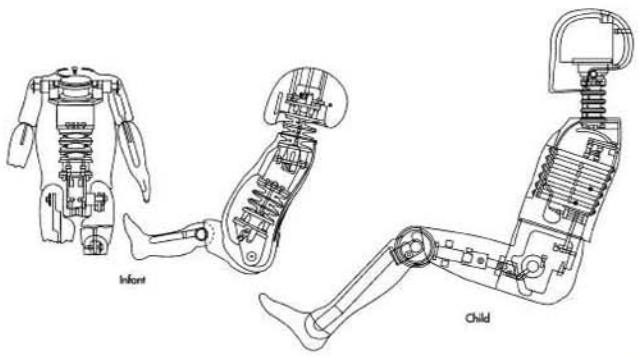
Canadian Institute of Child Health
Institut canadien de la santé infantile

Child Anthropometry:

A Literature Scan of National and International Publications

Submitted to Transport Canada,
Road Safety and Motor Vehicle Regulation Directorate



cover photos courtesy of Health Canada and www.howmade.com

Child Anthropometry:
A Literature Scan of National and International Publications

March 19, 2007

Submitted to Transport Canada,
Road Safety and Motor Vehicle Regulation Directorate
by the Canadian Institute of Child Health

Canadian Institute of Child Health
Institut canadien de la santé infantile

Table of Contents

Acknowledgements

The Canadian Institute of Child Health (CICH) would like to thank Transport Canada for providing financial support to complete this Child Anthropometry Literature Scan.

CICH wishes to acknowledge the hard work and commitment of the members of both the Steering Committee and Technical Advisory Committee who shared their expertise, vision and guidance in the development of the Literature Scan.

Steering Committee Members

Paul Boase, Road Safety Directorate, Transport Canada

Shelley Callaghan, Canadian Institute of Child Health

Regina De La Campa, Canadian Institute of Child Health

Shawna DiFilippo, Child Passenger Safety and Sports & Recreation Programs, Safe Kids Canada

Louise Hanvey, Canadian Nurses Association

Elaine Orrbine, Canadian Association of Paediatric Health Centres

Ian Pike, British Columbia Injury Research and Prevention Unit

Louise Poulin, CIHR, Institute of Human Development, Child and Youth Health

Maire Sinha, Road Safety Directorate, Transport Canada

Lynne Warda, Injury Prevention Committee, Canadian Paediatric Society

Technical Advisory Committee Members

Barbara Baines, Defect Investigations and Recalls, Transport Canada

Shelley Callaghan, Canadian Institute of Child Health

Aline Chouinard, Evaluation and Data Systems, Transport Canada

Peter Cripton, Department of Mechanical Engineering & Division of Orthopaedic Engineering Research, University of British Columbia

Regina De La Campa, Canadian Institute of Child Health

Jeannine Fraser, Canadian Institute of Child Health

Maire Sinha, Road Safety Directorate, Transport Canada

Robin Moore-Orr, Board of Directors, Canadian Institute of Child Health

Jay Rieger, Standards and Regulations, Transport Canada

Anne W. Snowdon, Faculty of Nursing, University of Windsor

A special thanks to the CICH Project staff who were directly involved in researching, writing and editing the Literature Scan.

Shelley Callaghan, Project Manager, Canadian Institute of Child Health

Regina De La Campa, Project Coordinator, Canadian Institute of Child Health

Jeannine Fraser, Scientific Advisor, Canadian Institute of Child Health

Design: Blackbird Publications, Communication and Design

Date of Publication: March 2007

Executive Summary

In 2003 motor vehicle collisions remained the leading cause of death and injury for children of all ages and as many as 10,000 children 12 years and under are injured or killed in traffic collisions every year in Canada (*CICH e-Parenting Network Vehicle Passenger Safety Fact Sheet*, 2004). It is important that the most appropriate and current data be used to ensure that car safety seats and restraints provide the best possible protection for children according to age, weight, height, seated height and other body measurements. Currently, Canada does not have a national pediatric surveillance system for collecting child anthropometry or nutritional data and the last time this information was collected was in 1970–1972.

The lack of current child anthropometry measurement data raises important technical questions. Can Canada rely on dated anthropometry data? Are the body dimensions of children in the 1970s still relevant in light of social and economic changes in Canadian society? Should Canada borrow or adopt U.S. or international reference anthropometry data? If Canada conducted a child anthropometry measurement study, what would be the design/methodological approach?

In light of these important research questions, Transport Canada's Road Safety and Motor Vehicle Regulation Directorate issued a competitive bid in October 2006, to undertake a Canadian-based child anthropometry measurement study. The result of this competitive tendering process was a partnership with the Canadian Institute of Child Health (CICH) to conduct a demonstration project on child anthropometry measurement.

The project involved four main activities:

a) A review of the types of child anthropometry data that currently exist, in Canada and internationally, and how this information is collected.

b) The identification of effective and reliable methodologies and protocols to measure children ages 0–12.

c) The assembly of tools, including training, for taking measurements and testing the agreed upon methodology on infants and children in Ottawa area child care centres and after school programs with a diverse socio-economic mix.

d) Preparation of reports that summarize the results of the review and the demonstration study including recommendations on the most accurate measurement protocols and appropriate methodology for collecting consistent, accurate, reliable and comprehensive child anthropometry data at a national level.

This report is the result of the information collected during the review of the available literature on child anthropometry in Canada and internationally. The methodology for this literature scan identified the following steps that were integral to the process:

1) identification of search terms to focus the literature scan;

2) a broad search of a variety of information sources;

3) establishment of inclusion criteria to ensure high-quality results;

4) review and summarization of appropriate articles and other information sources; and,

5) organization of information into a usable format.

The information was compiled under six broad categories: Nutritional Status and the Body Sizes of Children; Child Anthropometry for Restraint System Design; Child Anthropometry for Safety and Injury Prevention; Training; Types of Child Anthropometry Measurements; and, Statistics and Sampling Methods. The scan identified: 64 papers relevant to the Nutritional Status and the Body Sizes of Children (22 studies dealt specifically with childhood obesity issues); 15 papers were relevant to Child Anthropometry for Restraint System Design; 6 papers on Child Anthropometry for Safety and Injury Prevention; 21 publications on Anthropometry Training; and 16 studies on the Types of Child Anthropometry Measurements. These publications were reviewed for their Statistics and Sampling Methods and presented in the final category.

A number of issues emerge from the information collected in this literature review, including: a lack of child anthropometry data that is current, standardized, reliable and accurate within Canada and internationally. This is partly due to the fact that accurate weighing and measuring have three critical components that need to be met: technique, equipment, and trained measurers. The measuring technique needs to be standardized,

the equipment needs to be calibrated and trained measurers need to be reliable and accurate; this tends to be difficult to do as it is very time consuming and costly.

This scan of child anthropometry publications, available nationally and internationally, only provides a 'snapshot' of activities and gaps at the time it was conducted. The publications presented through this scan are diverse in nature, each looking at child anthropometry from their own unique perspective depending on their different priorities (e.g., development of growth charts, car seats, etc.) and areas of interest. However, through this scan a wealth of information on child anthropometry was gathered and consolidated, making it very useful to individuals working in the area of child anthropometry.

Background

The Canadian Institute of Child Health (CICH) and Transport Canada's Road Safety and Motor Vehicle Regulation Directorate are working together to provide the best protection possible to infants and children in their car and booster seats. In order to assess safety issues related to car and booster seats, reliable information on the physical characteristics of Canadian children and youth is essential.

Information about the size of children in Canada needs to be updated, as the most recent child anthropometry data was published in 1980 (Demirijan, 1980). Since then, there have been significant societal, health, environmental, and economic changes in Canada indicating that the physical measurements of children may have changed. This information is essential for car and booster seat manufacturers among other professionals, as car and booster seat designs need to accommodate the sizes and dimensions of the full age range of children who will use them.

The aim of the project was to 1) develop a methodology to collect anthropometry data on children aged 0–12 in Canada after a thorough scan of the national and international scientific literature; 2) develop and implement a protocol to pilot test the methodology; 3) make recommendations and propose a methodology for obtaining national data that would be used in the development of standards and regulations for automobile safety devices for safety car seats and restraints for child passengers.

The project was directed by a Steering Committee and a Technical Advisory Committee composed of members from the Canadian Association of Paediatric Health Centers, the Institute of Human Development, Child and Youth Health at the Canadian Institutes of Health Research, the BC Injury and Research & Prevention Unit, Safe Kids Canada, the Canadian Nurses Association, the Faculty of Nursing at the University of Windsor, the Canadian Paediatric Society, CICH and Transport Canada.

Purpose

The purpose of this report is to present a compilation of child anthropometry studies relevant to the development and implementation of protocols to measure children aged 0–12. The primary objectives of the literature search were to review and analyze information related to methods for measuring children. This was done to determine the best methodology to be used to collect child anthropometry data during the demonstration phase of this study.

The information presented in this report comes from a review and analysis of the available national and international scientific literature. Although every attempt was made to ensure this scan is as comprehensive as possible, it is important to note that it is not exhaustive, specifically at the international level where there were a large number of studies that were not relevant to the project.

Methods

The following search strategy was used to collect information on child anthropometry and child anthropometry data in Canada and around the world.

Search Strategy

The first step of the strategy was to conduct a broad search to identify key terms in order to learn what types of information relating to child anthropometry and child anthropometry studies were available. The idea was to become familiar with measurement devices, procedures, sample sizes, statistics and specialized software that are commonly used or that have worked in the past. This was accomplished by using Internet search engines such as Google and Yahoo.

The following search terms and parameters were used during this initial search:

Anthropometry; anthropometry studies; Anthropometry + children; Anthropometry + car safety; Anthropometry + restraints; Anthropometry + methods; Anthropometry + techniques; Anthropometry + ethics; Anthropometry + best practices; Anthropometry + guidelines; Anthropometry + research; Anthropometry + standards, Anthropometry + measurements, Anthropometry + databases, Anthropometry + statistics; Anthropometry + indices; and, various combinations of these.

Potential sources of information were identified using the above search terms/parameters and presented to the Steering and Technical Advisory Committees. The members made recommendations on more specific search terms. This search process identified organizations, associations and collaborative groups associated with the field of child anthropometry as well as potential initiatives and research projects.

Published scientific literature was identified through a systematic search of standard database search engines (PubMed, MedLine, SciFinder, Google scholar, etc.). Material that appeared relevant was downloaded, requested from the authors or purchased.

Articles were screened for relevance according to predetermined selection criteria based on relevance to the project objectives. Additional publications were identified by searching the bibliography of already screened articles. Information directly related to the project objectives was selected for review and incorporated into this report. Databases of literature were searched and citations were captured using Reference Manager™ software for ease in organization. Relevant articles and information were then categorized, summarized and incorporated into the main body of this report.

The large amount of information collected was synthesized and organized into 6 major groups based on categories that became apparent during the search. The categories were: nutritional status and the body sizes of children; restraint system design; safety and injury prevention; training; relevant child anthropometry measurements; and, statistics and sampling strategies. Furthermore, the information collected within each category was organized in a table format with the following headings: program focus, geographical focus, program objectives, target audience, date, training, measurement instruments, data, statistical analysis, summary of measured results, conclusions, problems and limitations and contact information. Some of the studies, reports or databases overlap between the categories selected but this was the most straightforward way to gather the information and present it in a format that would be usable.

Results

The results information was presented using the six main categories: Nutritional Status and the Body Sizes of Children, Child Anthropometry for Restraint System Design, Child Anthropometry for Safety and Injury Prevention, Training, Types of Child Anthropometry Measurements, Statistics and Sampling Methods. Appendix A highlights the most relevant studies under each of the main categories and presents this information in individual table format for quick reference. Appendix B is a collection of abstracts. The abstracts in Appendix B are organized by using the six main categories, described above.

Nutritional Status and the Body Sizes of Children

The scan identified 64 papers relevant to the Nutritional Status and the Body Sizes of Children, with 22 dealing specifically with childhood obesity issues (for abstracts see Appendix B). Of these studies the following six studies were considered the most relevant because they explored the area of child anthropometry specifically, were population based and described their procedures and techniques in detail. Below please find a description of these specific studies with detailed tables summarized in Appendix A, records 1 to 6.

WHO Multicenter Growth and Reference Study, WHO

A few major organizations over the last decades, including the World Health Organization (WHO) and the US Center for Disease Control and Prevention (CDC) have ventured into the area of child anthropometry. Their purpose has been to create growth charts to assess the degree to which physiological needs for growth and development are being met during the life of a child. In 1970, the first growth reference standard was recommended for international use by the National Centre for Health Statistics (NCHS) and WHO. However, in the early 1990's a group of experts selected to evaluate this international growth

reference unveiled deficiencies with the original standards document. This led to the onset of the WHO Multicenter Growth and Reference Study (MGRS), a new project that would set out to develop new growth charts to document how children should grow in all countries as opposed to merely describing how they grew at a particular time and place. Experts underscored the importance of ensuring that the new growth charts were consistent with best health practices (De Onis, 2004). The WHO MGRS, implemented between 1997 and 2003, currently describes how a child should grow and deviations from the norm are evidence of abnormal growth. The standards document is based on healthy children living under conditions that are likely to favour achievement of their full genetic growth potential (De Onis, 2004). Mothers selected for the study engaged in health-promoting practices such as breastfeeding and non-smoking. The study is unique in that it includes data from six different countries: Brazil, Ghana, India, Norway, Oman and the United States. The report also features the inclusion of windows of achievement for six gross motor development milestones (De Onis, 2004). (See Appendix A record 1; Appendix B Ref ID 11 for more information).

National Health and Nutrition Examination Survey III: Body Measurements (Anthropometry), CDC and 2000 CDC Growth Charts for the United States: Methods and Development

The NCHS growth charts that had been in use in the US since 1977 were revised in 2000 by a working group from the Vital and Health Statistics Office at the CDC. Most of the earlier versions of growth charts had severe limitations including a lack of coverage for infants and preschool children and a lack of ethnic, genetic, socio-economic, environmental and geographical representation. Growth charts for the US were developed by NCHS when nationally representative cross-sectional survey anthropometry data became available for most of the paediatric age range, namely from the National Health Examination Surveys I and II, the National Health and Nutrition Examination Survey I, and from the longitudinal growth study of the Fels Research Institute in Ohio (CDC, 2000). The objective of the revision process was to use improved statistical smoothing procedures together with the inclusion of more comprehensive national survey anthropometry data to provide health care professionals with a better instrument to evaluate the health status of children in the US (CDC, 2000). Statistical smoothing procedures are often used when the observed percentile points are plotted on a graph that when connected result in lines that are jagged or irregular due in part to sampling variability. (See Appendix A record 2 and 4; Appendix B Ref ID 101 and Ref ID 102 for more information).

1970–1972 Nutrition Canada National Survey, Nutrition Canada

National and international government agencies rely on growth charts for measuring the general well-being of child populations, formulating health and related policy, planning interventions and monitoring their effectiveness. The primary indicators used for this purpose are weight-for-age and height-for-age, along with various skinfold measurements, all requiring accurate age information to generate the appropriate nutritional/growth assessment. Growth charts currently in use describe existing growth patterns and can be used as a reference for a population.

National growth charts do not exist for Canadian children (Dietitians of Canada et al., 2004). At the population health level this information is very important. The most recent Canadian child anthropometry data was published in 1980, collected across ten Canadian provinces through the 1970–1972 Nutrition Canada National Survey (Demirjian, 1980). Height, weight, and selected body measurements such as seated height were reported for boys and girls up to age 19. A secular trend in the stature of Canadian boys and girls was evident when the data was analyzed. The average increase in stature for all ages over the last decade spanning the data was 2 cm for boys and 1 cm for girls (Demirjian, 1980). This was most apparent during and after puberty. Stature differences were also noted when three Canadian child populations of different racial origin were compared (Caucasian, First Nations and Inuit). Inuit children were reported to have the shortest legs of the three groups. A secular trend in weight was also evident although not as marked as it was for stature. The maximum difference was an increase of 1kg for boys and 2kg for girls (Demirjian, 1980). The Nutrition Canada report also presents comparisons between the Canadian national sample and a variety of national studies from other countries. For instance, it was reported that American children of all ages were taller and heavier than their Canadian counterparts (Demirjian, 1980). These findings illustrate the importance of taking into consideration ethnic differences in body measurements and the need to establish

national standards for each country (See Appendix A record 3; Appendix B Ref ID 68 for more information).

Secular trends in the body mass index of Canadian children, Tremblay et al.

Since the publication of the Nutrition Canada report in 1980, there have been significant societal, health, environmental, and economic changes in Canada indicating that the physical measurements of children may have changed. For example, the prevalence of overweight and obesity in school-aged children has increased significantly in recent years (Tremblay, M.S. et al., 2000; Janssen, I. et al., 2004; Veuglers, P.J. et al., 2005; Willms, J.D. et al., 2005). In 2004 it was reported that 18% of children and youth were overweight and 8% were deemed obese (Canadian Institute for Health Information, 2004). Similar rates have been reported for preschool children, suggesting similar trends of overweight and obesity in early childhood (Canning, P.M., et al. 2004; Willms, J.D. et al., 2004; Flynn, M.A., 2005; He, M. et al., 2004). In addition, there has also been a change in patterns of immigration to Canada. New immigrants are most notably from China, India and the Philippines; 20% of the Canadian population is now from visible minorities. (www.clbc.ca/files/ Reports/IHB_section_a.pdf). A study by Lin, Y.C. et al., (2004) presents comparisons of ethnic differences in anthropometry characteristics among four Asian peoples (Chinese, Japanese, Korean and Taiwanese). The means of 33 body dimensions and 31 bodily proportions are presented. The results show that there is a significant morphological difference among these groups of people in the same region. This highlights the need to investigate ethnic diversity as related to bodily dimensions and proportions. (See Appendix A record 5; Appendix B Ref ID 62 for more information).

Guide for Anthropometry Indicator Measurements, USAID

In 2003, the US Agency for International Development (USAID) developed a complete guide for Anthropometry Indicator Measurements as part of a series of reports prepared by the Food and Nutrition Technical Assistance Project (FANTA). USAID provides support for the development of monitoring and evaluation systems for developing countries. The guide is intended to provide the technical basis for the indicators and the recommended method for collecting, analyzing and reporting on the indicators (Cogill, B. 2003). The guide provides information on the impact indicators of child malnutrition: decreased percent of stunted children and decreased percent of underweight children, as well as on monitoring indicators of child malnutrition: increased percent of eligible children in growth monitoring/promotion and increased percent of children in growth promotion program gaining weight in the past three months. (See Appendix A record 6; Appendix B Ref ID 8 for more information).

Child Anthropometry for Restraint System Design

The scan identified 15 papers relevant to Child Anthropometry for Restraint System Design (for abstracts see Appendix B). Of these studies the following six studies were considered the most relevant because researchers have noted the importance of recognizing the marked differences between a child's body dimensions, proportions and biomechanical properties in addition to those of adults. In particular, the infant and child differ structurally from the adult in a number of ways that are critical to the design of products aimed to protect against impact forces. Below is a description of these specific studies with detailed tables summarized in Appendix A.

Canadian Paediatric Surveillance Report 2005: Lap Belt Syndrome Report, CPS

In 2003 motor vehicle collisions remained the leading cause of death and injury for children of all ages and as many as 10,000 children 12 years and under are injured or killed in traffic collisions every year in Canada (CICH e-Parenting Network Vehicle Passenger Safety Fact Sheet, 2004). There is a need to ensure that infant and children's safety car seats are properly installed and used. The 1996–2005 Canadian Paediatric Surveillance Program (Cyr et al., 2005) reports that at least 28 children in Canada (ages 4 to 12) suffered from lap-belt syndrome over a 24-month period. Lap-belt syndrome refers to injuries to the abdominal viscera and to the lumbar spine associated with seat-belt restraints (Cyr et al., 2005). These injuries are caused by the rapid deceleration characteristics of high-impact crashes, resulting in sudden flexion of the upper body around the fixed lap belt compressing on the abdominal viscera between the lap belt and the spine. Children are especially vulnerable to these injuries. Their organs are less protected by the thorax and pelvis, they have a lower centre of gravity, and their iliac crests are less developed than those of

adults, allowing the belt to ride up over the abdomen (Cyr et al., 2005). The authors report that only 4 out of the 28 children injured in this study were adequately restrained according to their age. When children outgrow their child safety seats, the use of seat belts designed for adults is not an acceptable alternative for booster seats (Cyr et al., 2005).

As more provinces/territories move to legislation requiring the use of booster seats in automobiles, the design, effectiveness and comfort of booster seats will become a greater concern. Currently, infant car seats, carriers and booster seats have been designed based on research and crash impact studies. This equipment is meant to best protect the child at each physical stage of development, related body strength and vulnerabilities. For instance, back-facing car seats with the appropriate recline are used in younger infants with padded harness straps to restrain the child.[1] Effective April 2007 an interim order has been brought in to all stage II CRS to 65lbs. Please visit Transport Canada's website for more information.

Product manufacturers provide information on the use of their product according to weight and standing height, or the height of the child's head on the seat or location of the shoulders in relationship to the harness. Information is needed on the relationship between seated height and stature, seated height and weight and seated height and age, together with an understanding of developmental stages of children so that this information can be incorporated into safety regulations as well as safety devices. Only in Quebec is a child's seated height used to determine the transition point from the use of a booster seat to using a seat belt (Cyr et al., 2005). (See Appendix A record 7; Appendix B Ref ID 115 for more information). Ontario uses standing height because no agreement has been reached on averages by age.

Child anthropometry for restraint system design, University of Michigan

The University of Michigan funded a study to allow for a compilation of a database of child anthropometry measurements for restraint system design (Weber, 1985). The purpose of the report was to present all available measurements that were likely to be of interest to the restraints designer in one single source. Because measurement procedures were as consistent as possible among the studies, raw data for the same measures were combined and are displayed as single data sets. Data tables and scatter plots are presented (scatter plots are truncated at age 10) for child dimensions from 0–10 years. This report is limited in that it only incorporates measurements taken by the researchers at the University of Michigan between 1975 and 1985. (See Appendix A record 8; Appendix B Ref ID 89 for more information).

Description and Performance of the Hybrid III 3 year-old, 6 year-old and small female test dummies in restraint system and out-of-position air bag environments, National Highway Traffic Safety Administration and Transportation Research Center Inc.

In 1987, with the introduction of air bags into the market and foreseeing the need for assessing the safety benefits for all sizes of vehicle occupants, the CDC funded a study on the development of a multi-sized Hybrid III-Based dummy family (Saul et al, 1997). Recognizing the need for dummies with improved biofidelity and extended measuring capability and capacity to evaluate the safety of children, CDC provided additional funding in 1989 to develop a design foundation for the Hybrid III-type child size dummies. The Society of Automotive Engineers (SAE), through its Hybrid III Dummy Family Task Group and later, also through the Dummy Testing Equipment Subcommittee, has continued the development work resulting in the construction of prototype Hybrid III-type 5th percentile female, 95th percentile male, six-year-old, three-year-old, and CRABI 12-month-old dummies. These families of dummies are used by car and booster seat manufacturers and researchers to design and test child restrain systems. (See Appendix B Ref ID 113 for more information). The dummies are a world SID ATD which Transport Canada helped to create.

Infants and children in the adult world of automobile safety design: pediatric and anatomical considerations for design of child restraints, Burdi et al.

A child's body dimensions, proportions and biomechanical properties are markedly different from that of an adult. Consequently, for design purposes, a child cannot be simply considered a scaled-down adult (Burdi, 1969). Protection of children against impact forces, notably occupant restraint sys-

[1] Rear-facing seats are encouraged until the child is as heavy as 30–35 lbs. and at least one year of age to reduce the risk of spinal cord injury. These seats have the effect of spreading the impact force over the baby's entire back, neck and head to protect the spine. This is in recognition of the baby's larger and heavier head size in relation to their bodies, low-neck strength, soft bones and loose ligaments.

tems, must account for the structural differences of children compared to adults. Burdi, et al., (1969) present a profile of the anatomy, anthropometry, growth and development of the infant and child. Age differences related to the proper design of child restraint systems are emphasized throughout the study. For example, the frequency of head injuries in children involved in auto collisions may be due to the child's proportionately large head and higher center of gravity. Sudden snapping or rotation of the relatively unrestrained child's head can traumatize related nerves, blood vessels and spinal cord segments. The skull is not yet an intact bony case for the brain but a series of broadly spaced elastic bones. Growth rates of different parts of the body vary with age. Differences in shape, size, structure and biomechanical properties of the infant and child and adult pelvic skeleton are clear and must be considered for safety design. Organs of the chest are housed in an elastic and highly compressible thoracic cage and are vulnerable to chest impact (Burdi, 1969). Other issues discussed include center of gravity of the body, the head mass in relation to the neck and general body proportions, positions of key organs and biomechanical properties of tissues. The study concludes that the most effective restraint systems for children are those that distribute impact forces over a large portion of the body (See Appendix A record 9; Appendix B Ref ID 94 for more information).

Protection of children on board vehicles: Influence of pelvis design and thigh and abdomen stiffness on the submarining risk for dummies installed on a booster, National Highway Traffic and Safety Administration

The differences in child structure are also argued by Chamouard and others (1996) when they identified significant problems with the pelvis and thigh dimensions of the three-year old and six-year old Hybrid III dummies. Child crash test dummies are scaled versions of an adult dummy. Pelvis measurements from 54 children sitting on the ground with their backs against a wall were compared to dummy dimensions in similar postures. The authors concluded that the combination of unrealistic thigh flesh and pelvis dimensions made the dummies much less susceptible to submarining than children. Submarining occurs when the pelvis slides below the lap portion of the belt, allowing the belt to load directly onto the abdomen (Reed, 2005). The data however, are limited in that the child anthropometry was measured in postures that are not representative of child postures in vehicle seats or boosters. In addition 3-D measurements of skeletal posture common to studies of this type were not made (Reed, 2005). (See Appendix A record 10 Appendix B Ref ID 114 for more information)

A New Database of Child Anthropometry and Seated Posture for Automotive Safety Applications, SAE Technical Papers Series

Reed et al., (2005) developed a detailed database on vehicle-seated anthropometry, posture, and position for children and adolescents sitting in harness restraints, belt-positioning boosters, and vehicle seats with three-point belts. This was done to develop a positioning procedure for 6-year old and 10-year-old crash dummies that provides representative posture and position on booster seats and vehicle seats. In addition, the data gathered will be used to develop a physical belt-fit assessment procedure for children from 40 to 100 lb that uses crash dummies (6-year-old and 10-year-old Hybrid III). This process would identify differences between children and crash dummies that could adversely affect the fidelity of crash-test assessments of belt positioning boosters (Reed, 2005). This new database quantifies the vehicle-seated postures of children and provides quantitative evidence of the effects of belt-positioning boosters on belt fit. The data provide guidance for child restraint design, crash dummy development, and crash dummy positioning procedures. (See Appendix A record 11; Appendix B Ref ID 4 for more information).

Child Anthropometry for Safety and Injury Prevention

The scan identified 6 papers on Child Anthropometry for Safety and Injury Prevention (for abstracts see Appendix B). Below are the 3 most relevant studies that were specifically developed to be used when designing consumer products and injury prevention programs. They also present a complete, detailed and practical description of the methodologies. Detailed tables are summarized in Appendix A.

Anthropometry of infants, children and youths to age 18 for product safety design, Highway Safety Research Institute Report

Children's organizations and others concerned with the safety, health, development and growth of children realized that although extensive data on child anthropometry data existed, the majority related to measures of height and weight and a few other dimensions that were primarily intended for paediatri-

cians. While the information could assist in the identification of health trends, dietary requirements and supplements, it was limited for the development of consumer products and injury prevention programs. Comprehensive, specific and functional child anthropometry data for consumer product design was non-existent until 1975 when the Consumer Product Safety Commission and the National Bureau of Standards of the USA commissioned a study to look at the physical characteristics of children as related to death and injury for consumer product design and use. As a result, many of the measurements taken during the study represented new information needed for the direct application to specific child safety problem areas. For example, infant buttock depth was determined to be the most critical measurement for the application to safe crib-slat interface design; crotch height was useful for bicycle frame height determination and minimum hand clearance is a unique dimension needed for determining what size openings a child or infant can squeeze a hand through (Snyder, 1977). For this study new measurement tools were designed, fabricated, tested and developed in order to ensure accurate and reproducible measurements of infants and children. The project continued in 1977 in order to expand on the database. This child anthropometric database represents one of the most comprehensive sources of anthropometric information for child product safety applications. (See Appendix A record 11; Appendix B Ref ID 85 for more information).

Anthropometry data of children for non-specialist users, Steenbekkers et al.

In a pilot study conducted by Steenbekkers et al. (1990), 33 anthropometry variables were measured on 633 children aged 0–5½ years. The variables for the measurements were chosen on the basis of international standards and on the results of preliminary data analysis of child injuries. This study focuses on two specific applications: anthropometry aspects of current regulations for cribs, playpens and toys and anthropometry aspects in the selection of wheelchairs for children. The paper concludes with a discussion on how to present anthropometry data for non-special users (Steenbekkers, 1990). (See Appendix B Ref ID 78 for more information).

Classroom furniture dimensions and anthropometry measures in primary school, Panagiotopoulou et al.

Several studies compare students' dimensions to the dimension of school furniture and determine whether this type of furniture is well-designed and promotes good sitting posture. (Knight, 1991; Linton, 1994; Evans, 1998; Balague, 2003). In Greece, a total of 180 (90 male and 90 female) students from three primary schools, aged seven to 12 years were measured for: stature, elbow height, shoulder height, upper arm length, knee height, popliteal height and buttock–popliteal length. In addition, the dimensions were measured for four different types of chairs and five types of desks used in classrooms. Finally, the anthropometry measures of the students and the furniture dimensions were compared in order to identify any incompatibility between them. The data indicated a mismatch between the students' bodily dimensions and the classroom furniture available to them. The chairs were too high and too deep and desks were also too high for the students. This situation has negative effects on the sitting posture of the children especially when reading and writing. (Panagiotopoulou, 2004) (See Appendix A record 12; Appendix B Ref ID 86 for more information).

Training

The scan identified 21 publications on anthropometry training (for abstracts see Appendix B). Of these studies the following six studies were considered the most relevant because standardized methods for training measurers and for collecting anthropometry data were utilized. Below are the details of these specific studies with complete abstracts found in Appendix A and B.

International Standards for Anthropometry Assessment, ISAK

Anthropometry similar to any other area of science depends on the measurer's compliance to particular rules of measurement as determined by the national and international standard bodies. Over the years, anthropometry has followed several traditions or schools of thought. As a result there has been a lack of standardization across the field, especially with regard to the identification of measuring sites or anatomical landmarks and in measurement techniques. This makes comparisons across time very difficult and in turn, the data become specific to the user (Marfell-Jones, et al. 2006).

Child anthropometry measurements comprise a series of noninvasive, inexpensive, and easy-to-perform methods for estimating body composition. However, they are operator dependent and to be useful they must be performed in a precise, standardized, and reproducible manner. Research recommends that any individual who performs the measurements should first undergo training to increase precision and skill. Without such training, considerable variance will occur both within and between observers in obtaining and interpreting the measurements. Standardized methods for collecting anthropometry data are available and should be utilized (Marfell-Jones, et al. 2006). (See Appendix B Ref ID 123 for more information).

