CHANGING PATTERNS OF GROWTH AND DEVELOPMENT AMONG THE EVENKI REINDEER HERDERS OF CENTRAL SIBERIA

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GARY J. SPENCER

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ABSTRACT

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Gary J. Spencer
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Advisor:
Dr. W.R. Leonard

This study investigates the changing patterns of physical growth and nutritional status among infants, children, and adolescents (aged 0-17 years) from the Evenki reindeer herders of Central Siberia. Two samples are compared: 253 individuals (116 males, 137 females) measured in 1991 and 1992, and 195 individuals (78 males, 117 females) measured in 1995. Overall, the Evenki of both samples show more compromised growth (in body weight, height and sum of skinfolds), especially during late childhood and adolescents, as compared to age-matched U.S. peers. Growth appears to be more compromised in the 1995 cohort, relative to the 1991/1992 cohort. Despite these declining nutritional conditions, it appears that protein reserves and physical activity have increased, since estimates of muscularity have also increased. Age and sex differences are evident in relation to these declining nutritional conditions. Anthropometric measures of nutritional status are poorer for the youngest children (0-5 years), as well as for the males (0-5 years and above 11 years old) in this sample. These changes are likely the consequence of the massive social and economic reforms that have taken place in Russia since the fall of the Soviet Union in 1991. These changes are consistent with the general declines in health status and life expectancy that have been recently documented throughout Russia.

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Chapter 1: Introduction

1.1 Growth as a Measure of Population Health and Nutritional Status

During the postnatal years, rates of human growth are most rapid during infancy and childhood--times when the child is especially sensitive to the surrounding environment. Consequently, the physical growth and development of children are sensitive indicators of the quality of the social, economic, and political environments in which they live (Bogin and Loucky, 1997). Indeed, as Eveleth and Tanner (1990) note, a child's growth rate reflects that child's state of health and nutritional status better than any other single index. They further explain that the average value of children's heights and weights accurately reflects the state of a nation's health and the average nutritional status of its citizens, once allowances have been made for genetic contribution to growth (Schell, 1986). In fact, Tanner (1981) has termed this application of anthropometry as *auxological epidemiology*, and defines it as "the use of growth data to search out, and later to define, sub-optimal conditions of health" (p. 142). The interpretation of growth data in assessing health and nutritional status involves the straightforward comparison of observed values to standards of good growth in healthy populations.

Growth measures are indicative of "average nutritional status." Human growth reflects not only the input of nutrients but also the stresses from the environment. Deficiencies in nutrition lead to a retardation of growth. Diseases place demands on the body for additional nutrients; if the body is not supplied with these nutrients, growth will be affected. Nutritional status is thus a net (rather than a gross) measure of nutrition. It represents not only what the human body takes in (as in studies of diet), but also the rates of nutrient utilization (affected by factors such as infectious diseases) and the absorption and/or assimilation of nutrients (Komlos, 1994; WHO, 1995). The combination and interaction of these processes contribute to much of the deficiency in growth or physical status that is observed in developing countries (Eveleth and Tanner, 1990; WHO, 1995). Anthropometric findings alone do not define the specific processes that are leading to malnutrition: interpretations of a growth deficit depend on the indices used, on the causes of the deficit, and on the socioeconomic status of the population under study (Eveleth and Tanner, 1990).

There are specific rationale underlying the use of child growth (in terms of height, weight, and body composition) as an indicator of the nutritional and health status of a community. Since height increases with time, it is an indicator of the history of the nutritional status and health of a child. However, weight increases and decreases with time, and thus may relate only to the child's more recent nutrition and health status (Bogin and Loucky, 1997; Herngreen et al., 1994; Waterlow et al., 1977). Circumferences and skinfolds are used to assess body composition (lean body mass and fat mass). Body composition is a proxy for nutritional status. Lean body mass is an indicator of the body's reserve of protein, and fat mass is an indicator of the body's energy reserve (Bogin and Loucky, 1997).

