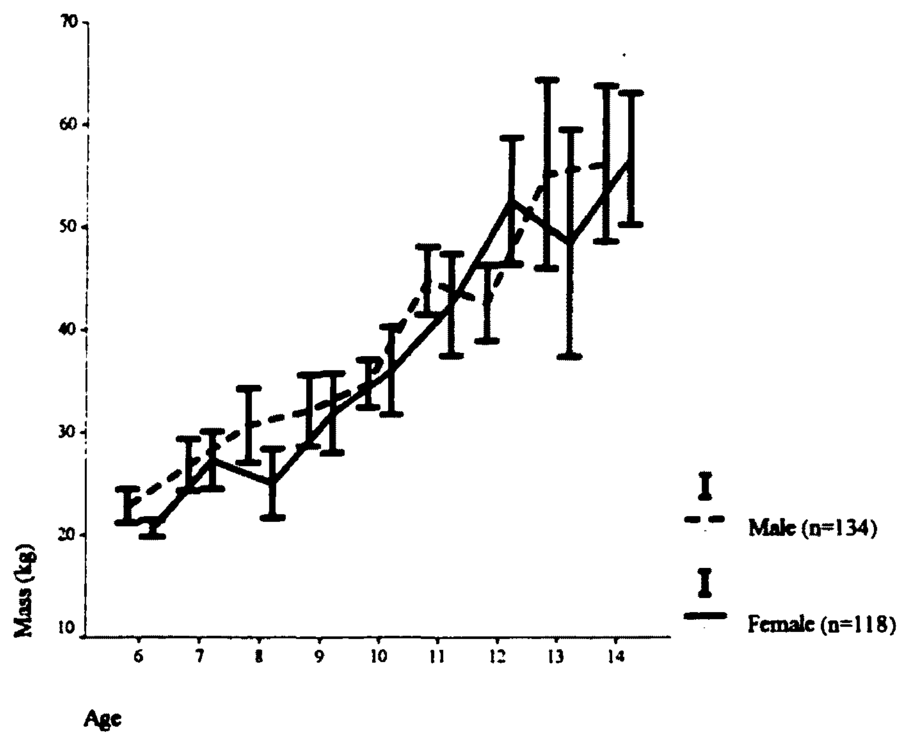


Figure 5.23: **Scatterplot distribution of male mass measurements compared to American and Canadian reference standards, BSS (n= 252)***

*(Dotted lines represent Canadian reference standards for mass (Fitness Canada 1985). Solid lines represent United States reference standards for mass (Hamill et al. 1977). Centiles are presented from top to bottom (i.e. 95th, 50th, 5th).

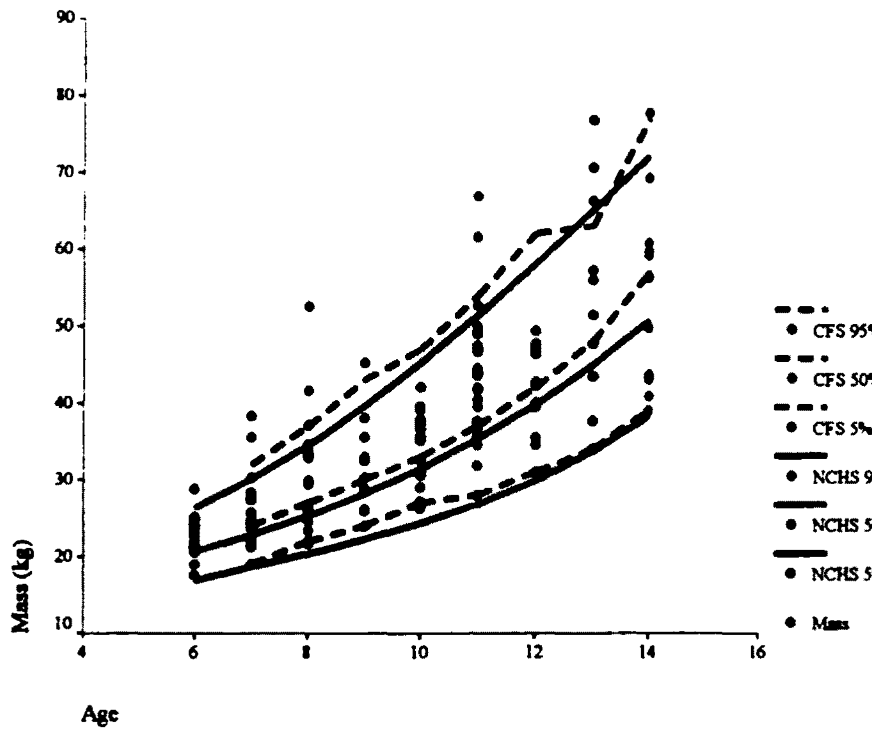


Figure 5.24: **Scatterplot distribution of female mass measurements compared to American and Canadian reference standards, BSS (n = 252)***

*(Dotted lines represent Canadian reference standards for mass (Fitness Canada 1985). Solid lines represent United States reference standards for mass (Hamill et al. 1977). Centiles are presented from top to bottom (i.e. 95th, 50th, 5th).

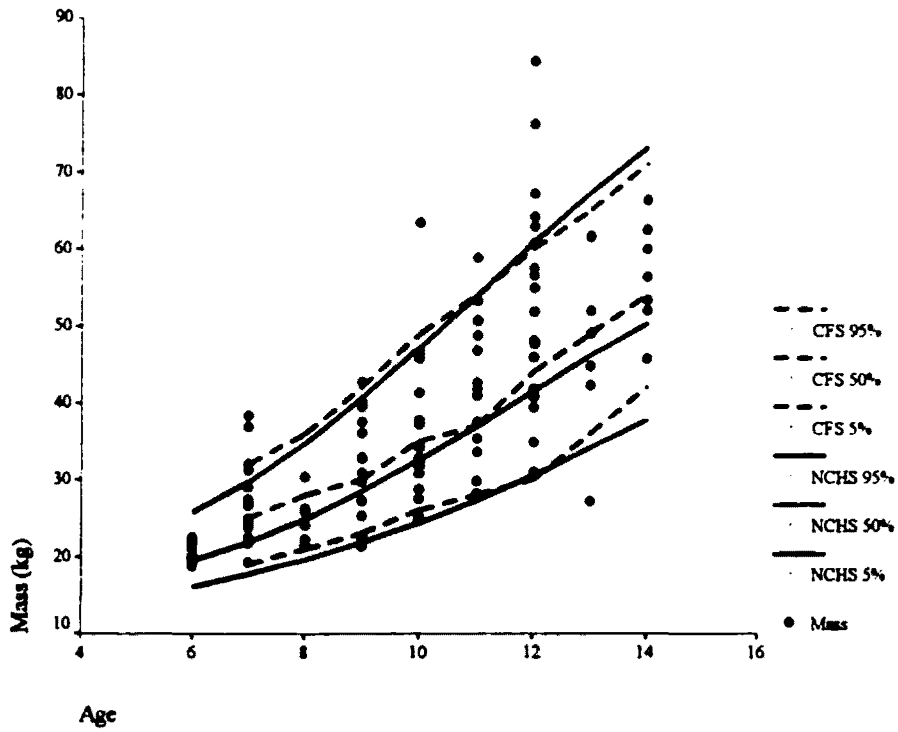


Figure 5.25: **Age-specific mean mass measurements with 95% CI compared to American and Canadian reference standards for males, BSS (n = 252)***

*Dotted lines represent Canadian reference standards for mass (Fitness Canada 1985). Solid lines represent United States reference standards for mass (Hamill et al. 1977). Centiles are presented from top to bottom (i.e. 95th, 50th, 5th).

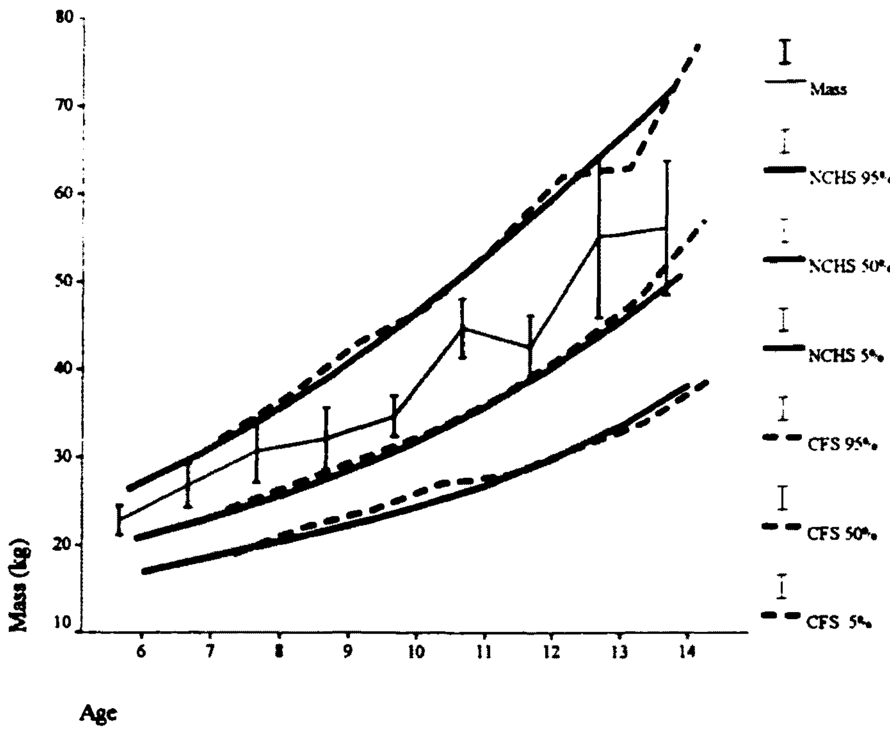
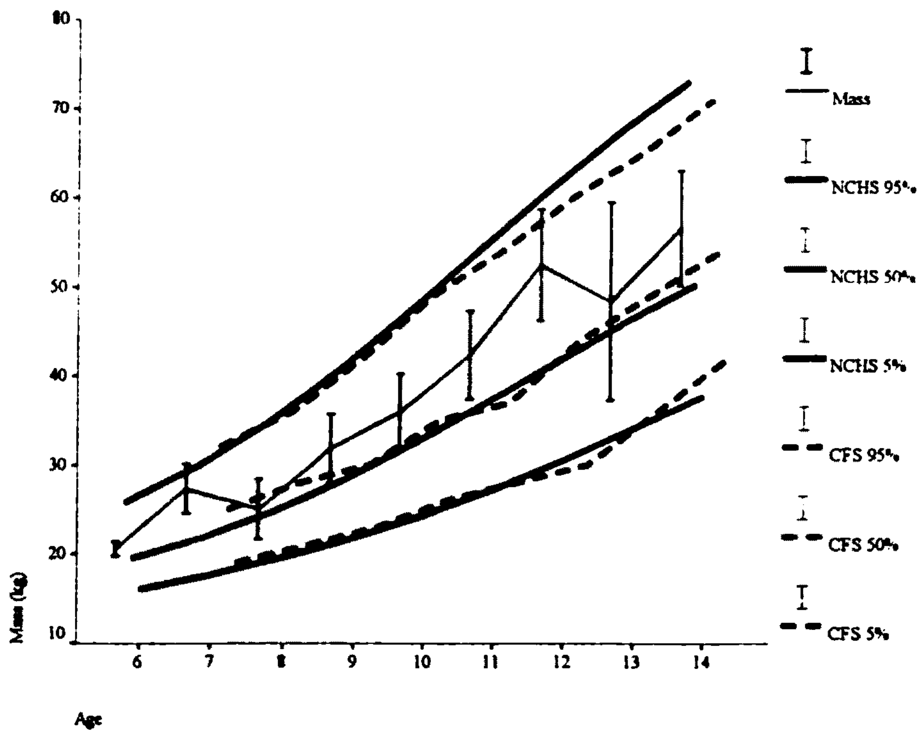


Figure 5.26: **Age-specific mean mass measurements with 95% CI compared to American and Canadian reference standards for females, BSS (n = 252)***

*(Dotted lines represent Canadian reference standards for mass (Fitness Canada 1985). Solid lines represent United States reference standards for mass (Hamill et al. 1977). Centiles are presented from top to bottom (i.e. 95th, 50th, 5th).



BMI

Figure 5.27 presents age-specific mean BMI values and 95% confidence intervals for male and female children in the *Burlington School Study*. Table 5.15 shows average BMI with standard deviations and samples size for age and sex. In general, the average BMI for male children is greater than that for female children at ages 6, 8, 9, 11, 13 and 14. Female children show higher average BMI values at ages 7, 10, and 12. No clear female adolescent growth spurt or divergence at age 14 is seen in this sample and likely reflects the small sample sizes and/or the age at which the sample is truncated.