Teaching modules, US Department of Health and Human Services

With the revision of the CDC Growth Charts in 2000, pediatric health care providers were in need to re-evaluate the tools they used and the approach in their clinical settings for the measurement of child anthropometry data. The US Department of Health and Human Services (2006) developed a series of teaching modules focusing on the techniques for measuring and recording infant length, weight, and head circumference and the techniques for obtaining and recording weight and stature for children and adolescents. The information in the modules is intended for the measurement of typically developing children. The modules present the importance of reliable and accurate measurements, the equipment used, techniques and growth chart interpretation information. (See Appendix B Ref ID 64 for more information).

Influence of knowledge, training and experience of observers on the reliability of anthropometry measurements in children, Vegelin, et al.

Several studies have investigated the impact of the measurer's level of technical knowledge, training and experience with measuring on the reliability of child anthropometry measurements. Despite instructions and encouraging careful measurements, these factors often significantly affect measurements and lead to interpretation difficulties, especially of short-term growth data. In 2003, Vegelin et al., designed a study where a cross-sectional study of 18 children, aged 2–7 years, were measured in duplicate by 12 observers with different backgrounds and levels of experience, protocol knowledge and protocol training (Vegelin, 2003). The main outcome measures, precision and accuracy, were expressed as technical error of measurement and average bias in comparison with an expert anthropometrist. As expected, the best educated and most experienced observers scored the best precision and accuracy (Vegelin, 2003). A practical training course of only a few hours does not seem to improve reliability significantly. To get a more reliable insight in growth of a child it is important to be aware of the influence on measurement outcome values of protocol knowledge and years of experience. Growth studies should use detailed anthropometry standardization protocols and train people to acquire better insight into these protocols. (Vegelin, 2003). (See Appendix A record 13; Appendix B Ref ID 25 for more information).

Measurement and standardization protocols for anthropometry used in the construction of a new international growth reference, WHO Multicentre Growth Reference Study, WHO

The WHO Multicentre Growth Reference Study (MGRS) (2004) was undertaken to generate new growth curves for assessing the growth and development of infants and young children from around the world. Appropriate training and continued standardization, adherence to specified methods and procedures, and monitoring of data quality were essential to reduce measurement error and minimize bias in multi-site studies. All candidates received standardized training, and only those who met the MGRS performance criteria were retained for the study. The measurement procedures and training guidelines were prepared by the MGRS Coordinating Centre at WHO in Geneva, based on best practices recommended in anthropometry manuals and in the literature. The initial training of anthropometrists at each site was carried out by an experienced anthropometrist following the procedures detailed in the MGRS protocol. All anthropometrists were trained to interview mothers, complete the study questionnaires, measure children as described in the protocol, avoid digit preference or transposition of numbers, record measurement values immediately after reading them, and write legibly to reduce mistakes during data transfer. Strict adherence to the measuring techniques and recording procedures was emphasized throughout the study. (See Appendix A record 14; Appendix B Ref ID 11 for more information).

Reliability of three length measurement techniques in term infants, Johnson et al.

A study of two experienced nurses described and compared the intra- and inter-examiner reliability of three length measurement techniques and to determine if the three measurement techniques yield significantly different measurements. The nurses obtained length measurements using the supine, paper barrier, and auto-length measurement techniques twice each from 48 healthy term infants. The nurses were blind to their own and to each other's measurements. The differences between length measurements by individual examiners and pairs of examiners are relatively large. Clinicians should be aware of the magnitude of error in length measurements and should interpret length measurements with caution. These findings also demonstrate that all clinicians in any setting should use the same technique to obtain length measurements. (Johnson, 1999). (See Appendix A; Appendix B Ref ID 99 for more information).

Child factor in measurement dependability, Lampl et al.

A primary consideration in longitudinal growth studies is the identification of growth from error components. While previous research has considered matters of measurement accuracy and reproducibility in detail, few reports have investigated the errors of measurement due to aspects of the physiology and cooperation of the child. In a study by Lampl et al (2001) the researchers directly assess this source of measurement undependability for the first time. Investigation of total measurement error variance in 925 recumbent length replicates taken over stasis intervals in growth identifies that between 60% and 70% of total measurement unreliability is due to child factor undependability. Individual differences are significant and longitudinal growth analyses should consider two to three times the technical error of measurement statistic as a reasonable estimate of the total unreliability for any single measurement of an infant's recumbent length (Lampl, 2001). (See Appendix B Ref ID 20 for more information).

Types of child anthropometry measurements

The scan identified 16 studies on the Types of Child Anthropometry Measurements (for abstracts see Appendix B). Of these studies, the following 3 studies were considered the most relevant because they were used specifically for restraint system design. Note that these studies overlap with the information detailed under the category: Restraint System Design. Below are the details of these specific studies with complete abstracts found in Appendix B under the Restraint System Design category.

Table 1. presents a list of the most common child anthropometry measurements that are used for product or restrain system design. The specific measurements in each of the studies below that were reviewed for the demonstration study can be found in Appendix B. The measuring instruments used by these researchers are also listed in the Appendices.

Table 1. Different types of child anthropometry measurements taken for product or restrain system design by three research groups.

Reed et al., (2005)	Snyder et al., (1977)	Weber et al., (1985)
(See Appendix B Ref ID 4, 85 and 89 for more information).		
Stature	Stature	Stature Supine Stature
Weight	Weight	Weight
Head Length	Head Breadth Head Depth Head Circumference	Head Breadth Head Length Head Circumference Head Height
	Neck Breadth Neck Circumference	Neck Breadth Neck Circumference
Erect Sitting Height	Sitting Height	Erect Sitting Height Supine Sitting Height
Shoulder Height	Shoulder Height, seated Shoulder Breadth Shoulder Depth	
Acromion Height		

Table 1. (continued)

Reed et al., (2005)	Snyder et al., (1977)	Weber et al., (1985)
Knee Height		Knee Height
Bideltoid Breadth		
Biacromial Breadth		Biacromial Breadth Shoulder Breadth Clavicale-Acromiun Length Acromiun-Radial Length Radial-Stylion Length
	Thigh Breadth, seated Thigh Breadth, standing Thigh Depth, seated	Thigh Breadth, seated Thigh Clearance Upper Thigh Circumference Upper Thigh Depth
		Tibial Height Calf Circumference Calf Circumference Height Calf Depth
		Gluteal Furrow Height
Hip Breadth	Hip breadth, seated	Hip breadth, seated Hip Height at Buttocks Hip Circumference Hip Breadth at Trochanter Iliocristale Height Iliospinale Height
Shoulder-Elbow Length	Shoulder-Elbow Length	Shoulder-Elbow Length
Elbow-Fingertip Length	Elbow-Fingertip Length	Elbow-Hand Length
Buttock-Knee Length		Buttock-Knee Length
Chest Depth Chest Width	Chest Breadth Chest Depth Chest Circumference	Chest Breadth Chest Depth Chest Circumference Chest Height
Abdomen Depth Abdomen Width	Abdominal depth, seated	
	Waist Breadth Waist Circumference	Waist Breadth Waist Circumference Waist Height
	Crotch Height	
	Rump-sole Length Rump-knee Length	
	Knee-sole Length	
		Upper Arm Circumference Upper Arm Length
		Forearm Circumference Forearm Breadth

Statistics and Sampling Methods

The publications mentioned in the above categories were reviewed for their Statistics and Sampling Methods and presented in this final category are the 5 publications with the most detail on sampling strategy and statistical analysis. Below are the details of these specific studies with complete abstracts found in Appendix A, records 3, 11, 4, 6 and 14.

1970–1972 Nutrition Canada National Survey, Nutrition Canada

Sample size is one of the most important factors that determine the precision of the statistical analysis in a population study. Other relevant factors that need to be considered during a population study include the study design (cross-sectional or longitudinal), the sampling design, the stratification criteria, the sampling frame, the timing of measurements and the methods use for curve fitting. Sampling strategies are important in order to determine geographic locations, ethnic and cultural variables and socioeconomic criteria that are needed to assure a representative population sample, especially in nationwide studies. Census data and census data guidelines are the most often used first step in the design of a sampling method. The sampling design for the Nutrition Canada provincial survey (1970–1972) was stratified by region (Atlantic, Quebec, Ontario, Prairies, and B.C.), income (low income and other income), season (winter or summer) and area (metropolitan, urban or rural). A random sampling strategy was used to identify males and females in 10 age-gender categories (males and females together for ages 0 to 4 and 5 to 9 years, males and females separately for ages 10-19, 20-39, 40-64 and 65 years and above). More than 27,000 individuals were selected for the survey, 46% of whom attended the survey clinics. The final sample size was 12,795 plus 894 pregnant women in their third trimester of pregnancy (who were recruited through local health units and were therefore not a probability sample). (See appendix A record 3; Appendix B Ref ID 68 under the category Nutritional Status and Body Sizes of Children for more information).

Anthropometry of infants, children and youths to age 18 for product safety design, Highway Safety Research Institute Report

In the national child anthropometry study conducted by Snyder et al. (1977), projected sampling locations were determined from census data on the racial and socioeconomic composition of the population in the U.S. Other factors at various age levels, such as specific information concerning all the schools in a particular district, including their racial and socioeconomic breakdowns were obtained. Particular schools at a location were then selected to provide the best population sample cross-sections desired. However, it is important to note that the student composition of a school would not ensure that the children actually measured were as projected, since measurements were taken only if consent forms by parents were obtained. In addition, even if a consent form was obtained, there was no guarantee that the child would consent on the day the measurements were taken. Unforeseen problems and events that occurred during the timeframe of the study had to be dealt with as the study progressed. For example, Memphis, Tennessee had to be omitted when disastrous tornadoes struck the city just prior to the measuring sessions; and Manhattan, Kansas was also omitted due to a teacher's strike. Nevertheless, even with continuous adjustments in the strategy of the design the outcome was considered representative.

In the study by Snyder et al. (1977), once a geographic location was decided upon, initial contacts were made by telephone, personal visits of a co-investigator and written correspondence. Listings of all schools and child care centers and nurseries and well child clinics in the area were obtained. When the study was approved by the school boards, specific schools were selected on the basis of the particular student makeup and the availability of a space in which to conduct the measurements. Originally, a sample size of 3,000 had been projected for the study. However, the data collection period was extended to allow a total population of 4,000 subjects to be measured from birth (two weeks) to age 13. In all, children were measured at 76 different locations. Geographical locations included schools, day care centers, nurseries, and clinics in Florida, Massachusetts, Ohio, Connecticut, Oregon, California, Arizona, and Michigan. Determination of geographic locations, ethnic and racial affiliations and socioeconomic criteria was important in order to assure a representative nationwide population sample and was projected by use of census data guidelines. The racial guidelines prepared by the Department of Health, Education and Welfare indicate that 11% of the U.S. population is African-American. Data obtained from questionnaires indi-

cated about 10% African-American, 86% Caucasian, 2% Asian, and 2% of mixed racial parentage. Also, the economic grouping from data provided by the Institute for Social Research (i.e., family income) proved to be a non-responsive item and it was removed from the later forms. (See appendix A record 11; Appendix B Ref ID 85 under the category Restraint System Design for more information).

National Health and Nutrition Examination Survey III: Body Measurements (Anthropometry), CDC

The NHANES (1999–2000) was a complex, multistage probability sample of the civilian non-institutionalized population of the United States. In-home personal interviews and Mobile Examination Center data were collected. The NHANES III (1999–2004) survey is designed to give an annual sample that is nationally representative. The survey is subject to the limits of increased sampling error due to (1) the smaller number of individuals sampled in the annual sample and (2) the smaller number of Primary Sampling Units (PSU) available for each annual sample. For NHANES 1999–2000, the first stage of selection was the PSU-level. The PSUs were defined as single counties. The sample frame for the NHANES PSUs was the list of PSUs selected for the current design of the National Health Interview Survey (NHIS).

For the current NHIS design, there are 358 PSUs in the annual sample. These PSUs are divided into four panels with each of the four panels comprising a nationally representative sample. In forming the four panels, large PSUs are split and the remaining PSUs are stratified according to population size, geographic region, and demographic characteristics. The National Medical Expenditure Survey (NMEP), conducted by the Agency for Health Research and Quality, uses two of the four panels. The remaining two panels are available for use by the NHANES. By splitting the large NHIS PSUs, there are approximately 200 PSUs available in the two national panels for the first stage-sampling frame for the NHANES.

In order to create six annual national samples, 120 of the 200 NHIS PSUs were selected using a measure of size related to 1990 Census county-specific information on the percent Mexican-American, percent African-American and the NHIS PSU-selection probability. Twenty PSUs were randomly assigned to each year in 1999–2004. For each year, a subset of 15 PSUs was selected with the remaining five PSUs held in reserve. Once a PSU was selected, the most current Census information, in this case the 1990 Census, was used to define segments of households. Within PSUs, the percent Mexican-American population was used to form four density strata: (1) less than 10 percent, (2) 10–25 percent, (3) 25–60 percent and (4) over 60 percent. In order to achieve a sufficient sample size of non-Hispanic Black and Mexican-Americans, within PSU selection probabilities for these domains were adjusted and extensive screening at the household level was required.

For the 26 PSUs in 1999–2000, the final sample consisted of 681 segments. Once a segment was selected, field representatives visited all households in the segment and a screener questionnaire was used to determine sample person eligibility. Individuals were selected into the sample according to fixed sampling fractions. The sampling fractions were adjusted for each of the four segment density strata by the factors 1.0, 1.9, 2.5, and 3.0 (for the corresponding density strata). Individual sampling fractions were set that distribute the sample into 53 age-sex-race-ethnicity domains for 1999. In order to meet survey objectives related to nutrition, the 2000 sample individual selection probabilities were modified to increase the number of sampled persons in low-income non-Hispanic White population domains. The addition of the low-income subdomains for non-Hispanic White domains gave 76 age-sex-race-ethnicity-income domains for 2000.

With 15 PSUs per year, approximately 5,000 sample persons can be examined. Because both the actual duration of data collection as well as the response rates varies by PSU, the actual range for the number of examined sample persons per PSU was from approximately 250 to 400. In sample selection for NHANES 1999–2000, there were 22,839 households screened. Of these, 6,005 households had at least one eligible sample person identified for interviewing. There were a total of 12,160 eligible sample persons identified. Of these, 9,965 were interviewed and 9,282 were examined. The overall response rate for those interviewed was 81.9 percent (9,965 out of 12,160) and the response rate for those examined was 76.3 percent (9,282 out of 12,160). Due to confidentiality considerations, the data year is not available on the current NHANES 1999–2000 public use data files.

Because differential probabilities of selection were used in NHANES 1999–2000, it was highly recommended that any sta-

tistical inference based on the survey data use the sample weights that are provided on the data file. The sample weights were calculated from the base probabilities of selection, adjusted for non-response, and post-stratified to match population control totals. For NHANES 1999–2000, weighting adjustments involved multiple levels. Due to the nested levels of data collection (screener, household interview, examination) and to keep the weights from being too variable, a non-response adjustment was applied at each level of data collection, that is, for the screener interview, the household interview and the MEC examination. Post-stratification was applied at each nested level as well. Both the final interview and final examination weights are provided. The interview weight should be used when an analysis uses only data from the household interview. If an analysis uses data from the MEC (MEC interview, examination, or laboratory data on the full MEC sample) exclusively, or in conjunction with the household interview data, the examination weight should be used. (See appendix A record 4; Appendix B Ref ID 102 under the category Nutritional Status and Body Sizes of Children for more information).

Guide for Anthropometry Indicator Measurements, USAID

Sample surveys are often the most feasible means of gathering the data required for program evaluations. The Anthropometric Indicator Measurements guide prepared by the Food and Nutrition Technical Assistance Project in 2003, is designed to provide guidance on how to choose samples of communities, households, and/or individuals for surveys in a manner that, when combined with appropriate indicators and evaluation study designs, will permit valid conclusions to be drawn on program effectiveness. The guide emphasizes the use of probability sampling methods, which are deemed essential to ensure objectivity in program evaluations. Estimates of population characteristics derived from sample surveys conducted following suggested guidelines may be expected to approximate the true population value within a specified margin of error with a known probability.

Defining measurement objectives involves answering the following three questions, which are discussed in detail in the text: What is to be measured? From whom? At what level of precision? The guide explains how to calculate sample sizes after it has been decided what is being measured and how to measure it. The procedure is broken down into three steps. First, the total number of sample elements must be determined. For this, formulas are provided to identify how many individuals must be sampled depending on whether progress is to be measured by changes in the proportion of the population that has a given characteristic or by changes in the mean of a given indicator. Second, the total number of elements must be converted into the number of households that must be contacted. Third, the total number of households needs to be turned into practical units (clusters and subjects within them) that will be visited by the survey team.

Sample selection is important and the guide defines probability sampling, explains why it is recommended, and explains step-by-step the various ways in which the clusters and elements in the sample size can be selected, depending on various circumstances. Suggestions are also given on how to deal with operational problems. Data analysis is addressed with a focus on the statistical issues of calculating weights and standard errors as they arise as a result of the combination of methods used to select clusters and elements. Formulas are provided for weight calculation for several typical combinations. (See appendix A record 6; Appendix B Ref ID 8 under the category Nutritional Status and Body Sizes of Children for more information).

The WHO Multicentre Growth Reference Study: Planning, study design, and methodology, WHO

In the WHO Multi-Growth Reference Study Group (MGRS) four set of criteria were used to arrive at the final sample size: the percentile of a given centile at a particular age, the precision of the slope of the median curve over a given age range, the precision of the median curve overall and the influence of the data at particular ages and the precision of the correlation between measurements in the same subjects at different ages (de Onis, 2004). Sample sizes were calculated for each of these four criteria and it was apparent that for each gender, a sample size of 200 for the longitudinal study and 200 for the cross-sectional study would provide adequate precision. Complex formulas are available to get these numbers but will not be presented here (de Onis, 2004).

A sampling strategy can also be applied to an international sample population. In 1996, the WHO Multi-Growth Reference Study Group (MGRS) began the process of selecting sites for the implementation of the study. The group needed to identify sites in each of the six major geographic regions of the world

and the process lasted for two years. The process entailed evaluation of specific eligibility criteria for study subpopulations based on their study protocol. Interested countries were asked to submit a checklist of criteria documenting the source of the epidemiological data provided. The main objective was to assess the growth of children in affluent communities and identify socioeconomic characteristics associated with growth in these populations. Information that was also important to the group included infant feeding patterns, mobility of the population, and availability of epidemiological data and sources of funding.

The MGRS study had two components, a longitudinal follow-up in which the children were recruited at birth and followed up at home until 24 months of age and a cross-sectional survey involving children 18 to 71 months. Infants for the longitudinal component were recruited from the selected hospitals and clinics where at least 80% of the subpopulations of interest lived. The recruitment strategies for the cross-sectional study varied by site. In Brazil, India and the US, children were recruited through a door-to-door survey of selected study areas. In Norway and Oman, children were identified through a national or health registry and in Ghana the children came from day care centers and nursery schools (de Onis, 2006).
(See appendix A record 1; Appendix B Ref ID 10 under the category Types of Child Anthropometry Measurements (Software and Technology) for more information).

Conclusion

A number of issues emerge from the information collected in this literature review, including: a lack of child anthropometry data that is current, standardized, reliable and accurate within Canada and internationally. This is partly due to the fact that accurate weighing and measuring have three critical components that need to be met: technique, equipment, and trained measurers. The measuring technique needs to be standardized, the equipment needs to be calibrated and trained measurers need to be reliable and accurate; this tends to be difficult to do as it is very time consuming and costly.

Some issues encountered in the child anthropometry field after a thorough scan of the literature were:

1) A lack of co-ordination between the sectors (health, safety and injury prevention, restraint systems design, road safety, etc.) pertaining to data collection and methods for collecting the data. Researchers collecting child anthropometry information need to communicate with each other to ensure that the data will be useful across the sectors. As it stands now, data collection tends to be specific for a particular purpose (i.e., nutritional or development status) and designers, health practitioners, etc. would benefit from systematic data collection that could result in a pool of usable, reliable and current set of child measurements.
2) Lack of funding for training, research, data collection and data management studies. The measuring technique needs to be standardized, the equipment needs to be calibrated and trained measurers need to be reliable and accurate. These necessary components make accurate data collection difficult and costly.
3) Limited data available on training, training techniques and qualified trainers. There are no national standards for anthropometry assessment and there is no national accreditation scheme. This is a key element in the objective maintenance of quality assurance.
4) No national child anthropometry data are available in Canada. Data users and data collectors are not working together. The data available are outdated and there have been significant societal, health, environmental, and economic changes in Canada indicating that the physical measurements of children may have changed.
5) The field of child anthropometry looks at children as scaled down models of adults. No special instruments, manuals or protocols for children are presently available except for those that address a few basic measurements such as height and weight. There are standardized methods for classical anthropometry that should be adapted to children.

A national child anthropometry strategy to address the lack of data available and to help individuals with the design of baby car seats, infant seats, child restraints, boosters seats and cushions is necessary to fill the co-ordination gap. However, the

Reference List

1. Balague, F., Dutoit, G., and Waldburger, M. Low back pain in school children. *Lancet 361*[9367], 1403-1404. 2003.
2. Burdi AR, Huelke DF, Snyder RG, and Lowrey GH. Infants and children in the adult world of automobile safety design: pediatric and anatomical considerations for design of child restraints. *Journal of Biomechanics 2*[3], 267-280. 1969.
3. Canning, P. M., Courage, M. L., and Frizzell, L. M. Prevalence of overweight and obesity in a provincial population of Newfoundland children. *Canadian Medical Association Journal 171*, 240-242. 2004.
4. *CDC. National Health and Nutrition Examination Survey III: Body Measurements (Anthropometry).* National Center for Health Statistics. 1-57. 1988. US Centers for Disease Control and Prevention.
5. Chamouard, F., Tarriere, C, and Boudrit, P. Protection of children on board vehicles: Influence of pelvis design and thigh and abdomen stiffness on the submarining risk for dummies installed on a booster. *Proceedings of the 15th International Conference on Enhanced Safety of Vehicles.* 1063-1075. 1996. Washington, D.C., National Highway Traffic and Safety Administration.
6. Cogill, B. *Anthropometry Indicators Measurement Guide. US Agency for International Development [Food and Nutrition Technical Assistance Project FANTA]*. 2003. Washington, D.C., Academy for Educational Development.
7. Cyr, C., Lemoine, C., and Santschi, M. *Canadian Paediatric Surveillance Report 2005: Lap Belt Syndrome Report*. 38-39. 2005. Ottawa, Ontario, Canadian Paediatric Society.
8. de Onis, M., Garza, C., Victora, C. G., Onyango, A. W., Frongillo, E. A., Martines, J., and WHO MULTICENTRE GROWTH REFERENCE STUDY GROUP. The WHO Multicentre Growth Reference Study: Planning, study design, and methodology. *Food Nutrition Bulletin 25[Supplement 1]*, 15-26. 2004.
9. de Onis, M., Onyango, A. W., Van den Broeck, J., Chumlea, W. C., Martorell, R., and WHO MULTICENTRE GROWTH REFERENCE STUDY GROUP. Measurement and standardization protocols for anthropometry used in the construction of a new international growth reference. *Food Nutrition Bulletin 25[Supplement 1]*, 27-36. 2004.
10. de Onis, M. and WHO MULTICENTRE GROWTH REFERENCE STUDY GROUP. *WHO Child Growth Standards based on length/height, weight and age. 95[Supplement 450]*, 76-85. 2006.
11. Demirjian, A. *Anthropometry Report-height, weight and body dimensions: a report from Nutrition Canada*. 1980. Ottawa, Health and Welfare Canada.
12. Dieticians of Canada, The College of Family Physicians of Canada, and Community Health Care Nurse Association of Canada. The Use of Growth Charts for Assessing and Monitoring Growth in Canadian Infants and Children. *Canadian Journal of Dietetic Practice and Research 65*[1], 22-32. 2004.
13. Evans, W. A., Courtney, A. J., and Fok, K. F. The design of school furniture of Hong Kong school children an anthropometry case study. *Applied Ergonomics 19*[2], 122-134. 1988.
14. Flynn, M. A., Hall, K., Noack, A., Clovechok, S., Enns, E., Pivnick, J., Naimish, A., Wouts, P., Best, M., and Pryce, C. Promotion of healthy weights at preschool public health vaccination clinics in Calgary: an obesity surveillance program. *Canadian Journal of Public Health 96*[6], 421-426. 2005.
15. He, M. and Sutton, J. Using routine growth monitoring data in tracking overweight prevalence in young children. *Canadian Journal of Public Health 95*, 419-423. 2004.
16. Janssen, I., Katzmarzyk, P. T., Boyce, W. F., King, M. A., and Pickett, W. Overweight and obesity in Canadian adolescents and their associations with dietary habits and physical activity patterns. *Journal of Adolescent Health 35*[5], 360-367. 2004.
17. Johnson, T. S., Engstrom, J. L., Haney, S. L., and Mulcrone, S. L. Reliability of three length measurement techniques in term infants. *Pediatric Nursing 25*[1], 13-17. 1999.
18. Knight, G. and Noyes, J. Children's behaviour and the design of school furniture. *Ergonomics 42*[5], 747-760. 1999.

19. Lampl, M., Birch, L., Picciano, M. F., Johnson, M. L., and Frongillo, E. A. Jr. Child factor in measurement dependability. *American Journal of Human Biology 13*[4], 548-557. 2001.

20. Lin, Y. C., Wang, M. J. J., and Wang, E. M. The comparisons of anthropometry characteristics among four peoples in East Asia. *Applied Ergonomics 35*, 173-178. 2004.

21. Linton, S. J., Hellsing, A. L., Halme, T., and Akerstedt, K. The effects of ergonomically designed school furniture on pupils' attitudes, symptoms and behaviour. *Applied Ergonomics 25*[5], 299-304. 1994.

22. Marfell-Jones, M., Olds, T., Stewart, A., and Carter, L. J. E. *International Standards for Anthropometry Assessment.* 1-137. 2006. Australia, International Society for the Advancement of Kinanthropometry.

23. Panagiotopoulou, G., Christoulas, K., Papanckolaou, A., and Mandroukas, K. Classroom furniture dimensions and anthropometry measures in primary school. *Applied Ergonomics 35*[2], 121-128. 2004.

24. Reed, M. P., Ebert-Hamilton, S. M., Manary, M. A., Klinich, K. D., and Schneider, L. W. *A New Database of Child Anthropometry and Seated Posture for Automotive Safety Applications. SAE Technical Papers Series*, 1-16. 2005. 400 Commonwealth Drive, Warrendale, PA 15096-0001 U.S.A. Tel: (724) 776-4841 Fax: (724) 776-5760, www.sae.org.

25. Saul, R. A., Pritz, H. P., McFadden, J., Backaitis, S. H., Hallenbeck, H., and Rhule, D. Description and Performance of the Hybrid III 3 year-old, 6 year-old and small female test dummies in restrain system and out-of-position air bag environments. Paper Number: 98-S7-O-01, 1-20. 1997. National Highway Traffic Safety Administration and Transportation Research Center Inc.

26. Snyder RG, Spencer, M. L., Owings, C. L., and Schneider, L. W. *Physical characteristics of children as related to death and injury for consumer product design and use*. 1-54. 1975. Ann Arbor, MI, Highway Safety Research Institute.

27. Snyder, R. G., Schneider, L. W., Owings, C. L., Reynolds, H. M., Golomb, D. H., and Schork, M. A. Anthropometry of infants, children and youths to age 18 for product safety design. Highway Safety Research Institute Report No. UM-HSRI-77-17. 1977. Ann Arbor, MI.

28. Steenbekkers, L. P. and Moenbroek, J. F. Anthropometry data of children for non-specialist users. *Ergonomics 33*[4], 421-429. 1990.

29. Tremblay, M. S. and Willms, J. D. Secular trends in the body mass index of Canadian children. *Canadian Medical Association Journal 163*[11], 1429-1433. 2000.

30. Vegelin, A. L., Brukx, L. J., Waelkens, J. J., and Van den Broeck, J. Influence of knowledge, training and experience of observers on the reliability of anthropometry measurements in children. *Annals of Human Biology 30*[1], 65-79. 2003.

31. Veugelers, P. J. and Fitzgerald, A. L. Prevalence of and risk factors for childhood overweight and obesity. *Canadian Medical Association Journal 173*, 607-613. 2005.

32. Weber, K., Lehman, R. J., and Schneider, L. W. Child anthropometry for restraint system design. Technical Report No. UMTRI-85-23. 1985. Ann Arbor, MI, University of Michigan Transportation Research Institute.

33. Wijnhoven, T. M. A., de Onis, M., Onyango, A. W., Wang, T., Bjoerneboe, G. E. A., Bhandari, N., Lartey, A., and Alasfoor, D. Assessment of gross motor development in the WHO Multicentre Growth Reference Study. Food and Nutrition Bulletin 25[1 (supplement 1)], S37-S45. 2004. United Nations University.

34. Willms, J. D. *Early childhood obesity: a call for early surveillance and preventive measures. 171*[3], 243-244. 2004.

35. Willms, J. D., Tremblay, M. S., and Katzmarzyk, P. T. Geographic and demographic variation in the prevalence of overweight Canadian children. *Obesity Research 11*[5], 668-673. 2003.

Appendix A: Summaries of Most Relevant Publications

Several of the main publications referred to in the first section of this literature scan are presented here in table format to provide more detailed information that may have not been captured in the abstract (additional publications referred to in the first section can be found in Appendix B). The tables are divided into categories to provide information in an organized manner. Reference id number and category refer to the abstract number as found in Appendix B. The tables list the project/program name, the organization (s) offering the program, the source of the publication, the geographical and program focus, the target audience and the date the program was first established. The tables present information on whether there was anthropometry training involved and what types of measuring instruments were used, the type of data that was collected and the statistical analysis or sampling strategies utilized. A summary of the measured results, conclusions reached together with any problems or limitations found are listed as well. The principal authors contact information is provided.