Three commonly-used indices that are derived from growth measurements are height-for-age, weight-for-age, and weight-for-height. Although these indices are related, each has a specific meaning in terms of the processes or outcome of growth impairment (Gibson, 1990; WHO, 1995). Height-for-age and weight-for-height have been recommended by the FAO / UNICEF / WHO expert committee on nutritional surveillance as being primary indicators of nutritional status in children (Waterlow et al., 1977). In discussing the significance of growth retardation caused by deficient food intakes and infection, Martorell (1985) notes that we should distinguish between *stunting* and *wasting*. *Stunting* refers to retardation in linear growth as measured by total body length or height. It implies that shortness is pathological, and reflects a process of failure to reach full linear growth potential as a result of suboptimal health and/or nutritional conditions (WHO, 1995). However, *wasting* measures the relationship of mass to length. It is widely used to describe a recent and severe process that has led to significant weight loss, usually as a consequence of acute starvation and/or severe disease (WHO, 1995). Children who are below -2 Z-scores of the NCHS/WHO reference for height for age or weight for age are respectively classified as stunted or wasted (Martorell, 1985; WHO, 1995).

Martorell (1985) believes that stunting and wasting have the same basic causes: deficient food intakes and infection. He argues that moderate and chronic food deficiencies will permit some degree of accommodation, allowing children to grow somewhat poorly but without wasting. However, severe and acute deficiencies (such as those experienced during seasonal periods of hunger) will not only cause many children to grow very poorly in length, but will also cause most of these children to show signs of wasting. According to Martorell (1985), because infections are sudden and their impact on appetite and metabolism is often substantial, these infections push already stressed, chronically-malnourished children into wasting.

Many studies have shown that there is an association between anthropometry and child morbidity. For example, malnourished children tend to have more severe diarrheal episodes as measured by duration, risk of dehydration or hospital admission, and associated growth faltering (Johnston, 1986; Martorell, 1985; WHO, 1995). Similarly, studies have shown a link between increased mortality and increasing severity of anthropometric deficits (Martorell, 1985; WHO, 1995). Thus, anthropometry is very useful for providing information on children's health and nutritional status. This application of anthropometry is made possible because growth is related to the multiple dimensions of health and development, to the underlying socioeconomic and environmental determinants of poor health and development, and to the basic causes of poor socioeconomic conditions and poor environment (Frongillo and Hanson, 1995).

1.2 Sexual Dimorphic Patterns of Growth and Development

Sexual dimorphism refers to the differences in size, shape, and proportion in the male and female body forms (Molnar, 1992). Sexual dimorphism in humans reflects the interplay of genetics, as well as the capacity of humans to react to different environments (Pucciarelli et al., 1993). The direction and magnitude of sexual dimorphism in humans vary according to age. In males, the basic dimorphic trend in infancy is a faster late-fetal and early infancy growth rate in body length, body weight, and head circumference (Lieberman, 1982). Early childhood is still a phase of rapid growth, despite the declining velocities in the growth rate. In middle childhood, there is a constant gain in height and weight , with relatively minor sex differences in growth and developmental patterns. Males, however, do retain their height and weight advantages until the chronologically earlier adolescent growth spurt of females (Johnston, 1986; Lieberman, 1982). As a consequence of the hormonal changes during adolescence, males usually end up taller (by about 5-10 percent) and heavier than females, and have less subcutaneous fat, and more muscle and bone (i.e., greater lean body mass) (Lieberman, 1982).

Some researchers argue that the variation in sexual dimorphism is the result of the nutritional status of different societies. For example, Gray and Wolfe (1980) note (from data collected from 216 societies around the world) that there is a significant association between the magnitude of sexual dimorphism and the security of the food supply, and between sexual dimorphism and the abundance of food. Stini (1969) reported that most of the residents of Heliconia, Colombia, live in a continual state of malnutrition. The result, he notes, is a reduction in stature (most pronounced in boys) and a concomitant reduction in sexual dimorphism for overall body size.