Table 5.15: Distribution of BMI, BSS (n = 252)

Age	Male (n)	Female (n)	Male Mean	SD	Female Mean	SD
6	14	12	15.94	1.37	15.41	0.95
7	16	16	16.74	1.30	17.53	2.27
8	19	6	17.98	2.69	15.65	0.90
9	12	14	17.77	2.09	17.48	2.41
10	17	20	17.38	2.04	19.06	3.46
11	25	15	20.39	2.76	19.70	3.33
12	10	21	18.22	1.43	21.73	4.15
13	10	7	20.38	3.34	19.31	4.13
14	11	7	21.47	3.52	20.73	1.89

The distribution of individual values in Figure 5.28 illustrates that the majority of boys' measurements are found within the 5th and 95th reference centiles for both reference populations, 90.3% for U.S. reference data and 86.6% for Canadian reference data. While

7.5% of individuals from the BSS exceed the American 95th centile, a slightly higher percentage of 9.2% exceed the Canadian 95th centile. Almost twice as many individuals are situated below the Canadian 5th centile when compared to the American 5th centile, (4.2% versus 2.2%). Almost 89% and 80% of females are found within the 5th and 95th centiles for American and Canadian reference data, respectively. While 11% of individuals are found above the US 95th centile, 17% are above the Canadian 95th centile. Only 1.7% of this sample are below the U.S. 5th centile and 2.8% below the Canadian 5th centile (see Figure 5.29).

The age-specific average BMI for male and female children with 95% confidence intervals in relation to American and Canadian national standards are presented in Figures 5.30 and 5.31. Figure 5.30 illustrates that male children in this study lie along the 70th centile for both reference populations. There is a general increase in BMI until age 8, followed by a downward trend to about the 55th centile until age 10. At age 11 average male BMI spikes back up to the 70th centile and then quickly decreases to about the 55th centile at age twelve. From 12 to fourteen years average male BMI increases back to about the 70th centile. Age-specific mean BMI for female children generally sit along the 55th centiles for both reference populations. At age 7 average BMI increases to about the 80th centiles and then suddenly decreases to about the 50th centile. From age 8 to twelve there is a steady increase in average BMI which peaks at about the 70th centile. There is a sudden decrease to about the 50th centiles where it remains until age 14. This erratic nature of Figure 5.31 likely reflects the small size of the BSS sample.

Analysis of Variance (ANOVA) testing the null hypothesis of no differences in BMI for sex and age and no interaction between the two variables is presented in Table 5.16. There is no significant difference in BMI between male and female children in this sample ($p<0.92$). There is a statistical difference for age ($p<0.001$) and a significant interaction between age and sex ($p<0.05$), relative to the BMI. These findings allow acceptance of the null hypothesis for no differences between males and females. The null hypothesis of no differences for age and interaction is rejected. This is reflected in Figure 5.27, where BMI generally increases with age. Interactions between age and sex are also reflected in Figure 5.27 through steeper increases in BMI with age among girls. Post-hoc tests reveal fewer statistical differences between age-specific means than was found for stature and mass. This is likely reflected by the larger erratic confidence intervals seen in Figure 5.27.

Table 5.16: Analysis of variance (ANOVA) for BMI, BSS (n = 252)

	Sum of Squares	df	Mean Square	F-value
Sex	0.07	1	0.07	0.01
Age	633.53	8	79.19	10.67*
Sex * Age	148.66	8	18.58	2.50 **
Within Subjects	1737.31	234	7.42	
Total	89915.60	252		
Corrected Total	2610.11	251		

*(p<0.001)
*(p<0.05)

Figure 5.27: **Age-specific mean BMI values with 95% CI for males and females, BSS (n = 252)**

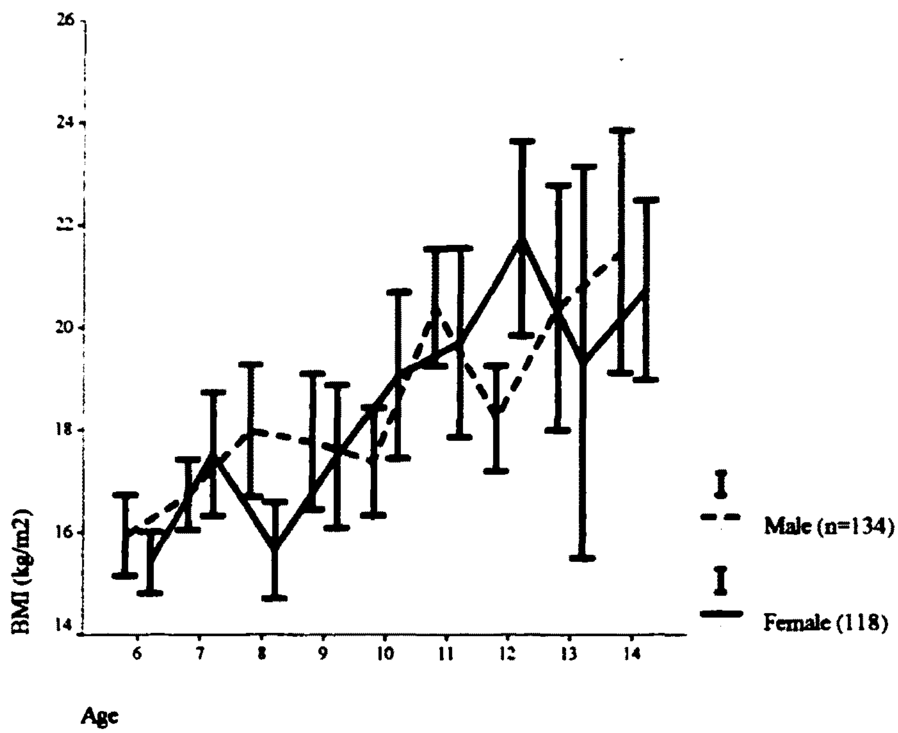


Figure 5.28: **Scatterplot distribution of male BMI values compared to American and Canadian reference standards, BSS (n= 252)***

*(Dotted lines represent Canadian reference standards for BMI (Fitness Canada 1985). Solid lines represent United States reference standards for BMI (Must et al. 1991b). Centiles are presented from top to bottom (i.e. 95th, 50th, 5th).

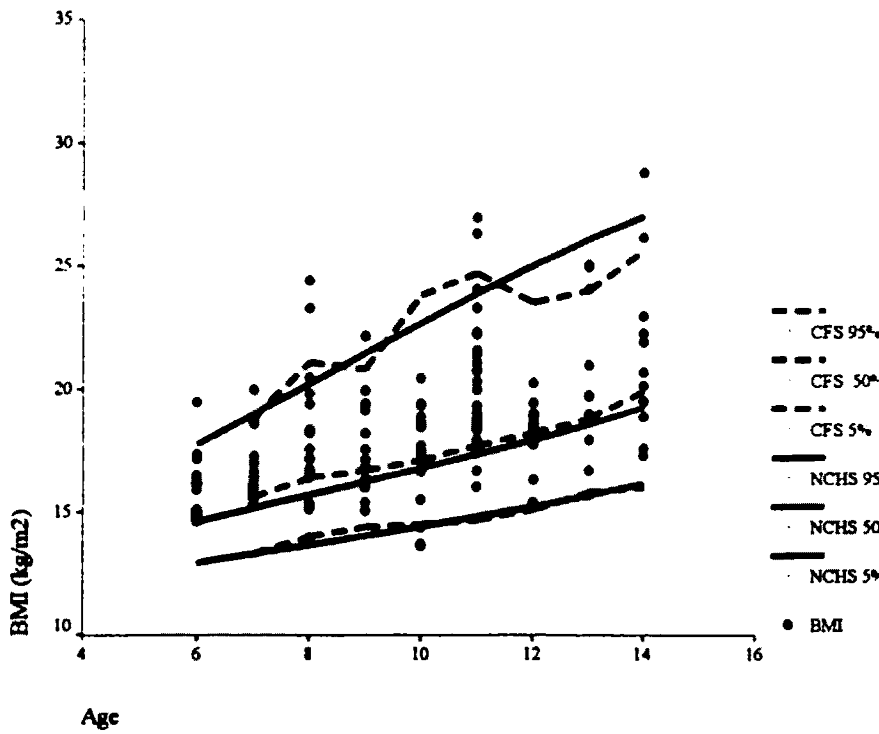


Figure 5.29: **Scatterplot distribution of female BMI values compared to American and Canadian reference standards, BSS (n = 252)***

*(Dotted lines represent Canadian reference standards for BMI (Fitness Canada 1985). Solid lines represent United States reference standards for BMI (Must et al. 1991b). Centiles are presented from top to bottom (i.e. 95th, 50th, 5th).

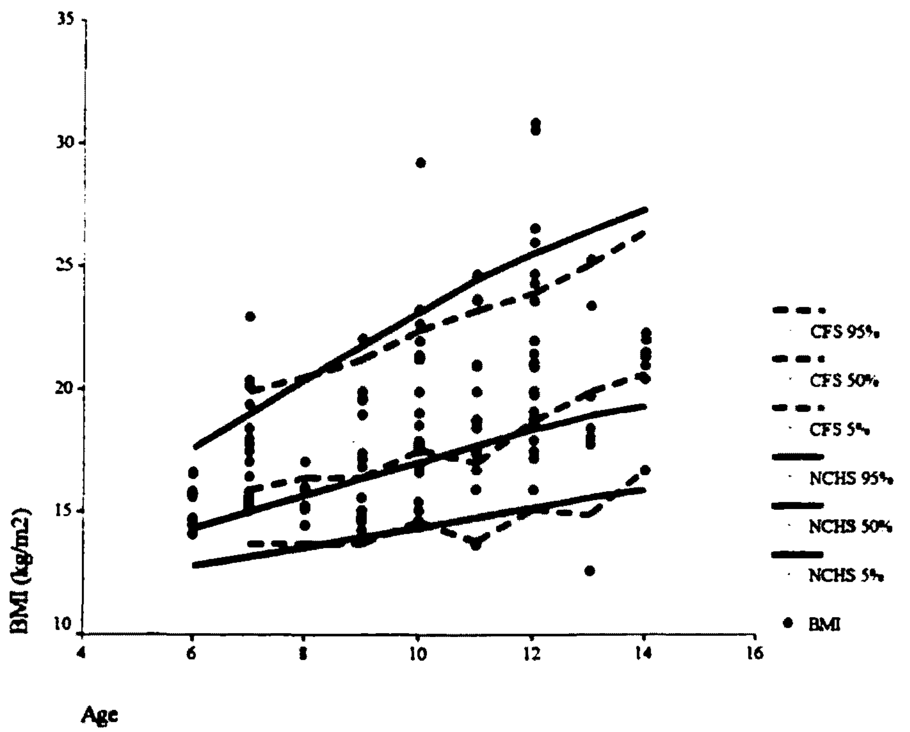


Figure 5.30: **Age-specific mean BMI values with 95% CI compared to American and Canadian reference standards for males, BSS (n = 252)***

*(Dotted lines represent Canadian reference standards for BMI (Fitness Canada 1985). Solid lines represent United States reference standards for BMI (Must et al. 1991b). Centiles are presented from top to bottom (i.e. 95th, 50th, 5th).

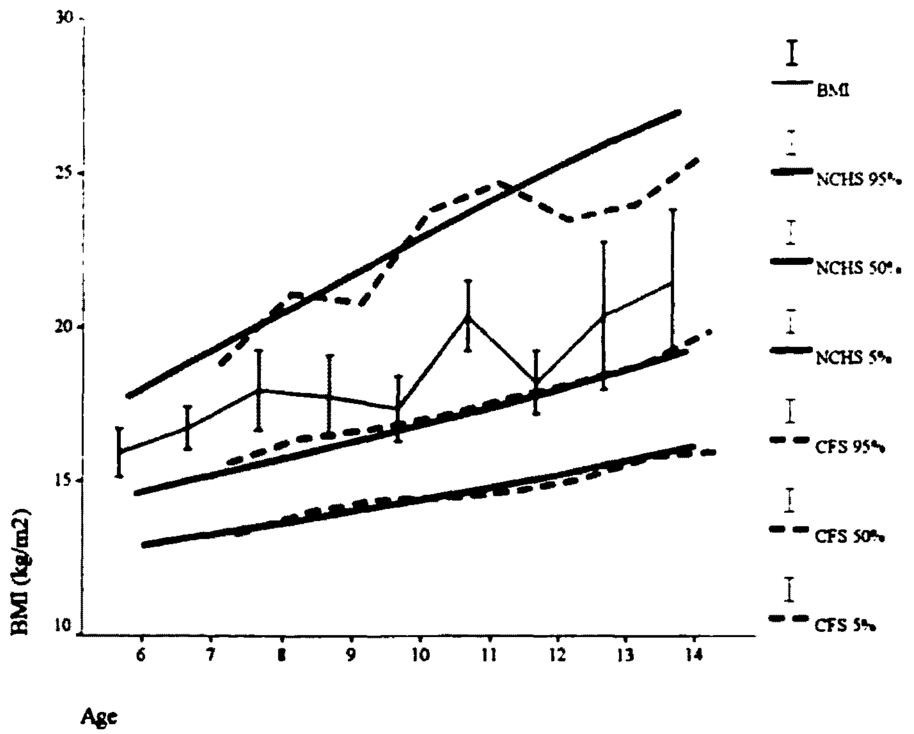
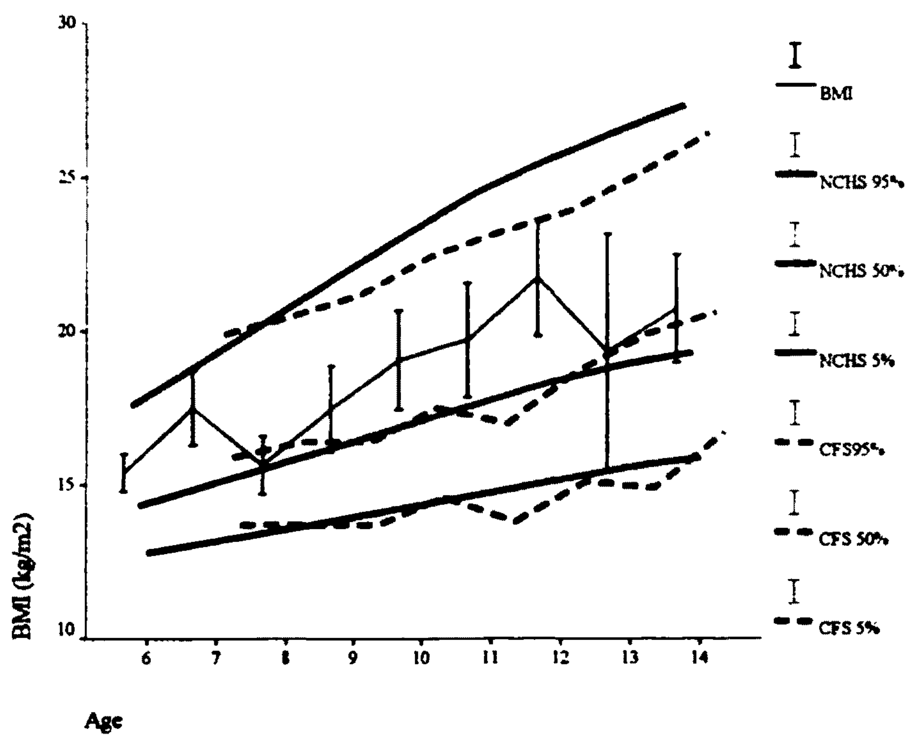