RECORD 1 (Appendix A: Summaries of Most Relevant Publications)

Description of Activity, Project or Program	
Reference Id #	11
Category	*Nutritional Status and the Body Sizes of Children*
Project/Program Name	Reliability of anthropometry measurements in the WHO Multicentre Growth Reference Study
Organization(s) Offering the Program	World Health Organization (WHO)
Source	Food and Nutrition Bulletin
Program Focus	The WHO Multicentre Growth Reference Study (MGRS) was undertaken to generate new growth curves for assessing the growth and development of infants and young children from around the world.
Geographical Focus	Brazil, Ghana, India, Norway, Oman and the USA
Program Objectives	To describe how reliability assessment data in the WHO Multicentre Growth Reference Study were collected and analyzed, and to present the results
Target Audience(s)	Infants and children from Brazil, Ghana, India, Norway, Oman and the USA
Date First Established	2006
Training	Described elsewhere (See record # 14)
Measurement Instruments	Described elsewhere (See record # 14)
Data	• There were two sources of anthropometry data (length, head and arm circumferences, triceps and subscapular skinfolds, and height) for these analyses • Data for constructing the WHO Child Growth Standards, collected in duplicate by observer pairs, were used to calculate inter-observer technical error of measurement (TEM) and the coefficient of reliability • The second source was the anthropometry standardization sessions conducted throughout the data collection period with the aim of identifying and correcting measurement problems
Statistical Analysis	• An anthropometry expert visited each site annually to participate in standardization sessions and provide remedial training as required • Reliability statistics reported for the standardization sessions were intra-observer technical error of measurement (TEM), inter-observer TEM and average bias • Coefficient of reliability, R, was measured for 6 anthropometry variables • Detailed equations given and explained
Summary of Measured Results	• Average bias was within acceptable limits of deviation from the expert, with head circumference having both lowest bias and lowest TEM • Teams tended to underestimate length, height and arm circumference, and to overestimate skinfold measurements • Intra- and inter-observer TEMs were comparable, and newborns, infants and older children were measured with equal reliability • The coefficient of reliability was above 95% for all measurements except skinfolds whose R coefficient was 75-93%
Conclusion	• Reliability of the MGRS teams compared well with the study's anthropometry expert and published reliability statistics. • Problems and limitations • Difficulties associated with keeping children fully stretched out and still for length/height measurements and in manipulating soft tissues for the other measurements were encountered
Contact Information	Dr. Mercedes de Onis Coordinator Growth Assessment and Surveillance Nutrition for Health and Development (NHD) World Health Organization 1211 Geneva, Switzerland 27 Fax: (41 22) 791 4156

RECORD 2 (Appendix A: Summaries of Most Relevant Publications)

Description of Activity, Project or Program	
Reference Id #	63
Category	*Nutritional Status and the Body Sizes of Children*
Project/Program Name	2000 CDC Growth Charts for the United States: Methods and Development
Organization(s) Offering the Program	US Centers for disease control and prevention (CDC)
Source	CDC, Department of Human Health and Human Services
Program Focus	To revise the growth charts from 1977 with more recent and comprehensive national data on body measurements in the US
Geographical Focus	USA
Program Objectives	This report provides detailed information on how the 2000 CDC growth charts for the United States were developed, expanding upon the report that accompanied the initial release of the charts in 2000.
Target Audience(s)	Infants and children from the USA
Date First Established	2000
Training	N/A
Measurement Instruments	N/A
Data	• Data obtained from the National Health Examination Surveys and the National Health and Nutrition Examination Surveys
Statistical Analysis	• Very detailed statistics on the derivation of growth charts are available • Smoothed percentile curves were developed in two stages. In the first stage, selected empirical percentiles were smoothed with a variety of parametric and nonparametric procedures. In the second stage, parameters were created to obtain the final curves, additional percentiles and z-scores • The revised charts were evaluated using statistical and graphical measures
Summary of Measured Results	• The 1977 National Center for Health Statistics (NCHS) growth charts were revised for infants (birth to 36 months) and older children (2 to 20 years). New body mass index-for-age (BMI-for-age) charts were created. Use of national data improved the transition from the infant charts to those for older children
Conclusion	• The evaluation of the charts found no large or systematic differences between the smoothed percentiles and the empirical data.
Problems and limitations	N/A
Contact Information	U.S. Department of Health and Human Services Centers for Disease Control and Prevention National Center for Health Statistics Hyattsville, MD 20782 Tel: (301) 458-4000 or 1-866-441-NCHS

RECORD 3 (Appendix A: Summaries of Most Relevant Publications)

Description of Activity, Project or Program	
Reference Id #	68
Category	*Nutritional Status and the Body Sizes of Children*
Project/Program Name	Anthropometry Report: height, weight and body dimensions
Organization(s) Offering the Program	Nutrition Canada
Source	Health and Welfare Canada
Program Focus	To assess the health and nutritional status of the Canadian child and adult population.
Geographical Focus	Canada across the ten Canadian provinces recognized at the time.
Program Objectives	To form a database against which past and future trends can be compared
Target Audience(s)	• Infants and children from the USA-Canadian population in general. Children of all ages. • The focus of this report is national but includes data on First Nations and Inuit • Comparisons, where appropriate, are made with data from other countries
Date First Established	1980
Training	• The technicians responsible for the anthropometry measurements were trained at the Centre de Recherche sur la Croissance Humaine of the University of Montreal. • The International Biological Program techniques were taught as used at the Growth Centre.
Measurement Instruments	• The Harpenden anthropometer for all length measurements • The Harpenden skinfold calipers • Toledo beam balance and a metal tape for weight and circumferences
Data Available	• Data was obtained from the Nutrition Canada National Survey of nutritional status carried out during 1970–1972 • These data provide the only nationally representative data for the Canadian population since the first national survey of height and weight carried out over 25 years ago
Statistical Strategy	• Probability sample design and estimates are based on weighted observations
Statistical Analysis	• For most measurements tables and curves give the mean, standard deviation, standard error, as well as the sample size and estimated population size for each age group • Tables also report the median value, 5th, 10th, 25th, 75th, 90th and 95th percentiles for each age interval • The inter and intra-measurer errors were not checked for statistical significance.
Summary of Measured Results	• The results of 19 child body measurements are given together with comparisons by sex, socio-economic status and racial/ethnic differences
Conclusion	• Along with secular trends identified for height and weight, the findings illustrate the importance of taking into consideration ethnic differences in body measurements and the need to establish national standards for each country.
Problems and limitations	N/A
Contact Information	Health Canada

RECORD 4 (Appendix A: Summaries of Most Relevant Publications)

Description of Activity, Project or Program	
Reference Id #	102
Category	*Nutritional Status and the Body Sizes of Children*
Project/Program Name	National Health and Nutrition Examination Survey III: Body Measurements (Anthropometry)
Organization(s) Offering the Program	US Centers for disease control and prevention (CDC)
Source	National Center for Health Statistics
Program Focus	Introduction to anthropometry, equipment, examination protocol, logs and records and quality control section are presented in this report on how the National Health and Nutrition Examination Survey III: Body Measurements was conducted.
Geographical Focus	USA
Program Objectives	To form a database against which past and future trends can be compared
Target Audience(s)	• American population in general. Children of all ages.
Date First Established	1988
Training	• Two health technicians were trained as both the examiner and the recorder
Measurement Instruments	• A stadiometer was used for standing height, Frankfort Horizontal plane was used for sitting height • The calipers were used for length and breadth measurements • An electronic digital scale and a metal tape for weight and circumferences • Skinfolds were measured with Holtain skinfold calipers
Data Available	No data available only protocols and record forms
Statistical Strategy	No sampling data available, done as part of the NHANES in 1988
Statistical Analysis	No statistical data available, done as part of the NHANES in 1988
Summary of Measured Results	N/A
Conclusion	N/A
Problems and limitations	• Body positioning, reading and recording measurements were the most common problems encountered • Standard procedure protocols for ensuring quality control are described
Contact Information	

RECORD 5 (Appendix A: Summaries of Most Relevant Publications)

Description of Activity, Project or Program	
Reference Id #	62
Category	*Nutritional Status and the Body Sizes of Children*
Project/Program Name	Secular trends in the body mass index of Canadian children
Organization(s) Offering the Program	Faculty of Kinesiology University of New Brunswick, Fredericton, NB
Source	*Canadian Medical Association Journal*
Program Focus	To investigate the various changes in society that have created the opportunity for more sedentary behaviour and the consumption of food that is high in kilojoules, which may lead to a progressive increase in body mass over time
Geographical Focus	Canada
Program Objectives	The purpose of this study was to examine secular changes in the body mass index (BMI) of Canadian children between 1981 and 1996.
Target Audience(s)	Canadian children and youth
Date First Established	2000
Training	As done for the above mentioned surveys
Measurement Instruments	• Questionnaires and measurements done in the Canada Fitness Survey
Data Available	• Nationally representative data from the 1981 Canada Fitness Survey • The 1988 Campbell's Survey on the Well-being of Canadians • The 1996 National Longitudinal Survey of Children and Youth
Statistical Strategy	As done for the above mentioned surveys
Statistical Analysis	• Regression analyses were used to assess population changes in BMI from 1981 to 1996 for children aged 7–13 years • Changes in the distribution of BMI results were evaluated by plotting the residuals from regression analyses of BMI on age, assessed separately by sex, using the 1981 data as baseline • The proportions of children exceeding the 85th and 95th age- and sex-specific percentiles from the 1981 (baseline) data were also calculated
Summary of Measured Results	• Since 1981, BMI has increased at the rate of nearly 0.1 kg/m2 per year for both sexes at most ages, indicating a clear secular trend toward an increase in BMI of Canadian children • The prevalence of overweight among boys increased from 15% in 1981 to 28.8% in 1996 and among girls from 15% to 23.6% • The prevalence of obesity in children more than doubled over that period, from 5% to 13.5% for boys and 11.8% for girls
Conclusion	Secular trends indicate that Canadian children aged 7-13 years are becoming progressively overweight and obese
Problems and limitations	
Contact Information	M.S. Tremblay Faculty of kinesiology University of New Brunswick, Fredericton, NB tremblay@unb.ca

RECORD 6 (Appendix A: Summaries of Most Relevant Publications)

Description of Activity, Project or Program	
Reference Id #	8
Category	*Nutritional Status and the Body Sizes of Children*
Project/Program Name	Anthropometry Indicators Measurement Guide [part of the Standardized Monitoring and Assessment of Relief and Transitions (SMART) Program]
Organization(s) Offering the Program	US Agency for International Development (USAID)
Source	Food and Nutrition Technical Assistance Project FANTA
Program Focus	To evaluate and monitor changes in body dimensions of children under 5 years to reflect the overall health and welfare of these populations in developing countries
Geographical Focus	International
Program Objectives	• To present a programming tool for use in consistent collection and reporting of nutritional anthropometry indicators and annual monitoring indicators and to provide suggestions for additional information related to monitoring and evaluation • This information will be used to track and improve child nutrition activities and performance
Target Audience(s)	• Children under the age of 5 in developing countries
Date First Established	2003
Training	• The guide is not meant to substitute for adequate technical and academic training needed to conduct problem analysis, design programs and for implementation • Field staff need to be trained to take anthropometry measurements, interviewing techniques and recording requirements
Measurement Instruments	• UNICEF electronic and hanging scales, TALC weighing scale • UNICEF length/height board, infant recumbent length board • UNICEF circumference metal tape • Step-by-step procedures available for taking measurements are presented to ensure a standard method for taking the measurements
Data Available	No data is available. The impact indicators discussed are: decreased percent of stunted children, decreased percent of underweight children, increased percent of eligible children in growth monitoring/promotion, increased percent of children in growth promotion program gaining weight in past 3 months.
Statistical Strategy	Detailed information provided on sampling error, sample size, survey sample size requirements
Statistical Analysis	• Statistical information on how to compare anthropometry data to reference standards • Z-scores, standard deviation, percentage of the median and percentiles, cut offs • Section on data analysis, how to present the data, calculation of indices and EPI INFO software
Summary of Measured Results	
Conclusion	To consider the advantages of including the monitoring indicators in annual reports to modify training, implementation and information management systems to incorporate these indicators in the future
Problems and limitations	
Contact Information	Food and Nutrition Technical Assistance Project Academy of Educational Development 1825 Connecticut Ave., NW Washington, D.C. 20009-5721 Tel: 202-884-8000 Fax: 202-884-8432 fanta@aed.org www.fantaproject.org

RECORD 7 (Appendix A: Summaries of Most Relevant Publications)

Description of Activity, Project or Program	
Reference Id #	115
Category	*Restraint System Design*
Project/Program Name	Canadian Paediatric Surveillance Report 2005: Lap Belt Syndrome Report
Organization(s) Offering the Program	Canadian Paediatric Society (CPS)
Source	*Canadian Paediatric Society Surveillance Report 2005*
Program Focus	To obtain epidemiologic data on the incidence and pattern of injuries encountered in the lap-belt syndrome
Geographical Focus	Canada
Program Objectives	• Identify at-risk age groups • Supply data that will help develop new strategies to adequately protect children in motor vehicles • Promote education and awareness of this rare syndrome among health care professionals
Target Audience(s)	Children in Canada up to 18 years of age
Date First Established	2005
Training	N/A
Measurement Instruments	N/A
Data Available	Lap-belt syndrome cases September 1, 2003 to August 31, 2005
Statistical Strategy	N/A
Statistical Analysis	N/A
Summary of Measured Results	• Twenty-eight children with injuries compatible with lap-belt syndrome were confirmed in Canada from 2003 to 2005; Their ages ranged between two and 15 years with a median of eight • The average Pediatric Trauma Score was seven (range 3–10) • Most of the crashes were head-on collisions (17/28) • The median speed at the time of impact was 97.5 km/h (range 50–120 km/h) • Most of the children (23/28) were seated in the back of a passenger car or a mini-van. Three children were seated in the middle front seat of a pick-up truck and two were front-seat passengers • Although 12 children were less than eight years old, only one was restrained in a booster seat (wearing only a lap belt) • Only three of the older children were properly restrained with a threepoint seat belt • Twenty-four children had an abdominal lesion. Of these, 17 had an intestinal injury (13 small bowel perforations, three small bowel infarcts, one delayed small bowel stricture, four colon perforations and two sigmoid lacerations), eight had mesenteric tears, three had hepatic lesions, one had a biliary tract laceration, five had splenic lacerations and three had a renal contusion. • Fourteen patients had an abdominal wall ecchymosis or contusion associated with abdominal injury • Twelve patients (43%) had lumbar spine fractures (five Chance-type fractures, four compression fractures of a vertebra, two fracture-dislocations of L2–L3 and one comminuted fracture of L2) • Seven of these patients (7/28, 25%) presented with a complete paraplegia below the level of the lesion and none recovered
Conclusions	• These study results call for high vigilance among physicians for lap-belt associated injuries in restrained paediatric victims especially if they present with ecchymosis, contusions or abrasions over the abdomen • Restrained children in motor vehicle crashes present with a wide spectrum of injuries; they have more abdominal solid organ injuries, a wider spectrum of spinal cord injuries than adult patients, and a high incidence of complete paraplegia
Problems and limitations	
Contact Information	Claude Cyr, MD Centre hospitalier universitaire de Sherbrooke 3001 12e Ave N, Sherbrooke QC J1H 5N4 Tel.: 819-346-1110, ext.14634 Fax: 819-564-5398 claude.cyr@usherbrooke.ca

RECORD 8 (Appendix A: Summaries of Most Relevant Publications)

Description of Activity, Project or Program	
Reference Id #	89
Category	*Restraint System Design*
Project/Program Name	Child anthropometry for restraint system design
Organization(s) Offering the Program	University of Michigan Transportation Research Institute
Source	*University of Michigan Transportation Research Institute Technical Report*
Program Focus	To present all available measurements that are likely to be of interest to the restrains designer will be found in one single source
Geographical Focus	USA
Program Objectives	• The purpose of this report is to present a compilation of the child anthropometry data from all three UM studies that are considered useful for child restraint design • In addition, dimensions unique to one study are presented along with measurement taken in more than one study
Target Audience(s)	Child restraint designers
Date First Established	1985
Training	N/A
Measurement Instruments	N/A
Data Available	• Because measurement procedures were as consistent as possible among the studies, raw data for the same measures have been combined and are displayed as single data sets • Tables and scatter plots are presented (scatter plots are truncated at age 10)
Sampling Strategy	Described elsewhere
Statistical Analysis	Described elsewhere
Summary of Measured Results	Described elsewhere
Conclusion	N/A
Problems and limitations	Report limited to presenting data from only 3 UM previous studies 1975–1985
Contact Information	University of Michigan Transportation Research Institute 2901 Baxter Road Ann Arbor, Michigan 48109-2150 Tel: 734-764-6504 Fax: 734-936-1081 umtri@umich.edu

RECORD 9 (Appendix A: Summaries of Most Relevant Publications)

Description of Activity, Project or Program	
Reference Id #	94
Category	*Restraint System Design*
Project/Program Name	Infants and children in the adult world of automobile safety design: pediatric and anatomical considerations for design of child restraints
Organization(s) Offering the Program	• University of Michigan Medical School, Biosciences Section and Department of Anthropology, The Highway Safety Research Institute, University of Michigan • Department of Paediatrics, University of Michigan Medical School
Source	*Journal of Biomechanics*
Program Focus	To demonstrate how infant and child differ structurally from the adult in a number of ways which are critical to the design for protection against impact forces and for adequate occupant restraint systems
Geographical Focus	USA
Program Objectives	The purpose of this paper is to bring together a profile of the anatomy, anthropometry, growth and development of the infant and child. Age differences related to the proper design of child restraint systems are emphasized
Target Audience(s)	Infants, children and youth
Date First Established	1969
Training	N/A
Measurement Instruments	N/A
Data Available	Data on the growth of the infant body as a whole, the head and neck, the chest, the abdomen, the vertebral column, the limbs and the biomechanical properties of the tissues
Sampling Strategy	N/A
Statistical Analysis	N/A
Summary of Measured Results	• The frequency of head injuries in children involved in auto collisions may be due to the child's proportionately large head and higher center of gravity • Sudden snapping or rotation of the relatively unrestrained child's head can traumatize related nerves, blood vessels and spinal cord segments • The skull is not yet an intact bony case for the brain but a series of broadly spaced elastic bones • Growth rates of different parts of the body vary with age • Differences in shape, size, structure and biomechanical properties of the infant and child and adult pelvic skeleton are clearcut and must be considered for safety design • Organs of the chest are housed in an elastic and highly compressible thoracic cage and are vulnerable to chest impact
Conclusion	Most effective restrain systems for children are those which distribute impact forces over a large portion of the body
Problems and limitations	Problems discussed include child-adult structural differences, center of gravity of the body, the head mass in relation to the neck and general body proportions, positions of key organs and biomechanical
Contact Information	Not available

RECORD 10 (Appendix A: Summaries of Most Relevant Publications)

Description of Activity, Project or Program	
Reference Id #	4
Category	*Restraint System Design*
Project/Program Name	A New Database of Child Anthropometry and Seated Posture for Automotive Safety Applications
Organization(s) Offering the Program	Society of Automotive Engineers (SAE)
Source	SAE Technical Papers Series
Program Focus	This paper presents a laboratory study of body dimensions, seated posture, and seatbelt fit for children weighing from 40 to 100 lb (18 to 45 kg) for the development of a child anthropometry measurements database
Geographical Focus	USA
Program Objectives	• To develop a detailed database on vehicle-seated anthropometry, posture, and position for children and adolescents sitting in harness restraints, belt-positioning boosters, and vehicle seats with three-point belts • To develop a positioning procedure for six-year old and 10-year-old crash dummies that provides representative posture and position on booster seats and vehicle seats • To develop a physical belt-fit assessment procedure for children from 40 to 100 lb that uses crash dummies (six-year-old and 10-year-old Hybrid III) • To identify differences between children and crash dummies that could adversely affect the fidelity of crash-test assessments of belt positioning boosters
Target Audience(s)	Children and youth weighing between 40 and 100 pounds
Date First Established	2005
Training	Not needed
Measurement Instruments	• A reconfigurable vehicle mockup set up was used • A FARO Arm coordinate digitizer was used for taking the 3D measurements • Standard anthropometry equipment was used to make the measurements
Data Available	• Sixty-two boys and girls were measured in three vehicle seats with and without each of three belt-positioning boosters • In addition to standard anthropometry measurements, three-dimensional body landmark locations were recorded with a coordinate digitizer in sitter-selected and standardized postures
Sampling Strategy	• Participants were recruited for testing by word of mouth, fliers and newspaper ads • The goal was to recruit children who spanned the range of potential users of belt positioning boosters with respect to stature and weight, including the range between the masses of the 6 year old and 10 year old Hybrid-III crash test dummies (23kg and 32 kg respectively)
Statistical Analysis	• Statistical analysis is required to weigh the results to be applicable for the target population • Statistical analysis have been developed previously for the application to adult occupant protection
Summary of Measured Results	• Qualitative observations suggested that children sat more slumped and with looser belt fit in these trials than in the subsequent standard posture trials • Asymmetric leg postures, slack in the lap portion of the belt, and belt routing over the abdomen were common • Slumping could be observed most clearly by noting the height of the participant's heads relative to the seat • As expected, the booster increases top-of-head height, and the effect is independent of stature • Top-of-head height is significantly greater in the standard posture than in the sitter-selected posture ($p<0.01$) and the effect is larger without the child restraint system, averaging 14 mm on the vehicle seat and 7 mm on child restraint system A
Conclusions	This new database quantifies the vehicle-seated postures of children and provides quantitative evidence of the effects of belt-positioning boosters on belt fit. The data will provide guidance for child restraint design, crash dummy development, and crash dummy positioning procedures.

(continued next page)

RECORD 10 (continued)

Description of Activity, Project or Program	
Reference Id #	4
Category	*Restraint System Design*
Project/Program Name	A New Database of Child Anthropometry and Seated Posture for Automotive Safety Applications
Organization(s) Offering the Program	Society of Automotive Engineers (SAE)
Problems and limitations	• Study is limited by the range of test conditions possible within the attention span of the participants • Only five child restrains systems were used a small fraction of the market • Study sample was relatively small • Recent data from the NCHS indicate that the upper percentiles of weight-for-stature, as measured by body mass index, are increasing for U.S. children (as they are for adults) • The current sample includes a wide distribution of weight-for-stature only in the upper stature ranges (above 130 cm) • An analysis of trends in this group should show the potential impact of shifts in average body mass index on belt fit for most children • Morbidly obese children were not included in this sample and additional data collection would be needed to quantify the effects of child obesity on posture and belt fit
Contact Information	SAE Permissions 400 Commonwealth Drive Warrendale, PA 15096-0001-USA Email: permissions@sae.org Tel: 724-772-4028 Fax: 724-772-4891

RECORD 11 (Appendix A: Summaries of Most Relevant Publications)

Description of Activity, Project or Program	
Reference Id #	85
Category	*Child Anthropometry for Safety and Injury Prevention*
Project/Program Name	Anthropometry of infants, children and youths to age 18 for product safety design
Organization(s) Offering the Program	Highway Safety Research Institute
Source	http://ovrt.nist.gov/projects/anthrokids/
Program Focus	The present study is a continuation and extension of the 1975 anthropometry survey sponsored by the Biomedical Department of the Highway Safety Research Institute and the Consumer Product Safety Commission and is an attempt to provide a more complete source of useful anthropometry data on children and youths through age 78
Geographical Focus	USA
Program Objectives	• To provide a complete source of anthropometry data on U.S. children for consumer product design, hazard assessment and guidance in establishing requirements or recommendations in standards • To develop a 1ist of traditional and functional anthropometry measurements most urgently needed on infants, children and youth from 2 weeks to 18 years for broad application to product safety design • To determine a measurement strategy and sampling procedure that would efficiently and accurately collect these data on a sample representative of the total U.S. population of infants, children and youth • To make necessary modifications to existing anthropometry instruments and assemble a second portable computer system for collecting these anthropometry data • Collect, reduce, and analyze the required dimensional data • Tabulate and present the data in a format or formats most useful to persons concerned with designing or establishing guidelines and standards for children's products, taking into consideration the potential functional applications
Target Audience(s)	USA infants (0-2 years), children and youth (2-18 years)
Date First Established	1975–1977
Training	Measurements were taken by two teams of trained anthropometrists
Measurement Instruments	• Standard anthropometers, calipers, and tape devices were modified to read electronically and input dimensional data directly to a mini-computer for data processing and storage • Each measurement is described along with a photograph and illustration • An automated anthropometry data acquisition system was used. • GPM Swiss standard anthropometers, calipers and measuring tapes were modified to provide electrical readouts.
Data Available	• Data on 87 measurements have been obtained on over 4100 additional subjects two weeks through 18 years of age, representing as nearly as possible the U.S. population with regard to race, demographic, and socio-economic factors • Tables and figures are available as well as diagrams of every measurement taken (2–18 years) • Separate tables, figures and diagrams for infants (0–2 years)

(continued next page)

RECORD 11 (continued)

Description of Activity, Project or Program	
Reference Id #	85
Category	*Child Anthropometry for Safety and Injury Prevention*
Project/Program Name	Anthropometry of infants, children and youths to age 18 for product safety design
Organization(s) Offering the Program	Highway Safety Research Institute
Sampling Strategy	• The Survey Research Center, University of Michigan, maintains economic, demographic, and sociological information on a national sample representative of the United States population consisting of 74 primary sampling units (PSU's) which are made up of one or more counties. These PSU's include the 12 largest standard metropolitan statistical areas (SMSA's) plus 62 other PSU's which are divided into two groups both representative of the population outside the 12 largest SMSA's. The sampling frame utilized in the Youth Fitness Study was selected from the 12 SMSA's in one of these halves, and consisted at the first stage of the 12 largest central cities, 22 suburban counties selected from these 12 SMSA's and the 31 counties outside the 12 SMSA's • 8 of the 12 cities were randomly selected and 10 counties neighboring the chosen 8 cities and 15 of the remaining 31 counties were then obtained by a random process. Within each of the chosen areas one school district was randomly selected. • Within each district a level or levels of schools [elementary school (usually K–6), intermediate school (usually 7–9) and high school (usually 10–12) 1 were selected. Schools were selected randomly from among those with a given grade range and grade levels were selected randomly so that the resulting sample was balanced in the ratio 2 elementary to 1 intermediate to 1 high school. • Unfortunately, selection of a school district or school by this sampling scheme did not guarantee its participation in the study. • Refusals of school boards, school superintendents, or principals, and practical limitations of school buildings such as space available made it necessary to select alternative districts or schools as scheduling progressed. Thus, the ideal of adhering rigidly to the original sampling scheme could not be realized and it was imperative to remain flexible. In each case where substitutions were necessary, however, every effort was made to make the substitution from the same city, county or geographic area.
Statistical Analysis	• 87 traditional and functional body measurements were taken on a sample of 4127 infants, children and youth • Summary statistics of measurement results are reported for 16 age groups along with scatter plots of the data points for the sexes combined and males and females separately • T-tests to ensure measurement reliability and consistency among measurers. • Mean, standard deviation, 5th, 50th, 95th percentiles and minimum and maximum values are given for each of the 87 measurements taken • Bivariate relationships of selected functions' measurements with weight or stature are provided along with regression data
Summary of Measured Results	The database represents the most comprehensive source of anthropometry information for application to child product safety currently available for product design.
Conclusion	
Problems and limitations	Representativeness of the sample, bias
Contact Information	Highway Safety Research Institute Huron Parkway at Baxter Road Ann Arbor, Michigan 48109 http://ovrt.nist.gov/projects/anthrokids/

RECORD 12 (Appendix A: Summaries of Most Relevant Publications)

Description of Activity, Project or Program	
Reference Id #	86
Category	*Child Anthropometry for Safety and Injury Prevention*
Project/Program Name	Classroom furniture dimensions and anthropometry measures in primary school
Organization(s) Offering the Program	Ergophysiology Laboratory Department of Physical Education and Sports Science Aristotle University of Thessaloniki, Greece
Source	*Applied Ergonomics*
Program Focus	Student's sitting posture, classroom furniture and the anthropometry measures of school children for design purposes
Geographical Focus	Greece
Program Objectives	To compare students' dimensions to the dimension of school furniture and determine whether this type of furniture is well-designed and promotes good sitting posture at school by taking into account dimensions of children
Target Audience(s)	School children aged 7 to 12 years
Date First Established	2004
Training	N/A
Measurement Instruments	N/A
Data Available	• Stature, elbow height, shoulder height, upper arm length, knee height, popliteal height and buttock–popliteal length were recorded for 180 students • The dimensions were measured for four different types of chairs and five types of desks prevalent in classrooms • The anthropometry measures of the students and the furniture dimensions were compared in order to identify any incompatibility between them
Statistical Analysis	Computation of descriptive statistics (Mean, Standard Deviation, Standard Error of the Mean) to describe the physical characteristics of the subjects
Summary of Measured Results	• The data indicated a mismatch between the students' bodily dimensions and the classroom furniture available to them • The chairs were too high and too deep and desks were also too high for the students • Specifically: Popliteal and seat height mismatch, buttock–popliteal length and seat depth mismatch, knee height and desk clearance mismatch, elbow and shoulder height and desk height mismatch
Conclusion	This situation has negative effects on the sitting posture of the children especially when reading and writing
Problems and limitations	
Contact Information	K. Mandroukas Ergophysiology Laboratory, Department of Physical Education and Sports Science Aristotle University of Thessaloniki Thessaloniki 62100, Greece Tel.: +30-310-992231-32 Fax: +30-310-992230 kmandrou@phed.auth.gr

RECORD 13 (Appendix A: Summaries of Most Relevant Publications)

Description of Activity, Project or Program	
Reference Id #	25
Category	*Training*
Project/Program Name	Influence of knowledge, training and experience of observers on the reliability of anthropometry measurements in children
Organization(s) Offering the Program	Catharina Hospital Department of Paediatrics Eindhoven, Netherlands
Source	*Annals of Human Biology*
Program Focus	Growth studies and the use of detailed anthropometry standardization protocols to train people to acquire better insight
Geographical Focus	Netherlands
Program Objectives	To elucidate the impact of the observer's level of technical knowledge, training and experience with measuring height and triceps skinfold thickness on the reliability of these measurements in children.
Target Audience(s)	Children aged 2–7
Date First Established	2003
Training	12 observers with different backgrounds and levels of experience, protocol knowledge and protocol training were employed
Measurement Instruments	N/A
Data	The main outcome measures, precision and accuracy, were expressed as technical error of measurement and average bias in comparison with an expert anthropometrist
Statistical Analysis	Ranking analysis and multiple regressions showed that precision and accuracy in measuring height and triceps skinfold thickness are mainly predicted by all round knowledge of the measurement protocol ($p < 0.05$) and the years of experience ($p < 0.05$)
Summary of Measured Results	• As expected, the best educated and most experienced observers scored the best precision and accuracy • A practical training course of only a few hours does not seem to improve reliability significantly
Conclusion	To get a more reliable insight in growth of a child it is important to be aware of the influence on measurement outcome values of protocol knowledge and years of experience
Problems and limitations	
Contact Information	a.l.vegelin@wkz.azu.nl

RECORD 14 (Appendix A: Summaries of Most Relevant Publications)

Description of Activity, Project or Program	
Reference Id #	11
Category	*Training*
Project/Program Name	Measurement and standardization protocols for anthropometry used in the construction of a new international growth reference
Organization(s) Offering the Program	World Health Organization (WHO)
Source	*Food and Nutrition Bulletin*
Program Focus	The WHO Multicentre Growth Reference Study (MGRS) was undertaken to generate new growth curves for assessing the growth and development of infants and young children from around the world. Appropriate training and continued standardization, adherence to specified methods and procedures, and monitoring of data quality are essential to reduce measurement error and minimize bias in multi-site studies.
Geographical Focus	Brazil, Ghana, India, Norway, Oman and the USA
Program Objectives	To describe the measurement protocols and routine standardization sessions that were used in the MGRS. The study protocols and quality control procedures can be applied in research settings without substantially increasing costs or complicating logistics.
Target Audience(s)	Infants and children from Brazil, Ghana, India, Norway, Oman and the USA
Date First Established	2004
Training	• All candidates received standardized training, and only those who met the MGRS performance criteria were retained for the study. The measurement procedures and training guidelines were prepared by the MGRS Coordinating Centre at WHO in Geneva, based on best practices recommended in anthropometry manuals and in the literature. • The initial training of anthropometrists at each site was carried out by an experienced anthropometrist following the procedures detailed in the MGRS protocol. All anthropometrists were trained to interview mothers, complete the study questionnaires, measure children as described in the protocol, avoid digit preference or transposition of numbers, record measurement values immediately after reading them, and write legibly to reduce mistakes during data transfer. Strict adherence to the measuring techniques and recording procedures was emphasized.
Measurement Instruments	• All study sites used the same measuring equipment. • Length was measured with the Harpenden Infantometer • A self-retracting, 0.7-cm-wide, flat metal tape with blank lead-in strip was used to measure circumferences. Metal tapes were chosen because they are more robust and accurate and stay in a single plane around the head. • Holtain/Tanner-Whitehouse Skinfold Caliper was used to measure skinfolds • To measure weight, portable electronic scales were used that have taring capability and are calibrated to 0.1 kg (UNICEF Electronic Scale 890 or Uniscale). Ideally, newborns should be measured with a scale of higher precision (within 10 g). • The equipment was calibrated regularly, usually daily before the home or hospital visits.
Data	Technical Error of Measurement (TEM) and coefficient of reliability Statistical Analysis
Statistical Analysis	Precision parameters were measured by using the TEM and the coefficient of reliability Anthropometry standardization sessions conducted throughout the data collection period with the aim of identifying and correcting measurement problems
Summary of Measured Results	Rigorous anthropometry protocol was described and tested to ensure high data quality
Conclusion	The rigorous anthropometry protocols described in this paper were set in place to ensure high data quality. These MGRS procedures serve as a model for research settings. The methods and procedures reviewed will be applicable to multi- and single-site studies. It will not be possible to be as rigorous in non-research settings, such as child clinics. At the very least, the procedures should be carefully documented in training manuals, staff members collecting anthropometry data should be trained and refresher sessions should be held periodically, weighing scales and any other instruments used should be maintained in good order and calibrated before use, and fieldworkers should be supervised.