It has been argued that, while males may be labile in their growth performance, females are more tightly canalized (Brauer, 1982; Lieberman, 1982; Stini, 1982). If either a nutritional improvement or a nutritional decrement occurs, the growth of females will be less and more slowly affected than that of males (Brauer, 1982). Since body size is generally smaller in females, sexual dimorphism decreases in cases of nutritional stress, and increases in cases of nutritional excess, chiefly through male responsiveness.

In discussing the phenomenon of reduced sexual dimorphism that is seen in populations that undergo environmental stress, Stini (1975) has argued that this reduced sexual dimorphism arises from reductions in male body size exceeding the reductions in female body size, and is thus adaptive rather than pathological. He (1988) points out that the need for reserves of fats and carbohydrates is, for adaptive reasons, greater in females than in males. Consequently, he explains that sexual dimorphism can be seen as the product of disruptive selection, with the survival of the species being insured by the attainment of different body composition in males and females (p.23).

Others, such as Little et al. (1983), have argued that the better anthropometric profile of females, especially the superior muscularity, might be the result of a training effect. For example, women may develop greater arm strength (hence, an improved muscularity of the upper arm) by practices such as lifting and carrying infants, water containers, and firewood as a part of their normal day-to-day activities.

In implicating diet (specifically, calorie intake) as an explanation for similar cases of sex differences observed among Turkana pastoralists, Little and Johnson (1986) have proposed that this reduced sexual dimorphism might be the result of several factors. Among these factors are: preferential allocation of foods to females, voluntary starvation of males to allow available food to be distributed to other family members, and an hereditary predisposition for adult male body composition to be markedly more linear than female body composition.

1.3 Determinants of Early Childhood and Adolescent Growth

In the following section, the main environmental factors that influence growth are discussed. The preschool-age years (birth to 5 years of age) are crucial in determining the future developmental events and the overall health status of an individual, even into adulthood. These years are a period of change, compensation, and initiation (Johnston, 1986). Children must adjust to the sometimes hostile environmental changes which they experience during this period, and there is usually compensation for the stress that is brought about by these changes. As well, there is usually some initiation of developmental and physiological regulation based upon internal mechanisms (Johnston, 1986). Consequently, growth prior to adolescence is relatively more sensitive to the environment, while growth during adolescence is strongly influenced by genetic factors.

Nevertheless, since most of the environmental factors responsible for variation in adolescent and early childhood growth are the same, this topic is treated here as a general overview of factors that influence growth. This author does, however, recognize the uniqueness of the different patterns of growth in early childhood and in adolescence. As a result, throughout the discussion, there is specific mention of the particular growth period, in cases where the author feels that its uniqueness warrants such attention.

1.3.1 Nutrition

Nutrition is an important source of growth variation among children during the infant and preschool-age years (from birth through to five years of age). Nutritional needs and influences are different at various phases of the growth years. There are six classes of nutrients that either directly or indirectly affect growth: carbohydrates, proteins, fats, vitamins, minerals, and water. However, as Malina (1987) notes, eating is a social behavior, and food consumption is regulated by culture. There is no guarantee that knowledge of nutrients within a culture will translate into effective food-related behavior. Thus, the precise nature of the nutritional ecosystem will differ markedly among different societies and socioeconomic levels (Johnston, 1986).

Ulijaszek and Strickland (1993) note that the greatest proportion of total energy expenditure (TEE) is expended on growth between the ages of 1 and 3 months. They also note that it is around this age (approximately 3 months) that the infant experiences the greatest weight gain. As the infant gets older, the energy cost of growth decreases, so that by 6 months of age it is approximately 15% of TEE, and subsequently becomes much lower (4% of TEE) by the infant's first birthday. It is, therefore, reasonable to assume that the adequacy of the total amount of food consumed will be the primary determinant of growth in early childhood (Bogin, 1988; Ulijaszek and Strickland, 1993).

In situations where children are suffering from undernutrition, the relationship between diet and growth becomes clearer. So strong is this relationship that the growth status of children has been universally accepted as the best indicator of nutritional status for both the individual child and the community (Bogin and Loucky, 1997; Johnston, 1986). In populations that experience food shortages, children experience growth delays and are shorter and lighter than children in populations with adequate or abundant supplies of food (Bogin, 1988). There have been many reports illustrating how the famines associated with World Wars I and II retarded the growth of both children and adolescents (Bogin, 1988; Tanner, 1962). For example, Bogin (1988) reports that the mean stature of Japanese children decreased between 1939 and 1949, and returned to pre-war levels by the mid-1950s.