Figure 5.31: Age specific mean BMI values with 95% CI compared to American and Canadian reference standards for females, BSS (n = 252)*

*(Dotted lines represent Canadian reference standards for BMI (Fitness Canada 1985). Solid lines represent United States reference standards for BMI (Must et al. 1991b). Centiles are presented from top to bottom (i.e. 95th, 50th, 5th).



Prevalence of "at risk for overweight" and overweight

To investigate the prevalence of "at risk for overweight" and overweight in children from the BSS between the ages of 6 and 14, BMI was calculated (see chapter 3) and compared to reference standards for American children published by Must et al. (1991b) and recommended by *The Expert Committee on Clinical Guidelines for Overweight in Adolescent Preventive Services* (Himes and Dietz 1994).

The proportion of children from the BSS in each centile category relative to American and Canadian reference standards is presented in Table 5.17. The majority of children found between the 5th and 85th centiles (NCHS, m = 79.1%, f = 71.2%; CFS, m = 73.3%, f = 68.9%). Children between 85th and 95th centiles are considered "at risk for overweight" and account for between 13.4% and 17.8% of the sample (NCHS, m = 13.4%, f = 17.8%; CFS, m = 17.5%, f = 14.2%) (see Table 5.17). Children above the 95th centile are considered overweight and account for between 7.5% and 17.0% (NCHS, m = 7.5%, f = 11%; CFS, m = 9.2%, f = 17.0%) (see Table 5.17). Chi-square analysis was conducted to test the null hypothesis that the proportion of "at risk for overweight" and overweight individuals is the same for males and females. Results indicate that there is no difference between males and females based on either reference sample employing both cut-off values for being "at risk for overweight" (i.e between the 85th and 95th centiles) and for overweight (i.e. greater than the 95th centile) (see Table 5.18 and Table 5.19).

Table 5.17: Distribution of BMI relative to national standards, BSS

	Male				Female			
	NCHS*		CFS**		NCHS		CFS	
Centiles	%	n	%	n	%	n	%	n
< 5	2.2	3	4.2	5	1.7	2	2.8	3
≥ 5 < 50	14.9	20	20.8	25	23.7	28	33	35
≥ 50 < 85	61.9	83	48.3	58	45.8	54	33	35
≥ 85 < 95	13.4	18	17.5	21	17.8	21	14.2	15
≥ 95	7.5	10	9.2	11	11	13	17	18
Totals		134		120		118		106

Table 5.18: Prevalence for "at risk for overweight" and overweight based on U.S. reference standards, BSS (252)
BMI based on NCHS data (Must et al. 1991b)

	At risk for overweight				Overweight			
	<85£	≥85<95†			<85	≥95‡		
	n	n	x^2	OR	n	n	x^2	OR
Male	106 (79.1%)	18 (13.4%)	1.21	1.47	106 (79.1%)	10 (7.5%)	1.25	1.64
Female	84 (71.2%)	21(17.8%)			84 (71.2%)	13 (11%)		

£ Cut off for children of "normal" weight
† Cut off for children "at risk for overweight"
‡ Cut off for children considered overweight
p = n/s
Males (n=134)
Females (n=118)

Table 5.19: Prevalence for "at risk for overweight" and overweight based on Canadian reference standards, BSS (252)
BMI based on CFS data, Fitness Canada (1985)

	At risk for overweight				Overweight			
	<85£	≥85<95†			<85	≥95‡		
	n	n	x^2	OR	n	n	x^2	OR
Male	88 (73.3%)	21 (17.5%)	.16	.86	88 (73.3%)	11 (9.2%)	2.26	1.86
Female	73 (68.9%)	15(14.2%)			73 (68.9%)	18 (17%)		

£ Cut off for children of "normal" weight
† Cut off for children "at risk for overweight"
‡ Cut off for children considered overweight
p = n/s
Males (n=120)
Females (n=106)

5.5: Comparison of *The Burlington Growth Study* and *The Burlington School Study*

To compare the BGS to the smaller BSS a random sample of equivalent size was extracted from the BGS's longitudinal data (n = 252). As the sample size for this comparison is small, statistical analysis is limited and caution is recommended when making interpretations. The comparison nevertheless allows secular trends to be observed between the two studies.

Stature

Age-specific mean stature measurements for males and females from the BGS and BSS is presented in Figures 5.32 and 5.33. Table 5.20 presents the distribution of mean stature, standard deviations and sample sizes for males and females from both studies. It is clear that males in the BSS are taller than those in the BGS at ages 6, 7, 8, 9, 11, 12, and 13. Females in the new study are taller at ages 6, 7, 8, 11, 12, 13, and 14.

Analysis of Variance (ANOVA) was used to test the null hypothesis of no difference in stature, sex, and age between the BGS and the BSS (see Table 5.21). There are significant differences in stature ($p < 0.001$), by sexe ($p < 0.01$) and by age ($p < 0.001$) between the two studies although this is not readily apparent in Figures 5.32 and 5.33.

Tamhanes's t^2 post-hoc tests illustrate significant differences between age-specific means for all ages except age fourteen. When the interaction effects between the variables were tested no significant results were identified (see Table 5.21).

Table 5.20: Distribution of stature, standard deviations and sample sizes, BGS vs. BSS (n = 454)

			BGS				BSS			
Age	**Male (n)**	**Female (n)**	**Male Mean**	**SD**	**Female Mean**	**SD**	**Male Mean**	**SD**	**Female Mean**	**SD**
6	14	12	115.65	3.39	115.46	5.37	119.45	4.30	115.76	3.23
7	16	16	121.68	4.82	123.31	4.19	126.12	7.65	124.40	5.63
8	19	6	128.54	4.74	125.94	4.52	129.86	6.67	126.25	4.93
9	12	14	130.91	4.18	130.76	5.81	134.18	5.04	134.30	7.21
10	17	20	141.41	5.32	139.7	7.40	141.28	4.68	136.71	6.70
11	25	15	146.72	5.72	143.17	7.77	147.80	5.84	146.25	6.73
12	10	21	149.67	6.99	151.64	6.73	152.57	6.01	154.35	7.22
13	10	7	156.27	6.12	155.07	9.02	163.48	6.36	157.57	6.72
14	11	7	165.39	5.95	157.11	8.02	161.26	7.70	165.07	6.13

Table 5.21: Analysis of Variance (ANOVA) for stature, BGS vs. BSS

	Sum of Squares	df	Mean Square	F-value
Source[a]	489.85	1	489.85	13.24*
Sex	289.79	1	289.79	7.83**
Age	90816.93	8	11.52.12	306.79*
Source* Sex	0.52	1	0.52	0.01
Source*Age	355.68	8	44.46	1.20
Sex*Age	3.52	8	44.08	1.19
Source*Sex*Age	493.98	8	61.75	1.67
Within Subjects	17317.46	468	37.00	
Total	9846217.90	504		
Corrected Total	115649.47	503		

[a]Source = BGS vs BSS
*(p<0.001)
**(p<0.01)

Figure 5.32: Age-specific mean stature measurements for males, BGS vs. BSS (n = 134)

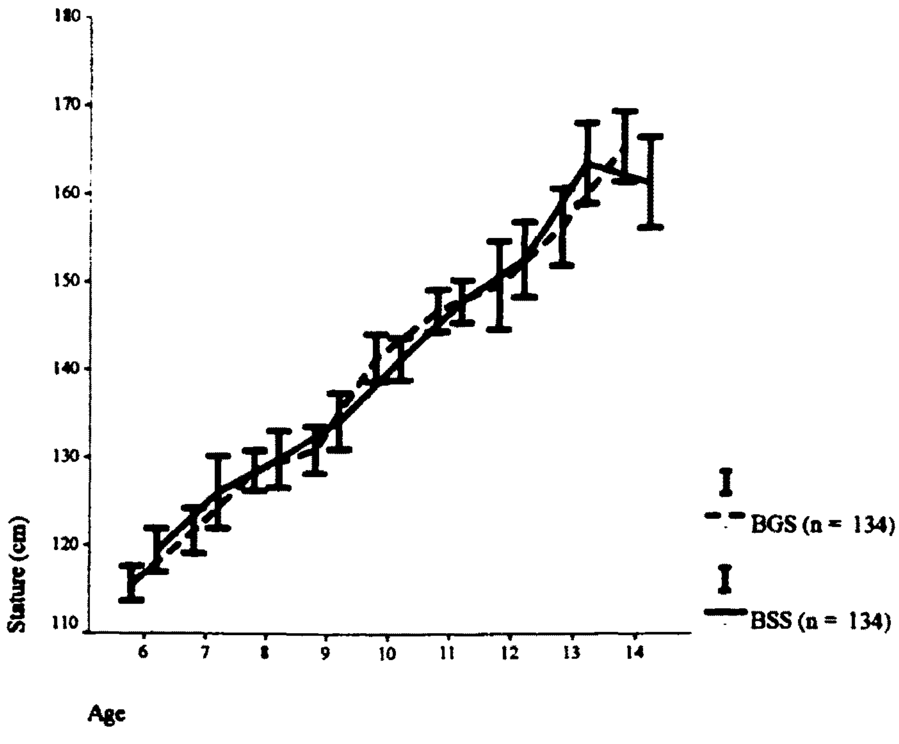
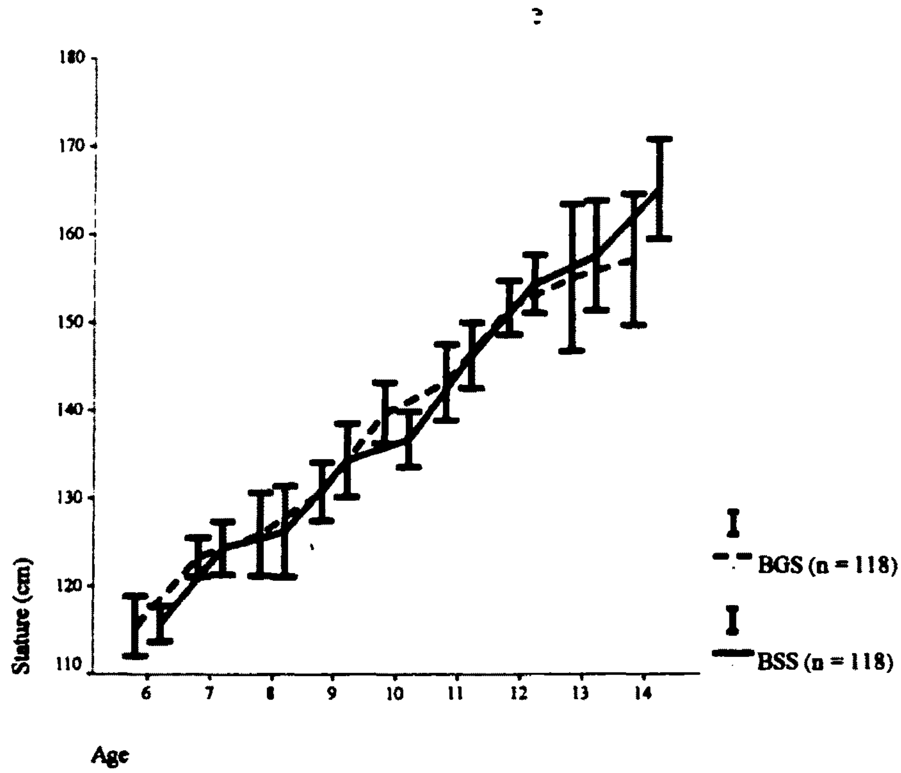


Figure 5.33: Age-specific mean stature measurements for females, BGS vs. BSS (n = 118)



Mass

Age-specific mean mass measurements for males and females from the BGS and the BSS are presented in Figures 5.34 and 5.35. Table 5.22 gives mean mass measurements, standard deviations and sample sizes for both studies. It is clear that males in the BSS study are heavier than their BGS counterparts at ages 6, 7, 8, 9, 11 and 13. Females are heavier in the BSS study at ages 7, 9, 10, 11, 12, 13, and 14

Analysis of Variance (ANOVA) testing the null hypothesis of no differences in mass between the BGS and BSS, sex, age and no interaction among these variables is presented in Table 5.23. Significant differences emerged between the studies ($p < 0.001$) and for age ($p < 0.001$), but not for sex ($p < 0.117$) or the three interaction effects (see Table 5.23). The null hypothesis of no differences in mass between the two studies and for age can be rejected, but can be accepted for sex. The null hypothesis of no differences in mass for all three interaction effects can be accepted. These differences are not readily apparent in Figures 5.34 and 5.35, but Tamhanes's t^2 post-hoc tests illustrate significant differences between specific means at ages most except for 8, 9, 11, 13 and 14.