(continued next page)

RECORD 14 (continued)

Description of Activity, Project or Program	
Reference Id #	11
Category	*Training*
Project/Program Name	Measurement and standardization protocols for anthropometry used in the construction of a new international growth reference
Organization(s) Offering the Program	World Health Organization (WHO)
Problems and limitations	• Factors that affected measurement accuracy and precision included the identification of landmark features when measuring soft tissues (arm circumference and skinfolds). • In some sites, the teams experienced difficulties in taking measurements because they did not mark the upper-arm midpoint or the subscapular point. In this respect, the Coordinating Center's ongoing monitoring of anthropometry data and the regular participation of the WHO lead anthropometrists in site standardization sessions were extremely important for detecting and correcting problems.
Contact Information	Dr. Mercedes de Onis Coordinator Growth Assessment and Surveillance Nutrition for Health and Development (NHD) World Health Organization 1211 Geneva, Switzerland 27 Fax: (41 22) 791 4156

Appendix B: Reference List by Category and Abstracts

Reference List by Subject

Abstracts and source information of all the studies reviewed for this literature scan are presented below. The abstracts are organized into six specific categories: nutritional status and the body sizes of children; restraint system design; safety and injury prevention; training; relevant child anthropometry measurements; and, statistics and sampling strategies.

Nutritional Status and the Body Sizes of Children

1. Ref ID: 28

   Bicego, J. T., Sommerfelt, A. E., and Bicego, G. T. Child anthropometry in cross-sectional surveys in developing countries: an assessment of the survivor bias. *American Journal of Epidemiology 135*[4], 438–449. 1992.

   Abstract: In cross-sectional surveys, the sample of children with anthropometry measurements is not representative of all children in a birth cohort, since only children surviving to the survey date are measured. This survivor bias may have implications for studies of trends and differentials in anthropometry indicators. In this paper, the effects of the survivor bias on the estimates of child anthropometry indicators are assessed by 1) reviewing evidence from longitudinal studies on the prevalence of malnutrition among deceased children and among surviving children and by 2) analyzing retrospective data on child mortality and cross-sectional data on child anthropometry in 17 national surveys that are part of the Demographic and Health Surveys Program. It is concluded that comparisons of anthropometry data across geographic units, population subgroups, and calendar time are marginally affected by the survivor bias, unless mortality differences between the birth cohorts are very large (e.g., well over 50 per 1,000 births).

   The effects of survivor bias in cross-sectional surveys of anthropometry measurements of children, that is overestimates due to omission of children that died before the survey date, were estimated by reviewing longitudinal studies for prevalence of malnutrition in deceased and surviving children, and analyzing retrospective data on child mortality and cross-sectional data on child anthropometry. Data were taken from 17 Demographic and Health Surveys, collected from 1986–1989. The odds ratio of the prevalence of malnutrition in deceased to that of living children was computed to assess how much worse the nutritional status of deceased children is to surviving children. In most countries 50% of the dead children were malnourished. The ratios were higher if malnutrition was more severe, specifically if the differences were pronounced for weight for age, and weight for height, or for severe stunting, below -3 SD from the median height for age. The proportion dead among children 3–36 months ranged from 2.5% in Sri Lanka to 15% in Mali, and was higher in older children. The largest bias was seen in weight for age: e.g., in Mali, where mortality is highest, the proportion of underweight increased by 4.6%, and of severely underweight by 2.7%. There was a relationship between level of malnutrition and child mortality at the country level, with considerable variation between countries, and a few outstanding outliers, countries whose malnutrition was much higher than expected from mortality rates. The effects of mother's education and of length of preceding birth interval were computed, and the odds ratio rose only from 1.8 to 2.2. It was concluded that comparisons of anthropometry data across countries and time are only marginally affected by survivor bias, unless the mortality differences between birth cohorts are very large, over 50/1000 births.

2. Ref ID: 7

   Daniel, M., Gamble, D., Henderson, J., and Burgess, S. Diabetes Prevalence, Behavioural and Anthropometry Risk Factors, and Psychosocial Constructs in Three Aboriginal Communities in Central British Columbia. *Chronic Diseases in Canada 16*[4]. 1995.

   Abstract: To counter non-insulin-dependent diabetes mellitus (NIDDM) among aboriginal populations in the Okanagan region of British Columbia, a diabetes prevention and control project was initiated in 1994. This report presents the results of baseline diagnostic and risk factor screening among high-risk samples in three communities (n = 189). Persons with established diabetes and those at

familial risk for NIDDM were measured for physiological, anthropometry and behavioural risk factors, as well as psychosocial constructs. Persons at risk underwent oral glucose tolerance tests. For adults 18 years and older, crude regional prevalence rates for diabetes and impaired glucose tolerance were 36.1 per 1000 and 7.8 per 1000, respectively. Proportions of individuals above the 70th percentile values from the Canada Fitness Survey for body mass index and waist-to-hip ratio were 60% and 73%, respectively. Of all persons sampled, cases of hypercholesterolemia (50%), hypertriglyceridemia (38%) and hyperinsulinemia (12%) were highly prevalent. Individuals with diabetes were characterized by poor control.

3. Ref ID: 68
Demirjian, A. Anthropometry Report-height, weight and body dimensions: a report from Nutrition Canada. 1980. Ottawa, Health and Welfare Canada.
Abstract: The anthropometry data described in this report form part of the Nutrition Canada National Survey of nutritional status carried out during 1970–1972. These data provide the only nationally representative data for the Canadian population since the first national survey of height and weight carried out over 25 years ago. The report therefore forms a valuable data base against which past and future trends can be compared. The focus of this report is national but includes data on First Nations and Inuit. In addition comparisons, where appropriate, are made with data from other countries. This report deals primarily with height, weight and selected body measurements. The second volume of this series will report the data on skinfold measurements and deal with the assessment of obesity in the Canadian population.

4. Ref ID: 3
Haque F, de la Rocha AG, Horbul BA, Desroches P, and Orrell C. Prevalence of childhood obesity in northeastern Ontario: a cross-sectional study. *Canadian Journal of Dietetic Practice and Research 67*[3], 143–147. 2006.
Abstract: In Canada, the incidence of childhood obesity has tripled within the past 20 years. The prevalence of obesity in the Timmins, Ontario, student population was studied to gain knowledge for program planning and resource allocation, and to compare Centers for Disease Control and Prevention (CDC) criteria with Cole's international criteria for childhood obesity. Anthropometry measurements of 801 students were taken. Students were chosen from randomly selected schools for each grade. Data were analyzed according to age, gender, and ethnicity. Data were also compared with other studies. Intragroup comparisons were performed using hypothesis testing for significance with the z table and chi-square test. Overweight and obesity prevalence was 28% according to CDC criteria. No statistical difference was found between genders or among ethnic groups, or between this study and other Canadian studies. In comparison with the CDC criteria, Cole's international criteria indicated less obesity and increased overweight prevalence. These differences were not statistically significant. The findings suggest that in the northern Ontario community of Timmins, the prevalence of childhood obesity is of epidemic proportions. When the findings are shared with different agencies, this study will help the health unit to take necessary public health measures to curb the epidemic.

5. Ref ID: 103
Torrance, G. M. Campbell Survey Results for Youth. [Fitness Development Unit], 1–23. 1991. Fitness Canada.
Abstract: The Campbell Survey tells us about the participation rates and the most popular activities among Canadians. It also helps us to pinpoint the changes in their patterns of physical recreation and physical fitness between 1981 and 1988. As hinted by the survey's name, the advisory committee arrived at the design for the 1988 well-being survey by expanding the content of the 1981 Canada Fitness Survey to include more detailed information on such aspects of well-being as nutritional habits, physical and mental health, and attitudes toward physical activity. The majority of the results were collected from 4000 Canadians by means of a questionnaire completed in select households by all members aged 10 and older. The anthropometry and fitness measurements were taken according to the Canadian Standardized Test of Fitness and collected by qualified fitness testers from household members between 7 and 69 who successfully completed the PAR-Q and agreed to the testing.

6. Ref ID: 55
Vonk, R., de Kleuver, M., Ie, E. H., and Voorhoeve, H. W.
Growth of under five-year-old children in Kyeni, Kenya.
Tropical and Geographical Medicine 45[4], 175–178. 1993.
Abstract: During a three-months period a cross-sectional study of the measurements of head circumference, mid-upper-arm circumference (MUAC) and weight was performed in 515 under five-year-old children in Kyeni, Kenya. Growth of Kyeni children seems to develop according to international standards for weight-for-age, MUAC-for-age and head circumference and for all parameters the average remains above minus 2 SD of the standard. Despite the presence of anthropometry malnutrition and downward trend in weight-for-age, MUAC-for-age and to a lesser degree the head circumference-for-age, the average growth of the Kyeni children in Kenya is within normal limits of international references.
A cross-sectional study was performed during a 3-month period on 515 children 0–5 years old who attended the daily maternal and child health clinic of Consolata Hospital in Kyeni, Embu District, Kenya, to determine growth and nutritional status through weight-for-age, head circumference and mid-upper-arm circumference (MUAC). It was found that the average growth of these children developed according to international standards for the 3 parameters and remained above minus 2 standard deviations (SD).
At age 4 months for females and 5 months for males, both sexes showed a downward trend in weight-for-age. With increasing age, a larger proportion fell below minus 2 SD of the standard (2.2% of the 0–3 month age group, 16.6% between 6 months and 5 years). This criterion revealed that an average 10.3% of the children were malnourished. However, since many of the children were stunted and weight-for-height was normal, the minus 2 SD is too high a criterion. The MUAC measurement, which reflects weigh-for-height, gives a more accurate figure of malnutrition. Using the Blankhart classification for this criterion, 3.7% of these children were malnourished and 16.0% were borderline for a total of 19.7% insufficiently nourished children. These estimates may also be too high and may result in too many children being classified as borderline, however, since they assume a constant MUAC from 6–60 months, which is not the case. Cross-tabulation of the data above age 6 months results in the presumably more realistic figure of 2.2% anthropometry malnutrition, 24.7% borderline, and 73.1% well nourished. It is recommended that MUAC be included in routine clinical measurements. In conclusion, despite the presence of anthropometry malnutrition and the age-related downward trend in indicators, the children exhibited average growth in terms of international standards.

7. Ref ID: 84
Banerjee, S., Morgan, R. J. H., Rees, S. A., and Latif, A. H. A.
Height screening at school: ineffective without high standards and adequate resources. *Archives of Disease in Childhood 88*, 477–481. 2003.
Abstract: The Coventry Consensus in 1998 recommended a single height measurement of all children at school entry or around the age of 5 years and prompt referral of children with height <0.4th centile for further assessment, in order to identify undetected and treatable asymptomatic growth disorders. The aim was to determine adherence and practicalities of following the Coventry Consensus recommendations in a community setting and the cost implications. Anthropometry data of all children born between September 1992 and August 1993 in the Rhondda and Taff Ely area and measured in school year September 1998 to August 1999 were obtained from the National Child Health System (NCHS) and analyzed in July 2000. Only 1592 (67.6%) of 2354 eligible children had their height measured. The NCHS could only flag up height data <2nd centile. Only five of the 15 children with height <0.4th centile were referred initially. Height measurements were not transcribed onto centiles in 75% of the case notes reviewed. When initially recalled, six of the 15 eligible children failed to attend the referral clinic. No new growth disorder was identified in any of these children. A conservative estimate of the cost to the health authority was £14 550 (US$23 300; €20 500) per annum.
The study shows poor coverage and compliance together with a lack of parental awareness that short stature could be a potential health problem even in asymptomatic children. For a low yield programme to be successful and cost effective at the national level, a near 100% coverage is required. Further training of professionals in growth meas-

urement and interpretation along with a campaign to raise both public and professional awareness is needed.

8. Ref ID: 22
Buyken, A. E., Hahn, S., and Kroke, A. Differences between recumbent length and stature measurement in groups of 2- and 3-y-old children and its relevance for the use of European body mass index references. *International Journal of Obesity (London) 29*[1], 24–28. 2005. Research Institute of Child Nutrition, Dortmund, Germany.
Abstract: The objective was to compare length and stature measurements of young children and to examine the relevance of any difference for comparison with body mass index (BMI) references designed for use from birth to adulthood. A total of 426 2-y-old and 525 3-y-old children included in the Dortmund Nutritional and Anthropometryal Longitudinally Designed (DONALD) Study. Length and stature were measured to the nearest millimeter using a stadiometer. Agreement between both measurements at age 2 and 3 y, respectively, was determined by mean differences and by comparison with the German BMI reference. The average length of 2-y-old girls and boys was 88.3 (3.1) and 89.9 (3.2) cm, mean differences (stature minus length) were -0.47 (0.65) and -0.45 (0.64) cm. The corresponding BMI values were 16.18 (1.3) and 16.46 (1.2) kg/m2, with mean differences of +0.17 (0.24) and +0.16 (0.23). According to stature, 9.4% of the girls and 10.8% of the boys were overweight (>90th percentile), while length classified 7.1 and 9.4% as overweight. Similar mean differences between length and stature were observed at age 3 y: -0.53 (0.62) and -0.47 (0.65) cm in height and +0.17 (0.20) and +0.14 (0.20) kg/m2 in the BMI of girls and boys, respectively. According to stature, 7.6 and 7.3% were overweight as opposed to 5.4 and 4.8% using length. The observed differences increased with higher BMI levels. Changing measurements from length to stature results in an upward shift of BMI, not reflected in current European BMI references. This small but systematic error may result in misinterpretation of individual BMI levels or trend observations.

9. Ref ID: 8
Cogill, B. Anthropometry Indicators Measurement Guide. US Agency for International Development [Food and Nutrition Technical Assistance Project FANTA]. 2003. Washington, D.C., Academy for Educational Development.
Abstract: This guide provides information on the Anthropometry Impact Indicators and the Annual Monitoring Indicators for Maternal and Child Health/Child Survival and income related Title II activities. The impact indicators are: decreased percent of stunted children, decreased percent of underweight children, increased percent of eligible children in growth monitoring/ promotion, increased percent of children in growth promotion program gaining weight in past 3 months. The report focuses on children in developing countries under the age of 5 years.

10. Ref ID: 59
Cole, T. J. and Hall, D. M. B. What use is the BMI? *Archives of Disease in Childhood 91*, 283–286. 2006.
Abstract: The House of Commons Select Committee on obesity, and two expert groups in the USA, recommend that the body mass index (BMI) of every school child should be measured each year and the result sent home to the parents. The BMI correlates sufficiently well with direct measures of total body fat to support its use, on an anonymous basis, as a public health tool for monitoring progress in dealing with the obesity epidemic. However, the BMI is an imperfect proxy for obesity because there is much individual variability in the relationship between BMI and body fat, cardiovascular risk factors, and long term health outcomes. Whatever BMI cut offs are selected for determining the advice to parents, a high BMI calls for further evaluation and interpretation and the policy proposed by the Select Committee, to send BMI results to parents, is therefore in effect a screening programme.

11. Ref ID: 87
Dieticians of Canada, The College of Family Physicians of Canada, and Community Health Care Nurse Association of Canada. The Use of Growth Charts for Assessing and Monitoring Growth in Canadian Infants and Children. *Canadian Journal of Dietetic Practice and Research 65*[1], 22–32. 2004.
Abstract: Because no geographically diverse growth chart existed, in 1978 the World Health Organization (WHO) adopted the reference curves of the American National Centre for Health Statistics (NCHS) for international use. Until recently, these reference charts were the most widely used in Canada secular changes in growth, availability of improved statistical methods for smoothing growth curves, and concerns related to limitations of the existing infant growth charts led to revisions of these charts and the release in May 2000 of 16 new growth charts from the CDC. They consist of charts for infants from birth to age three for weight, recumbent length, head circumference, and weight-for-recumbent length, and a set for children and adolescents from ages two to 20 for weight, height, and body mass index. Weight-for-stature charts, which are only applicable for weights and heights covering ages two to approximately five, were also continued, in order to smooth the transition to using the BMI charts. The charts are available in two forms. Individual charts include only one set of percentile curves per page (e.g., weight-for-age) and have the grid scaled with English units (pounds, inches). Clinical charts include two sets of curves per page (e.g., weight-for-age and height-for-age), have the grid scaled to metric units with English units in a secondary scale, and contain a data entry box to record individual patient measurements and parental heights. The clinical charts were designed for use by health care providers.In adults, BMI has been the most widely investigated and commonly accepted index for classifying adiposity, as well as the most useful indicator for identifying health risk associated with overweight. International recommendations for the use of BMI as a first indicator in assessing fatness in children and adolescents are relatively new. Because adiposity varies with age and gender during childhood and adolescence, BMI is age and gender specific; consequently, BMI is plotted according to age, using sex-specific charts. BMI-for-age provides a reference of overweight for older children and adolescents that was previously not available. It is consistent with adult BMI, so it can be used continuously from age two to adulthood, and can therefore track body size throughout the lifecycle. In addition, BMI-for-age is also a predictor of health risks and future risk of being overweight. It is strongly associated with clinical risk factors for the diseases associated with overweight. BMI is significantly correlated with direct measures of body fat, as well as subcutaneous measures. BMI is now recommended for screening overweight in children (over age two) and adolescents, rather than weight-for-stature. BMI values at ages below two have not been associated with adolescent or adult obesity; use of BMI before 24 months of age is therefore not recommended. Weight-for-stature and BMI-for-age are not interchangeable and do not produce equivalent results. Weight-for-stature percentiles tend to be lower than BMI-for-age centiles.

12. Ref ID: 27
Gorstein, J. and Akre, J. The use of anthropometry to assess nutritional status. *World Health Statistics Quarterly 41*[2], 48–58. 1988.
Abstract: Anthropometry (the use of body measurements to assess nutritional status) is a practical and immediately applicable technique for assessing children's development patterns during the first years of life. An evaluation of their growth also provides useful insights into the nutrition and health situation of entire population groups.
Anthropometry indicators are less accurate than clinical and biochemical techniques when it comes to assessing individual nutritional status. In many field situations where resources are severely limited, however, anthropometry can be used as a screening device to identify individuals at risk of undernutrition, followed by a more elaborate investigation using other techniques. Similarly, growth monitoring permits the detection of individuals with faltering growth, who can then be appropriately referred to specialized care. Thanks to the standardization that has taken place in recent years, changes in trends over time with respect to the nutritional situation can be evaluated in countries where national food and nutrition surveillance

systems have been developed, or where nationally representative cross-sectional surveys have been conducted some years apart using identical, or nearly identical, methodologies. Although data that can be used to evaluate trends are limited, some insight can be gained into the nutritional situation and changes occurring over time in a number of countries. Prevalence figures for underweight (low weight-for-age) have been prepared using standard methods of data collection, analysis and presentation, for several countries in Africa, the Americas and Asia. As such, they fail to differentiate between wasting and stunting, or to evaluate differences between age groups. Also, they do not necessarily reflect trends in other countries in the same or other regions. Still, it is interesting, if not statistically significant, that there has been a general improvement in the nutritional status of preschool children. Inter-country trend comparisons are difficult for two main reasons. Firstly, the time between surveys is occasionally different and, secondly, despite efforts to standardize data analysis and presentation, different cut-off points have been used to calculate prevalence figures and estimate the extent of undernutrition. However, the use of identical cut-off points is not essential for making inter-country trend analyses since it is the general trends in growth deficit and nutritional status over time which is being evaluated. Over the past 20 years, there has been substantial progress in the standardization of anthropometry, which is the use of body measurements to asses the nutritional status of individuals and groups. This brief examination of use of anthropometry to assess nutritional status has tried to highlight its possibilities for exploring nutritional status trends over time. Although other methods have been employed for this purpose, including clinical and biochemical techniques, none is as immediately applicable in purely practical terms as anthropometry. Children's development patterns during the 1st years of life, when growth is the most rapid, provide much information about their nutritional history, both immediate and cumulative. An evaluation of this growth provides useful insights into the nutrition and health situation not only of individuals but also of entire population groups. An admitted drawback in the present analysis is the limited availability of data despite the wealth of country information that is known to have been collected nationally and regionally. It nevertheless demonstrates how such data, when used judiciously, can permit the identification of risk groups, contribute to the development of appropriate food and nutrition policies, and serve as a baseline against which change over time can be realistically evaluated. It is hoped that with increased cooperation among those responsible, nationally and internationally, for growth assessment and nutritional epidemiology, both the quantity and quality, and the successful management and application of this information will increase.

13. Ref ID: 79
    Hsiao, H., Long, D., and Snyder, K. Anthropometry differences among occupational groups. *Ergonomics 45*[2], 136–152. 2002.
    Abstract: In a pilot study, 33 anthropometric variables were measured on 633 children aged 0–5.5 years. The variables were chosen on the basis of international standards and on the results of preliminary analysis of collisions. Methodical aspects of this pilot study are presented in this paper, followed by two applications: anthropometric aspects of current regulations for cribs, playpens and toys; anthropometric aspects in the selection of wheelchairs for children. The paper concludes with a discussion on how to present anthropometric data for non-special users.

14. Ref ID: 41
    Kaplowitz, H. J., Cronk, C. E., Martorell, R., and Rivera, J. Longitudinal principal components analysis of patterns and predictors of growth in Guatemalan children. *American Journal of Human Biology 3*[2], 169–180. 1991.
    Abstract: Longitudinal principal components (LPC) analysis was used to assess growth patterns in children from rural Guatemala in order to determine if this methodology could provide additional information regarding correlates of growth compared to more traditionally used methods based on attained size and increments. LPC analysis reduces measures at many points in time into a few parameters. However, LPC analysis requires complete data, and many cases may be lost due to missing values. Thus the potentially greater sensitivity of LPC analysis should be weighed against the reduced power resulting from smaller sample sizes. Component indices representing centile level and centile

shift, attained size, and 3 to 36 month increments of growth in length and weight were used as the dependent variables in multiple regression models in order to examine the effects of environmental variables, such as home dietary intake, supplementation, and prevalence of diarrhea on growth. Regardless of which growth index, i.e., attained size, incremental change, or principal component, was used, regression results were similar; higher nutritional intakes were generally associated with greater and more rapid growth from birth to age 3 years. The possible advantages of LPC analysis over more traditional methods were not great; therefore, LPC analysis is not recommended as the method of choice in this population.

15. Ref ID: 63
Kuczmarski, R. J., Ogden, C. L., Grummer-Strawn, L. M., Flegal, K. M., Guo, S. S., Wei, R., Mei, Z., Curtin, L. R., Roche, A. F., and Johnson, C. L. CDC growth charts: United States. *Advanced Data 8*[314], 1–27. 2000.
Abstract: This report presents the revised growth charts for the United States. It summarizes the history of the 1977 National Center for Health Statistics (NCHS) growth charts, reasons for the revision, data sources and statistical procedures used, and major features of the revised charts. Data from five national health examination surveys collected from 1963 to 1994 and five supplementary data sources were combined to establish an analytic growth chart data set. A variety of statistical procedures were used to produce smoothed percentile curves for infants (from birth to 36 months) and older children (from 2 to 20 years), using a two-stage approach. Initial curve smoothing for selected major percentiles was accomplished with various parametric and nonparametric procedures. In the second stage, a normalization procedure was used to generate z-scores that closely match the smoothed percentile curves. The 14 NCHS growth charts were revised and new body mass index-for-age (BMI-for-age) charts were created for boys and girls (http://www.cdc.gov/growthcharts). The growth percentile curves for infants and children are based primarily on national survey data. Use of national data ensures a smooth transition from the charts for infants to those for older children. These data better represent the racial/ethnic diversity and the size and growth patterns of combined breast- and formula-fed infants in the United States. New features include addition of the 3rd and 97th percentiles for all charts and extension of all charts for children and adolescents to age 20 years. Created with improved data and statistical curve smoothing procedures, the United States growth charts represent an enhanced instrument to evaluate the size and growth of infants and children.

16. Ref ID: 40
Lampl, M. and Johnson, M. L. Identifying saltatory growth patterns in infancy: A comparison of results based on measurement protocol. *American Journal of Human Biology 9*[3], 343–355. 1997.
Abstract: The present analyses address the question of how frequently time-intensive growth measurements need to be taken in order to provide sufficient data for the statistical identification of pulsatile saltatory growth patterns during infancy. The daily serial growth measurements of three infants during 4 months are analyzed in seven subsets, which include progressively fewer data points from daily to weekly intervals. Saltatory growth pulse identification and growth pattern analyses are compared between the temporally distinctive data sets by the saltatory algorithm and continuous curvilinear models. Statistically significant pulse identification and saltatory growth pattern resolution decrease with time intervals > 2–5 days in these data sets. These results suggest that the convenience of a Monday, Wednesday, Friday protocol may not be sufficient to characterize saltatory growth in individual infants, and the dependability factor is a significant source of error that may contribute to growth pattern misperception in data collected by infrequent protocols.

17. Ref ID: 88
Lin, Y. C., Wang, M. J. J., and Wang, E. M. The comparisons of anthropometry characteristics among four peoples in East Asia. *Applied Ergonomics 35*, 173–178. 2004.
Abstract: This study presents comparisons of ethnic difference in anthropometry characteristics among four peoples, i.e., Chinese, Japanese, Korean, and Taiwanese, in East Asia. Anthropometry data from the four East Asian countries were compared. The means of 33 body dimensions and 31 bodily proportions are presented. Also, 15 segmental proportions are illustrated. The results of statistical

analyses showed that there is a significant morphological difference among these peoples in the same region. The Mainland Chinese body shape has a narrower body with mid-range limbs. The Japanese body shape is wider with shorter limbs. The Korean body shape is mid-range among the four peoples, but the upper limbs are longer. The Taiwanese body shape has wide shoulder and narrow hip with large hands and long legs. The ethnic diversity in bodily proportions should be considered as well as the mean dimensions.

18. Ref ID: 46
Mascarenhas, M. R., Zemel, B., and Stallings, V. A. Nutritional assessment in pediatrics. *Nutrition 14*[1], 105–115. 1998.
Abstract: Nutritional status affects every pediatric patient's response to illness. Good nutrition is important for achieving normal growth and development. Nutritional assessment therefore should be an integral part of the care for every pediatric patient. Routine screening measures for abnormalities of growth should be performed on all pediatric patients. Those patients with chronic illness and those at risk for malnutrition should have detailed nutritional assessments done. Components of a complete nutritional assessment include a medical history, nutritional history including dietary intake, physical examination, anthropometrys (weight, length or stature, head circumference, midarm circumference, and triceps skinfold thickness), pubertal staging, skeletal maturity staging, and biochemical tests of nutritional status. Alternative measures for linear growth assessment (e.g., lower leg and upper arm measures) can be performed on patients unable to stand or who have musculoskeletal deformities. Bone densitometry can be used to assess bone mineralization and the risk of fracture. Nutritionally at risk patients may benefit from determination of resting energy expenditure by indirect calorimetry. The use of age, gender, and disease-specific growth charts is essential in assessing nutritional status and monitoring nutrition interventions. The importance of accurate measurements using trained personnel and appropriate equipment cannot be overemphasized.

19. Ref ID: 42
Meaney, F. J., Farrer, L. A., Opitz, J. M., and Reynolds, J. F. Clinical anthropometry and medical genetics: A compilation of body measurements in genetic and congenital disorders. *American Journal of Medical Genetics 25*[2], 343–359. 1986.
Abstract: Anthropometry has become an important tool in the study of genetic conditions, particularly as a diagnostic aid for the clinical geneticist. However, many practicing physicians do not do anthropometry of patients for several reasons, such as: appropriate measurements in a given situation are unknown; normative reference data are unavailable; or analysis and interpretation of the data are confusing. In this review we present an annotated compilation of informative measurements for hereditary and congenital disorders and a guide to normative anthropometry data of use in evaluation and diagnosis of such disorders. Further development of multivariate approaches will enhance the application of anthropometry as a means of identifying and classifying a syndrome and documenting the natural history of many disorders. Continued cooperation among physicians, geneticists, and anthropologists for the collection and assessment of patient and normative data is essential if these goals are to be realized.

20. Ref ID: 54
Myatt, M., Khara, T., and Collins, S. A review of methods to detect cases of severely malnourished children in the community for their admission into community-based therapeutic care programs. *Food and Nutrition Bulletin 27*[3], 7–23. 2006.
Abstract: The complexity and cost of measuring weight-for-height make it unsuitable for use by community-based volunteers. This has led community therapeutic care programs to adopt a two-stage screening and admission procedure in which mid-upper-arm circumference (MUAC) is used for referral and weight-for-height is used for admission. Such a procedure results in many individuals being referred for care on the basis of MUAC but subsequently being refused treatment because they do not meet the weight-for-height admission criterion. This "problem of rejected referrals" has proved to be a major barrier to program uptake. The objective was to systematically review

methods to detect cases of severely malnourished children in the community for their admission into community-based therapeutic care programs. Clinical and anthropometry methods for case detection of severely malnourished children in the community were reviewed with regard to their ability to reflect both mortality risk and nutritional status. MUAC, with the addition of the presence of bipedal edema, was found to be the indicator best suited to screening and case detection of malnutrition in the community. The case definition "MUAC < 110 mm OR the presence of bipedal edema," with MUAC measured by a color-banded strap, is suitable for screening and case detection of malnutrition in the community for children aged between 6 and 59 months. Monitoring and discharge criteria were also reviewed. There is no compelling evidence to support a move away from using weight in combination with clinical criteria for monitoring and discharge.