Populations that depend on subsistence agriculture for their food may face periodic food shortages due to variations in rainfall, temperature, crop diseases and pests (Bogin, 1988). For example, Leonard (1989) has investigated the nutritional and social determinants of growth at high altitude, using food consumption (of 33 households) and anthropometric data collected from the town of Nuñoa, Peru. The anthropometric results show that children of the upper socioeconomic status (SES) group are significantly taller and heavier than those of the lower SES group. The members of the higher SES group also have significantly higher caloric intake levels than those of the lower SES group. Leonard (1989) concludes that the more reliable and less variable resource base of an urbanized diet among the higher SES households contributed to the better growth of their children, while the fluctuating availability of locally-produced foods and restricted access to non-traditional products among the lower SES households were reflected in their growth deficits.

Bogin (1988) indicates that cultural behavior related to infant and child feeding practices also contributes to differences in nutritional status and growth between populations. He reports that young children in rural villages of Guatemala had access to sufficient food, but that these traditional foods (eg., corn and beans) did not have the caloric density to meet the children's growth requirements. Post et al. (1997) compared high socioeconomic status (HSES) and low socioeconomic status (LSES) children from Bolivia to the NCHS percentiles, and found that the HSES children closely approximated the 50th percentile for height, while the LSES children were small for their age and approximated only the 5th percentile. There was no difference between the two groups of children with respect to total protein intake or in the rate of protein intake/kilogram body weight. However, there was a difference in protein quality, and it is argued by these authors that the growth potential of the LSES children may have been hampered by the lower protein quality in their primarily vegetable diet, compared to the higher protein quality in the predominately animal diet of the HSES children (Leonard et al., 1994a; Post et al., 1997). Thus, caloric insufficiency and the overall lower nutritional quality of foods that are inappropriate for the digestive capabilities of young children lead to undernutrition and compromised growth (Bogin, 1988).

Inadequate levels of nutrition delay skeletal growth. Eveleth (1986) reports that in an impoverished area of rural Guatemala, the average diet is protein-deficient. As a result, the time of the first appearance of hand-wrist ossification centers was delayed until the first year of age in the Guatemalan children when compared to American children in Ohio. This delay in skeletal growth, as well as the delay in the development of soft tissues of the body, ultimately results in a delay in the rate of maturation. Bogin (1988) reports that delays in the skeletal maturation of undernourished Thai children caused their period of growth to be extended a year longer than that of children from the United States. However, the delays in length-growth that the Thais experienced throughout their lives meant that, as adults, they were much shorter than their U.S. peers, as they only approximated the fifth percentile of the U.S. reference population (Bogin, 1988).

1.3.2 Infections

Infections are a major cause of poor growth and development among children of developing countries, contributing significantly to malnutrition and to high mortality rates. The most important of these infections are diarrheal diseases.

For example, in Latin America, diarrheal infection was found to be the major cause of death in children below the age of 5, with malnutrition being the direct or underlying cause of death (Chen, 1983). Similarly, Chen reports that in rural Bangladesh, diarrhea was responsible for 28.6% of all deaths in children under the age of 5. It accounted for 13.7% of all infant deaths and 44% of deaths among children between the ages of 1 and 4 (Chen, 1983).

The effect of diarrheal diseases (and other infections as well) on growth velocity is greatest during the first year of life (Martorell and Habicht, 1986; Ulijaszek and Strickland, 1993). Research in rural Guatemala has revealed that diarrhea is more common in the first 3 years of life, with the highest prevalence being reported in the first 6 to 18 months of life (Martorell and Habicht, 1986). Passive immunity declines as the infant gets older; at the same time, active immunity rises, due to exposure to infective agents, with the lowest point in immunity status occurring between 3 and 6 months of age (Ulijaszek and Strickland, 1993). An important quality of breast milk is its anti-infective property. Prolonged breastfeeding has been shown to reduce the risk of dying in Bangladeshi children between the ages of 12 and 35 months, relative to children who are no longer being breast fed (Ulijaszek and Strickland, 1993).