Table 5.22: Distribution of mass, standard deviations and sample size, BGS vs. BSS (n =454)

			BGS				BSS			
Age	**Male (n)**	**Female (n)**	**Male Mean**	**SD**	**Female Mean**	**SD**	**Male Mean**	**SD**	**Female Mean**	**SD**
6	14	12	22.03	3.50	20.81	3.05	22.80	2.81	20.63	1.30
7	16	16	23.83	2.31	25.23	2.61	26.81	4.71	27.32	5.22
8	19	6	27.83	2.84	26.72	2.66	30.69	7.48	25.05	3.21
9	12	14	28.63	2.67	28.31	3.13	32.14	5.51	31.84	6.70
10	17	20	36.59	6.19	34.07	4.46	34.71	4.50	35.98	9.11
11	25	15	38.55	6.86	37.04	6.56	44.74	8.02	42.39	8.95
12	10	21	44.65	7.97	41.31	7.85	42.52	5.13	52.45	13.59
13	10	7	47.62	6.72	45.03	11.05	55.07	12.84	48.36	11.98
14	11	7	56.32	8.71	53.39	11.66	56.10	11.31	56.56	6.95

Table 5.23: Analysis of variance (ANOVA) results for mass, BGS vs. BSS

	Sum of Squares	df	Mean Square	F-value
Source[a]	778.02	1	778.02	15.61*
Sex	122.76	1	122.76	2.46
Age	46733.30	8	5841.66	117.23*
Source* Sex	27.77	1	27.77	0.56
Source*Age	549.77	8	68.72	1.38
Sex*Age	498.71	8	62.34	1.25
Source*Sex*Age	723.14	8	90.39	1.81
Within Subjects	23320.76	468	49.83	
Total	732850.92	504		
Corrected Total	76762.10	503		

[a]Source = BGS vs BSS
*($p<0.001$)

Figure 5.34: Age-specific mean mass measurements for males, BGS vs. BSS (n = 134)

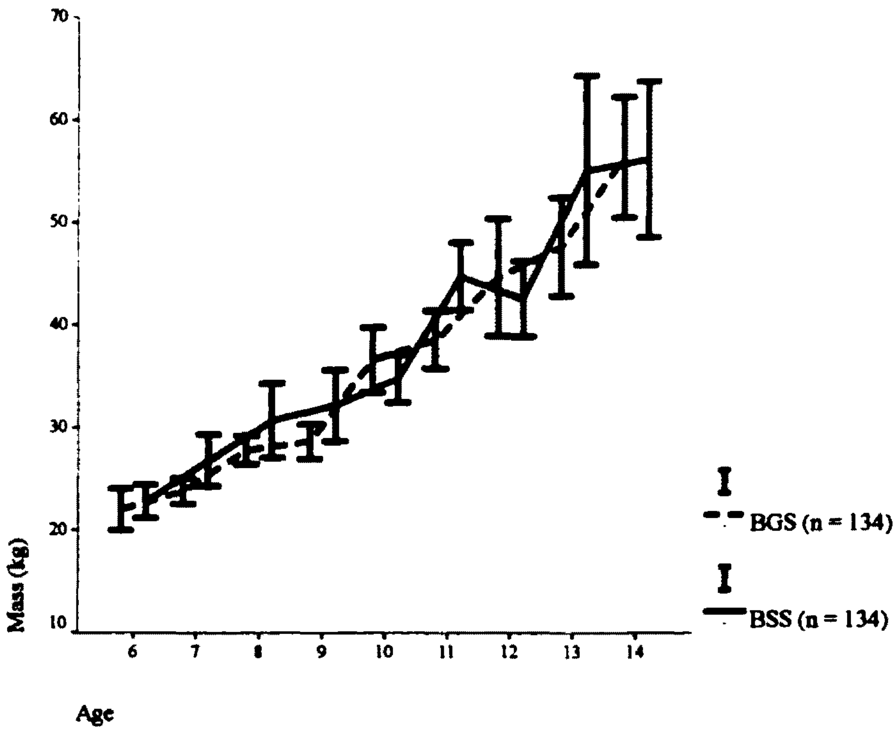
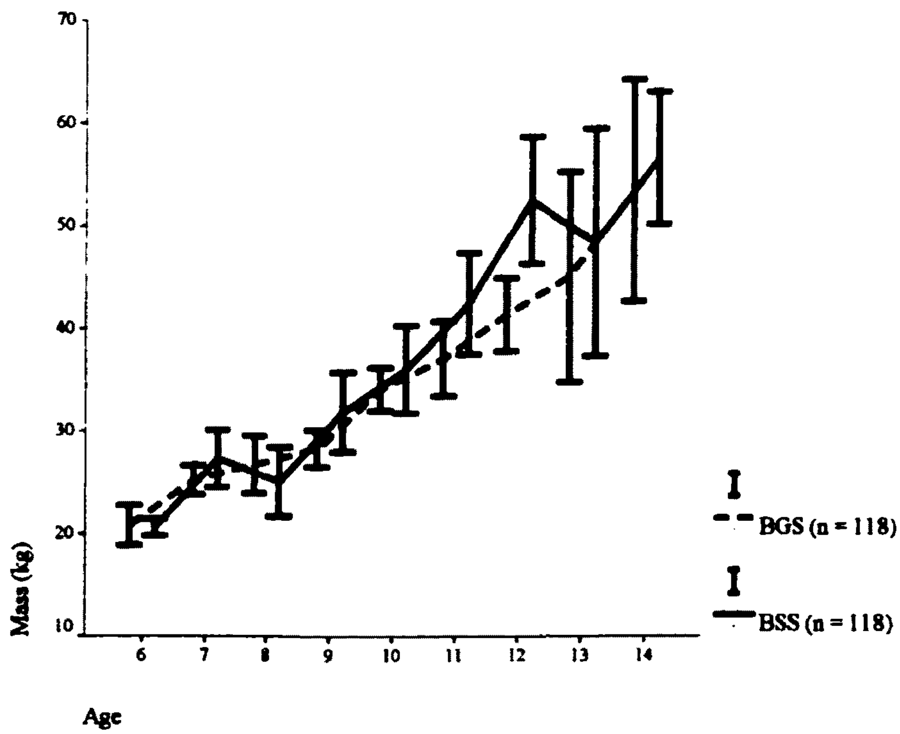


Figure 5.35: Age-specific mean mass measurements for females, BGS vs. BSS (n = 118)



BMI

Age-specific mean BMI values for males and females from the BGS and the BSS are presented in Figures 5.36 and 5.37 respectively. Table 5.24 gives the average BMI, standard deviations and sample sizes for both studies. It is clear that males in the BSS study have a greater average BMI at all ages except for ages 6, 10 and 12. Females in the BSS have higher average BMI except at ages 6 and 8 years.

Analysis of Variance (ANOVA) testing the null hypothesis of no differences in BMI between the BGS and BSS, sex, age and no interactions between these variables is presented in Table 5.25. There are significant differences in average BMI between the two studies ($p < 0.01$) and between age categories ($p < 0.001$), but not between the sexes. The three interaction effects are also not significant. This allows rejection of the null hypothesis of no differences in BMI between the two studies and for age, although this is not immediately obvious in Figures 5.36 and 5.37. The null hypothesis of no differences in BMI for sex and the three interaction effects are accepted. Tamhanes's t^2 post-hoc tests reveal significant differences in specific means at fewer ages than was found for stature and mass.

Table 5.24: Distribution of BMI, standard deviations and sample sizes, BGS and BSS, (n = 252)

			BGS				BSS			
Age	**Male (n)**	**Female (n)**	**Male Mean**	**SD**	**Female Mean**	**SD**	**Male Mean**	**SD**	**Female Mean**	**SD**
6	14	12	16.43	2.18	15.54	1.37	15.94	1.37	15.41	0.95
7	16	16	16.07	0.73	16.61	1.70	16.74	1.30	17.53	2.27
8	19	6	16.83	1.35	16.83	1.30	17.98	2.69	15.65	0.90
9	12	14	16.67	0.80	16.54	1.37	17.77	2.09	17.48	2.41
10	17	20	18.19	2.04	17.40	1.30	17.38	2.04	19.06	3.46
11	25	15	17.84	2.42	18.01	2.37	20.39	2.76	19.70	3.33
12	10	21	19.85	2.91	17.87	2.52	18.22	1.43	21.73	4.15
13	10	7	19.43	1.96	18.54	3.27	20.38	3.34	19.31	4.13
14	11	7	20.63	3.38	21.42	3.26	21.47	3.52	20.73	1.89

Table 5.25: **Analysis of variance (ANOVA) for BMI, BGS vs. BSS (n = 252)**

	Sum of Squares	df	Mean Square	F-value
Source[a]	49.43	1	49.43	8.43*
Sex	2.69	1	2.69	0.46
Age	1004.83	8	125.60	21.43*
Source* Sex	4.11	1	4.11	0.70
Source*Age	63.99	8	8.00	1.37
Sex*Age	46.93	8	5.87	1.00
Source*Sex*Age	139.73	8	17.47	2.98
Within Subjects	2742.78	468	5.86	
Total	169618.76	504		
Corrected Total	4210.40	503		

[a]Source = BGS vs BSS
*(p<0.01)
**(p<0.001)

Figure 5.36: Age-specific mean BMI values for males, BGS vs. BSS (134)

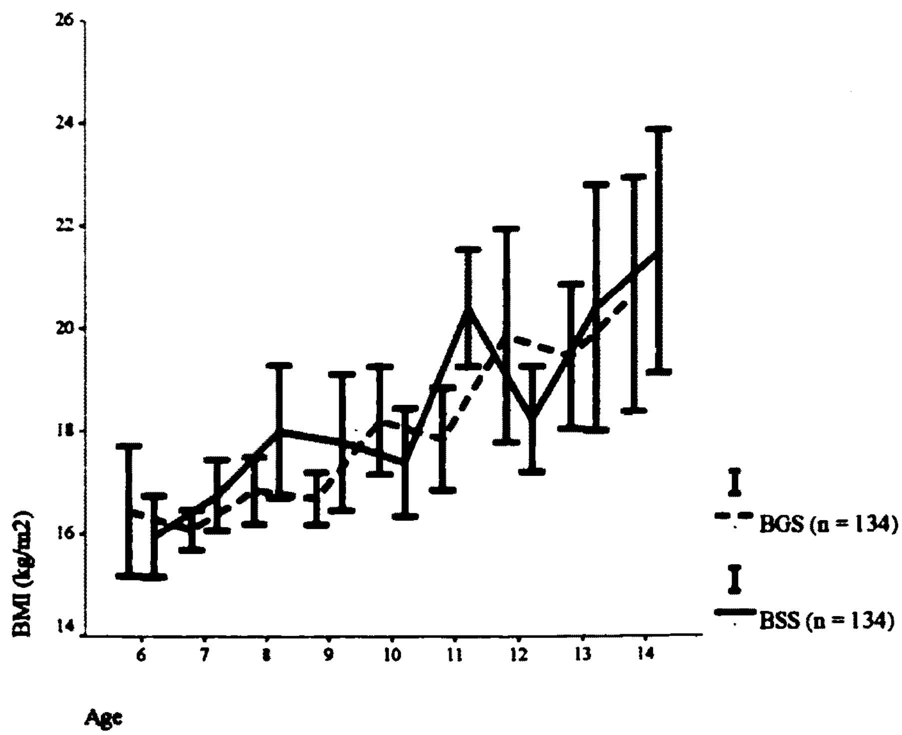
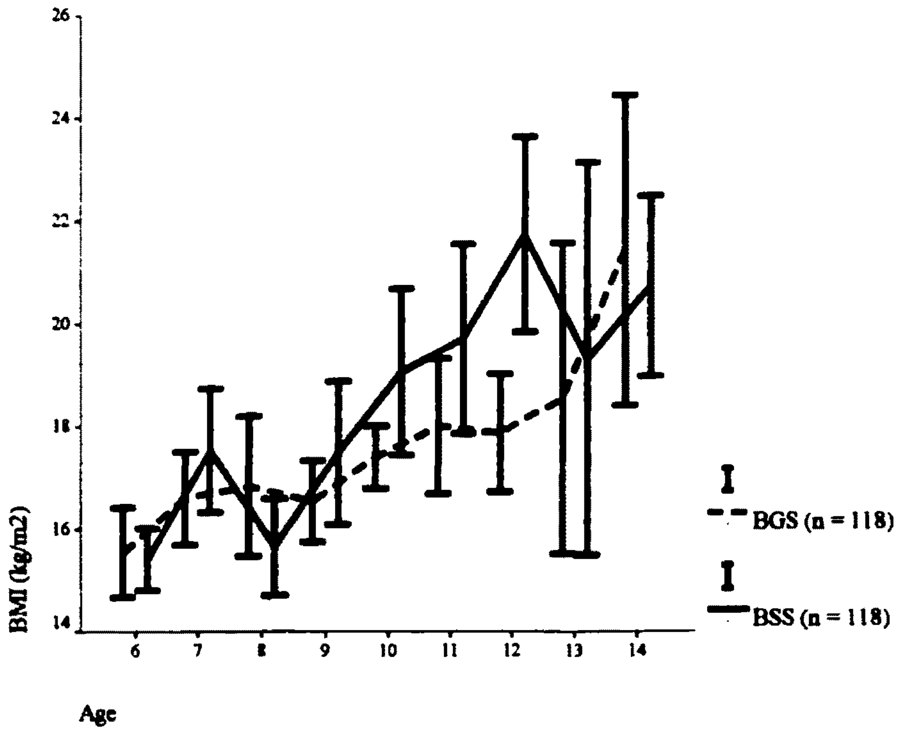