21. Ref ID: 69
Nash, A., Corey, M., Sherwood, K., Secker, D., Saab, J., and O'Connor, D. L. Growth assessment in infants and toddlers using three different reference charts. *Journal of Paediatric Gastroenterology and Nutrition 40*[3], 283–288. 2005.
Abstract: The objective was to determine if the proportion of children < or =24 months old in a tertiary care facility defined as at risk of undernutrition or overnutrition differs according to different references used for assessment: the Centers for Disease Control and Prevention (CDC), National Center for Health Statistics (NCHS) or Tanner-Whitehouse (Tanner) growth charts for weight-for-age and length-for-age. Lengths and weights were measured on infants (207 female, 341 male) aged < or =24 months admitted from or attending clinics in the General Pediatric or Respiratory Medicine Programs at The Hospital for Sick Children, Toronto. Weight-for-age and length-for-age percentiles and percent ideal body weight were electronically computed. The proportion of all children whose weight-for-age was <3rd percentile (at risk of undernutrition) was greatest using the CDC growth charts (22.5%) compared with the NCHS (15.9%) or Tanner (19.2%) growth charts. Likewise, the proportion of all infants/toddlers with percent ideal body weight <90 (at risk of undernutrition) was greatest using the CDC (32.3%) compared with the NCHS (22.1%) or Tanner (25.9%) growth charts. In contrast, the percentage of children whose percent ideal body weight was > or =110% (at risk of overnutrition) was least using the CDC (18.1%) compared with the NCHS (26.1%) or Tanner (22.4%) growth charts. More children aged < or =24 months will be defined as at risk of undernutrition and fewer at risk of overnutrition when using weight-for-age or percent ideal body weight and the CDC growth charts compared with the NCHS or Tanner growth charts. As a result, requests for a more detailed nutritional assessment for undernutrition will likely follow implementation of the CDC growth charts in a tertiary care setting. As the CDC, NCHS and Tanner growth charts are growth "references" rather than "standards," other than for screening purposes, they should not be used in isolation when assessing growth and nutritional status.

22. Ref ID: 70
Ogden, C. L., Kuczmarski, R. J., Flegal, K. M., Mei, Z., Guo, S., Wei, R., Grummer-Strawn, L. M., Curtin, L. R., Roche, A. F., and Johnson, C. L. Centers for Disease Control and Prevention 2000 growth charts for the United States: improvements to the 1977 National Center for Health Statistics version. *Paediatrics 109*[1], 45–60. 2002.
Abstract: The objective was to present a clinical version of the 2000 Centers for Disease Control and Prevention (CDC) growth charts and to compare them with the previous version, the 1977 National Center for Health Statistics (NCHS) growth charts. The 2000 CDC percentile curves were developed in 2 stages. In the first stage, the empirical percentiles were smoothed by a variety of parametric and nonparametric procedures. To obtain corresponding percentiles and z scores, we approximated the smoothed percentiles using a modified LMS estimation procedure in the second stage. The charts include of a set of curves for infants, birth to 36 months of age, and a set for children and adolescents, 2 to 20 years of age. The charts represent a cross-section of children who live in the United States; breastfed infants are represented on the basis of their distribution in the U.S. population. The 2000 CDC growth charts more closely match the national distribution of birth weights than did the 1977 NCHS growth charts, and the disjunction between

weight-for-length and weight-for-stature or length-for-age and stature-for-age found in the 1977 charts has been corrected. Moreover, the 2000 CDC growth charts can be used to obtain both percentiles and z scores. Finally, body mass index-for-age charts are available for children and adolescents 2 to 20 years of age. The 2000 CDC growth charts are recommended for use in the United States. Pediatric clinics should make the transition from the 1977 NCHS to the 2000 CDC charts for routine monitoring of growth in infants, children, and adolescents.

23. Ref ID: 39
Ramirez, M. E., Brauer, G. W., Prior, A. M., and Ward, R. H. Biological variability in a migrating isolate, the Tokelau Islands: Child growth in different environments. *American Journal of Human Biology 3*[2], 189–201. 1991.
Abstract: The magnitude and rates of growth have been compared among two cross-sectional samples of Tokelau children on the basis of 26 anthropometry dimensions. One of the samples consisted of children living on the Tokelau Islands. The migrant sample consisted of children of Tokelau descent who were living in New Zealand. The comparison between samples suggest significant differences in the rate of linear growth at the younger ages. However, most differences were not significant among 17 year olds. The results support the hypothesis that even when the original environment is favorable, qualitative changes in the environment may affect the general pattern of growth. The effects of an accelerated growth pattern cannot be determined at this time.

24. Ref ID: 73
Reyes, M. E., Tan, S. K., and Malina, R. M. Urban-rural contrasts in the growth status of school children in Oaxaca, Mexico. *Annals of Human Biology 30*[6], 693–713. 2003.
Abstract: The growth status of school children resident in an urban colonia and in a rural indigenous community in Oaxaca, southern Mexico, was considered in the context of two objectives, current status and the magnitude of urban-rural differences over a span of about 30 years. Both communities were initially surveyed in 1968 and 1972. Height, body mass, segment lengths, skeletal breadths, limb circumferences, and subcutaneous fatness were taken on 361 rural (177 boys, 184 girls) and 339 urban (173 boys, 166 girls) school children, aged 6–13 years. Additional variables were derived. Height and body mass were significantly greater in urban compared with rural children. Sitting height, estimated leg length and skeletal breadths on the trunk were also larger in urban than in rural school children, but only the difference in skeletal breadths was significant after age and body size were statistically controlled. Urban and rural children did not consistently differ in skeletal breadths on the extremities and limb circumferences. Subcutaneous fatness was more variable. After controlling for age and body size, rural girls had thicker skinfolds. The magnitude of the urban-rural difference in boys in 2000 was greater for body mass, BMI and triceps skinfold, and reduced for height, sitting height, leg length, and arm and estimated arm muscle circumferences compared with 1970. The magnitude of the urban-rural difference in girls was greater in 2000 than 30 years earlier for body mass, height, sitting height, leg length and BMI. Urban-rural differences for arm and arm muscle circumferences and the triceps skinfold were slightly smaller over the interval. Children resident in an urban colonia were taller and heavier than children resident in a rural indigenous community. After controlling for age and body size, urban-rural differences in skeletal breadths and limb circumferences were reduced or eliminated, but skinfold thicknesses were greater in rural girls. The magnitude of urban-rural differences in body size has decreased over approximately 30 years in boys, but has increased in girls.

25. Ref ID: 53
Schlenker, J. and Ward, R. Development and Application of a Paediatric Anthropometry Evaluation System. *Canadian Journal of Dietetic Practice and Research 60*[1], 20–26. 1999.
Abstract: Children with developmental disabilities are at increased nutritional risk because of feeding problems, abnormal levels of physical activity, and altered weight and growth patterns. Children with physical disabilities are often more difficult to measure because of muscular contractures, spasms, scoliosis, and the presence of splints, braces, or wheelchair accessories. In addition, body weights may be difficult to obtain for heavier children with limited

access to wheelchair scales. The purpose of this project was to produce a package of anthropometry measurements easier to use in children with physical disabilities but still applicable to able-bodied children, and computer software to generate growth charts. The project included the development of growth charts for each anthropometry measurement, using data from the Coquitlam Growth Study (921 children aged six to 18) and the Sunny Hill Growth Study (567 children aged one to 5.9). The custom computer software allows serial plotting of a child's measurements on growth charts, permitting comparative assessment of growth and muscle and adipose tissue development. The resultant Sunny Hill Anthropometry Pediatric Evaluation System (SHAPES) provides a tool for nutritional assessment and monitoring after intervention. The use of SHAPES is illustrated with a case study of a child who represented a challenge to traditional nutritional evaluation.

26. Ref ID: 74
Shepard, J., Lavallee, H., Lariviere, G., Rajic, M., Brisson, G. R., Beaucage, C, Jequier, J. C., and La Barre, R. Physical capacity of Canadian children: a comparison among French-Canadian, English-Canadian, and Eskimo children. II. Anthropometry and pulmonary volume. *Union Medical du Canada 104*, 259–269. 1975.

27. Ref ID: 80
Smith, S. A. and Norris, B. J. Changes in the body sizes of UK and US children over the past three decades. *Ergonomics 47*[11], 1195–1207. 2004.
Abstract: The major sources of published anthropometry data on children are now over two decades old. Due to concern being expressed regarding the continued validity of such data, changes in the body sizes of the U.K. child population over the past three decades have been considered. Comparisons were also made between the size of the current U.K. child population to the current U.S. child population, and to the most comprehensive source of measured data on U.S. children (but which are now over 20 years old). The growth of children in the U.K. and U.S. over the past three decades was assessed for an indication of secular growth trends. Stature increases were found to have generally been less than body weight increases (as a percentage) at 5th percentile, mean and 95th percentile levels for U.K. children, and U.K. children were found to be closer in size to U.S. children now than they were 30 years ago.

28. Ref ID: 35
van't Hof, M. A. and Haschke, F. The Euro-Growth Study: why, who, and how. *Journal of Paediatric Gastroenterology and Nutrition 31*[Supplement 1], 3–13. 2000.
Abstract: Assessment of growth is important in health management of infants and children. Evaluation of growth performance requires anthropometry measurements, with proper interpretation depending on the use of appropriate references. Europe-specific growth references have not been available. The purpose of the present study was to generate such references for infants and children from birth to 3 years of age. The study was further intended to assess the influence of nutrition and lifestyle factors on growth. The Euro-Growth Study was designed as a multicenter longitudinal cohort study. This report describes the study design, the sample (cohort), and the methods used. Quality control measures included standardized measurement techniques with ongoing cross-sectional and longitudinal consistency checks. Selectivity in participation and discontinuation and reproducibility of data over time were evaluated. Of 2,245 infants who were enrolled in the study at 22 study sites in 11 countries, 1,746 (78%) provided longitudinal data until 12 months of age, 1,205 (57%) until 24 months of age, and 1071 (48%) until 36 months of age. Anthropometry measurements were performed on 21,773 occasions. As a result of cross-sectional and longitudinal data checks, 209 data points (0.09% of all data points) were rejected. Comparison of participant's demographic data with those of nonparticipating local subjects indicated that the cohort was selective in maternal age (higher), maternal education level (higher), household location, and family structure. The withdrawal rate during the study was low (24%), and withdrawals occurred at random. Analysis of reproducibility over time resulted in the elimination of the data from one study site. The Euro-Growth Study provided longitudinal growth data from a large cohort of normal European children. Because of the chosen sampling method, the study cohort ws somewhat selective relative to the local background population. Internal validity was satisfactory in that the reproducibility

of anthropometry measurements was high in 21 sites and the withdrawal rate was low and random.

29. Ref ID: 45
Zemel, B. S., Riley, E. M., and Stallings, V. A. Evaluation of methodology for nutritional assessment in children: anthropometry, body composition, and energy expenditure. *Annual Review in Nutrition 17*, 211–235. 1997.
Abstract: Nutritional status in children is an indicator of health and well-being at both the individual and the population level. Screening for malnutrition should be an integral part of pediatric care universally. Nutritional intervention requires repeated measurement of nutritional status to assess severity and to track progress over time. Methodological issues in the assessment of nutritional status are reviewed with emphasis on anthropometry measurement, body composition, and energy expenditure of children at risk for malnutrition. Use of reference data, measurement error, maturational effects, and hereditary factors are among the issues reviewed and serve as guidelines in the interpretation of measurement of nutritional status.

30. Ref ID: 76
Monthly growth status from a longitudinal study of Canadian infants. *Canadian Journal of Public Health 81*[3], 215–221. 1990.
Abstract: Reference data for weight, recumbent length and head circumference at 1-month intervals from 1 through 18 months have been developed from measurements of 351 healthy infants born at term in Montreal or Toronto. Each infant was measured serially from 1 to 18 months. A 3-parameter mathematical model was fitted to the serial data for each infant. The model fitted the serial data well for almost all the infants as evaluated by the residual mean square errors. Subsequently, values were estimated for each month of age from 1 through 18 months for each infant. These estimated values allowed the development of reference data that have been presented in tables and in graphs.

31. Ref ID: 106
The National Longitudinal Survey of Children and Youth. 1996. Human Resources Development Canada and Statistics Canada.
Abstract: The National Longitudinal Survey of Children and Youth (NLSCY), developed jointly by Human Resources Development Canada and Statistics Canada, is a comprehensive survey which follows the development of children in Canada and paints a picture of their lives. The survey monitors children's development and measures the incidence of various factors that influence their development, both positively and negatively. The second cycle, carried out in 1996 and 1997, interviewed parents of the same children as Cycle 1 and provides unique insights into the evolution of children and their family environments over a two-year period. The NLSCY will continue to collect information on these same children every two years as they move into youth and adulthood.

32. Ref ID: 102
CDC. National Health and Nutrition Examination Survey III: Body Measurements (Anthropometry). National Center for Health Statistics. 1–57. 1988. US Centers for Disease Control and Prevention.
Abstract: Introduction to anthropometry, equipment, examination protocol, logs and records and quality control section are presented in this report on how the National Health and Nutrition Examination Survey III: Body Measurements was conducted.

33. Ref ID: 107
Mirwald, R. L. 1964–1973 Saskatchewan Growth and Development Study. Ostyn, M. Beunen G. Simons J. *International Series on Sport Sciences. 9*. 1978. Baltimore, MA, University Park Press.

34. Ref ID: 101
National Center for Health Statistics. Change in the Physical Dimensions of Children in the United States: Results from the National Health and Nutrition Examination Surveys from the National Center for Health Statistics. 1–67. 1998.
Abstract: This report presents data analyses on body dimensions of U.S. children (up to and including 18 years old) using data from nationally representative surveys con-

ducted ,by the National Center for Health Statistics (NCHS) over the last thirty years. In particular, we compare mean values from a baseline period in the mid 1970s with recent results for the Third National Health and Nutrition Examination Survey (NHANES III) conducted between 1988 and 1994. We find a significant increase in size over all age ranges and both genders for the following five measurements: weight, height, head circumference, wrist breadth, and biacromial breadth. For these measurements, we found a statistically significant increase in 65% of the age categories assessed. Of the six measures investigated for this report, the only measurement that did not follow the pattern of increased size was sitting height, which showed a statistically significant decrease for young children (up to age 7 years) and no increase for older children. Possible explanations for this change include demographic changes in the population and measurement bias. We feel that the change is more likely due to differences in survey procedures over time.

35. Ref ID: 72
Shephard, R. J. and Rode, A. Growth patterns of Canadian Inuit children. A longitudinal study. *Arctic Medical Research 54*[2], 60–68. 1995.
Abstract: A longitudinal study has examined the growth of height, sitting height, body mass and triceps skinfolds in a sample of Inuit (281 boys and 266 girls) attending the Igloolik School between the years 1981 and 1989. Heights were around the 10th percentile of U.S. norms for 1970. A peak height velocity of 9.2 +/- 2.3 cm/year was reached by girls at 11.3 +/- 0.7 years, and in boys the peak rate of 8.6 +/- 3.7 cm/year was seen at 13.5 +/- 0.8 years. Sitting heights were also low relative to urban norms. Body mass approached the 50th percentile of U.S. norms, giving a large mass for height ratio at all ages. Triceps thicknesses for the girls were around the 10th percentile of urban norms, and in the boys began around the 25th percentile, but dropped steadily to the 5–10th percentile. No significant differences of growth patterns were seen between cohorts formed from students born in the years 1970/72, 1973/74 and 1975/76. However, comparison with earlier cross-sectional surveys in the same community showed a secular trend to greater stature and greater skinfold readings as the community had become acculturated to such features of modern living as mechanized transport and television. There were no systematic differences of growth rates between the summer and the winter seasons, and nutrition was good throughout. We thus conclude that the short stature has an inherited basis. Attention is drawn to the problem of interpreting curves of growth and weight for height in populations with an unusual body build.

36. Ref ID: 13
Araújo, C. L., Albernaz, E., Tomasi, E., Victora, C. G., and WHO Multicentre Growth Reference Study Group. Implementation of the WHO Multicentre Growth Reference Study in Brazil. *Food and Nutrition Bulletin 25*[Supplement 1], 53–59.
Abstract: The World Health Organization (WHO) Multicentre Growth Reference Study (MGRS) South American site was Pelotas, Brazil. The sample for the longitudinal component was drawn from three hospitals that account for approximately 90% of the city's deliveries. The cross-sectional sample was drawn from a community survey based on households that participated in the longitudinal sample. One of the criteria for site selection was the availability of a large, community based sample of children whose growth was unconstrained by socioeconomic conditions. Local work done in 1993 demonstrated that children of families with incomes at least six times the minimum wage had a stunting rate of 2.5%. Special public relations and implementation activities were designed to promote the acceptance of the study by the community and its successful completion. Among the major challenges of the site were serving as the MGRS pilot site, low baseline breastfeeding initiation and maintenance rates, and reluctance among pediatricians to acknowledge the relevance of current infant feeding recommendations to higher socioeconomic groups.

37. Ref ID: 16
Baerug, A., Bjoerneboe, G. E. A., Tufte, E., Norum, K. R., and WHO Multicentre Growth Reference Study Group. Implementation of the WHO Multicentre Growth Reference Study in Norway. *Food and Nutrition Bulletin 25*[Supplement 1], 72–77. 2004.

Abstract: The World Health Organization (WHO) Multicentre Growth Reference Study (MRGS) European site was Oslo, Norway. Oslo has a high breastfeeding rate. Ninety-nine percent of mothers initiate breastfeeding soon after delivery, and 80% continue for at least six months. There is no evidence that socioeconomic conditions constrain growth. As in other sites, the study had two components, longitudinal and cross-sectional. Recruitment for the longitudinal component was conducted in three hospitals that account for most births in Oslo. Approximately 850 subjects were screened in one year by using a systematic allocation scheme to recruit a sample of about 300. Recruitment for the cross-sectional component was based on a systematic interval sampling scheme prepared by the National Registry. More than 4,000 subjects were screened to achieve the required sample size. One of the major challenges of the study was to achieve an acceptable participation rate; great efforts were made to motivate pregnant women via the health care system and the media.

38. Ref ID: 15
Bhandari, N., Taneja, S., Rongsen, T., Chetia, J., Sharma, P., Bahl, R., Kumar Kashyap, D., Bhan, M. K., and WHO Multicentre Growth Reference Study Group. Implementation of the WHO Multicentre Growth Reference Study in India. *Food and Nutrition Bulletin 25*[Supplement 1], 66–71. 2004.

Abstract: The World Health Organization (WHO) Multicentre Growth Reference Study (MGRS) Asian site was New Delhi, India. Its sample was drawn from 58 affluent neighborhoods in South Delhi. This community was selected to facilitate the recruitment of children who had at least one parent with 17 or more years of education, a key factor associated with unconstrained child growth in this setting. A door-to-door survey was conducted to identify pregnant women whose newborns were subsequently screened for eligibility for the longitudinal study, and children aged 18 to 71 months for the cross-sectional component of the study. A total of 111,084 households were visited over an 18-month period. Newborns were screened at birth at 73 sites. The large number of birth in facilities used by this community, the geographically extensive study area, and difficulties in securing support of pediatricians and obstetricians for the feeding recommendations of the study were among the unique challenges faced by the implementation of the MGRS protocol at this site.

39. Ref ID: 18
Dewey, K. G., Cohen, R. J., Nommsen-Rivers, L. A., Heinig, M. J., and WHO Multicentre Growth Reference Study Group. Implementation of the WHO Multicentre Growth Reference Study in the United States. *Food and Nutrition Bulletin 25*[Supplement 1], 84–89. 2006.
Abstract: The World Health Organization (WHO) Multicentre Growth Reference Study (MRGS) North American site was Davis, California. For the longitudinal cohort (0–24 months), 208 infants were enrolled between January and December 1999 from five area hospitals at which nearly all Davis women give birth. The target sample size was lower in the United States than in the other sites, because recruitment in the United States was restricted to mothers who were willing to exclusively breastfeed for at least 4 months and continue breastfeeding for at least 12 months. For the cross-sectional component, a mixed-longitudinal design was used, which required approximately 500 subjects. The subjects were recruited by going door-to-door, with the sampling scheme based on the distribution of the subjects of the longitudinal study within the city. The cross-sectional sample was recruited between January and July 2001. Major challenges during implementation were maintaining daily communication with hospital personnel and scheduling home visits.

40. Ref ID: 14
Lartey, A., Owusu, W. B., Sagoe-Moses, I., Gomez, V., Sagoe-Moses, C., and WHO Multicentre Growth Reference Study Group. Implementation of the WHO Multicentre Growth Reference Study in Ghana. *Food and Nutrition Bulletin 25*[Supplement 1], 60–65. 2004.
Abstract: The World Health Organization (WHO) Multicentre Growth Reference Study (MGRS) African site was Accra, Ghana. Its sample was drawn from 10 affluent residential areas where earlier research had demonstrated the presence of a child subpopulation with unconstrained growth. This subpopulation could be identified on the basis of the father's education and household income. The subjects for the longitudinal study were enrolled from 25 hos-

pitals and delivery facilities that accounted for 80% of the study area's births. The cross-sectional sample was recruited at 117 day-care centers used by more than 80% of the targeted subpopulation. Public relations efforts were mounted to promote the study in the community. The large number of facilities involved in the longitudinal and cross-sectional components, the relatively large geographic area covered by the study, and the difficulties of working in a densely populated urban area presented special challenges. Conversely, the high rates of breastfeeding and general support for this practice greatly facilitated the implementation of the MGRS protocol.

41. Ref ID: 12
Onyango, A. W., Pinol, A. J., de Onis, M., and WHO Multicentre Growth Reference Study Group. Managing data for a multicountry longitudinal study: experience from the WHO Multicentre Growth Reference Study. *Food Nutrition Bulletin 25*[Supplement 1], 46–52. 2004.
Abstract: The World Health Organization (WHO) Multicentre Growth Reference (MGRS) data management protocol was designed to create and manage a large data bank of information collected from multiple sites over a period of several years. Data collection and processing instruments were prepared centrally and used in a standardized fashion across sites. The data management system contained internal validation features for timely detection of data errors, and its standard operating procedures stipulated a method of master file updating and correction that maintained a clear trail for data auditing purposes. Each site was responsible for collecting, entering, verifying, and validating data, and for creating site-level master files. Data from the sites were sent to the MGRS Coordinating Centre every month for master file consolidation and more extensive quality control checking. All errors identified at the Coordinating Centre were communicated to the site for correction at source. The protocol imposed transparency on the sites' data management activities but also ensured access to technical help with operation and maintenance of the system. Through the rigorous implementation of what has been a highly demanding protocol, the MGRS has accumulated a large body of very high-quality data.

42. Ref ID: 17
Prakash, N. S., Mabry, R. M., Mohamed, A. J., Alasfoor, D., and WHO Multicentre Reference Study Group. Implementation of the WHO Multicentre Growth Reference Study in Oman. *Food and Nutrition Bulletin 25*[Supplement 1], 78–83. 2004.
Abstract: The World Health Organization (WHO) Multicentre Growth Study (MGRS) Middle East site was Muscat, Oman. A survey in Muscat found that children in households with monthly incomes of at least 800 Omani Rials and at least four years of maternal education experienced unconstrained growth. The longitudinal study sample was recruited from two hospitals that account for over 90% of the city's births; the cross-sectional sample was drawn from the national Child Health Register. Residents of all districts in Muscat within the catchment area of the two hospitals were included except Quriyat, a remote district of the governorate. Among the particular challenges of the site were relatively high refusal rates, difficulty in securing adherence to the protocol's feeding recommendations, locating children selected for the cross-sectional component of the study, and securing the cooperation of the children's fathers. These and other challenges were overcome through specific team building and public relations activities that permitted the successful implementation of the MGRS protocol.

Obesity

1. Ref ID: 110
Canning, P. M., Courage, M. L., and Frizzell, L. M. Prevalence of overweight and obesity in a provincial population of Newfoundland children. *Canadian Medical Association Journal 171*, 240–242. 2004.
Abstract: More and more school-aged children in Canada and elsewhere are becoming overweight or obese. Many countries are now reporting a similar trend among preschool children. However, little information is available on the prevalence of overweight and obesity among preschool children in Canada. In addition, available data are based on reported rather than measured heights and weights. We conducted this study to determine the prevalence of overweight and obesity, using measured heights and weights, in the 1997 cohort of children aged 3–5 years born in

Newfoundland and Labrador. We calculated the body mass indices (BMIs) using heights and weights measured by public health nurses during the province-wide Preschool Health Check Program conducted between October 2000 and January 2003. Descriptive data on the children's BMIs and prevalence estimates were generated and analyzed by sex and age with the use of the classification system recommended by the International Obesity Task Force. Data were available for 4161 of the 5428 children born in 1997; boys and girls were equally represented (50.1% and 49.9% respectively). Overall, 25.6% of the preschool children in the cohort were overweight or obese. The rates did not differ significantly by sex or age group. These results indicate that a high proportion of children aged 3–5 years in Newfoundland and Labrador are overweight or obese. It appears that prevention measures should begin before the age of 3 years.

2. Ref ID: 108
Charbonneau-Roberts, G., Saudny-Unterberger, H., Egeland, G. M., and Kuhnlein, H. V. Body mass index may overestimate the prevalence of overweight and obesity among the Inuit. *International Journal of Circumpolar Health 64*[2], 163–169. 2005.
Abstract: Body mass index (BMI) is a widely used body weight classification system but has known limitations, and may need to be adjusted for sitting height in order to be useful as an indicator of health risks in special populations. Data confirm that Inuit and Far East Asians have shorter legs and relatively higher sitting heights compared with all other populations. Using standing height alone to calculate the BMI may overestimate the number of individuals that are overweight and obese, and at risk for type 2 diabetes mellitus and cardiovascular disease among the Inuit. Measuring sitting height allows for the calculation of a sitting height-to-standing height ratio (SH/S) which can be used to correct the observed BMI. Incorporating sitting height measurements into health research could help formulate Inuit-specific screening guidelines.

3. Ref ID: 75
de Onis, M. The use of anthropometry in the prevention of childhood overweight and obesity. 28. *International Journal of Obesity and Related Metabolic Disorders* [Supplement 3], 81–85. 2004.
Abstract: The objective is to review concepts and propose measures related to the use of anthropometry for early identification of excessive weight gain in children. Review of results from national and international studies focusing on the assessment of childhood growth, and evaluation of the weight-for-height z-scores of individual children using the 1977 National Center for Health Statistics and the 2000 Centers for Disease Control and Prevention growth charts. At present, few countries (23%) use indicators based on weight and height measurements to classify child body weight status. Less than one-third of growth monitoring programmes assess the growth of children beyond 6 y of age. Growth charts based on descriptive samples of populations undergoing increasing trends of childhood overweight and obesity result in substantial underestimation of true rates of these conditions. Early recognition of excessive weight gain relative to linear growth should become standard clinical practice by the following: (a) the routine collection of height measurements to enable monitoring weight-for-height and body mass index (BMI); (b) the expansion of existing monitoring programmes to include the assessment of all children up to 18 y at least once a year; (c) the interpretation of weight-for-height and BMI indices based on prescriptive reference data; and (d) the early intervention after an increase in weight-for-height or BMI percentiles has been observed.

4. Ref ID: 61
Despres, J. P., Macdonald, S. M., Reeder, B. A., and Chen, Y. Obesity in Canada: a descriptive analysis. *Canadian Medical Association Journal 157*[1], 3. 1997.
Abstract: The objective is to describe the distribution of body fat, prevalence of obesity, and knowledge of cardiovascular disease in Canadian adults. Design: Population-based, cross-sectional surveys. Setting: Ten Canadian provinces between 1986 and 1992. Participants: A probability sample of 29 855 men and women aged 18 to 74 years was selected using health insurance registration files in each

province. Anthropometry was performed on 19 841 (66%) of these adults. Outcome measures: Body mass index (BMI); waist circumference; ratio of waist to hip circumference; knowledge of causes of heart disease. Results: The overall prevalence of obesity (BMI >/= 27 kg/cm) increased with age and was greater in men (35%) than in women (27%). Abdominal obesity was also higher in men and increased with both age and BMI. Canadians with lower levels of education had a higher prevalence of obesity, which appeared at a young age. Canadians in Atlantic Canada mentioned lack of exercise, poor diet and smoking as causes of heart disease less frequently than those living in central or western Canada. Conclusions: Obesity continues to be common among Canadian adults. Policy and programs to promote healthy body weights must be intensified and directed at specific sociodemographic groups. During the last 20 years, obesity in Canadians has drawn the attention of clinicians, the private sector and government. The recognition of obesity as a health issue by the federal government led to the development of Canadian Guidelines for Healthy Weights, the Task Force on the Treatment of Obesity and Canada's Food Guide to Healthy Eating, as well as other documents promoting healthy weights and healthy eating. Complementing these initiatives, national projects such as Participation and Active Living have promoted physical activity to Canadians over the last two decades. The adverse effects of being overweight are being reported with increasing frequency. Diabetes, hypertension, cardiovascular disease and some cancers are associated with obesity. Various measures of body fat distribution, including body mass index (BMI), waist circumference (WC) and the ratio of waist to hip circumference (WHR) have been developed and related to cardiovascular risk. Economic costs have also been identified. A range of anthropometry data on Canadians were collected in the 1978 Canada Health Survey, the 1981 Canada Fitness Survey and the 1988 Campbell's Survey on Well-Being in Canada, which was a longitudinal follow-up of the 1981 survey. In 1985 and 1990, the Health Promotion Survey collected self-reported data on height and weight. The General Social Surveys, which focused on health in 1985 and 1991, also estimated obesity in Canadians based on self-reported data. In the 1978 Canada Health Survey of Canadians aged 20–69 years, 31% of participants had a BMI over 27 kg/cm" (34% of men and 29% of women). For the same age groups, the 1981 Canada Fitness Survey showed that 29% of men and 19% of women had a BMI greater than 27 kg/cm, with an overall rate of 24%. These two surveys also demonstrated an uneven distribution of BMI across Canada, obesity being more prevalent in the eastern provinces than the western. The 1988 Campbell's Survey, based on BMI, amount of subcutaneous fat or location of fat revealed that 50% of men and 41% of women aged 15–65 years were at health risk due to obesity. More recently the General Social Surveys reported that the prevalence of overweight (BMI >/= 27 kg/cm among men aged 25–64 years, increased from 20% in 1985 to 30% in 1991. In women, the age-standardized prevalence of overweight increased from 14% to 20% in the same period. Using similar methods, the Health Promotion Survey showed that, between 1985 and 1990, the prevalence of overweight rose from 19% to 27% in men and 14% to 18% in women, aged 18 years and over. Comparisons suggest a lower prevalence of obesity. in Europe than in North America. In Great Britain, the prevalence of obesity. (BMI > 30 kg/cm) doubled between 1980 and 1991. A BMI over 30 kg/cm was found in approximately 10% of people in the majority of the populations within the WHO MONICA project. An upward trend in obesity within the last two decades is reported in the Netherlands, the United States, the Czech Republic, Finland and Sweden. As part of the Canadian heart health initiative, population-based surveys of the prevalence of cardiovascular risk factors, attitudes and knowledge were undertaken in all 10 provinces. This provides a unique opportunity to examine the distribution of body weight and its correlation to risk factors for cardiovascular disease and various physiologic measures.