Consequently, many authors (Chen, 1983; Ferro-Luzzi, 1984; Tanner, 1994) have noted a negative relationship between diarrheal infection and physical growth and development. An investigation into the regression of infectious disease prevalence in Gambian children analyzed by monthly body length and weight gain, showed that diarrhea prevalence was associated with reductions in both linear growth and weight. According to Chen, seasonal standardized regressions of the diarrhea and growth data suggest that, had gastroenteritis been eliminated completely, Gambian children would have achieved growth rates of 200 to 400 grams per month over a period of 10 months. This growth velocity is similar to that of children from well-nourished populations (Chen, 1983).

1.3.3 Growth and Development, Nutrition and Infection

The preceding discussions have shown that children are very susceptible to infections and have relatively high nutritional requirements. These two aspects interact to make young children vulnerable to growth failure and malnutrition, especially in those societies with high infectious load and limited food availability (Martorell and Habicht, 1986). In the first three months of life, weight gain in infants from developing countries is, for the most part, comparable to that observed in infants from the developed world (Martorell and Habicht, 1986; Ulijaszek and Strickland, 1993). Breast milk is adequate to sustain the weight gain during this period. In most societies, dietary supplementation begins after the infant is 3 months old. This is also the point at which the infant experiences the lowest immunity. Also, at this point, the breast milk concentration and absolute intake of Iga, IgG, IgM, C3, C4, lactoferrin and secretory component in infants is declining (Ulijaszek and Strickland, 1993).

Thus, it is at this point that diarrheal diseases become more prevalent. The term *weanling diarrhea* has been used to refer to the diarrheas and dysenteries that affect babies as a result of the transition from breast-feeding to dietary supplementation. Many authors have confirmed that weaning foods are the major vehicles for the transmission of fecal pathogens during infancy (Bogin, 1988; Hauspie et al., 1996; Martorell and Habicht, 1986). The main problems that have been implicated are contamination of food and water, unclean cooking vessels and utensils, and poor personal hygiene in handling foods (Chen, 1983).

Consequently, the prevalence of diarrheal disease is often very high during the infant's first year of life. Ulijaszek and Strickland (1993) note that in the age range of 3 to 12 months, the proportion of TEE expended in growth is about two-thirds of that which is needed to sustain the growth of an infant along the 5th percentile of weight for age. This does not mean that the energy available for growth is this low. Instead, it may be that the available energy is higher but is inefficiently utilized, possibly as a result of diarrheal infection (Ulijaszek and Strickland, 1993).

Chen mentions four basic mechanisms that could account for the effects of infection on growth: food intake, absorption, metabolism, and direct loss. Reduction of food intake during diarrhea may be due to child anorexia, maternal food-withholding behavior, or both. Clinical disturbances, such as dehydration, electrolyte imbalance, fever, vomiting, or abdominal discomfort, are usually the cause of anorexia. Food-withholding behavior could be a response to child anorexia or to culturally-ingrained changes of dietary practices, either in response to illness or as an active component of disease management. Diarrhea hastens the transit time of food within the digestive system, compromising the time that is available for absorption, and may generate osmotic forces against the movement of substance from the lumen into the circulation.

Systemic infections disturb virtually all normal metabolic and endocrine functions. In general, the magnitude of nutrient loss associated with catabolism is related to the severity and duration of fever. Finally, there is some evidence of direct protein loss, as well as the loss of other nutrients in the gastrointestinal tract, during certain diarrheal diseases (Chen, 1983).