Figure 5.37: Age-specific mean BMI values for females, BGS vs. BSS (n = 118)



Prevalence of "at risk for overweight" and overweight

Table 5.27 presents the proportion of children in each centile category for the BGS and the BSS, relative to American and Canadian reference standards. The majority of children are situated between the 5th and 85th centiles for both studies, although a smaller percentage of the BSS is found within the 5th and 85th centiles (**BGS**: NCHS, m = 81.3%, f = 83.8%; CFS, m = 85%, f = 82.2% and **BSS**: NCHS, m = 80.5%, f = 71.1%; CFS, m = 68.3%, f = 61.8%). Children between 85th and 95th centiles are considered "at risk for overweight" and account for between 6.7% and 22.5% of males and females from both studies (**BGS**: NCHS, m = 14.9%, f = 14.4%; CFS, m = 10.8%, f = 6.7% and **BSS**: NCHS, m = 11.9%, f =17.7%; CFS, m = 22.5%, f = 12.7%). Children above the 95th centile are considered overweight and account for between 0.8% and 15.2% of males and females from both studies (**BGS**: NCHS, m = 0.37%, f = 1.69%; CFS, m = 4.1%, f = 0.8% and **BSS**: NCHS, m = 7.4%, f = 11%; CFS, m = 9.1%, f = 15.2%). Chi-square analysis testing the null hypothesis that the proportion of "at risk for overweight" and overweight is the same for males and females in the two studies was conducted. Results indicate that there is no statistical difference in the proportion of "at risk for overweight" and overweight between males from the BGS and BSS, based on American reference standards (df 1: x^2 = .35). In contrast, males from the BSS were more likely to be considered "at risk for overweight" compared to males from the BGS based on Canadian reference data (df 1: $x^2 = 6.92$; $p < 0.01$), but no difference was found in the proportion of overweight males in the two studies using the two reference standards (Table 5.28). A similar finding using the 85th centile as a cut-off for "at risk for overweight" is seen in females (NCHS, df 1: $x^2 = 1.11$; CFS, df 1: $x^2 = 4.04$; $p < 0.05$)(see Table 5.29). In contrast, the proportion of overweight females (i.e. greater than the 95th centile) is greater in the BSS compared to the BGS when employing either reference standard (NCHS, df 1: $x^2 = 9.22$; $p < 0.01$: CFS, df 1: $x^2 = 18.36$, $p < 0.001$)(see Table 5.29).

In other words, results indicate that in general there are more children "at risk for overweight" and overweight in Burlington, Ontario at present than there were two to five decades ago, especially among females in the overweight category. These findings mirror similar trends worldwide for increased adiposity (WHO 1998).

Table 5.26: Distribution of BMI relative to national standards, BSS and BGS

	Male				Female			
	NCHS	NCHS	CFS	CFS	NCHS	NCHS	CFS	CFS
	BSS	BGS	BSS	BGS	BSS	BGS	BSS	BGS
Centiles	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
< 5	3 (2.2)	5 (3.7)	5 (4.2)	1 (0.8)	2 (1.7)	11 (9.3)	3 (2.8)	4 (3.8)
≥ 5 < 50	20 (14.9)	30 (22.4)	25 (20.8)	51 (42.5)	28 (23.7)	39 (33)	35 (33)	49 (46.2)
≥ 50 < 85	83 (61.9)	74 (55.2)	58 (48.3)	50 (41.6)	54 (45.8)	49 (41.5)	35 (33)	44 (41.5)
≥ 85 < 95	18 (13.4)	20 (14.9)	21 (17.5)	13 (10.8)	21 (17.8)	17 (14.4)	15 (14.2)	8 (7.5)
≥ 95	10 (7.5)	5 (3.7)	11 (9.2)	5 (4.1)	13 (11)	2 (1.7)	18 (17)	1 (0.9)
Totals	134	134	120	120	118	118	106	106

Table 5.27: **Prevalence for "at risk for overweight" and overweight based on U.S. and Canadian reference standards for males, BGS vs. BSS (n = 252)**
BMI based on NCHS and CFS standards (Must et al. 1991b; Canada Fitness 1985)

	At risk for overweight				Overweight			
	<85 £	≥85<95 †			<85	≥95 ‡		
NCHS	n (%)	n (%)	x^2	OR	n	n	x^2	OR
BGS Male	109 (81.3)	20 (14.9)	.35	.81	109 (81.3)	5 (0.37)	1.60	2.02
BSS Male	108 (80.5)	16 (11.9)			108 (80.5)	10 (7.4)		
CFS								
BGS Male	102 (85)	13 (10.8)	6.92*	2.58	102 (85)	5 (4.1)	3.46	2.74
BSS Male	82 (68.3)	27 (22.5)			82 (68.3)	11 (9.1)		

£ Cut off for children of "normal" weight
† Cut off for children "at risk for overweight"
‡ Cut off for children considered overweight
* ($p < 0.01$)
NCHS Males (n=134)
CFS Males (120)

Table 5.28: **Prevalence for "at risk for overweight" and overweight based on U.S. and Canadian reference standards for females, BGS vs BSS (n = 252)**
BMI based on NCHS and CFS standards (Hamill et al. 1977; Fitness Canada 1985)

	At risk for overweight				Overweight			
	<85 £	≥85<95 †			<85	≥95 ‡		
NCHS	n (%)	n (%)	x^2	OR	n	n	x^2	OR
BGS Female	99 (83.8)	17 (14.4)	1.11	1.46	99 (83.8)	2 (1.69)	9.22*	7.66
BSS Female	84 (71.1)	21 (17.7)			84 (71.1)	13 (11)		
CFS								
BGS Female	97 (82.2)	8 (6.7)	4.05**	2.49	97 (82.2)	1 (0.8)	18.36***	23.92
BSS Female	73 (61.8)	15 (12.7)			73 (61.8)	18 (15.2)		

£ Cut off for children of "normal" weight
† Cut off for children "at risk for overweight"
‡ Cut off for children considered overweight
* ($p < 0.01$)
** ($p < 0.05$)
*** ($p < 0.001$)
NCHS Females (n=118)
CFS Females (n = 106)

5.6: Summary

It is clear that on average boys are taller, heavier and have a larger BMI than girls except during the female adolescent growth spurt, which occurs between the ages of 11 and 14. This is generally true for both the BGS and the BSS, however there is more variation between males and females in the BSS, likely because of sample size. These patterns for stature, mass and BMI in Burlington are consistent with what other researchers have found during the last one hundred and fifty years (Eveleth and Tanner 1976, 1990; Krogman 1970). The results also compare favorably to both American and Canadian reference standards, with the Burlington samples following at or slightly above the 50th centile, reflecting normal growth patterns. Different interpretations of the findings emerge depending on which of the two reference standards are employed. This is discussed in more detail in the next chapter.

Employing the BMI as an indicator of excess adiposity, the distribution of BMI and the prevalence of "at risk for overweight" and overweight were calculated for an abstracted random sample from the longitudinal BGS, and for the new BSS. As indicated, males generally have a higher BMI than females, although the distribution is complicated by the larger confidence intervals produced by small sample sizes.

The prevalence rates of "at risk for overweight" and overweight children in the two Burlington samples range between 0.37% and 14.9% for males and 0.8% and 14.4%

for females from the BGS, depending on which reference standards are employed. In the BSS, between 7.4 and 22.5% of males are "at risk for overweight" and overweight compared to 11% and 17.7% of females, again depending upon which reference standards are used to calculate increased adiposity. This substantial increase in overweight is quite similar to increases that have been seen on a global scale by other researchers (Ajlouni et al. 1998; Al-Isa 1998; Blokstra and Kromhout 1991; Gordon-Larsen et al. 1997; Power et al. 1997b). Although the differences between males and females between the two studies are statistically significant, caution is recommended in interpreting the findings due to the small sample available for this analysis.

"Tracking" of annual BMI and inter-age comparisons are investigated by employing the longitudinal data from the BGS. The correlations for annual age to age comparisons and inter-age comparison produce strong statistically significant, positive correlations ranging from 0.64 to 0.95. Further, males have higher age-to-age correlations than females that are more stable over the nine year time period. Similar results have been found by other researchers "tracking" adiposity rates (Clarke and Lauer 1993; Guo et al. 1994; Katzmarzyk et al. 1999).

The above results are discussed in the following chapter relative to American and Canadian reference standards and other studies that employ stature, mass and the BMI as variables to assess growth and development.

Chapter 6

Discussion

6.1: Introduction

This chapter explores the results from the current study with reference to the three central themes outlined in chapter one and which have been alluded to throughout: 1) public health and anthropometry, 2) methodological considerations and anthropometry, and 3) historical studies and anthropometry. Stature and mass are discussed in tandem, while BMI is discussed separately.

6.2: Public Health and Anthropometry

Stature and Mass

When stature and mass are compared at two or more points over a lengthy time period, researchers are generally interested in understanding whether children and/or adults have been getting taller, heavier, shorter or lighter. Fluctuations in growth patterns, often referred to as secular changes, reflect positive and negative growth and development in a population and can provide a window for understanding the general health and well-being, or lack thereof, for that population.

Results from the Burlington study indicate that stature and mass, on average, are greater in the recent BSS at most ages for each sex, when compared to the earlier BGS, suggesting a secular increase in these measures over the last 50 years (see Table 5.20 and 5.22, chapter 5). Actual differences appear quite small, although ANOVA results indicate significant differences between the two samples ($p<0.001$) (see Table 5.21 and 5.23, chapter 5). These findings are akin to the results of other studies, conducted in North America and abroad, that have shown similar gains in stature and mass for children over the last century. A case in point is the study by Sugarman and colleagues (1990) who found secular increases among Navajo school children, ages 5 - 17 years, between 1969 and 1989. They discovered that boys and girls had mean height increases of 6.1% and 4.4% respectively, while weight increased by 28.8% and 18.7%, respectively. Dubrova et al. (1995), who studied Russian females and their offspring between 1950 and 1990, also recognized secular increases in stature and mass, as did Hoppa and Garlie in their 1998 study of stature changes among Toronto children from 1891 to 1977. Similar secular increases in stature and mass have been seen in a multitude of studies of children and adolescents over the past several years (see Table 6.1). Secular increases for stature and mass have also been recognized over the last 150 years among the adult population.[1]

This global trend toward increased stature and mass is generally regarded as a reflection of significant improvements in standards of living, nutrition, and health care

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[1] See for example, Kimura 1984; Little et al. 1983; Mann et al. 1962; Mendez and Behrhosrts 1963; Mueller et al. 1980; Roede 1985; Sabharwal et al. 1966.

(Eveleth and Tanner 1976,1990; Gorden-Larsen et al. 1997; Hoppa and Garlie 1998; Malina et al. 1987:519; Prince 1995; Sobral 1990). Although the complex interactions between biology and environment underlying growth were not investigated in this study it is quite possible that the observed secular trends for Burlington, Ontario stem from general improvements in socioeconomic status and in health services during the 1970s and 1980s (C.C.C. 1967; Loverseed 1988). Increased sedentary behaviour and over nutrition likely account for the increased mass observed in the Burlington study.

BMI, "at risk for overweight" and overweight

Of substantially greater interest to researchers and the general public, are the changes in the composite BMI measurement during the last two decades that reflect an ever increasing trend towards being "at risk for overweight" and overweight worldwide (see Ajlouni et al. 1998; Al-Isa et al. 1998; Campaigne et al. 1994; Flegal et al. 1998; Gordon-Larsen 1997; Kuczmarski et al. 1994; Martorell et al. 1998; Melnik 1998; Popkin and Udry 1998; Power et al. 1997b).