5. Ref ID: 60

Despres, J. P., Lambert, J., and Reeder, B. A. Correlation between cardiovascular disease risk factors and simple anthropometry measures. *Canadian Medical Association Journal 157*[1], 46. 2006.

Abstract: The objective is to assess simple anthropometry measures as indicators of the concurrent presence of high

blood pressure, dyslipidemia and diabetes mellitus in adults. Design: Population-based, cross-sectional surveys. Setting: Five Canadian provinces between 1990 and 1992. Participants: A probability sample of 16 007 men and women aged 18 to 74 years was selected using health insurance registration files in each province. This study is based on the 9826 adults (61%) for whom anthropometry measurements were obtained. Outcome measures: Step-wise multiple logistic regression analysis was used to model the association between demographic, anthropometry and risk variables and the presence of high systolic and diastolic (DBP) blood pressure, elevated levels of total (TC), high-density lipoprotein (HDL) and low-density lipoprotein cholesterol, C/HDL ratio, triglyceride levels (TRIG) and self-reported diabetes mellitus. Age group and sex are strongly associated with all three conditions. Sedentary lifestyle is significantly associated with high DBP, depressed HDL and elevated TC/HDL and TRIG. Anthropometry measures are moderately associated with all conditions. The measures of body fat (body mass index) as well as abdominal fat distribution (waist circumference and ratio of waist to hip circumference) play an approximately equal role. Patients' age, sex, level of physical activity, body fat and abdominal fat distribution can be used as indicators of the probability of high blood pressure, dyslipidemia and diabetes mellitus. The 1988 Canadian report on healthy weights concluded that distribution of adipose tissue may be a better indicator of the presence of risk factors for cardiovascular disease and diabetes than weight-to-height indices. Until recently, the ratio of waist to hip circumference (WHR) has been suggested as a useful measurement of body fat distribution, and many studies have been conducted on the association between WHR and cardiovascular risks. Abdominal fat has been associated with hypertension. Studies have also shown that the relative risk of cardiovascular disease, myocardial infarction, ischemic heart disease and stroke increases by 2 to 11-fold, depending on the end point, between the first and fifth quintiles of WHR distribution. An increase in risk was also observed with WHR values over specific cut-off points, independent of the degree of obesity. Cross-sectional as well as cohort studies showed that WHR was also better associated with risk of cardiovascular disease in women than in men. Abdominal fat accumulation, as estimated by WHR, has been associated with increases in levels of plasma triglycerides and glucose, elevated systolic and diastolic blood pressure and resistance to insulin. Furthermore, if we add a measure of obesity or excess weight, the indicative capacity of WHR is improved in women and in men. An optimal or healthy range has been identified for body mass index (BMI) but, due to lack of sufficient epidemiologic data, not for waist circumference (WC) or WHR. It has been suggested that the risk of developing health problems increases linearly beyond specific cut-off points; however, the exact relation between obesity and fat distribution and cardiovascular risk factors is unclear. The objective of this study was to examine the indicative capacity of WHR and WC at different levels of BMI, for the presence of high blood pressure, abnormal lipid levels and diabetes. Methods Non-institutionalized Canadian men and women, between the ages of 18 and 74 years, participated in sample surveys conducted between 1986 and 1992 in all 10 provinces. Details of the survey methods have been described earlier. In brief, a probability sample of 29 977 people was selected using the health insurance registration files of each province and invited to participate. Height and weight were measured in all provinces, whereas WC and hip circumference (HC) were measured only in Alberta, Manitoba, Ontario, Quebec and Saskatchewan. In these 5 provinces, 16 007 people were invited to participate. A sample of 9826 people, for whom all 4 anthropometry measurements (weight, height, WC and HC) and at least 1 metabolic variable were available, was studied for this paper. Participants in the study sample were significantly older (mean age 38 years) than those not included because full data were not available (mean age 43 years, $p < 0.001$). However, there was no significant difference between the two groups with respect to sex or the prevalence of high blood pressure or diabetes. Anthropometry measurements were performed in the morning on fasting (12 h) participants dressed in indoor clothing without shoes. Height was measured to the nearest centimeter, with participants standing on a hard surface against a wall, using a square and tape measure fixed to the wall.

6. Ref ID: 51
Flynn, M. A., Hall, K., Noack, A., Clovechok, S., Enns, E., Pivnick, J., Naimish, A., Wouts, P., Best, M., and Pryce, C. Promotion of healthy weights at preschool public health vaccination clinics in Calgary: an obesity surveillance program. *Canadian Journal of Public Health 96*[6], 421–426. 2005.
Abstract: The objective is to evaluate the acceptability and feasibility of a surveillance program of overweight and obesity in preschool children in Calgary, and to provide advice for families to promote healthy weights. Children (mean age 4.9+/-0.6 years) attending pilot-site clinics in September 2002 and all clinics in Calgary between February 2003–December 2003 (n=7048). The growth assessment protocol and resources supported a three-pronged approach to promote healthy weights (healthy eating, active living and positive body image). Public health nurses were trained in standardized measurement techniques and information resources. Links with physicians were made to facilitate continuity of care. Children's weight and height measurements were plotted on the Weight-for-Stature growth chart and used to identify children as obese (> or =95th percentile), healthy weight (> or =5th, <95th) or underweight (<5th). Subsequent analysis calculated the Body Mass Index (BMI)-for-Age to identify overweight children (> or =85th, <95th percentile). The protocol was pilot tested and subsequently implemented in all Calgary public health clinics. The majority (98%) of parents were either very happy or happy with information received during the visit. Public health nurse counseling confidence significantly improved after the pilot ($p<0.001$). Data indicated that 9% of children were obese, 15% were overweight and 3% were underweight. This approach to identifying children's weight status appeared satisfactory to stakeholders, maximized use of existing resources to establish a surveillance program for Calgary, and provided an opportunity to give parents health-promoting advice on healthy weights.

7. Ref ID: 50
Flynn, M. A., McNeil, D. A., Maloff, B., Mutasingwa, D., Ford, C., and Tough, S. C. Reducing obesity and related chronic disease risk in children and youth: a synthesis of evidence with 'best practice' recommendations. *Obesity reviews: an official journal of the International Association for the Study of Obesity 7*[Supplement 1], 7–66. 2006.
Abstract: Childhood obesity is a global epidemic and rising trends in overweight and obesity are apparent in both developed and developing countries. Available estimates for the period between the 1980s and 1990s show the prevalence of overweight and obesity in children increased by a magnitude of two to five times in developed countries (e.g., from 11% to over 30% in boys in Canada), and up to almost four times in developing countries (e.g., from 4% to 14% in Brazil). The goal of this synthesis research study was to develop best practice recommendations based on a systematic approach to finding, selecting and critically appraising programmes addressing prevention and treatment of childhood obesity and related risk of chronic diseases. An international panel of experts in areas of relevance to obesity provided guidance for the study. This synthesis research encompassed a comprehensive search of medical/academic and grey literature and the Internet covering the years 1982–2003. The appraisal approach developed to identify best practice was unique, in that it considered not only methodological rigour, but also population health, immigrant health and programme development/evaluation perspectives in the assessment. Scores were generated based on pre-determined criteria with programmes scoring in the top tertile of the scoring range in any one of the four appraisal categories included for further examination. The synthesis process included identification of gaps and an analysis and summary of programme development and programme effectiveness to enable conclusions to be drawn and recommendations to be made. The results from the library database searches (13,158 hits), the Internet search and key informant surveys were reduced to a review of 982 reports of which 500 were selected for critical appraisal. In total 158 articles, representing 147 programmes, were included for further analysis. The majority of reports were included based on high appraisal

scores in programme development and evaluation with limited numbers eligible based on scores in other categories of appraisal. While no single programme emerged as a model of best practice, synthesis of included programmes provided rich information on elements that represent innovative rather than best practice under particular circumstances that are dynamic (changing according to population subgroups, age, ethnicity, setting, leadership, etc.). Thus the findings of this synthesis review identifies areas for action, opportunities for programme development and research priorities to inform the development of best practice recommendations that will reduce obesity and chronic disease risk in children and youth. A lack of programming to address the particular needs of subgroups of children and youth emerged in this review. Although immigrants new to developed countries may be more vulnerable to the obesogenic environment, no programmes were identified that specifically targeted their potentially specialized needs (e.g., different food supply in a new country). Children 0–6 years of age and males represented other population subgroups where obesity prevention programmes and evidence of effectiveness were limited. These gaps are of concern because (i) the pre-school years may be a critical period for obesity prevention as indicated by the association of the adiposity rebound and obesity in later years; and (ii) although the growing prevalence of obesity affects males and females equally; males may be more vulnerable to associated health risks such as cardiovascular disease. Other gaps in knowledge identified during synthesis include a limited number of interventions in home and community settings and a lack of upstream population-based interventions. The shortage of programmes in community and home settings limits our understanding of the effectiveness of interventions in these environments, while the lack of upstream investment indicates an opportunity to develop more upstream and population-focused interventions to balance and extend the current emphasis on individual-based programmes. The evidence reviewed indicates that current programmes lead to short-term improvements in outcomes relating to obesity and chronic disease prevention with no adverse effects noted. This supports the continuation and further development of programmes currently directed at children and youth, as further evidence for best practice accumulates. In this synthesis, schools were found to be a critical setting for programming where health status indicators, such as body composition, chronic disease risk factors and fitness, can all be positively impacted. Engagement in physical activity emerged as a critical intervention in obesity prevention and reduction programmes. While many programmes in the review had the potential to integrate chronic disease prevention, few did; therefore efforts could be directed towards better integration of chronic disease prevention programmes to minimize duplication and optimize resources. Programmes require sustained long-term resources to facilitate comprehensive evaluation that will ascertain if long-term impact such as sustained normal weight is maintained. Furthermore, involving stakeholders in programme design, implementation and evaluation could be crucial to the success of interventions, helping to ensure that needs are met. A number of methodological issues related to the assessment of obesity intervention and prevention programmes were identified and offer insight into how research protocols can be enhanced to strengthen evidence for obesity interventions. Further research is required to understand the merits of the various forms in which interventions (singly and in combination) are delivered and in which circumstances they are effective. There is a critical need for the development of consistent indicators to ensure that comparisons of programme outcomes can be made to better inform best practice.

8. Ref ID: 6
Hanley, A. J. G., Harris, S. B., Barnie, A., Gittelsohn, J., Wolever, T. M. S., Logan, A., and Zinman, B. The Sandy Lake Health and Diabetes Project: Design, Methods and Lessons Learned. *Chronic Diseases in Canada 16*[4], 149–156. 1995. Public Health Agency of Canada.
Abstract: This paper presents the methodology used in a prevalence study of non-insulin-dependent diabetes mellitus (NIDDM) among native Canadians living in an isolated northwestern Ontario community. Volunteers aged 10 and older were screened using a 75-g oral glucose tolerance test in accordance with the World Health Organization's criteria. Interviewer-administered questionnaires were used to col-

lect information on demographics, current and historical physical activity, diet, family history of diabetes and health knowledge. Anthropometry measurements included body mass index, waist-to-hip ratio and percent body fat from bioelectrical impedance analysis. Fitness level was assessed using a three-stage step test. Participation and community response were excellent, and this can be attributed in large part to the partnership that was established between the researchers and the community, and the employment of local people as recruiters and interviewers. The many valuable lessons learned during the process are discussed.

9. Ref ID: 3
Haque F, de la Rocha AG, Horbul BA, Desroches P, and Orrell C. Prevalence of childhood obesity in northeastern Ontario: a cross-sectional study. *Canadian Journal of Dietetic Practice and Research 67*[3], 143–147. 2006.
Abstract: In Canada, the incidence of childhood obesity has tripled within the past 20 years. The prevalence of obesity in the Timmins, Ontario, student population was studied to gain knowledge for program planning and resource allocation, and to compare Centers for Disease Control and Prevention (CDC) criteria with Cole's international criteria for childhood obesity. Anthropometry measurements of 801 students were taken. Students were chosen from randomly selected schools for each grade. Data were analyzed according to age, gender, and ethnicity. Data were also compared with other studies. Intragroup comparisons were performed using hypothesis testing for significance with the z table and chi-square test. Overweight and obesity prevalence was 28% according to CDC criteria. No statistical difference was found between genders or among ethnic groups, or between this study and other Canadian studies. In comparison with the CDC criteria, Cole's international criteria indicated less obesity and increased overweight prevalence. These differences were not statistically significant. The findings suggest that in the northern Ontario community of Timmins, the prevalence of childhood obesity is of epidemic proportions. When the findings are shared with different agencies, this study will help the health unit to take necessary public health measures to curb the epidemic.

10. Ref ID: 2
He, M and Beynon, C. Prevalence of overweight and obesity in school-aged children. *Canadian Journal of Dietetic Practice and Research 67*[3], 125–129. 2006.
Abstract: Childhood obesity is a public health concern in Canada. Few published anthropometry data are available to indicate obesity prevalence in Canadian children. Obesity prevalence is reported for school-aged children in 11 London, Ontario, schools. Data on body weight and height were obtained using standardized procedures. United States Centers for Disease Control and Prevention (CDC) body mass index (BMI)-for-age references and Cole's international BMI reference were used to classify the children's weight categories. The study included 1,570 pupils aged six to 13. The CDC BMI references categorized 16.6% and 11.8% of children as overweight and obese, respectively. In comparison, when the Cole BMI reference and cut-off points were used, 17.5% and 7.6% of children were classified as overweight and obese, respectively. Overweight is prevalent in the study population. Public health interventions are warranted to curb the obesity epidemic in school-aged children.

11. Ref ID: 112
He, M. and Sutton, J. Using routine growth monitoring data in tracking overweight prevalence in young children. *Canadian Journal of Public Health 95*, 419–423. 2004.
No abstract available.

12. Ref ID: 109
Janssen, I., Katzmarzyk, P. T., Boyce, W. F., King, M. A., and Pickett, W. Overweight and obesity in Canadian adolescents and their associations with dietary habits and physical activity patterns. *Journal of Adolescent Health 35*[5], 360–367. 2004.
Abstract: To present recent overweight and obesity prevalence rates for 11–16-year-old Canadian youth and to examine associations between overweight and obesity with dietary habits and leisure-time physical activities. Nationally representative sample of 11–16-year-old adolescents (n = 5890) from the Canadian component of the 2001/02 World Health Organization Health Behaviour in School-Aged Children Survey were used. Height, weight, dietary habits, and leisure-time activities were determined

from self-report. Age- and gender-specific prevalence rates of overweight and obesity were calculated based on international body mass index cut-points. Logistic regression was employed to examine the association among measures of overweight, obesity, and lifestyle habits. Fifteen percent of 11–16-year-old Canadian youth were overweight (pre-obese) and 4.6% were obese in 2002. These prevalence rates were greater in boys than girls ($p < .001$), but did not vary according to age. There were no clear associations observed between dietary habits and measures of overweight and obesity. However, physical activity levels were lower ($p < \text{or} = .05$) and television viewing times were higher ($p < .01$) in overweight and obese boys and girls than normal-weight youth. The prevalence rates of overweight and obesity in Canadian youth are high. The results suggest that physical inactivity and sedentary behaviors are strongly related to obesity in Canadian adolescents.

13. Ref ID: 52
Patterson, L., Jarvis, P., Verma, A., Harrison, R., and Buchan, I. Measuring children and monitoring obesity: surveys of English Primary Care Trusts 2004–2006. *Journal of Public Health*, in print. 2006.
Abstract: Child obesity has unclear determinants and consequences. A precautionary approach requires best-guess interventions and large-scale surveillance. This study was to determine the current measurement activities and the information systems required for child obesity surveillance. Design: Questionnaire-based surveys. Setting: Primary Care Trusts (PCTs) in United Kingdom. Participants: Two hundred and forty-seven (82%) PCTs in 2004 and 240 (79%) in 2006. Main measures: Children's ages at which height and weight are routinely measured, the type of personnel taking the measurements, arrangements for recording data, information systems and uses of the data. PCTs measure height/length and weight most commonly at 6 weeks (74%) and 5 years (74%) — also at 6–12 months (58%), 1.5–2.5 years (50%), 2.5–4 years (40%), 11 years (18%) and 7 years (11%). Seventy-seven per cent of PCTs transferred the measurements to a database — 26 different information systems were named. Six per cent of PCTs in 2004, rising to 34% in 2006, used the data to produce public health reports. Body mass index (BMI) surveillance requires new arrangements in 25% of PCTs at school entry and 80% at transfer to senior school. Important aspects of child obesity surveillance not yet addressed are pre-school measurement, longitudinal assessment and the public health requirements of (child) electronic health records.

14. Ref ID: 65
Power, C., Lake, J. K., and Cole, T. J. Measurement and long-term health risks of child and adolescent fatness. *International Journal of Obesity and Related Metabolic Disorders 21*[7], 507–526. 1997.
Abstract: This paper reviews child and adolescent adiposity measures and associated long-term health risks. The first section argues that anthropometry measures are practical for large scale epidemiological studies, particularly the body mass index. Limitations of this and other measures are presented. The second section summarizes the evidence on the relationship between child and adolescent and adult adiposity. This is based on a search for relevant literature in the following computerized databases: Medline (1985–96), BIDS (EMBASE and Science Citation Index 1985–96). The literature search revealed that the child to adult adiposity relationship is now well-documented, although methodological differences hinder comparisons. Nonetheless, consistently elevated risks of adult obesity are evident for fatter children, although the prediction of adult obesity from child and adolescent adiposity measures is only moderate. Fewer studies could be identified in relation to long-term health risks of child and adolescent adiposity. It is therefore difficult to specify categories of risk associated with childhood adiposity without more information from long-term studies. Further evidence is also required to confirm the suggestion from some studies that adult disease risks are associated with a change in adiposity from normal weight in childhood to obesity in adulthood. However, on the basis of the evidence available, it is argued that population-based approaches to the prevention of obesity are likely to be more effective than approaches targeted as fat children. Population-based approaches are desirable, first because of the poor prediction of adult obesity from child and adolescent measures, and second, because of risks of

adult mortality and morbidity may be elevated for individuals who become overweight after adolescence.

15. Ref ID: 58
Rudolf, M. C. J., Levine, R., Feltbower, R., Connor, A., and Robinson M. The TRENDS Project: development of a methodology to reliably monitor the obesity epidemic in childhood. *Archives of Disease in Childhood 91*, 309–311. 2006.
Abstract: The government has set a target to halt the rise in childhood obesity in those aged under 11 years by 2010, but no system is in place to ascertain if this has been achieved. We aimed to develop a simple and reproducible methodology to monitor trends in childhood obesity.
A purposive sample of 10 primary schools and three secondary schools was selected. Children were measured with parental 'opt out' consent in reception class; year 4 and year 8 (aged 5, 9 and 13 years old respectively). Measurements were compared with those obtained locally in 1996–2001. Calculations were then performed to ascertain the sample size required to confidently identify a halt in the rise in obesity using three growth measures. A total of 999 children were measured with ascertainment of 95% in primary and 85% in secondary schools. The proportion of overweight and obese children aged 9 and 13 years old had increased since 1996–2001, although only 9-year-olds showed a significant rise. A general trend of an increase in obesity was observed with increasing age. Calculations showed that 1900–2400 children per age group are needed to detect a halt in the rise in obesity based on mean body mass index (BMI) standard deviation scores (SDS) by 2010 with 90% power, whereas 4200–10 500 children are needed for other measures. We have developed a simple, cost-effective methodology for accurately measuring the epidemic and recommend the use of mean BMI SDS for demonstrating if a halt has been achieved.

16. Ref ID: 5
Saksvig, B. I., Gittelsohn, J., Harris, S. B., Hanley, A. J. G., Valente, T. W., and Zinman, B. A Pilot School-Based Healthy Eating and Physical Activity Intervention Improves Diet, Food Knowledge, and Self-Efficacy for Native Canadian Children. *Journal of Nutrition 135*, 2392–2398. 2005.
Abstract: The Sandy Lake school-based diabetes prevention program is a culturally appropriate intervention for Ojibway-Cree students in the 3rd, 4th, and 5th grades. This paper reports the results of the program in changing dietary intake behaviors and related psychosocial factors. Physical activity results are not included. The study was a pretest/post-test, single-sample design conducted during the 1998–1999 school year. A total of 122 students completed all 4 measurements (anthropometry, 24-h dietary recall, and 2 questionnaires), at baseline and follow-up. There were significant increases ($P < 0.0001$) in dietary intention, dietary preference, knowledge, and dietary self-efficacy, and in the curriculum knowledge scale between baseline and follow-up. Intervention exposure was significantly associated with being in the highest category for knowledge about foods that were low in dietary fat [Medium Exposure odds ratio (OR): 3.4; $P < 0.05$; High Exposure OR: 6.4; $P < 0.05$], being in the highest category for dietary self-efficacy (Medium Exposure OR: 3.7; $P < 0.05$; High Exposure OR: 3.9; $P < 0.1$), being in the highest category for knowledge about curriculum concepts (Medium Exposure OR: 3.4; $P < 0.05$; High Exposure OR: 9.4: $P < 0.01$), and for having met the age + 5 g dietary fiber intake/d (Medium Exposure OR: 2.9; $P < 0.1$; High Exposure OR: 11.0; $P < 0.01$). Exposure to the intervention was not associated with dietary intent or the percentage of energy from dietary fat. This program was associated with improved knowledge and the psychosocial factors related to healthy eating and dietary fiber intake of students in a remote First Nations community.

17. Ref ID: 83
Sarría, A., Moreno, L. A., García-Llop, L., Fleta, J., Morellón, M. P., and Bueno, M. Body mass index, triceps skinfold and waist circumference in screening for adiposity in male children and adolescents. *Acta Paediatrica 90*[4], 387–392. 2001.
Abstract: Simple anthropometry measurements and indices are the most commonly used tools for assessing body composition. Only a few papers have examined the sensitivity and specificity of the body mass index (BMI) against total body fat percentage (TBF%) from underwater weighing in children and adolescents. The objective of the

study was to evaluate the screening performance of BMI, triceps skinfold thickness and waist circumference for excess TBF%. A total of 175 healthy volunteer males, aged 7.0-16.9 y, participated in the study. TBF% was measured using underwater weighing as the reference method. Receiver operating characteristic (ROC) curves were constructed to assess the value of the three anthropometry measurements as a screening measure for total adiposity. Sensitivity and specificity were calculated at several percentile cut-offs for BMI, triceps skinfold and waist circumference. The areas under the ROC curves were also calculated, and were 0.86 for BMI, 0.90 for triceps skinfold and 0.88 for waist circumference. The point on the ROC curve closest to 1 corresponded to the 70th percentile for BMI, to the 75th percentile for triceps skinfold, and to the 70th percentile for waist circumference.

18. Ref ID: 105
Torrance, G. M., Hooper, M. D., and Reeder, B. A. Trends in overweight and obesity among adults in Canada (1970–1992): evidence from national surveys using measured height and weight. *International Journal of Obesity and Related Metabolic Disorders 26*[6], 797–804. 2002.
Abstract: To examine secular trends in obesity and overweight among Canadian adults between 1970 and 1992. The impact of education level and smoking on weight trends is explored. Adults aged 20–69 participating in three national health surveys which obtained measured height and weight: the Nutrition Canada Survey conducted between 1970 and 1972 (analysis sample n=5963); the Canada Health Survey of 1978–1979 (analysis sample n=3622); and the Canadian Heart Health Surveys conducted between 1986 and 1992 (analysis sample n=17 699). Comparison of percentage overweight (age-standardized body mass index (BMI) 25.0-29.9) and obese (age-standardized BMI > or = 30.0) by sex, education level and smoking status across the three surveys. Among men, the proportion overweight and obese increased steadily from 1970–1972 to 1986–1992. Among women, there was a substantial increase in the proportion overweight and obese between 1970–1972 and 1978–1979, then an increase in proportion obese, but not overweight, between 1978–1979 and 1986–1992. Although the prevalence of obesity increased in all education levels, the sub-groups with the greatest relative increase are men in the primary education category, and women in the secondary and post-secondary between 1970–1972 and 1986–1992. An increase in the prevalence of obesity was greatest among current smokers and, to a lesser extent, among former smokers. While excess weight has become an increasing public health problem among Canadian adults, the rate of increase in prevalence of obesity since 1970 varied with sex, education level and smoking status. There is a need for new data on measured heights and weights of Canadian adults and children and youth to update trends.

19. Ref ID: 62
Tremblay, M. S. and Willms, J. D. Secular trends in the body mass index of Canadian children. *Canadian Medical Association Journal 163*[11], 1429–1433. 2000.
Abstract: Various changes in society have created the opportunity for more sedentary behaviour and the consumption of food that is high in kilojoules, which may lead to a progressive increase in body mass over time. The purpose of this study was to examine secular changes in the body mass index (BMI) of Canadian children between 1981 and 1996. Nationally representative data from the 1981 Canada Fitness Survey, the 1988 Campbell's Survey on the Well-being of Canadians and the 1996 National Longitudinal Survey of Children and Youth were used in the analysis. Regression analyses were used to assess population changes in BMI from 1981 to 1996 for children aged 7–13 years. Changes in the distribution of BMI results were evaluated by plotting the residuals from regression analyses of BMI on age, assessed separately by sex, using the 1981 data as baseline. The proportions of children exceeding the 85th and 95th age- and sex-specific percentiles from the 1981 (baseline) data were also calculated. Since 1981, BMI has increased at the rate of nearly 0.1 kg/m2 per year for both sexes at most ages, indicating a clear secular trend toward an increase in BMI of Canadian children. The prevalence of overweight among boys increased from 15% in 1981 to 28.8% in 1996 and among girls from 15% to 23.6%. The prevalence of obesity in children more than doubled over that period, from 5% to 13.5% for boys and

11.8% for girls. Secular trends indicate that Canadian children aged 7–13 years are becoming progressively overweight and obese.

20. Ref ID: 104
Veugelers, P. J. and Fitzgerald, A. L. Prevalence of and risk factors for childhood overweight and obesity. *Canadian Medical Association Journal 173*, 607–613. 2005.
Abstract: Increases in childhood overweight and obesity have become an important public health problem in industrialized nations. Preventive public health action is required, but more research of risk factors is required before evidence-based initiatives can be developed and targeted effectively. We investigated the association between childhood overweight and obesity and risk factors relating to dietary habits, activities, parents and schools. In 2003 we surveyed grade 5 students and their parents and school principals in Nova Scotia. We measured height and weight and assessed dietary habits (using Harvard's Youth/Adolescent Food Frequency Questionnaire), physical and sedentary activities, and parental and school-based risk factors. We estimated neighbourhood income by averaging, per school, the postal-code level means of household income of residential addresses of children attending that school. We used multilevel logistic regression to evaluate the significance of these risk factors for overweight and obesity. On the basis of measurements taken of 4298 grade 5 students, we estimated the provincial prevalence of overweight to be 32.9% and of obesity to be 9.9%. Children who bought lunch at school were at increased risk of overweight (fully adjusted odds ratio [OR] 1.39, 95% confidence interval [CI] 1.16-1.67), whereas those who ate supper together with their family 3 or more times a week were at decreased risk (OR 0.68, 95% CI 0.52-0.88). Physical education classes 2 or more times a week at school were associated with a decreased risk of overweight (OR 0.61, 95% CI 0.43–0.87) and obesity (OR 0.54, 95% CI 0.33–0.88). Children in high-income neighbourhoods were half as likely to be obese as their peers living in low-income neighbourhoods (OR 0.50, 95% CI 0.36–0.70). Parents and schools provide important opportunities for public health initiatives for reducing childhood overweight and obesity. Children and schools in low-income neighbourhoods should receive priority in public health initiatives to reduce future socioeconomic inequalities in health.

21. Ref ID: 71
Willms, J. D., Tremblay, M. S., and Katzmarzyk, P. T. Geographic and demographic variation in the prevalence of overweight Canadian children. *Obesity Research 11*[5], 668–673. 2003.
Abstract: To examine the geographic and demographic variation in the prevalence of overweight Canadian children. Using BMI data from the 1981 Canada Fitness Survey and the 1996 National Longitudinal Survey of Children and Youth, this study assessed: 1). the prevalence of overweight and obesity among Canadian boys and girls ages 7 to 13 years; 2). secular trends in the prevalence of overweight from 1981 to 1996, by province and adjusted for age and sex; and 3). provincial variation in the prevalence of overweight, before and after adjusting for socioeconomic and demographic characteristics. The prevalence of boys and girls classified as overweight in 1996 was 33% and 26%, respectively. The corresponding figures for obesity were 10% for boys and 9% for girls. Provincial variation was observed with a trend of increasing risk of being overweight from west to east. Socioeconomic status was inversely related to the prevalence of overweight regardless of geographic region. The risk of being overweight was more related to geography (province) than demographic variables (income and family background); however, the effect of secular trends (1981 to 1996) exceeded the effect of geographic or demographic variables. The prevalence of childhood overweight and obesity is increasing in all areas of Canada and can be explained only partially by geographic or demographic characteristics.

22. Ref ID: 111
Willms, J. D. Early childhood obesity: a call for early surveillance and preventive measures. 171[3], 243–244. 2004.

Restraint System Design

1. Ref ID: 94
   Burdi AR, Huelke DF, Snyder RG, and Lowrey GH. Infants and children in the adult world of automobile safety design: pediatric and anatomical considerations for design of child restraints. *Journal of Biomechanics 2*[3], 267–280. 1969.
   Abstract: The infant and child differ structurally from the adult in a number of ways which are critical to the design for protection against impact forces and for adequate occupant restraint systems. The purpose of this paper is to bring together a profile of the anatomy, anthropometry, growth and development of the infant and child. Age differences related to the proper design of child restraint systems are emphasized. Problems discussed include child-adult structural differences, center of gravity of the body, the head mass in relation to the neck and general body proportions, positions of key organs and biomechanical properties of tissues.