1.3.4 Socioeconomic Status

The sensitivity of growth to various factors in the social environment is quite remarkable. Socioeconomic factors form the complex developmental ecosystem that determines the development of the child during its early years of growth. The socioeconomic status (SES) of a family is usually determined by such factors as: parental educational or occupational status and household income. Children of lower SES families are smaller, and often they mature less rapidly than children of higher SES households (Bogin, 1988). In industrialized countries, most of the height differences between children of nonmanual and unskilled manual classes (typically around 3 cm) is established between the ages of 9 months to 3 years (Hauspie et al., 1996).

It is important to note that the above-mentioned social variables (e.g., income, number of children in the household, parental education, occupational status, per capita income, and the degree of urbanization) do not influence growth directly. According to Bielicki and Welon (1982), these variables must be viewed as influencing growth via some "primary" environmental factors, with which social variables are correlated. They list four primary factors: nutrition, morbidity, physical workload, and greater growth-promoting psychological stimuli from parents, schools, and peers (Bielicki and Welon, 1982).

The effect of family income on the growth-influencing factors is obvious: families with greater income will consume greater amounts of foods that are principal sources of animal protein, minerals, and vitamins, as well as other nutrients that are considered essential for growth (Bielicki and Welon, 1982; Post et al., 1997). The effect that the number of children might have on growth-influencing factors is also obvious. The greater the number of children, the less the amount of money available for each family member. According to Bielicki and Welon (1982), in Poland, the annual per capita consumption of principal food items (such as meat, eggs, butter, cheese, fruits, and vegetables) in the households of salaried workers and private farmers declines dramatically with any increase with the number of persons in the household. Since the number of persons in a household is correlated strongly with the number of children in a family, the preceding suggest that the number of dependents in the home may affect growth primarily through nutrition (Bielicki and Welon, 1982).

The mode of action of parental education on growth is more complex. It manifests itself largely through income and nutrition. Education is important in ensuring child survival. For example, educated mothers are more likely to seek professional health care. As the skills and methods of the mother are enhanced, food distribution within the household is also affected. High literacy rates among females correlate with decreases in infant mortality rates, increases in family nutrition, and decreases in population growth (Frongillo and Hanson, 1995). Bielicki and Welon (1982) suggest that the effect of parental education on growth (more specifically, on stature and menarcheal age) may reflect differential parental utilization of the available income, rather than the actual amount of money available per member of the family. Research has also shown that the effect of maternal education is stronger than that of paternal education (Bielicki and Welon, 1982).

Occupational status is a principal determinant of family income in most industrialized societies. Bielicki and Welon (1982) report that the most significant and spectacular example of the influence of parental occupation on the growth of Polish children is evident in the case of rural farm (peasant) families. They note that the quality of diet, regularity of meals during the day, and the general nutritional status of peasant children are considerably poorer than those of the children of unskilled manual workers. Furthermore, the poorer nutritional status of the peasant children is also reflected in their delayed maturation and short stature (see also Bogin, 1988).

Despite the various physical and psychosocial deficits that are often ascribed to urban environments, there are aspects of this environment that enhance growth (Bielicki and Welon, 1982; Bogin, 1988; Johnston, 1986). Urban communities, in contrast to rural ones, generally have easier access to health-care facilities, and also enjoy significantly better sanitary conditions. The effect of urbanization on growth may also be indirectly related to nutrition. In Poland, the system of food distribution has consistently favored the large urban centers over smaller rural towns and villages (Bielicki and Welon, 1982).

A number of researchers have also found a relationship between fat distribution and SES. For example, Bogin and Sullivan (1986) have found that sexual dimorphism in fat distribution among Guatemalan children (between the ages of 7 and 14) is SES dependent. Their results show that low SES children are not sexually dimorphic, whereas high SES children are dimorphic, with boys showing a more centripetal fat pattern than girls. They further note that SES influences the distribution of fat stores. The results here show that as SES decreases, subcutaneous fat becomes more centripetal; that is, relative amounts of arm fat decrease, and relative amounts of trunk fat increase (Bogin and Sullivan, 1986; see also Bogin, 1988) .