In this study, the BMI among males and females follows the same general pattern outlined for stature and mass (i.e. males generally have larger BMI values except during the female adolescent growth spurt). BMI, however, is much more variable than stature and mass. This may reflect the fluctuations in mass during the mid-teens and after, when parental influences on nutrition and physical activity tend to wane. Sample size may also contribute to the variability seen in BMI values in the BSS sample.

Secular increases in the prevalence of overweight and obesity have clearly been seen over the past 30 years (Gordon-Larsen et al. 1998; Kuczmarski et al. 1994; Sugarman et al. 1990). Unfortunately, direct comparisons of results between studies is difficult owing to methodological and practical differences. In the Burlington study, the 85th to the 95th centile is used to identify children "at risk for overweight" and above the 95th centile to identify overweight individuals, following the recommendation of Himes and Dietz (1994) and the World Health Organization (WHO 1997). Using these standards, it is clear that more children in the BSS (1998-1999) are categorized as being "at risk for overweight" and overweight than in the earlier BGS (1952-1972) (Table 6.1). This apparent secular increase in the BMI and in "at risk for overweight" and overweight children in the current study is consistent with the results from other studies conducted in North America. For example, a 1994 Canadian study indicates that the prevalence for childhood obesity in Canada ranges from 7% (King et al. 1985) to 43% (Stephens and Craig 1990), depending on whether obesity is self-reported or based on objective measurements, and on what measure of obesity is employed (i.e BMI or skinfolds) (cf. Canadian Task Force on the Periodic Health Examination 1994). Lechky (1994) indicates that the prevalence of obesity has increased 50% in children aged 6 - 11 years and 40%

among adolescents aged 12 - 17 years; while Østbye and colleagues (1995) find that the prevalence of overweight in males and females is 52.4% and 32.8%, respectively and obesity is 33.6% and 22. 8%, respectively. This is somewhat higher than that found in the Burlington study (Table 6.1).

In the United States, a study of African American children aged 11-15 years by Gordon-Larsen and colleagues (1997) found that BMI increased for all age groups between 1970 and 1990. Employing the 95th centile as an indicator of obesity they found that in 1990, 17% of males and 18% of females were overweight compared to 6% and 9% in 1970. An increase of 3% to 24% for males and 10 to 34% for females was found when using the 85th centile to reflect overweight between 1970 and 1990. Melnik and colleagues' (1998) study of 2nd and 5th graders in New York city, based on the 85th centile, found that 37.5% of second grade students and 31.7% of fifth grade students were overweight. When using the 95th centile, the prevalence of overweight was 19.9% and 17.8% respectively. A number of other studies have also found similar increases in overweight and obesity in the United States (see Table 6.1).

The phenomenon is not limited to North America, but has been found among children and adolescents worldwide (see for example, Al-Awadi and Amine 1989; Eaton et al. 1990; Jeffery et al. 1984; Magbool 1994; Rasheed et al. 1994; Stark et al. 1981; Stewart and Brook 1983; The Royal College of Physicians 1983; Wolfe et al. 1994).

Similar trends for increased overweight and obesity have also been found among adults.[2]

"Tracking" of BMI or other adiposity indicators has become more common, as researchers seek to understand the timing for the onset of overweight and obesity and whether adult obesity can be predicted from childhood and adolescent measurements. Opinions vary. For example, Serdula and colleagues (1993) found that the risk of adult obesity is 2 to 2.6 times greater in preschool children who are obese compared to preschool children who are not. This rate of risk for adult obesity increased to between 3.9 and 6.5 times when obese school age children were compared to non-obese school age children. Similarly, Whitaker and colleagues (1997) found that young adult obesity is associated with child obesity at 3-5 years but not at 1-2 years. This suggests that establishing a critical age for the onset of obesity is desirable and possible, but research is limited (Katzmarzyk et al. 1999). A number of other studies have seen similar results regarding the "tracking" of adiposity indicators (see Schroeder and Martorell 1998; Guo et al. 1994; Power and et al. 1997a; Baumgartner and Roche 1988; Katzmarzyk et al. 1999; Casey et al. 1992; Clarke and Lauer 1993; Gasser et al. 1995; Guo et al. 1994; Rolland-Cachera et al. 1987, 1989; Power et al. 1997b).

In general, it appears that the prediction of adult obesity depends on the age at

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[2] For studies relating to increased overweight and obesity in adults, see Canada's Health Promotion Survey 1990; Malina et al 1987; Merideth 1963, 1976; Kuczmarski et al. 1994; Feinleib 1985; Flegal et al. 1998; McGarvey et al. 1993; Knolwer et al. 1991; Shah et al. 1991; Sichieri et al. 1991; Kuskowska-Wolk and Rossner 1990, 1991;, Al-Isa; 1998; Atalah 1993; Beckles et al. 1995; Campos et al. 1992; Sinha 1995.

which obesity manifests itself (i.e. the older the child, the better the predictive value available) and the extent of obesity (i.e. the more obese the child, the more likely that individual will become obese as an adult). In the current study, "tracking" of BMI values over a nine year period revealed significant associations for inter-age comparisons and the status of BMI at age 14 when compared to younger ages ($p < 0.001$). This suggests positive outcomes for the prediction of BMI at two different periods for this study. The predictive value appears to increase when measurements are taken close together (i.e. age 10 and 14 vs. age 6 and 14). While the Burlington findings tend to agree with those from other studies, somewhat higher correlation coefficients were detected ($r = 0.64$ to 0.95). This may reflect the longitudinal nature of the BGS sample and the tightness of the 6-14 age cohort.

6.3: Methodological Considerations in Anthropometry

As indicated throughout this study, inter-study comparisons of anthropometrical results are important, but difficult, owing to various methodological and practical differences used to collect and assess growth information. These include disparate measurement techniques, the use of different reference standards, and a plethora of definitions and indices to define "at risk for overweight", overweight and obesity. In general, these difficulties are more directly applicable to the measurement and identification of overweight and obesity rather than to the collection and analysis of stature and mass (see chapter two and below).

Stature and Mass

Stature and mass are the two most commonly measured variables in studies of the growth and development of the human form owing to the ease with which they can be collected. In general, the collection of stature and mass is trouble free, allowing for easy inter-study comparisons. Some problems do arise, however, from the use of different anthropometric equipment. For instance, portable stature rods, stature rods attached to beam scales, measuring apparatus attached to walls, spring scales and portable scales, can all produce slightly different measurements. The magnitude of the differences however tends to be quite small and does not affect comparisons (Malina et al. 1974:63). Subject positioning, parallax difficulties and intra-observer error can also introduce measurement error into a study, but again these errors are fairly small if the procedures are done carefully (Malina et al. 1974:63). In the Burlington study, following the lead of other researchers, I employed the measurement techniques outlined in **Anthropometric Standardization Reference Manual** (Lohman et al. 1988) and collected all the measurements myself to limit the amount of introduced error. An intra-observer error study performed on the new BSS indicated a low technical error of measurement and high reliability coefficients for stature and mass comparable to other studies using similar methodology (see Cameron 1984:101; Malina et al. 1974:66).

The analysis of stature and mass measurements presents other difficulties for the researcher interested in conducting comparisons between studies, although these problems are less complex than those associated with obesity and overweight (see below). The primary difficulty, in this case, is the statistic used to interpret stature and mass. In the majority of cases, mean or average stature and mass are used to describe the sample; in others, median and log transformations of stature and mass are employed to alter the distribution of raw data. This hampers straightforward comparisons between studies. The Burlington study follows the most common protocol by employing mean stature and mass for analysis of the samples.

A second difficulty that arises during the analysis of information on stature and mass relates to the choice of reference standards used to interpret the data. Several researchers have argued that a single, nationally (or internationally) representative reference sample should be employed in order to standardize comparisons within and between studies (Gibson 1990; Hamill et al. 1979). Ideally, a standardized reference sample would permit a baseline value against which deviations can be measured. At present, the reference sample recommended by the World Health Organization (WHO 1997) stems from the United States and is based on several nationally representative surveys of the population conducted since the 1960s. Other information in these reference samples comes from data collected by the Fels Longitudinal growth study which began in 1929. Some researchers have argued against a single global standard, asserting that growth data should be based on reference samples from similar populations because individuals in different countries grow and develop differently than those in the United States (Goldstein and Tanner 1980; Macfarlane 1995). The most significant problem with this argument is that many countries have not developed reference standards; those that have are based primarily on individuals from the higher socioeconomic classes and do not reflect the majority of the population any more than the United States reference standards.

In the Burlington study I described my two samples relative to the American and Canadian reference standards for stature and mass (Hamill et al. 1977; Canada Fitness 1985). Differences in interpretation emerge when the Burlington results are compared to these two reference standards. A case in point is the classification of individuals into different centile categories for stature, mass and BMI. These differences are largely due to the fact that the Canadian standards were drawn from a smaller sample compared to the U.S. standards. The methodology used for collecting data in the Canada Fitness Survey (1985:2) may also contribute to the problem. For instance, stature and mass were estimated if no measurements were available. In other Canadian surveys stature and mass often have been self-reported (for example, Østbye et al. 1995), and may produce over-estimates of stature and under-estimates of mass. The age grouping of reference standards may also introduce differences. In the U.S. reference standards age categories are grouped around mid-age (i.e. a 7 year old reflects children aged 6.51-7.49), whereas in Canadian standards the ages are rounded to the nearest whole age. The Burlington study follows the U.S. methodology for calculating age groups. The argument about which reference standards to adopt will likely continue and is addressed in the following chapter.

BMI, "at risk for overweight", overweight and obesity

Although some difficulties arise from the measurement, analysis, and comparison of stature and mass, they are quite minimal when compared to the problems facing researchers attempting to quantify and interpret overweight and obesity from a sample of individuals.

The first problem facing researchers is that there is little agreement on the definition of "at risk for overweight", overweight and obesity. In general, overweight and obesity are the result of excess adipose tissue on the body reflected by the increased number or size of fat cells (for example, Poskitt et al. 1995). However, definitions of obesity reflect cultural ideologies surrounding what is consider overweight or obese (Poskitt et al. 1995).

The second major problem that researchers encounter is how to measure body fat and quantify overweight and obesity? As illustrated in Chapter 2, a number of technologically complex methods are available to measure overall body fat and estimate overweight and obesity (see Shephard 1991). The primary problem with all of these methods is the time and cost involved in collecting the data, and the invasive nature of some of the methods. Other less complex methods have been developed to estimate body fat and overweight, including skinfold measurements, weight to hip ratios and weight to height ratios. Although skinfold information, when measured correctly, presents an effective method for interpreting overweight and obesity, identification of the specific landmarks for conducting these measurements is sometimes difficult, especially in morbidly obese individuals. Furthermore, the underlying muscle is often mistakenly included in the skinfold measure and the invasion of personal space sometimes limits the ability to attempt this type of measurement. In the BSS, for example, school board officials would not permit me to collect skinfold data because of the intimate nature of the measurement. Various weight to hip and weight to height ratios have also been developed to reflect overall body fat and classify obesity. Unfortunately, some of them create problems for interpreting results because these ratios are not comparable across studies. More importantly, there are no reference standards against which to compare these various indices. The BMI (Quetelet's index, weight/height^2) avoids these pitfalls. It has proven to be the most useful ratio with which to investigate relative fat. The BMI generally has strong correlations with skinfold measurements (Himes and Dietz 1994), is based on the most common and least variable measurements, and has well developed reference standards. It remains the method of choice for this and many other studies investigating overweight and obesity (Himes and Dietz 1994; WHO 1998). The versatility of the BMI also provides a significant advantage for investigating overweight and obesity from historical studies.

6.4: Anthropometry in Historical Studies

The final theme highlighted throughout this study is the value of anthropometry in historical perspective. As stated above, stature and mass have been recognized as significant indicators of individual and population health and as such, have been collected in the past for a multitude of reasons (i.e. growth studies, military recruitment and medical surveys). These measurements are collected using methods essentially unchanged over the past two hundred years. The composite BMI, derived from these measurements, also provides important information regarding health and nutrition in the population, and hence, also provides a significant advantage for looking at changes in overweight, obesity and the general health and nutrition from the past to the present. On the other hand, there is increasing difficulty in acquiring many of the anthropometrical measurements that have been used in the past for assessing growth and development (i.e., testicular and breast development and development of secondary sexual characteristics) as the procedures are considered to be far too invasive. As discussed previously, the initial proposal for the BSS project was rejected by school board officials until it was agreed that only stature and mass would be collected. Even so, there were many questions from parents and the students themselves that indicated a large degree of discomfort with the study. Consequently, conducting studies in the school setting proved difficult. Hence, it is important to find avenues of research for evaluating child growth, especially in view of the current concern over increased obesity worldwide. I believe that continued research on school children could prove to be valuable, especially if nutritional and activity pattern information can be collected to assist in interpreting the growth data. However, significant efforts to explain the research to the schools, parents and students needs to be undertaken in order to gain access to such data. The use of such historical studies, like the Burlington Growth Study, may be helpful in establishing research relationships with schools and parents in the present setting and for developing research designs to examine changes in growth patterns from the past to the present.