2. Ref ID: 116
   Cameron, L., Segedin, E., Nuthall, G., and Thompson, J. Safe restraint of the child passenger. *Journal of Paediatrics and Child Health 42*, 752–757. 2006.
   Abstract: The aim of this study was to understand the need for, and use of, booster seats in the 4–12 years age group and to identify risk factors for booster seat-non-use. A cross-sectional sample of 1101 children aged 4–12 years traveling in 663 privately owned vehicles was taken from the Auckland region. Auckland is New Zealand's largest population centre, with a population of over 1.5 million. Information was gathered using a short questionnaire followed by direct inspection to identify those children using booster seats. The SafetyBeltSafe USA '5-step rule' was used to look at those children not using a booster seat to determine whether one was still required. While booster seat use has improved significantly in younger children since a similar study in 1992, only 40% of sampled children requiring a booster seat were using one. Booster seat use by children requiring them declined sharply as age increased. While 93% of 5- to 8- year-olds required a booster, only 30% were using one. The requirement for booster seats fell dramatically to 34% of 9- to 12-year-olds, but only 3% were using one. The high rate of need for booster seats and the lack of use of booster seats in children aged 5–8 years is a strong argument for legislation and education programmes targeting this age group. While the proportion of 9- to 12-year-olds needing a booster drops sharply, there would likely be benefits from educating parents on the '5-step rule' or similar method to help identify the 30% of these older children that would continue to benefit from a booster seat. Rear seating should be promoted alongside booster seat use in the age group 4–12 years.

3. Ref ID: 114
   Chamouard, F., Tarriere, C, and Boudrit, P. Protection of children on board vehicles: Influence of pelvis design and thigh and abdomen stiffness on the submarining risk for dummies installed on a booster. Proceedings of the 15th International Conference on Enhanced Safety of Vehicles. 1063–1075. 1996. Washington, D.C., National Highway Traffic and Safety Administration.

4. Ref ID: 119
   Evans, W. A., Courtney, A. J., and Fok, K. F. The design of school furniture of Hong Kong school children an anthropometry case study. *Applied Ergonomics 19*[2], 122–134. 1988.
   Abstract: Anthropometry data of Hong Kong schoolchildren have been collected and analyzed in order to develop recommendations for the design of chairs and tables for use in Hong Kong Government co-educational schools. The anthropometry data for Hong Kong have been compared with data from a Western population (United Kingdom) and another Asian population (Japan). Five sizes of chair and table combinations have been proposed to accommodate six primary and seven secondary forms (pupils aged from 6 to 18 years). The recommended design dimensions, based on the anthropometry characteristics of the Hong Kong target populations, are discussed in relation to recommendations from previous research in this area.

5. Ref ID: 120
Knight, G. and Noyes, J. Children's behaviour and the design of school furniture. *Ergonomics 42*[5], 747–760. 1999.
Abstract: Children spend a large part of their school days in the classroom, and yet the effect of the design of school furniture on their behaviour and health has received comparatively little attention in the UK. An experimental study is reported that compares the effects on children's behaviour and sitting position of traditional classroom furniture with a recently designed chair known as 'Chair 2000' and associated tables. It was found that children showed a modest but significant improvement in on-task behaviour and a marked change in sitting positions following the introduction of the newly-designed furniture. However, these benefits need to be considered in the light of polarized opinion for and against the new furniture, and a high level of reported incidence of back pain significantly related to the frequency of non-standard sitting. In the absence of radically redesigned furniture, it is suggested that children should be given more choice in their seating, and better guidance should be given to individuals involved in education in order to inform their decision-making about classroom furniture and the postural, anthropometry and orthopaedic aspects of sitting and related activities.

6. Ref ID: 81
Kolich, M. Automobile seat comfort: occupant preferences vs. anthropometry accommodation. *Applied Ergonomics 34*, 177–184. 2003.
Abstract: Automobile seat design specifications cannot be established without considering the comfort expectations of the target population. This contention is supported by the published literature, which suggests that ergonomics criteria, particularly those related to physiology, do not satisfy consumer comfort. The objective of this paper is to challenge ergonomics criteria related to anthropometry in the same way. In this context, 12 subjects, representing a broad range of body sizes, evaluated five different compact car seats during a short-term seating session. Portions of a reliable and valid survey were used for this purpose. The contour and geometry characteristics of the five seats were quantified and compared to the survey information. Discrepancies were discovered between published anthropometry accommodation criteria and subject-preferred lumbar height, seatback width, cushion length and cushion width. Based on this finding, it was concluded that automobile seat comfort is a unique science. Ergonomics criteria, while serving as the basis for this science, cannot be applied blindly for they do not ensure comfortable automobile seats.

7. Ref ID: 121
Linton, S. J., Hellsing, A. L., Halme, T., and Akerstedt, K. The effects of ergonomically designed school furniture on pupils' attitudes, symptoms and behaviour. *Applied Ergonomics 25*[5], 299–304. 1994.
Abstract: We tested the effects of implementing ergonomically designed school furniture on measures of comfort, sitting posture and symptoms. Three classes of fourth graders (10 years old) were randomly assigned either to a control group using traditional furniture or to an experimental group which received the ergonomically designed furniture. In both groups questionnaires were completed and sitting behaviour was observed twice before and after the intervention as well as at a five-month follow-up period. Although the experimental groups rated their furniture as being significantly more comfortable, differences in actual sitting behaviour were small. The experimental class experienced a reduction in musculoskeletal symptoms relative to the control group after implementing the ergonomically designed furniture. Since pupils did not automatically sit 'properly' in the ergonomic furniture, these results demonstrate the need for proper instructions and adjustment. Increased comfort and decreased symptoms may be used to motivate pupils to sit correctly. Our results suggest that furniture design is one aspect of a multidimensional problem.

8. Ref ID: 86
Panagiotopoulou, G., Christoulas, K., Papanckolaou, A., and Mandroukas, K. Classroom furniture dimensions and anthropometry measures in primary school. *Applied Ergonomics 35*[2], 121–128. 2004.
Abstract: The purpose of this study was to compare students' dimensions to the dimension of school furniture, in primary school, and determine whether this type of furniture

is well-designed and promotes good sitting posture at school by taking into account the dimensions of the children.
A total of 180 (90 male and 90 female) students, from three primary schools in Thessaloniki, Greece, participated in the study. Their ages ranged from 7 to 12 years. The following human body dimensions were measured: stature, elbow height, shoulder height, upper arm length, knee height, popliteal height and buttock–popliteal length. In addition, the dimensions were measured for four different types of chairs and five types of desks prevalent in classrooms. Finally, the anthropometry measures of the students and the furniture dimensions were compared in order to identify any incompatibility between them.
The data indicate a mismatch between the students' bodily dimensions and the classroom furniture available to them. The chairs are too high and too deep and desks are also too high for the pupils. This situation has negative effects on the sitting posture of the children especially when reading and writing.

9. Ref ID: 4
Reed, M. P., Ebert-Hamilton, S. M., Manary, M. A., Klinich, K. D., and Schneider, L. W. A New Database of Child Anthropometry and Seated Posture for Automotive Safety Applications. SAE Technical Papers Series, 1–16. 2005. 400 Commonwealth Drive, Warrendale, PA 15096-0001 U.S.A. Tel: (724) 776-4841 Fax: (724) 776-5760, www.sae.org.
Abstract: This paper presents a laboratory study of body dimensions, seated posture, and seatbelt fit for children weighing from 40 to 100 lb (18 to 45 kg). Sixty-two boys and girls were measured in three vehicle seats with and without each of three belt-positioning boosters. In addition to standard anthropometry measurements, three-dimensional body landmark locations were recorded with a coordinate digitizer in sitter-selected and standardized postures. This new database quantifies the vehicle-seated postures of children and provides quantitative evidence of the effects of belt-positioning boosters on belt fit. The data will provide guidance for child restraint design, crash dummy development, and crash dummy positioning procedures.

10. Ref ID: 113
Saul, R. A., Pritz, H. P., McFadden, J., Backaitis, S. H., Hallenbeck, H., and Rhule, D. Description and Performance of the Hybrid III 3 year-old, 6 year-old and small female test dummies in restrain system and out-of-position air bag environments. Paper Number: 98-S7-O-01, 1-20. 1997. National Highway Traffic Safety Administration and Transportation Research Center Inc.

11. Ref ID: 117
Snyder R.G., Spencer, M. L., Owings, C. L., and Schneider, L.W. Physical characteristics of children as related to death and injury for consumer product design and use. 1–54. 1975. Ann Arbor, MI, Highway Safety Research Institute.

12. Ref ID: 85
Snyder, R. G., Schneider, L. W., Owings, C. L., Reynolds, H. M., Golomb, D. H., and Schork, M. A. Anthropometry of infants, children and youths to age 18 for product safety design. Highway Safety Research Institute Report No. UM-HSRI-77-17. 1977. Ann Arbor, MI.

13. Ref ID: 78
Steenbekkers, L. P. and Moenbroek, J. F. Anthropometry data of children for non-specialist users. *Ergonomics 33*[4], 421–429. 1990.
Abstract: In a pilot study, 33 anthropometry variables were measured on 633 children aged 0-5.5 years. The variables were chosen on the basis of international standards and on the results of preliminary analysis of accidents. Methodical aspects of this pilot study are presented in this paper, followed by two applications: anthropometry aspects of current regulations for cribs, playpens and toys; anthropometry aspects in the selection of wheelchairs for children. The paper concludes with a discussion on how to present anthropometry data for non-special users.

14. Ref ID: 92
Vezin, P. and Verriest, J. P. Development of a set of numerical human models for safety. 2006.
Abstract: The objective of the EC funded HUMOS2 project is to develop Finite Element (FE) human models representing a large range of the European population and allowing an accurate injury risk prediction for victims involved in

road accidents. A human model of a male in a driving position close to the 50th percentile — HUMOS model — resulting of the previous HUMOS project was presented (Robin [1]) at the ESV conference in 2001. The present paper focuses on the new developments that have been made in the still running HUMOS2 project. Firstly, methods allowing the personalization (anthropometry, geometry and position) of human numerical models have been developed. They include a scaling tool enabling to derive any individual model from the original one through mesh control points and statistical relationships between external and internal dimensions. These were established from geometric data collected on standing and sitting human volunteers with a low dose bi-plane X ray system but also directly measured on isolated bone parts. A positioning tool has also been developed, based on a set of reference postures including seated car occupant, out of positions (OOPs) and pedestrian postures, in order to adjust and test the models for different sitting and standing postures. Secondly, experimental work has been conducted on human volunteers in order to identify the influence of muscular tensing on body response to moderate impacts. A data base of biomechanical test results, appropriate for model validation, has been set up. It includes new biomaterial laws for ligament and skeletal muscles, as well as existing cadaver tests results coming from former EC projects and Heidelberg University. It and will be further completed by specific tests performed by consortium members. Ongoing work includes injury prediction rules introduction in the models then, extensive testing of the model in various conditions defined for validation.

15. Ref ID: 89

Weber, K., Lehman, R. J., and Schneider, L. W. Child anthropometry for restraint system design. Technical Report No. UMTRI-85-23. 1985. Ann Arbor, MI, University of Michigan Transportation Research Institute.

Abstract: The purpose of this report is to present, in English units, a compilation of the child anthropometry data from all three UM studies that are considered useful for child restraint design. Because measurement procedures were as consistent as possible among the studies, raw data for the same measures have been combined and are displayed as single data sets. In addition, dimensions unique to one study are presented along with measurement taken in more than one study. Thus all available measurements that are likely to be of interest to the restrains designer will be found in this single source, given in units more familiar to the US designer.

Safety and Injury Prevention

1. Ref ID: 93

Arbogast, K. B., Mong, D. A., Marigowda, S., Kent, R. W., Stacey, S., Mattice, J., Tanji, H., Higuchi, K., and Rouhana, S. W. Evaluating Abdominal Paediatric Injuries. 2006.

Abstract: Abdominal injuries, along with lumbar spine fractures, are part of a constellation of injuries referred to as “seat belt syndrome”. Geometrical characteristics of the pelvis and abdomen of younger children place them at higher risk for these injuries. Efforts to design restraints that mitigate these injuries are limited as no current pediatric anthropomorphic dummy (ATD) can accurately quantify the abdominal response to belt loading. This paper describes progress on a four-phase project to address this gap involving pediatric anthropometrys, real-world abdominal injury risk, abdominal biomechanical structural response and injury tolerance from a porcine model, and development of an abdominal insert for the 6-year-old ATD based on these data. Internal anthropometry measures consisted of radiological assessment of abdominal depth, height, and circumference at multiple horizontal planes. External measures consisted of distances, determined by digital photography, taken between skeletal markers while the child was seated on a vehicle seating apparatus with and without a booster seat. Field investigation identified three unique kinematic patterns resulting in abdominal injury: presubmarining where the belt is initially out of position, classic submarining where the belt starts in position and the pelvis moves under the belt with the torso reclined, and submarining/jackknifing where the pelvis slides under the belt, and the torso flexes forward. The biomechanical studies developed age- and size-based correlations between pediatric swine and humans. Biomechanical tests performed using the most appropriately sized porcine model will be used to define the structural and injury

response of the pediatric abdomen to realistic loading conditions.

2. Ref ID: 118
Balague, F., Dutoit, G., and Waldburger, M. Low back pain in school children. *Lancet 361*[9367], 1403–1404. 2003.
No abstract available.

3. Ref ID: 115
Cyr, C., Lemoine, C., and Santschi, M. Canadian Paediatric Surveillance Report 2005: Lap Belt Syndrome Report. 38–39. 2005. Ottawa, Ontario, Canadian Paediatric Society.
Abstract: The study confirmed 28 cases of lap-belt syndrome with high prevalence of spinal fracture (43%) and permanent spinal cord lesion (25%). Although 12 children were less than eight years old, only one was restrained in a booster seat (wearing only a lap belt). Seat belts save lives; however, if worn incorrectly they can cause important abdominal and lumbar spine injuries. There is an urgent need for aggressive education efforts to ensure adequate child restraint use in motor vehicles.

4. Ref ID: 91
Durbin, D. R., Chen, I., Smith, R., Elliott, M. R., and Winston, F. K. Effects of seating position and appropriate restraint use on the risk of injury to children in motor vehicle crashes. *Paediatrics 115*[3], e305–e309. 2005.
Abstract: Currently, many states are upgrading their child restraint laws to include provisions for the use of age-appropriate restraints through 6 to 8 years of age, with some also requiring rear seating for children, enabling the laws to be in closer alignment with best-practice recommendations. To evaluate the relationships of seating position and restraint status to the risk of injury among children in passenger vehicle crashes. This was a cross-sectional study of children <16 years of age who were involved in crashes of insured vehicles in 15 states, with data collected via insurance claims records and a telephone survey. A probability sample of 17980 children in 11506 crashes, representing 229106 children in 146613 crashes, was collected between December 1, 1998, and November 30, 2002. Parent reports were used to define restraint status, seating position, and occurrence of clinically significant injuries, with the use of a previously validated instrument. Approximately 62% of the children used seat belts, 35% used child restraints, and 3% used no restraint. Nearly 4 of 5 children sat in the rear seat, with one half of all children being restrained appropriately for their age in the rear, although this varied according to the age of the child. Overall, 1.6% of children suffered serious injuries, 13.5% had minor injuries, and 84.9% did not have any injury. Unrestrained children in the front were at the highest risk of injury and appropriately restrained children in the rear were at the lowest risk, for all age groups. Inappropriately restrained children were at nearly twice the risk of injury, compared with appropriately restrained children (odds ratio [OR]: 1.8; 95% confidence interval [CI]: 1.4–2.3), whereas unrestrained children were at >3 times the risk (OR: 3.2; 95% CI: 2.5–4.1). The effect of seating row was smaller than the effect of restraint status; children in the front seat were at 40% greater risk of injury, compared with children in the rear seat (OR: 1.4; 95% CI: 1.2–1.7). Had all children in the study population been appropriately restrained in the rear seat, 1014 serious injuries (95% CI: 675–1353 injuries) would have been prevented (with the assumption that restraint effectiveness does not depend on a variety of other driver-related, child-related, crash-related, vehicle-related, and environmental factors). Age-appropriate restraint confers relatively more safety benefit than rear seating, but the 2 work synergistically to provide the best protection for children in crashes. These results support the current focus on age-appropriate restraint in recently upgraded state child restraint laws. However, it is important to note that considerable added benefit would be realized with additional requirements for rear seating.

5. Ref ID: 90
Nance, M. L., Lutz, N., Arbogast, K. B., Cornejo, R. A., Kallan, M. J., Winston, F. K., and Durbin, D. R. Optimal restraint reduces the risk of abdominal injury in children involved in motor vehicle crashes. *Annals of Surgery 239*[1], 127–131. 2004.
Abstract: The American Academy of Pediatrics has established guidelines for optimal, age-appropriate child occupant restraint. While optimal restraint has been shown to reduce the risk of injuries overall, its effect on specific types of injuries, in particular abdominal injuries, has not

been demonstrated. Cross-sectional study of children aged younger than 16 years in crashes of insured vehicles in 15 states, with data collected via insurance claims records and a telephone survey. A probability sample of 10927 crashes involving 17132 restrained children, representing 210926 children in 136734 crashes was collected between December 1, 1998 and May 31, 2002. Restraint use was categorized as optimal or suboptimal based on current American Academy of Pediatrics guidelines. The outcome of interest, abdominal injury, was defined as any reported injury to an intra-abdominal organ of Abbreviated Injury Scale >or=2 severity. Among all restrained children, optimal was noted in 59% (n = 120473) and suboptimal in 41% (n = 83555). An associated abdominal organ injury was noted in 0.05% (n = 62) of the optimal restrained group and 0.17% (n = 140) of the suboptimal group. After adjusting for age and seating position (front vs. rear), optimally restrained children were more than 3 times less likely [odds ratio 3.51 (95% confidence interval, 1.87–6.60, P < 0.001)] as sub-optimally restrained children to suffer an abdominal injury. Of note, there were no abdominal injuries reported among optimally restrained 4- to 8-year-olds. Optimally restrained children are at a significantly lower risk of abdominal injury than children sub-optimally restrained for age. This disparity emphasizes the need for aggressive education efforts aimed not only at getting children into restraint systems, but also the importance of optimal, age-appropriate restraint.

6. Ref ID: 97

Weber, K. Crash Protection for Child Passengers: A review of best practices. *UMTRI Research Review 31*[3], 1–28. 2000. Ann Arbor, Michigan, Research Information and Publications Center of the University of Michigan Transportation Research Institute.

Abstract: Child restraint systems provide specialized protection for small occupants whose body structures are still immature and growing. There is a wide variety of systems from which to choose, and different types of restraints are appropriate for children of different ages and sizes. Even with the most appropriate child restraint (CR), however, the way in which it is installed and used can have an effect on its performance. This review describes the theory behind the design of occupant restraint systems and applies these principles to the special needs of children. A distinction is made between child restraints, which themselves provide the restraint structure, and positioning devices, such as boosters, which help the vehicle belt fit the child. Throughout each section, current concepts of best practice are given, including the changes brought on by passenger airbags, and future directions are indicated.

Training

Ref ID: 95

Guimarey, L. M., Piedrabuena, A. E., and Barros Filho Ade, A. Training and standardization of personnel for performing an anthropometry study in school children. *Archivos Latinoamericanos de Nutricion 31*[2], 303–313. 1981.

Abstract: In order to avoid ponderable errors among the anthropometrists working in a project of school health, a training model was developed. Four subjects were trained (A, B, C and D). Significant and highly significant differences in the reading of skinfold (F = 5.15) and height (F = 8.17) were observed only with subject C. These differences were not present in the last reading, which means that there was an improvement in the determinations. Analyzing all subjects, it was possible to verify that subject D presented significant and highly significant differences with the other subjects (skin fold delta 5% - 6.16 and delta 1% = 8.08, arm circumference delta 5% = 0.50 and delta 1% = 0.67, height delta 5% = 0.27). This subject, however, had the lowest variability in the readings, which means that this systematic error was personal. The method that was applied is useful in the training and standardization of anthropometrists, and for the detection of those subjects who present systematic errors.

Ref ID: 37

Harrison, G. G., Galal, O. M., Ritenbaugh, C. X., Shaheen, F. M., Abdel-Azim Wahba, S., Kirksey, A., and Jerome, N. W. Dependability and precision of anthropometry measures in a longitudinal field study in an Egyptian village. *American Journal of Human Biology 3*[5], 479–487. 1991.

Abstract: Reliability and its components, precision and dependability, are analyzed for a complex dataset involving

longitudinal anthropometry measurements on subjects of varying ages in an Egyptian village setting. Results are compared with other published datasets. Technical error of measurement is similar to or compares favorably with other datasets for both adults and children. Overall reliability is strongly influenced by dependability coefficients, which are calculated in this analysis over relatively longer time periods (2 weeks for young children and longer for older individuals) than in other comparable datasets. It is evident that some components of the theoretical construct of imprecision, i.e., measurement error derived from variation over longer periods of time in factors contributing to accuracy, are actually captured in the analytical component of variance called undependability.

Ref ID: 38

Himes, J. H. Reliability of anthropometry methods and replicate measurements. *American Journal of Physical Anthropology 79*[1], 77–80. 1989.

Abstract: The Spearman-Brown Prophesy formula, derived from psychometrics, may be used in anthropometry studies to describe the relationship between the intraclass reliability coefficient for a single measurement and the reliability resulting from the mean of replicate measurements. This theory may be applied to determine expected reliabilities of anthropometry protocols using replicate measurements and to determine the numbers of replicate measurements necessary to achieve desired levels of reliability.

Ref ID: 21

Himes, J. H. Minimum time intervals for serial measurements of growth in recumbent length or stature of individual children. *Acta Paediatrica 88*[2], 120–125. 1999.

Abstract: A method is presented to estimate minimum time intervals for meaningful measurements of growth in recumbent length or stature on individual children. These intervals are based on the statistical features of growth, and consider the reliability of measurement, expected rates of growth, and variation in attained length or stature. Because of the assumptions used, the intervals should be considered as minima, except in some predictable cases. During the prepubescent period there are no differences in minimum intervals calculated for boys and girls. The intervals are shortest during the rapid growth attending infancy, and increase to 0.39 y (4.7 mo) at 8 y of age in boys and girls, and to 0.43 y (5.2 mo) at 10 y of age in boys. A reference curve of minimum intervals for length and stature during the prepubescent period is presented with an equation for more precise estimation of measurement intervals. To accommodate the pubescent growth spurt and its normal variation in timing, 0.5 y is recommended as the minimum interval during pubescence when the maturational timing of the child is unknown. These minimum measurement intervals should be appropriate for almost all individual children when growth in recumbent length or stature is measured serially.

Ref ID: 99

Johnson, T. S., Engstrom, J. L., Haney, S. L., and Mulcrone, S. L. Reliability of three length measurement techniques in term infants. *Pediatric Nursing 25*[1], 13–17. 1999.

Abstract: To describe and compare the intra- and inter-examiner reliability of three length measurement techniques and to determine if the three measurement techniques yield significantly different measurements. Two experienced, mother-baby nurses each obtained length measurements using the supine, paper barrier, and Auto-length measurement techniques twice each from 48 healthy term infants. The nurses were blind to their own and to each other's measurements. The order of the nurses and the order of the measurement techniques were randomized. For intra-examiner reliability, RN-1 had smaller mean absolute differences for the Auto-length measurements. RN-2 had similar mean absolute differences for all three measurement techniques. The percentage of differences < or = 1 cm were smallest for the supine measurements for RN-1 and not remarkably different between the measurement techniques for RN-2. For inter-examiner reliability, the mean absolute differences between the pairs of measurements were smallest for the Auto-length measurements for Set-1 and for the paper-barrier measurements for Set-2. The percentage of differences < or = 1 cm between the pairs of measurements for Set-1 were not remarkably different and were lowest for the supine measurements for Set-2. The mean measurements obtained by the supine, paper-barrier, and the Auto-length measurements were respectively: 50.88, 50.33, and 49.67 cm. The differences between the means were statistically signif-

icant (X2 = 56.56, p = .0000). The differences between length measurements by individual examiners and pairs of examiners are relatively large. Clinicians should be aware of the magnitude of error in length measurements and should interpret length measurements with caution. These findings also demonstrate that all clinicians in any setting should use the same technique to obtain length measurements.

Ref ID: 30

Klipstein-Grobusch, K., Georg, T., and Boeing, H. Interviewer variability in anthropometry measurements and estimates of body composition. *International Journal of Epidemiology 26*[Supplement 1], 174–180. 1997.

Abstract: The extent of intra- and inter-interviewer variability both in anthropometry measurements and in estimates of body composition was assessed and the possibility of systematic variation due to interviewer differences investigated. Seventeen interviewers trained in the anthropometry measurement technique and 10 healthy volunteers (4 men, 6 women) participated in the study on measurement variability. To ensure participation of all interviewers the study was carried out on three different days. On each of these days interviewers got randomly allocated to the subjects being present. Each interviewer took 12 measurements — body weight, body height, sitting height, circumferences of waist, hip, and midarm, skinfolds (biceps, triceps, subscapular, and suprailiac), chest breath and depth — per subject on two occasions. From these measurements, body mass index, waist-to-hip ratio, percentage of body fat, fat mass, fat free mass and metric index were determined. For all anthropometry variables variance components, reliability coefficients (R) and coefficients of variation (CV) were estimated and systematic differences of measurements between interviewers were assessed. Measurement reliability in basic anthropometry measures expressed as variance components, reliability coefficients and coefficients of variation was influenced to a greater extent by inter-interviewer variability (R: 0.858–0.999; CV: 0.1–20.9) than intra-interviewer variability (R: 0.979–0.999; CV: 0.0–6.4). The respective estimates of body composition exhibited comparatively higher reliability (Rinter: 0.975–0.999; Rintra: 0.995–0.999). Measurements more prone to subjectivity, e.g., skinfolds showed lower reliability (CVinter: 9.3–20.9; CVintra: 3.6–6.4). Although the absolute variation in measures due to interviewers was small, systematic differences among interviewers were clearly evident in all measurements and estimates except sitting height in this group of subjects. Anthropometry measures and estimates of body composition obtained in the current study show the feasibility of detailed anthropometry data collection by multiple interviewers in large-scale epidemiological studies.

Ref ID: 20

Lampl, M., Birch, L., Picciano, M. F., Johnson, M. L., and Frongillo, E. A. Jr. Child factor in measurement dependability. *American Journal of Human Biology 13*[4], 548–557. 2001.

Abstract: A primary consideration in longitudinal growth studies is the identification of growth from error components. While previous research has considered matters of measurement accuracy and reproducibility in detail, few reports have investigated the errors of measurement due to aspects of the physiology and cooperation of the child. The present study directly assesses this source of measurement undependability for the first time. Investigation of total measurement error variance in 925 recumbent length replicates taken over stasis intervals in growth identifies that between 60% and 70% of total measurement unreliability is due to child factor undependability. Individual differences are significant and longitudinal growth analyses should consider two to three times the technical error of measurement statistic as a reasonable estimate of the total unreliability for any single measurement of an infant's recumbent length. These results raise issues regarding analytic methods as applied to serial growth data.

Ref ID: 29

Marks, G. C., Habicht, J. P., and Mueller, W. H. Reliability, dependability, and precision of anthropometry measurements. The Second National Health and Nutrition Examination Survey 1976–1980. *American Journal of Epidemiology 130*[3], 578–587. 1989.

Abstract: The components of reliability for eight anthropometry measures were studied in 95 male and 134 female subjects from the Second National Health and Nutrition Examination Survey (NHANES II). The contributions to unreliability variance (Sr2) that occur as a result of measur-

ing errors (Sp2, imprecision variance) and of intrasubject fluctuations in a measurement due to physiologic factors (Sd2, undependability) were estimated (Sr2 = Sp2 + Sd2). Unreliability was then related to the between-subject variance (S2) to estimate the reliability (R = 1 – (Sr2/S2)) of the measurement. Four of the anthropometry measurements (weight, height, sitting height, and arm circumference) had reliabilities in excess of R = 0.97. In the first three of these, measurement imprecision made up two thirds or less of unreliability, and undependability (Sd2) was stable by two weeks. Lesser but still acceptable reliabilities were obtained for triceps and subscapular skinfolds, bitrochanteric breadth, and elbow breadth (R = 0.81-0.95). For these variables imprecision (Sp2) was the major source of error. Furthermore, the unreliability (Sr2) between observers was twice as high or more than the unreliability within observers for these variables, evidence that imprecision (Sp2) is the single most important source of unreliability in these anthropometry measurements. Unreliability standard deviations of skinfolds increased in a linear manner with skinfold thickness corresponding to an unreliability coefficient of variation of 13–19 per cent. None of the other measurements showed such scale effects. Analyses of the kind suggested will help epidemiologists decide whether reliability can be increased by improving precision, and whether there is a need to improve reliability in the first place. Reliability appears to be adequate for all anthropometry in the NHANES II.

Ref ID: 19

Martorell, R., Habicht, J. P., Yarbrough, C., Guzmán, G., and Robert E. The identification and evaluation of measurement variability in the anthropometry of preschool children. *American Journal of Physical Anthropology 43*[3], 347–352. 1975. National Institute of Child Health and Human Development, National Institutes of Health, Bethesda, Maryland, Klein Division of Human Development, Institute of Nutrition of Central America and Panama (INCAP), Guatemala City, Guatemala, C. A.

Abstract: Measurement variability estimates for 18 different anthropometry dimensions were collected within the context of an ongoing longitudinal investigation of preschool Guatemalan children. Estimates of total measurement variance, intra-observer variance, and short-term intra-subject variance are presented for each variable. A simple procedure for the evaluation of measurement variance in cross-sectional and longitudinal investigations is described in which the total measurement variance is expressed as a percentage of the appropriate inter-subject variance. This statistic serves as an index of the relative reproducibility of anthropometry variables.

Ref ID: 82

Meunier, P. and Yin, S. Performance of a 2D image-based anthropometry measurement and clothing sizing system. *Applied Ergonomics 31*, 445–451. 2000.

Abstract: Two-dimensional, image based anthropometry measurement systems offer an interesting alternative to traditional and three dimensional methods in applications such as clothing sizing. These automated systems are attractive because of their low cost and the speed with which they can measure size and determine the best-fitting garment. Although these systems have appeal in this type of application, not much is known about the accuracy and precision of the measurements they take. In this paper, the performance of one such system is assessed. The accuracy of the system was analyzed using a database of 349 subjects (male and female) who were also measured with traditional anthropometry tools and techniques, and the precision was estimated through repeated measurements of both a plastic mannequin and a human subject. The results of the system were compared with those of trained anthropometrists, and put in perspective relative to clothing sizing requirements and short-term body changes. It was concluded that image-based systems are capable of providing anthropometry measurements that are quite comparable to traditional measurement methods (performed by skilled measurers), both in terms of accuracy and repeatability.

Ref ID: 43

Moreno, L. A., Joyanes, M., Mesana, M. I., González-Gross, M., Gil, C. M., Sarría, A., Gutierrez, A., Garaulet, M., Perez-Prieto, R., Bueno, M., and Ascensión, M. Harmonization of anthropometry measurements for a multicenter nutrition survey in Spanish adolescents. *Nutrition 19*[6], 481–486. 2003.