1.4 The Role of Genetic and Environmental Factors in the Control of Growth

The relative contributions of genetics and environment to variation in growth among individuals are a hotly debated by auxologists. There is no doubt that growth is a product of the continuous and complex interaction of heredity and environment. The focal point of debate stems from (or at least should stem from) the degree to which genetic factors and environmental factors have an impact upon growth. At the core of this debate is the issue of whether growth standards that have been developed in industrialized countries are appropriate for measuring children in the developing world. Those who contend that there should be one reference for all populations claim that growth differences that can be attributed to racial or ethnic background (i.e., genetic differences) are very small, and that most of the variation in growth is highly dependent on environmental circumstances (Graitcer and Gentry, 1981; Marshall, 1981). However, those who favor local references argue that there are ethnic differences in growth, and that using the same chart for different ethnic groups leads to interpretive mistakes for different groups at different ages (Van Loon et al., 1986).

Marshall (1981) compared data from groups of preschool children from several developing countries. Among well-nourished children, height and weight differences that were attributed to racial or ethnic backgrounds were very small (less than 6%). The differences in growth among children of different socioeconomic classes, but of the same ethnic and geographical backgrounds, were many times greater. Marshall concluded that child growth is mainly influenced by socioeconomic status, rather than by race or ethnicity. He recommended the use of one reference for all countries to evaluate the impact of hostile environmental factors on the growth of preschool children.

1.5 Genetics of Size: Genes, Height, and Body Proportions

The term *ethnic* is usually used to refer to populations with a common cultural background, while the term *racial* is most often used to indicate populations with a common biological background (Damon, 1969). However, as Malina points out, there is much overlap between these concepts, so that the term *ethnic* is often used to include both culturally and biologically distinct groups.

The investigation of how genotype influences the height of children has been brought about by two basic designs: one assesses differences in growth between ethnic groups, and the other assesses the association between anthropometric measurements of relatives sharing an estimated proportion of identical genes (Rona, 1981). Studies that employ the first design either compare the same ethnic groups (those sharing genetic endowment) living in different environments, or different ethnic groups living in similar environments. For example, Johnston et al. (1976) used longitudinal data to compare the patterns of growth among three groups of children: Guatemalans living in their homeland, Americans living in Guatemala, and Americans living in the U.S.A. All children were of upper socioeconomic status. The data were separated into a pre-adolescent and adolescent component. The adolescent component revealed no significant difference in the heights of the two American samples, but a significant difference in the heights of Americans and Guatemalans living in Guatemala. Prior to adolescence, there was no significant difference in height between the two ethnic backgrounds living in Guatemala. On the basis of these results, these authors concluded that growth, prior to adolescence, is relatively more sensitive to the environment, and that during adolescence, genetic determinants of growth are more strongly expressed.

Bogin (1988) notes that, although white and black adults living in the United States have the same average height, the body proportions of the two groups are significantly different when socioeconomic variables are controlled. For individuals of the same height, blacks have shorter trunks and longer extremities than whites, especially in the lower legs and forearms (Bogin, 1988). A comparison of body proportions among Europeans, Asiatics, Afro-Americans, and Australian Aborigines reveals that Asiatics have the greatest sitting height relative to leg lengths, while the Australian Aborigines and Afro-Americans have the longest legs (Eveleth and Tanner, 1990). These differences are assumed to be genetic in origin, since better environmental circumstances appear to produce relatively longer, not shorter, legs. For a given sitting height, Africans, in the United States and in Africa, have considerably longer legs than Europeans (Eveleth and Tanner, 1990).

Family studies compare monozygotic and dizygotic twins' concordance, and parent-child and sib-sib correlations. Most of the work in this area indicates very well the family-line control of height (Davies, 1988; Tanner, 1990). However, Rona (1981) notes that, while the high correlation in most studies between close relatives is an indication of the influence of genes, it can also be seen as evidence that common environment plays a role in the variation of growth. For example, Bogin (1988) notes that higher correlations in parent-child growth during the child's adolescence may not only indicate a greater expression of genetically-inherited growth potential, but that it may also be a reflection of the greater length of time that adolescents have spent living with their parents, in comparison to pre-adolescent children (since parent-child correlations in height were lower during the pre-adolescent years). However, studies (Macdonald and Stunkard, 1990; Stunkard et al., 1990) of identical twins, who are reared apart, employ the most effective designs for distinguishing the importance of shared genes from that of shared environments.