Table 6.1: Summary Review of articles related to changes in stature, mass, BMI, "at risk for overweight", overweight and "tracking"

Study	Location	Sample	Method	Variables	Results
Abraham and Nordsieck (1960) Follow-up Study	Hagerstown, Md. (1937 - 1939 and 1958), United States	children 10 - 13 years old boys = 977 girls = 966 Adults = 120	Physical examination, with indoor clothing, no shoes	Height, weight and relative weight	- Overweight children tend to become overweight adults more often than children of average weight.
Baumgartner and Roche (1988) Retrospective Study	Melbourne (1954 - 1968), Australia	Semi-longitudinal database varies in size. Longitudinal database = 83 children (4 - 14 years of age). males = 42 females = 41	Standard Anthropometrical Methodology	Stature, weight, skinfolds, skeletal age and BMI	- Mean BMI increased with age for each sex. - Inter-age correlations for BMI were approximately stable across age ($\bar{x}$ r = 0.90).
Campaigne et al. (1994) Cross-sectional study	Berekley, Cincinnati and Rockville (1990s)	Girls, 9 and 10 years old African American (n = 1213) Caucasian (n = 1166)	Standard Anthropometrical Methodology	Height, weight, BMI (85th centile) and skinfolds. Reference standards taken from Frisancho (1990)	- African American girls were taller, heavier and had a greater BMI at each age. BMI above 85th centile (34.7% and 24.7% vs. 19.1% and 22.9%). - Both groups taller, heavier and have greater BMI values than comparative reference standards.
Canadian Task Force on the Periodic Health Examination (1994) Review article	Canada	Childhood	Medline search regarding overweight and obesity in childhood	Height, weight, skinfold thickness, BMI	- Prevalence of childhood obesity in Canada (7% to 43%). - Recommends continued collection of height and weight information to monitor the situation. - Evidence does not support the inclusion or exclusion of obesity screening, treatment of obesity, exercise or family based education, from periodic health examination. Low energy diets for children are not recommend as these have a greater adverse affect.

Table 6.1: Summary Review of articles related to changes in stature, mass, BMI, "at risk for overweight", overweight and "tracking"

Clegg (1982) Cross-sectional	Isle of Lewis, Scotland	Children 11-13 years of age males=133 females=120	Followed IBP full list of measurements	Stature, weight, ponderal index, relative sitting height, log of skinfolds, arm muscle and bone area	- Males from west of Island heaviest and fattest. - Argues that environmental factors rather genetic factors are the key reasons. - Although about the same stature as UK references standards, the children were lighter.
Cronk et al. (1982) Longitudinal study	Pooled data from Berkeley, Denver, Fels, Harvard, Guidance, and Oakland longitudinal growth studies (begun in 1920s and early 1930s)	Children 3 months to 18 years. Sample sizes vary males = 21 - 277 females = 20 - 263	Standard anthropometric methodology	BMI, calculated from stature and weight	- "Tracking" BMI has better continuity in females during childhood and adolescence. - Males generally larger BMI values except during the female adolescent growth spurt.
Garlie (2000) Mixed - longitudinal	Canada (1953-1972 and 1999)	Children 3 to 20 years n = 1367 and 6 -14 years (n =252)	Standard anthropometrical methodology	Stature, Mass, BMI	- Secular trend apparent for stature, mass and BMI between BGS and BSS - Significant increases in "at risk for overweight" and overweight between the BGS and BSS, especially among girls.
Gasser et al. (1994) Prospective Longitudinal study	Zurich Growth Study Switzerland (1954-1974)	Children 1 month to 20 years males = 120 females = 112	N/A	W/H, W/H^2, W/H^3 and W/H^p and skinfolds	- W/H^2 most reasonable index of obesity to use from childhood to adulthood. - Usual log transformations were unsatisfactory and recommend separate transformations for stature and mass, and BMI.

Table 6.1: Summary Review of articles related to changes in stature, mass, BMI, "at risk for overweight", overweight and "tracking"

Gordon-Larsen et al. (1997) Cross-sectional	Philadelphia (1950s - 1990s)	African American Children 11- 15 years of age (1960) males = 372 females = 375) (1970) males = 291 females = 262) (1990) males =203 females = 189).	Standard anthropometric methodology	Stature, weight, upper arm circumference and skinfolds	- Increased stature, weight and BMI over time. - 85th centile 1970 to 1990 (m = 3% to 24%; f = 10 to 34%). - 95th centile from 1970 to 1990 (m = 6.0% and 17.0%; f = 9.0% and 18%).
Guo et al. (1994) Retrospective longitudinal study	Fels, Guidance, Harvard and Oakland (1929-1960)	Caucasian Children 1 to 18 years and again at 35 +/- 5 years males = 277 females = 278	Standard anthropometric methodology	Stature, recumbent length, weight and BMI	- Childhood overweight, based on BMI, has value for predicting adult overweight at 35 years. - The older the child the better the prediction value, using BMI.
Henneberg and Louw (1998) Cross-sectional study	Cape Town, South Africa (1986-1988)	"Cape Coloured" children, 5-20 years old. Urban males = 906 females =1068 Rural males = 834 females = 940	Standard anthropometric methodology	Height, weight, skinfolds and other anthropometric measures. No BMI	- Heights and weights of prepubertal urban children match U.S. standards but decline somewhat post-pubertally. - Rural children lie about 1 standard deviation below the urban sample. Improvements in living conditions should target the rural areas.
Himes and Dietz (1994) Review of overweight guidelines	United States	Adolescents	N/A	BMI, skinfolds	- Screening important - Recommends cut-offs - Overweight, BMI >= 95th percentile - "At risk for overweight", BMI >= 85th < 95th.

Table 6.1: Summary Review of articles related to changes in stature, mass, BMI, "at risk for overweight", overweight and "tracking"

Hoppa and Garlie (1998) Cross-sectional	Toronto, Canada and United States (1891-1977)	Children (4 to 18 years old). males (655 - 39,550) females (657 - 38,503)	N/A	Stature	- Positive trend for increased attained height for age from 1891-1977. - Reflects continued global trend in stature.
Janghorbani and Parvin (1998) Cross-sectional	Kerman, Iran (1995)	Iranian school girls ages 14-21 (n = 1000)	Standard anthropometric methodology	Height, weight, BMI and other anthropometric variables	- Grade 1 BMI(25-29) 4.6%. - Grade 2 BMI (20-29.9)7%. - Grade 3 BMI (>40) 0%. - Underweight BMI(15-19.9) 54.6%. - Very Underweight BMI (<15) 1.6%. - Low prevalence of overweight and high prevalence of underweight.
Katzmarzyk et al. (1999) Follow-up study	Canada (1981, 1988)	Canadians 7-69 years of age males = 1048 females = 1063	Standard anthropometric methodology	Stature, body mass, waist circumference and skinfolds, BMI	- Obesity and adipose tissue distribution demonstrated significant tracking in the Canadian population. - BMI "tracking", 0.53 - 0.91.
Lechky (1994) Report	Canadian	Children 6-17 years	N/A	N/A	- 20% of Canadian children are overweight. - Last 15 years obesity has grown by 50% in children 6-11 years old and 40% in children 12-17 years old.
Magbool (1994) Cross-sectional and cluster sample	Saudi Arabia	children six to 16 years males = 10,731 females 10,907	Standard anthropometric methodology	Stature, weight, BMI, age transformation of reference standards	- BMI increased with age for each sex. - Median BMI was higher in females for all ages. - Generally lower BMI than U.S. reference standards except for females after the female pubertal growth spurt. - Attributes differences to genetic influence that is set by the age of seven years and is more important than environmental factors.

Table 6.1: Summary Review of articles related to changes in stature, mass, BMI, "at risk for overweight", overweight and "tracking"

Malina et al. (1987) Cross-sectional	United States 1928, 1972, 1983	Mexican American children 7-17 years old (1928) males = 707 females 735 (1972) males = 619 females = 650 (1983) males = 403 females = 465	Standard anthropometric methodology, with one pound subtracted for clothing to mimic nude weight	Median stature, mass and BMI	- Males and females show secular increases in stature, mass and BMI. - Males have a greater secular changes than females in stature. - Weight was more variable but changes larger than stature. - Girls showed a larger gain in BMI than males.
Martorell et al. (1998) National Surveys	South America (1986 - 1996).	Children (1 to 5 years old) and Women	Standard anthropometric methodology, with one pound subtracted for clothing to mimic nude weight	stature, weight, BMI defined in terms of z-scores, plus other anthropometric data	- Overweight in chidlren 1-5 years of age ranges from 6% to 24% among 13 countries. - Prevalence was greater in urban households of higher SES. - Child obesity increased with maternal education. - No general pattern of change in children over time.
Melnik et al. (1998) Cross-sectional	New York, New York	Second grade males = 332 females = 360 Fifth grade males = 315 females = 389)	Standard anthropometric methodology with one pound subtracted for clothing to mimic nude weight	Stature, mass, BMI, household questions	- Overweight is prevalent among elementary students in NYC. - 2nd grade overweight - Males, 85th centile (40%); 95th centile (22.7%). Females, 85th centile (35.2%); 95th centile (17.3%). - 5th grade - Males (34.3% and 21.8%); females (29.6% and 14.6%). - Sex and ethnic differences are present for overweight.

Table 6.1: Summary Review of articles related to changes in stature, mass, BMI, "at risk for overweight", overweight and "tracking"

Must (1996) Review	United States	Childhood	N/A	BMI	- Short-term morbidity and mortality not generally associated with obesity. - Long term health consequences arise from long term obesity. - Obesity in children often means obesity in adulthood. - Greater health effects are found on those who are obese at a younger age and who carry it longer. - Females appear to be less affected.
Must et al. (1992) Follow-up Study	United States, Harvard Growth Study	Childhood (13-18 years), same children as adults 55 years later.	Standardized methods from the Harvard Growth Study (1922-1935)	BMI	- 52% of the subjects overweight during adolescence were overweight as adults. - Relative risks of death from all causes for men about 2 times greater among those who had been overweight in adolescence. - No increase in relative risk for women according to weight category. - Overweight in adolescence increased the risk of morbidity for several conditions in men, women, or both and it compromised functional capacity in women. - Several adverse health effects occur in adulthood are associated with being overweight during adolescence.
Pett and Ogilivie (1953) Health Survey	Canadian	Children 2-19 yeras old and adults 20- 65+	Standardized anthropometrical methodology	Stature, mass and skinfolds	- developed standardized numbers for stature, mass and skinfolds from the Canadian population.
Popkin and Udry (1998) National survey	Untied States, Anglo, African American, Hispanic and Asian American	Children aged 12-22 years of age	Standardized anthropometrical methodology	BMI	- Males were more obese than females except for Black males who were larger than females. - A total of 26.5% of the sample were obese. White non-Hispanics 24.2%, black non-Hispanics 30.9%, Hispanics 30.4%, Asian-Americans 20.6%. - Asian Americans and Hispanic adults are more than twice as likely to be obese than are first generation residents of the United States.

Table 6.1: Summary Review of articles related to changes in stature, mass, BMI, "at risk for overweight", overweight and "tracking"

Power et al. (1998) Review	N/A	children		stature, mass, BMI	- Review of studies examining the basic methods for assessing child and adolescent adiposity. - Summary of evidence on the relationship between child, adolescent and adult adiposity (i.e. tracking) - Review of the long term outcomes of child and adolescent adiposity. - Fatter children tend to be obese in adulthood. - Obese adults are generally not obese as children. - Associations of adult obesity strengthen with increasing age in childhood.
Power et al. (1997)	Britain	children 7, 11, 16, 23 and adults 33	Standardized anthropometrical methodology	stature, mass BMI, log_e(weight), log_e(BMI) and -1/BMI	- Adult height was well predicted from childhood (r= 0.7) for both sexes, between height at ages 7 and 33). - Correlations were weaker for BMI (r=.033 males, r=0.37 for females ages 7 and 33 years. These increased with age. - Obese children tend to be obese adults. - Obese adults generally were not obese as children. - A strong association between timing of puberty and BMI. - High BMI for early maturerers. Obese adults could not be identified as obese children, hence preventative measures should be population based.
Robinson (1999) Randomized Controlled Trial	United States	3rd and 4th grade children (mean age 8.9 years) n = 192)	NA	stature, mass, BMI, skinfolds,	- Children in the intervention group had significant decreases in BMI compared to control group. -Intervention group also showed significant differences in amount of television viewing and meals eaten in front of the television. - No significant differences in the intake of high-fat food, or physical exercise. - Reduction in televison, videotape and video games may be a good approach to obesity prevention in childhood.