Abstract: Although the need for accurate anthropometry measurement has been repeatedly stressed, reports on growth and physical measurements in human populations rarely include estimates of measurement error. We describe the standardization process and reliability of anthropometry measurements carried out in a pilot study. For the intraobserver assessment of anthropometry measurements, we studied 101 adolescents (58 boys and 43 girls) from five cities. For interobserver assessment, we studied 10 adolescents from thesame class in Zaragoza and different from those in the intraobserver sample. For skinfold thickness, intraobserver technical errors of measurement (TEMs) in general were smaller than 1 mm; for circumferences, TEMs in general were smaller than 1 cm. Intraobserver reliability for skinfold thickness was greater than 95% for almost all cases; for circumferences, intraobserver reliability generally was greater than 95%. Interobserver TEMs ranged from 1 to 2 mm for the six skinfold thicknesses measured; for circumferences, TEMs were smaller than 1 cm for the arm, biceps, and waist and between 1 and 2 cm for the hip and thigh. Interobserver reliabilities for skinfold thickness and circumference were always greater than 90%, except for biceps skinfold. Our results are in agreement with those recommended in the literature. Therefore, these anthropometry measures seem to be adequate to assess body composition in a multicenter survey in adolescents.

Ref ID: 36

Pelletier, D. L., Low, J. W., and Msukwa, L. A. H. Sources of measurement variation in child anthropometry in the Malawi maternal and child nutrition study. *American Journal of Human Biology 3*[3], 227–237. 1991.

Abstract: An examination of intra- and inter-observer error in child anthropometry and variation between two skinfold calipers was conducted as part of a large prospective study of maternal and child nutrition in Malawi, Central Africa. Measurements include length, weight, head and arm circumferences, triceps and subscapular skinfolds, and estimated cross-sectional arm fat and arm muscle areas. Total observer error, expressed as a percentage of total variance in each trait, is 3.2% for length, weight, and head circumference; 7% for arm circumference; 10% for arm fat area; and 16-20% for skinfolds and arm muscle area. When total observer error is divided into the two additive components studied, intraobserver error represents approximately 50% or more of total observer error for most traits. An exception is the subscapular skinfold for which intra-observer represents 38% of total observer error. Errors of this magnitude will cause an attenuation of approximately 10% in the correlation coefficients between anthropometry and other variables, and a loss of power in attempting to detect associations between anthropometry variables and either their determinants or outcomes. However, the effects of errors of this magnitude are minor compared to those encountered in studies correlating nutrient intake with other variables. This study also finds that the SlimGuide caliper systematically overestimates skinfolds at low readings and underestimates skinfolds at high readingss relative to the Lange caliper.

Ref ID: 32

Skinner, A. M., Cieslak, Z., MacWilliam, L., Solimano, A., and Kitson, H. F. The measurement of knee-heel length in newborn infants using a simple vernier calipers. 86[5], 512–517. 1997.

Abstract: To assess the usefulness of a simple vernier calipers for measuring knee-heel length in neonates. Using a simple vernier calipers, knee-heel length was measured five times by 2 observers in 50 babies (29M, 21F; mean birthweight 1597 g; median gestational age at birth 29 weeks) at a median postnatal age of 11 days. A subgroup of 20 babies had knee-heel length measured similarly at weekly intervals for 3 weeks. Corrected gestational age and weight were simultaneously recorded. One observer was experienced in using the vernier calipers. The precision of the calipers was established using 4 steel gauge blocks of varying length (7.62–10.17 cm). The calipers were very precise when measuring steel gauge blocks. In babies, there was a downward trend across the first 2 measurements for both observers, the measurements stabilizing over the last three. Using the final three measurements per baby (n = 50), the experienced observer had a mean standard deviation of 0.023 cm and mean coefficient of variation 0.23% when measuring an average knee-heel length of 9.99 cm. The inexperienced observer had a mean standard deviation of 0.057 cm and a mean coefficient of variation of 0.56%,

when measuring an average knee-heel length of 10.14 cm. The inter-observer reliability, measured by the intra-class correlation coefficient, was 0.99. The agreement between observers was such that one observer measured knee-heel length consistently less (0.15 cm, SD 0.18 cm) than the other. The reliability for knee-heel length velocity was lower (R = 0.85), but agreement between observers was high with an average difference of 0.016 cm/week. Knee-heel length was significantly correlated ($p < 0.001$) with corrected gestational age ($r = 0.85$) and with weight ($r = 0.96$). There was a weaker but significant correlation ($r = 0.47$, $p < 0.001$) between knee-heel length velocity and rate of weight gain (g/day), indicating that weight gain may not always be accompanied by an increase in linear growth. The measurement of knee-heel length by a simple vernier calipers is an accurate, reproducible and non-invasive method of assessing short-term linear growth in neonates. However, it is recommended that measurements of knee-heel length in a individual baby should be made by a single experienced observer.

Ref ID: 100

Sutter, K., Engstrom, J. L., Johnson, T. S., Kavanaugh, K., and Ifft, D. L. Reliability of head circumference measurements in preterm infants. *Pediatric Nursing 23*[5], 485–490. 1997.

Abstract: To describe and compare the intra- and interexaminer reliability of head circumference measurements obtained with paper and cloth tape measures. Two experienced neonatal nurses each obtained head circumference measurements using both paper and cloth tape measures twice each, from 49 clinically stable, preterm infants. The nurses were blind to their own and to each other's measurements. The order in which the measurements were obtained was randomized. The differences within and between examiners for cloth and paper tape measurements were described using mean absolute differences, standard deviation of net differences, technical error of measurement, minimal and maximal differences, percentage of differences 0.25 and 0.5 cm, and percentage of error. Wilcoxon matched-pairs, signed-ranks tests demonstrated significantly greater intraexaminer reliability for measurements obtained with the paper tape for both of the nurses. Wilcoxon matched-pairs, signed-ranks tests also demonstrated significantly greater interexaminer reliability for measurements obtained with the paper tape for both the first and second measurement sets. Intra- and interexaminer differences were consistently smaller when the examiners used paper tape measures.

Ref ID: 26

Ulijaszek, S. J. and Kerr, D. A. Anthropometry measurement error and the assessment of nutritional status. *British Journal of Nutrition 82*[3], 165–177. 1999.

Ref ID: 64

US Department of Health and Human Services. Accurately Weighing and Measuring Technique. 2006. http://www.depts.washington.edu/growth/index.htm

Abstract: With the availability of the 2000 CDC Growth Charts, this is an opportune time for all pediatric health care providers to re-evaluate the tools they use and the approach they have in their clinical setting for measurement, plotting and interpretation of growth charts. This module reviews techniques for measuring and recording infant length, weight, and head circumference and reviews the technique for obtaining and recording weight and stature for children and adolescents. The information in this module is intended for the measurement of typically developing children. Another module provides information on the measurement techniques to be used when children have special physical considerations and the techniques described here are not feasible.

Ref ID: 25

Vegelin, A. L., Brukx, L. J., Waelkens, J. J., and Van den Broeck, J. Influence of knowledge, training and experience of observers on the reliability of anthropometry measurements in children. *Annals of Human Biology 30*[1], 65–79. 2003.

Abstract: To elucidate the impact of the observer's level of technical knowledge, training and experience with measuring height and triceps skinfold thickness on the reliability of these measurements in children. Despite of instructions and encouraging careful measurements, these factors may significantly affect measurements and lead to interpretation difficulties, especially of short term growth data. A cross-sectional study was designed in which 18 children, aged

2–7 years, were measured in duplicate by 12 observers with different backgrounds and levels of experience, protocol knowledge and protocol training. The main outcome measures, precision and accuracy, were expressed as technical error of measurement (TEM) and average bias (AB) in comparison with an expert anthropometrist. As expected, the best educated and most experienced observers scored the best precision and accuracy. By ranking analysis and multiple regressions we learned that precision and accuracy in measuring height and triceps skinfold thickness are mainly predicted by allround knowledge of the measurement protocol ($p < 0.05$) and the years of experience ($p < 0.05$). A practical training course of only a few hours does not seem to improve reliability significantly. To get a more reliable insight in growth of a child it is important to be aware of the influence on measurement outcome values of protocol knowledge and years of experience. Growth studies should use detailed anthropometry standardization protocols and train people to acquire better insight into these protocols.

Ref ID: 23

Voss, L. D., Bailey, B. J., Cumming, K., Wilkin, T. J., and Betts, P. R. The reliability of height measurement (the Wessex Growth Study). *Archives of Disease in Childhood 65*[12], 1340–1344. 1990.

Abstract: The two major components of reliability are accuracy and reproducibility. Three studies of the reliability of height measurement in children are reported. In the first, a standard meter rod was used to spot check the accuracy of installation of 230 measuring instruments in one health district in Wessex, UK. The readings obtained ranged from 90.0 to 108.5 cm and showed the urgent need for the positioning of instruments to be regularly checked. In a second study, to examine the reproducibility of height measurement, two experienced observers measured 10 young children (106.0 to 152.0 cm), three times on five instruments of different design. The observations were blind and in random order. The estimated standard deviation for a single height measurement was generally in the range 0.2–0.3 cm. Over 95% of the variance was attributable to the child, very little to the instrument or observer. Finally, the conditions of the second study were modified to examine the effect on reproducibility of non-blind and non-randomized measurements, as usually occurs in the clinic. A lower but inevitably false estimate of the error was obtained. It is recommended that the error of height measurement, appropriately established and expressed in simple terms, be stated in every published growth study.

Ref ID: 24

Voss, L. D. and Bailey, B. J. Equipping the community to measure children's height: the reliability of portable instruments. *Archives of Disease in Childhood 70*[6], 469–471. 1994.

Abstract: To compare (1) the reliability of two expensive and two inexpensive measuring instruments, suitable for use in the community and (2) the reliability of experienced compared with inexperienced observers. 1) Ten children aged 5–12 years were each measured three times blindly, and in random order, by two experienced observers using four different portable instruments. (2) Four groups of four children aged 5–11 years were each measured three times blindly, and in random order by four experienced and one inexperienced measurer, using two different portable instruments. The precision of height measurements made by different observers using different instruments, expressed in each case as the standard deviation of a single height measurement (SDshm). (1) No significant difference in precision was found between instruments, SDshm ranging from 0.22–0.34 cm. The two observers using apparently the same technique, did however record significantly different absolute heights. (2) No significant difference in precision was found between experienced and inexperienced observers. Inexpensive height measuring equipment, once accurately installed, is no less reliable than the most expensive. Inexperienced observers can, with care, measure as reliably as those with long experience. Every effort should be made, however, to ensure that the progress of individual children is monitored not only by the same observer, but on a long term basis.

Types of Child Anthropometry Measurements (Software and Technology)

1. Ref ID: 1
   de Onis, M. and WHO Multicentre Growth Reference Study Group. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. World Health Organization, 1–452. 1995.

2. Ref ID: 57
   de Onis, M., Yip, R., and Mei, Z. The development of MUAC-for-age reference data recommended by a WHO Expert Committee. *Bulletin of the World Health Organization 75*[1], 11–18. 1997.
   Abstract: Low mid-upper-arm circumference (MUAC), determined on the basis of a fixed cut-off value, has commonly been used as a proxy for low weight-for-height (wasting). The use of a fixed cut-off value was based on the observation that MUAC showed small age- and sex-specific differences. However, in 1993, a WHO Expert Committee concluded that age independence is not reflected in the true pattern of mid-upper arm growth, recommended the use of MUAC-for-age, and presented age- and sex-specific MUAC reference data developed with observations obtained from a representative sample of children in the USA aged 6–59 months. In this article, we explain the methodology for the development of these data, present age- and sex-specific growth curves and tables and discuss the applications and limitations of MUAC as a nutritional indicator. To develop the reference data, estimates were first obtained for the mean and standard deviation of MUAC for each month of age using 7-month segmental regression equations; a 5th-degree and a 3rd-degree polynomial in age was then used to describe the mean and standard deviation, respectively, of MUAC-for age. These curves show important age-specific differences and significant sex-specific differences for boys and girls < 24 months of age. Correct interpretation of MUAC with regard to nutritional status requires the use of MUAC-for-age reference data such as those presented here.

3. Ref ID: 10
   de Onis, M., Garza, C., Victora, C. G., Onyango, A. W., Frongillo, E. A., Martines, J., and WHO Multicentre Growth Reference Study Group. The WHO Multicentre Growth Reference Study: Planning, study design, and methodology. *Food Nutrition Bulletin 25*[Supplement 1], 15–26. 2004.
   Abstract: The World Health Organization (WHO) Multicentre Growth Reference Study (MGRS) is a community-based, multicountry project to develop new growth references for infants and young children. The design combines a longitudinal study from birth to 24 months with a cross-sectional study of children aged 18 to 71 months. The pooled sample from the six participating countries (Brazil, Ghana, India, Norway, Oman, and the United States) consists of about 8,500 children. The study subpopulations had socioeconomic conditions favorable to growth, and low mobility, with at least 20% of mothers following feeding recommendations and having access to breastfeeding support. The individual inclusion criteria were absence of health or environmental constraints on growth, adherence to MGRS feeding recommendations, absence of maternal smoking, single term birth, and absence of significant morbidity. In the longitudinal study, mothers and newborns were screened and enrolled at birth and visited at home 21 times: at weeks 1, 2, 4, and 6; monthly from 2 to 12 months; and every 2 months in their second year. In addition to the data collected on anthropometry and motor development, information was gathered on socioeconomic, demographic, and environmental characteristics, perinatal factors, morbidity,and feeding practices. The prescriptive approach taken is expected to provide a single international reference that represents the best description of physiological growth for all children under five years of age and to establish the breastfed infant as the normative model for growth and development.

4. Ref ID: 11
   de Onis, M., Onyango, A. W., Van den Broeck, J., Chumlea, W. C., Martorell, R., and WHO Multicentre Growth Reference Study Group. Measurement and standardization protocols for anthropometry used in the construction of a new international growth reference. *Food Nutrition Bulletin 25*[Supplement 1], 27–36. 2004.
   Abstract: Thorough training, continuous standardization, and close monitoring of the adherence to measurement procedures during data collection are essential for mini-

mizing random error and bias in multicenter studies. Rigorous anthropometry and data collection protocols were used in the WHO Multicentre Growth Reference Study to ensure high data quality. After the initial training and standardization, study teams participated in standardization sessions every two months for a continuous assessment of the precision and accuracy of their measurements. Once a year the teams were restandardized against the WHO lead anthropometrist, who observed their measurement techniques and retrained any deviating observers. Robust and precise equipment was selected and adapted for field use. The anthropometrists worked in pairs, taking measurements independently, and repeating measurements that exceeded preset maximum allowable differences. Ongoing central and local monitoring identified anthropometrists deviating from standard procedures, and immediate corrective action was taken. The procedures described in this paper are a model for research settings.

5. Ref ID: 9
de Onis, M. and WHO Multicentre Growth Reference Study Group. Reliability of anthropometry measurements in the WHO Multicentre Growth Reference Study. *Acta Paediatrica 95*[Supplement 450], 27–37. 2006. Taylor and Francis.
Abstract: To describe how reliability assessment data in the WHO Multicentre Growth Reference Study (MGRS) were collected and analysed, and to present the results thereof. There were two sources of anthropometry data (length, head and arm circumferences, triceps and subscapular skinfolds, and height) for these analyses. Data for constructing the WHO Child Growth Standards, collected in duplicate by observer pairs, were used to calculate inter-observer technical error of measurement (TEM) and the coefficient of reliability. The second source was the anthropometry standardization sessions conducted throughout the data collection period with the aim of identifying and correcting measurement problems. An anthropometry expert visited each site annually to participate in standardization sessions and provide remedial training as required. Inter- and intra-observer TEM, and average bias relative to the expert, were calculated for the standardization data. TEM estimates for teams compared well with the anthropometry expert. Overall, average bias was within acceptable limits of deviation from the expert, with head circumference having both lowest bias and lowest TEM. Teams tended to underestimate length, height and arm circumference, and to overestimate skinfold measurements. This was likely due to difficulties associated with keeping children fully stretched out and still for length/height measurements and in manipulating soft tissues for the other measurements. Intra- and inter-observer TEMs were comparable, and newborns, infants and older children were measured with equal reliability. The coefficient of reliability was above 95% for all measurements except skinfolds whose R coefficient was 75–93%. Reliability of the MGRS teams compared well with the study's anthropometry expert and published reliability statistics.

6. Ref ID: 44
de Onis, M. and WHO Multicentre Growth Reference Study Group. WHO Child Growth Standards based on length/height, weight and age. 95[Supplement 450], 76–85. 2006.
Abstract: To describe the methods used to construct the WHO Child Growth Standards based on length/height, weight and age, and to present resulting growth charts. The WHO Child Growth Standards were derived from an international sample of healthy breastfed infants and young children raised in environments that do not constrain growth. Rigorous methods of data collection and standardized procedures across study sites yielded very high-quality data. The generation of the standards followed methodical, state-of-the-art statistical methodologies. The Box-Cox power exponential (BCPE) method, with curve smoothing by cubic splines, was used to construct the curves. The BCPE accommodates various kinds of distributions, from normal to skewed or kurtotic, as necessary. A set of diagnostic tools was used to detect possible biases in estimated percentiles or z-score curves. There was wide variability in the degrees of freedom required for the cubic splines to achieve the best model. Except for length/height-for-age, which followed a normal distribution, all other standards needed to model skewness but not kurtosis. Length-for-age and height-for-age standards were constructed by fitting a unique model that reflected the 0.7-cm average difference

between these two measurements. The concordance between smoothed percentile curves and empirical percentiles was excellent and free of bias. Percentiles and z-score curves for boys and girls aged 0–60 mo were generated for weight-for-age, length/height-for-age, weight-for-length/height (45 to 110 cm and 65 to 120 cm, respectively) and body mass index-for-age.

7. Ref ID: 96
de Onis, M. and WHO Multicentre Growth Reference Study Group. Enrolment and baseline characteristics in the WHO Multicentre Growth Reference Study. *Acta Paediatrica Supplement 450*, 7–15. 2006.
Abstract: To describe the WHO Multicentre Growth Reference Study (MGRS) sample with regard to screening, recruitment, compliance, sample retention and baseline characteristics. A multi-country community-based study combining a longitudinal follow-up from birth to 24 mo with a cross-sectional survey of children aged 18 to 71 mo. Study subpopulations had to have socio-economic conditions favourable to growth, low mobility and > or = 20% of mothers practising breastfeeding. Individual inclusion criteria were no known environmental constraints on growth, adherence to MGRS feeding recommendations, no maternal smoking, single term birth and no significant morbidity. For the longitudinal sample, mothers and newborns were screened and enrolled at birth and visited 21 times at home until age 24 mo. About 83% of 13 741 subjects screened for the longitudinal component were ineligible and 5% refused to participate. Low socioeconomic status was the predominant reason for ineligibility in Brazil, Ghana, India and Oman, while parental refusal was the main reason for non-participation in Norway and USA. Overall, 88.5% of enrolled subjects completed the 24-mo follow-up, and 51% (888) complied with the MGRS feeding and no-smoking criteria. For the cross-sectional component, 69% of 21 510 subjects screened were excluded for similar reasons as for the longitudinal component. Although low birthweight was not an exclusion criterion, its prevalence was low (2.1% and 3.2% in the longitudinal and cross-sectional samples, respectively). Parental education was high, between 14 and 15 y of education on average. The MGRS criteria were effective in selecting healthy children with comparable affluent backgrounds across sites and similar characteristics between longitudinal and cross-sectional samples within sites.

8. Ref ID: 98
Brooke-Wavell, K., Jones, P. R., and West, G. M. Reliability and repeatability of 3-D body scanner (LASS) measurements compared to anthropometry. *Annals of Human Biology 21*[6], 571–577. 1994.
Abstract: The Loughborough Anthropometry Shadow Scanner (LASS) digitizes the body, to give size and shape in three dimensions. After some manipulation of data, body measurements can be taken from the computerized scan. This paper compares LASS measurements with anthropometry measurements, and examines intra- and inter-observer differences of both techniques. LASS and anthropometry measurements were generally similar. Although there were small but significant ($p < 0.05$) differences at some sites, these differences were explained by difficulties in making horizontal tape measurements, and by differences in site location on LASS scans due to imperfect site markers. Standard errors of measurement due to intra-observer differences were generally smaller by LASS (1.1–5.3 mm) than anthropometry (2.0–7.2 mm); however, inter-observer differences were similar by both techniques (3.0–13.1 mm for anthropometry compared to 1.3–8.3 mm for LASS). Repeatability of 3-D measurements taken from computerized whole-body scans was no better than that from traditional anthropometry measurements; however, the scan data have a far greater utilization, for they provide information on body shapes, segmental volumes and surface areas as well as size.

9. Ref ID: 33
Davies, H. A., Pickering, M., and Wales, J. K. A portable knemometer: a technique for assessment of short-term growth. *Annals of Human Biology 23*[2], 149–157. 1996.
Abstract: Knemometry is the technique of choice for short-term growth studies, as it is the only anthropometry technique available that allows sufficiently accurate measurement of the lower leg (in anatomical terms, the leg) to enable changes in leg length to be detected over as short an interval as a week or less. The portable knemometer, like the Valk knemometer, essentially consists of two main

parts: a rigid metal frame holding the footplate, measuring ruler and plateau and a moveable chair that moves on frictionless rollers on a track on the base of the frame. Unlike the Valk knemometer there is a standardized seat position for all subjects, making it easier and quicker to use. Assessment of technical error was done using mean coefficient of variation (CV) of lower leg length measurements done on the portable knemometer. Comparison of measurements made by two different observers was made by using percentage reliability. A small PR implies consistency between the two methods or observers being compared. Measurements from 164 visits were used to calculate the machine precision. Mean CV using all four measurements was 0.13% and using only three, having discarded the first, was 0.11%. Given a mean lower leg length of 246.3 mm for the children studied this translates to a machine precision of 0.32 mm if all four measurements are used and 0.27 mm if the last three measurements in the set are used. The mean difference in lower leg length between observers was 0.11 mm. Percentage reliability between the two observers for the portable knemometer was 0.03%. For comparison, PR for standing height and sitting height are 0.37% and 0.86% respectively. PR between the Valk and the portable knemometer was 0.04%.

10. Ref ID: 56
Mei, Z., Grummer-Strawn, L. M., de Onis, M., and Yip, R. The development of a MUAC-for-height reference, including a comparison to other nutritional status screening indicators. *Bulletin of the World Health Organization 75*[4], 333–341. 1997.
Abstract: Mid-upper-arm circumference (MUAC) based on a single cut-off value for all the children less than 5 years of age has been used for many years as an alternative nutritional status index for children during famines or refugee crises, and as an additional screening tool in non-emergencies. However, it has recently been questioned whether MUAC is age- and sex-independent. After reviewing the scientific evidence underlying the use and interpretation of MUAC, a WHO Expert Committee recommended a new MUAC-for-age reference for under-5-year-olds. In some settings, however, it is difficult to assess a child's age and in such circumstances MUAC-for-height may be a good alternative. The height-based QUAC stick is a simple means of adjusting MUAC cut-offs according to height, and the MUAC-for-height reference and the construction and use of the QUAC stick are described in this article. Described also is the use of the receiver operating characteristic (ROC) curve method to evaluate the performance of MUAC, MUAC-for-age, and MUAC-for-height in screening malnourished children. It is often difficult to collect child height and weight measurements among refugee and famine-stricken populations. Mid-upper-arm circumference (MUAC) based upon a single cut-off value for all children younger than age 5 years has therefore been used for many years as a proxy nutritional status index for children in such situations, and as an additional screening tool in non-emergencies. It has recently been questioned whether MUAC is age- and sex-independent. After reviewing the scientific evidence on the use and interpretation of MUAC, a World Health Organization Expert Committee recommended a new MUAC-for-age reference for children under age 5 years. It is, however, sometimes difficult to assess a child's age. MUAC-for-height could be used in such circumstances. The height-based Quaker Arm Circumference (QUAC) measuring stick is a simple way of adjusting MUAC cut-offs according to height. The QUAC method measures the arm circumference at the mid-upper level and compares that value with the child's height. A standard QUAC stick is proposed which facilitates the comparison of data between countries. The MUAC-for-height reference and the construction and use of the QUAC stick are described. Also described is the use of the receiver operating characteristic (ROC) curve method to evaluate the performance of MUAC, MUAC-for-age, and MUAC-for-height in screening malnourished children.

11. Ref ID: 67
Murphy, C. A., Carstens, K., and Villamayor, P. Electronic growth charts: watching our patients grow. AMIA Annual Symposium Proceedings, 1058. 2005.
Abstract: Pediatric Growth Charts have been used in the pediatric community since 1977. The first growth charts were developed by the National Center for Health Statistics as a clinical tool for health care professionals. The growth charts, revised in 2000, by the Center for Disease Control

consists of a series of percentile curves for selected body measurements in children. Capitalizing on the benefits of our Electronic Medical Record (EMR), and as a byproduct of nursing electronic documentation of routine heights, weights, and frontal occipital circumferences, our system plots the routine measurements without additional intervention by the staff. Clinicians can view the graphs online or generate printed reports as needed during routine examination for outpatient or hospitalized care. This abstract outlines the background, design process, programming rules utilized to plot growth curves, and the evaluation of the electronic CDC growth charts in our organization.

12. Ref ID: 31
Schreiner, P. J., Pitkaniemi, J., Pekkanen, J., and Salomaa, V. V. Reliability of near-infrared interactance body fat assessment relative to standard anthropometry techniques. *Journal of Clinical Epidemiology 48*[11], 1361–1367. 1995.
Abstract: We examined the repeatability of near-infrared interactance (NIR) body fat determination as compared with that of body mass index (BMI), waist-to-hip ratio (WHR), and waist girth. Thirty-nine volunteers (16 men, 23 women) had percent body fat (%BF) measurements made with a portable NIR device as well as the standard anthropometry indices of height, weight, waist girth, and hip circumference. Frame size and physical activity levels were also determined. For each participant, three independent measurements of each index were made by two trained readers during a 2-week period. The two readers varied significantly in their measurement of %BF and hip circumference. The variability in %BF was largely due to differences between the first and the second measurements, and only for one of the readers. Second and third measurements were not statistically significantly different for either reader, suggestive of a training effect. Variance component calculations revealed that the reliability of NIR is 95.3%, compared with 99.9% for BMI; 93.4% for waist girth; and 82.4% for WHR, with the majority of the remaining variance accounted for by the method itself. We conclude that the NIR method has good repeatability, with low intra- and inter-observer variability, provided that readers are carefully trained. However, the NIR device offers little advantage in reliability over conventional measures of adiposity such as waist girth or BMI, and requires additional input of weight, height, frame size, physical activity level, age, and gender data to calculate % BF. Associations of NIR and other anthropometry indices with cardiovascular risk factors in this population will provide additional insight into the merit of NIR body fat assessment.

13. Ref ID: 48
Wang, M. J., Wang, E. M., and Lin, Y. C. The anthropometry database for children and young adults in Taiwan. *Applied Ergonomics 33*[6], 583–585. 2002.
Abstract: A large-scale anthropometry survey project was recently completed in Taiwan. This database contains the anthropometry data for worker and student (children and young adult) populations with ages ranging from 6 to 65. The worker population database has ages ranging from 18 to 65. Some of the commonly applied anthropometry data were previously reported in Wang et al. (1999). The anthropometry data for the student population are presented in this report. The ages of the student population ranges from 6 to 18 and includes 1254 senior high school students (632 males and 622 females), 3293 junior high school students (1682 males and 1611 females), and 3505 elementary school students (1818 males and 1687 females). The student subjects were recruited from four geographical areas in Taiwan: north, central, south and east. The sample size in each area was determined based on the student population distribution reported by the Ministry of Education in Taiwan. Two hundred and sixty-six measurements were taken from each of the high school students and 245 measurements were taken from each of the elementary school students.

14. Ref ID: 34
Watt, V., Pickering, M., and Wales, J. K. A comparison of ultrasonic and mechanical stadiometry. *Archives of Disease in Childhood 78*[3], 269–270. 1998.
Abstract: To compare an ultrasonic height measuring device (Gulliver) with mechanical stadiometry and the classical "book and tape measure" method. Blinded duplicate measurements of height were made on each of 14 chil-

dren by a pair of observers using a stadiometer (H) and Gulliver (G). Height was measured on a further 18 children by parents and an auxologist using Gulliver and the book and tape method (TM), and the results were compared with those obtained with a single stadiometry measurement. Finally, measurement of a rigid metal box was made on 10 occasions by the three methods. In the group of 14 children, the mean difference (range) in height (H minus G) was +2.8 cm (+0.5 to +4.55 cm), with H giving a systematically higher value in 276 of 280 individual measurements. In the group of 18 children, height by H was greater than by G or TM in 47 of 52 individual measurements. The mean (SD) height of the box by H (61.60 (0.07) cm) was greater than by G (60.96 (0.15) cm; $p < 0.001$) but not TM (61.4 (0.16) cm; $p > 0.05$). G and TM produced three times less reliable estimations of height than H, but with a large difference in cost, and there was evidence of systematic underrecording of height by 0.5 cm with G. Stadiometry is precise and reproducible, and can detect true changes in height over one month periods in mid-childhood, and should remain the standard way of observing growth. The book and tape method can produce clinically acceptable quarterly estimations of height that can be performed in the home.

15. Ref ID: 77
Young JT, Carter K, Marion MS, and Greendale GA. **A simple method of computing hip axis length using fan-beam densitometry and anthropometry measurements.** *Journal of Clinical Densitometry 3*[4], 325–331. 2000.
Abstract: Hip axis length (HAL), a simple measure obtained from dual X-ray absorptiometry (DXA) scans of the proximal femur, predicts hip fracture, independent of bone mineral density and age. Owing to a magnification error associated with newer fan-beam DXA, automatic calculation of HAL, which is available in pencil-beam DXA, is inaccurate. The purpose of this study was to model HAL, measured from a pencil-beam DXA, as a function of HAL from a fan-beam DXA combined with other anthropometry measures. Proximal femur scans were performed using pencil- and fan-beam DXA in 21 women (ages 24–60). Height, weight, hip circumference, subject thickness, height of the greater trochanter and anterior superior iliac spine from the scanning table, and HAL as measured by a ruler from the scan printouts were recorded. Anthropometry measurements were taken by two researchers; all but the greater trochanter were reproducible ($r >$ or $= 0.92$). A simple linear model using the manual measurement of HAL from the fan-beam scan, height, weight, body mass index, and hip circumference was able to predict HAL measured using the pencil-beam DXA with a high degree of accuracy ($R(2) >$ or $= 0.96$). The fan-beam-acquired values of HAL using our model are nonbiased and accurate estimates of the "gold standard" pencil-beam method. This model may provide researchers and clinicians with a simple method of calculating HAL using fan-beam DXA.

16. Ref ID: 49
Zankl, A. and Molinari, L. **ABase-a tool for the rapid assessment of anthropometry measurements on handheld computers.** *American Journal of Medical Genetics Part A 121*[2], 146–150. 2003.
Abstract: Anthropometry is widely recognized as an important method in the evaluation of dysmorphic children. Nevertheless, it has never gained widespread clinical use. We believe that this has mainly practical reasons: appropriate growth charts are not readily available at the bedside or in clinic and taking multiple measurements and plotting them into corresponding growth charts is a time-consuming task. Here we describe a computer program that overcomes both problems: ABase compares entered anthropometry measurements to a database of age- and sex-matched reference values, calculates the centile rank and displays the result either as text or as a digitized growth chart. The program runs on small handheld computers that can easily be carried around in a shirt pocket.