Table 6.1: Summary Review of articles related to changes in stature, mass, BMI, "at risk for overweight", overweight and "tracking"

Rolland-Cachera et al. (1987) Longitudinal	French (Began in 1953)	children 1 month to 21 years Sample size varies	Standard anthropometrical methodology	stature, mass and BMI	- Twice as many fat infants became fat adults. - Only 42% of lean, medium and fat stayed in their original category. - Adiposity rebound was an important factor related to fatness.
Rollan-Cachera et al. (1982) Longitudinal	French (Began in 1953)	Children 1 to 16 years Sample size varies	Standard anthropometrical methodology	stature, mass, W/H, BMI, W/H^3	- BMI proved the most useful index to assess adiposity in children.
Serdula et al. (1993) Epidemiological review	(1970 -1992)	Children and follow up at adult ages.	NA	BMI, W/H^3, W/H^b, W/H, Skinfolds	- Comparisons are difficult because of study design, definitions of obesity and analytical methods used. - Correlations varied considerably but associations were positive. - 26% to 41% of obese preschool children were obese as adults. - 42-63%) obese school age children were obese as adults. - All studies and all ages showed that the risk of adult obesity was at least twice as high for obese children as for non-obese. - Risk was higher among children who were at higher levels of obesity and who were obese at older ages. - Most obese adult were not obese as children.
Sugarman et al. (1990) Cross- sectional surveys	United States, 1955, 1968, 1981,1989	children 5 to 17 years of age Sample size varies	standardized anthropometrical methodologies	Stature, mass, BMI	- Twice as many children exceeded the 95th centile of weight for ages. - Secular trend in stature, mass and BMI between 1955 and 1989. - Stature (m = 6.1% and f = 4.4%) - Weight (m = 28.8% and f = 18.7%)

Chapter Seven

Conclusions

The primary purpose of this study was to investigate changes in stature, mass and BMI within and between two groups of children from Burlington, Ontario during the last 50 years of the twentieth century. This research was further designed to examine the prevalence of "at risk for overweight" and overweight children from the Burlington Growth Study and the Burlington School Study relative to U.S. and Canadian reference standards. "Tracking" of BMI values over a 9 year duration in the BGS was also investigated as a means to assess its predictive value for inter-age associations, annually and for longer periods (i.e. associations at age 6 and 14 years).

In Canada, the United States and abroad, studies have detected increases in stature, mass, BMI, overweight and obesity among children during the last century (see Bogin 1999; Eveleth and Tanner 1990; Hoppa and Garlie 1998; Malina et al. 1987). These changes are thought to result from complex interactions between the biology, environment and culture of the human mammal (Bogin 1999; Eveleth and Tanner 1990). Although the Burlington study was not designed to identify the web of interactions related to transformations of growth patterns, it provides a unique opportunity to examine such changes in a relatively ethnically homogenous group of children over a 50-year period in a localized region of Canada. The BGS and BSS samples both indicate a population of children experiencing normal growth, with both samples on average lying at or just above the 50th centiles compared to U.S. and Canadian reference standards (Hamill et al. 1977; Fitness Canada 1985; Must et al. 1991b).

The Burlington Growth Study (1952-1972), a mixed-longitudinal sample collected over a twenty year period, offers a clear look at growth from the young child to the young adult during the post-war expansion era of the 1950s and 1960s. The Burlington School Study (1998-1999), a cross-sectional sample of children attending one of the schools contained in the BGS, made it possible to investigate stature, mass, BMI, "at risk for overweight" and overweight among Canadian children in the 1990s. Comparison of the results from the two studies identified the presence of small but significant secular changes in stature and mass. More importantly the findings point to substantial increases in overweight children and those “at risk for overweight” in the Burlington, Ontario region over the study period, especially among females, who were at double the risk of becoming overweight in the recent BSS compared to the BGS.

The findings mirror patterns found in Canada, the United States and elsewhere (see for example, Al-Isa 1998; Gordon-Larson et al. 1997; Lechky 1994:78; Sugarman et al. 1990). I am unaware at this time of any other Canadian study that investigates changes in stature, mass and BMI in children from a contemporary study conducted in the same locality as an earlier historical study. The Saskatchewan Growth and Development Study (SGDS), however, is currently conducting a follow-up study of the participants from their original investigation (1964-1974). The SGDS originally included male and female children who were followed from ages 7 to 17 years in an attempt to evaluate changes in physiological response to a variety of variables. The follow-up study attempts to recall original participants in an effort to evaluate how adolescent physical activity patterns affect adult health outcomes (Bailey 1969; Department of Kinesiology, University of Saskatchewan 1996-1998).

Few studies are still in operation which investigate growth phenomenon in a single area over a lengthy time frame. One notable exception in the United States is the Fels Growth Study, which collects and analyzes growth data under the auspices of the Wright State University in Ohio. The Fels study has collected growth data since its inception in 1929 and continues to follow participants of the study and/or their offspring (Roche 1992). Globally, there are numerous studies that attempt to unravel the patterns of human growth and development and evaluate the importance of biological, cultural and environmental factors affecting human growth patterns. Many of these are based in developing countries and have tried to analyze growth in a longitudinal fashion, however, they are generally short term, lasting only a few years. Further, they have not benefitted from the many long term historical growth studies initiated at the beginning of this century in several developed countries (Bogin 1999).

Although it was beyond the scope of this study to investigate the factors contributing to secular trends in growth in Burlington, it is likely that the observed increase in stature reflects the continued trend in this direction seen globally during the past 150 years. Such increases are often associated with improvements in nutrition, sanitation and health care (Eveleth and Tanner 1990; Hoppa and Garlie 1998). The magnitude of the increase in the proportions of children "at risk for overweight" and already overweight in the BSS data is cause for concern as it augurs serious future problems for adult health (Bouchard 1997:926; Guo et al. 1994; Himes and Dietz 1994). These include significant increases in chronic diseases, such as diabetes and various types of cancers (Must et al. 1992; WHO 1997) and a significant burden on health care services (Birmingham et al. 1999; Lechky 1994:78).

The recent rise in the number of overweight and obese children is often considered to be a product of increased amounts of sedentary behaviour (e.g.,. time spent in television viewing and computer use, as well as a lack of physical activity, either in or out of school) and consumption of foods high in fat (or caloric intake), among other biological, social and environmental factors (NIH 1993; WHO 1997). In reality, to ascribe an increase in overweight and obesity, let alone stature and mass, to either biological or environmental factors is too simplistic. As Bogin (1999:240) argues, "... the biological development of the human being is always due to the interaction of both genes and the environment". The distinction between genes and the environment can be difficult to ascertain but it seems clear that environmental and cultural factors have a strong influence on the growth and development of children (Bogin 1999; Eveleth and Tanner 1990).

In North America, foods high in fat are often associated with convenience foods and tend to reflect the busy lifestyles of parents who have little time for cooking well balanced meals in the home. Consumption of high energy foods, in terms of caloric intake instead of fat intake, are also related to increased adipose tissue. A case in point for calorie laden foods comes from a comment made by one of the teachers I met while conducting this study. She indicated to me that breakfast for some of the students consists of a pack of skittles (candy) and/or chips. Certainly, follow-up research on the BSS should include nutrition and activity pattern studies.

The BGS's longitudinal data also made it possible to track BMI values from ages 6 to 14. Significant inter-age correlations ranging from $r = 0.62$ to $r = 0.95$ were found. These correlations remained relatively stable over the nine year period, suggesting that "tracking" BMI provides strong predictive value for assessing inter-age comparisons of BMI. Continued work with this data will investigate how children "at risk for overweight" and overweight track during the same 9 years. The research may shed light on a critical period when children become overweight and whether they stay overweight or move in and out of overweight categories. Although success in pinpointing such a critical age has, to date, been limited (Katzmarzyk 1999), it represents an important step toward developing appropriate age-specific preventive measures.

Recent studies attempting to predict the onset of obesity (i.e. "tracking" of adipose indicators) in adults from child and adolescent measurements of fatness have had varying degrees of success. Several researchers have found that BMI in children, and other measures of adiposity, strongly correlate with adult onset of overweight and obesity (for example, Guo et al. 1994) . However, correlations for such predictions are higher from adolescent measurements than from childhood measurements. Further, the method of measurement, the cut-off used to identify "at risk for overweight", overweight or obesity and the time of follow-up, all affect the success of these "tracking" methods.

This study adds fuel to the on-going debate surrounding appropriate reference standards to be employed for assessing deviations from the normal patterns of growth. Clearly, different interpretations of the Burlington findings (particularly with respect to the prevalence of children "at risk for overweight" and already overweight) can be made depending on whether the U.S. or Canadian reference standards are used. Employing a single reference standard is far more valuable than a number of reference standards that are based on data collected and analyzed using different methods. At present, the United

States reference sample provides the largest representative growth surveys on a heterogeneous population. I recommend continued use of U.S. standards as the baseline criteria for evaluating growth data.

The Burlington study also underscores the importance of the social climate in which measurements of the human body are collected. Comparison of perceptions of data deemed appropriate for study in the 50 year period covering the BGS and BSS is instructive. Human biology textbooks on the subject of child growth and development before and during the 1960s emphasize the "whole child" approach in this area of inquiry (see for example Lowrey 1973). During this period, information on stature and mass was collected, among other anthropometric variables that included assessment of sexual development through the collection of information on breast and genital development, secondary sexual characteristics, mental development through the administration of IQ tests, and skeletal growth evaluated via a battery of x-rays. Most of these texts also include photographs of the subjects in their underwear or nude to demonstrate the method of data collection or variations in growth. Many of these types of data were collected by the *Burlington Growth Study* researchers. In contrast, I was only permitted by the Halton School Board to collect stature and mass information, even though my initial proposal included the collection of skinfold measures. The point I wish to make here is that there has been shift in views, held by much of the public, against amassing of information on body size and shape, especially in children.

This was made clear to me from the outset of the BGS from the guidelines set out by the school board. First, I was only to measure stature and mass. Even so, some board members, parents and children considered this to be too invasive. Second, I was only permitted to collect this information if I were accompanied by a female colleague. Third, I was required to collect the data in a visible area so that the students were protected, but secluded enough so that none of the students were embarrassed by having other students nearby. This restriction on data collection is important as it points to the need to develop research strategies to work within such restrictions or to find other sources of data. Sources for such data might come from the measurement of children in hospitals or physicians' offices. One limitation to this approach however is that children in this situation are often ill, whether acutely or chronically, and this would bias the results of the study (i.e. sick children may be growing at different rates relative to healthy children). Another approach might be to measure children who attend public recreation centers. This has the advantage of offering access to a large number of children, many of whom would be wearing light clothing. However, such an approach would introduce a bias towards children who are active and underestimate the actual number of children who are "at risk for overweight" or are overweight. By and large, the best approach for gaining access to the greatest number and range of children is through the school system. One way to circumvent some of the difficulties encountered in the BSS is to make greater efforts to persuade teachers, parents and students of the importance of monitoring weight in children in light of the obesity epidemic currently facing the world population.

Finally, this study highlights the advantages of using archived growth data (BGS) to investigate secular trends in child growth. Stature and mass, both important variables used in assessing a population's growth and state of health, can be transformed into indices that reflect the relative fat mass of that population, helping to determine whether there have been changes in the proportion of individuals "at risk for overweight" or already overweight. When historical data are compared to contemporary findings, statements about secular changes in public health can be made and used to form the basis for policy-making. The findings from the Burlington study suggest that public health initiatives should focus on educating children and adults to increase their physical activity patterns and limit their sedentary behaviours. This would include suggestions for a reduction in television viewing and computer use, while increasing active pursuits and consuming foods that are lower in fat or calories (Canadian Task Force 1994; Robinson 1999). As a participant in this effort, schools should monitor food programs, making sure they meet the necessary nutritional standards. They should also promote more time for physical fitness by making physical education classes mandatory. These simple suggestions are important considerations in the face of a global epidemic of overweight and obese children and adolescents.

APPENDIX A

Dear Parents:

I am a Ph.D. student in the Department of Anthropology at McMaster University. My doctoral thesis investigates changes in the growth of children in the Burlington area from the 1950s to 1990s. From the 1950s to the 1970s "The Burlington Growth Study" collected the heights and weights of almost 90% of the children living in Burlington. My study aims to determine whether there have been changes in child growth patterns since the original study was conducted. To do so, I will be collecting height and weight measurements of children currently living and going to school in the Burlington region. The information on this group of children will then be compared to the original findings of the Burlington Growth Study. I would very much like to include your child in this study.

I plan to measure each student participating in this study during a 5-minute session in January 1999. If possible, this will be done during physical education classes. I assure you that none of the results will identify children by name, so complete anonymity is assured. I would be happy to provide you with the information on your child's measurements.

This study has been officially approved by your child's school principal and the Halton Region District School Board's Research Advisory Committee. Further, approval has been given through the Ethics Research Committee at McMaster University. When the study has been completed a copy of my Ph.D. dissertation and any accompanying data will be available in the school library for interested parents and children. I also plan to offer a talk on my findings at the school.

I would appreciate it if you would complete the form at the bottom of this letter and return it to your child's teacher by **January 13, 1999**. If your child is shy or unwilling to be measured on the research day, he/she will be able to withdraw with my complete understanding and no attempt will be made to persuade him/her participate.

I sincerely appreciate your co-operation. If you would like to receive more information about the study, please contact me or my faculty supervisor through the school principal.

Thank you,

Todd Garlie
PhD Student
Department of Anthropology
McMaster University
1280 Main Street West
Hamilton, Ontario
L8S 4M2

Telephone: (905) 525 - 9140 (x24423)
E-mail: garlietn@mcmail.cis.mcmaster.ca
Fax: (905) 522 - 5993

Student's Name________________________________

CHECK HERE

☐ I give permission for my child to participate in the McMaster University study conducted by Todd Garlie

☐ I do NOT give permission for my child to participate in the McMaster University study conducted by Todd Garlie

Signature of parent/guardian____________________________

PLEASE RETURN TO YOUR CHILD'S TEACHER BY (January 13, 1999)

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