1.6 Genetics of Body Composition: Genes, Fatness, and Fat Distribution

Fatness and fat distribution have been recognized as major contributing factors in the determination of degenerative diseases later in life. Body composition measures are known to be influenced by environmental exposure and personal behavior (Newman et al., 1990). Measures of body composition also change naturally with growth and aging (Bouchard, 1996; Mueller, 1982). However, measures of body composition are also influenced by individual genotype (Bouchard et al., 1990; Stunkard et al., 1990; Teasdale et al., 1990).

Correlations between monozygotic twins who were raised apart are similar to those of monozygotic twins who grew up together. Studies that report such results suggest that the shared rearing environment does not contribute to the variation in the body-mass index (BMI) (Macdonald and Stunkard, 1990; Stunkard et al., 1990). The similarity between monozygotic twins who were raised apart is assumed to be due to genetic effects alone, and so the correlations between the members of such pairs are a direct estimate of heritability. Genetic factors appear to be major determinants for the body-mass index in Western society, and may account for as much as 70 percent of the variance (Macdonald and Stunkard, 1990).

Similarly, Bouchard et al. (1990) investigated the differences in the responses of pairs of identical twins to long-term overfeeding. The similarities within each pair of twins in their response to overfeeding was significant with respect to body weight, percentage body fat, fat mass, and estimated subcutaneous fat. The variance of these outcome measures was significantly greater among pairs than within pairs. Consequently, genetic factors are most likely responsible for the intrapair similarity in the adaptation to long-term overfeeding, and for the variations in weight gain and fat distribution among the pairs of twins.

In a review of the topic of nature-versus-nuture in shaping body composition, Sims (1990) warns that these results should not be taken to mean that non-genetic factors are not important determinants for body fat. Many studies have investigated the health impact that results from changing from subsistence economies to cash economies; these studies have reported increases in the incidence of chronic degenerative diseases, including obesity. One such study, by Zimmet (1979), reports on similar changes in the Pacific regions. Stunkard et al. (1990) note that their results should be interpreted in the light of the concept of heritability. They explain that the concept of heritability does not imply an invariant, immutable genetic influence. Instead, it describes the genetic influences found among persons living in a particular range of environmental conditions. Thus, under different environmental conditions, different estimates of heritability might be obtained (Stunkard et al., 1990).

Ethnic differences in body composition have been found. In the United States, black children and youths have, on average, less total subcutaneous fat than do white children and youths (Malina, 1993), and the black children have relatively less subcutaneous fat on their extremities in comparison to white children (Bogin, 1988). Eveleth and Tanner (1990) note that Africans in Africa mostly have lower skinfolds than Europeans. It is not known if there is a genetic component underlying these differences, which, on the surface, appear to be purely derived from environmental differences.

Well-nourished populations of Asiatic origin have greater subscapular skinfolds than do African or European populations. A number of studies show that Mexican-Americans have greater subscapular (but not triceps) skinfolds than do Europeans and Afro-Americans in the same poverty classification (Eveleth and Tanner, 1990:190). Bogin and Sullivan (1986) found that, in general, Guatemalan children and youths have greater subscapular (but not triceps) skinfolds than do age-matched subjects of the NCHS references. Local reference data may therefore be the most appropriate to use when assessing body composition, nutritional status, and anthropometric risk factors for chronic diseases (Bogin and Sullivan, 1986: 528).

1.7 Cross-sectional and Longitudinal Growth Studies

For comparative surveys of children's growth in different populations, the most important information concerns the mean and variability of anthropometric measures for groups of children. Thus, the type of growth study that is utilized in this approach is a cross-sectional one (Eveleth and Tanner, 1990). Cross-sectional studies are those in which children are measured at each stage of their development, but no individual is measured more than once. Cross-sectional data are generally averaged according to groups, and thus provide general information of the growth that has been attained at the time of the survey (Malina and Bouchard, 1991). In studying the growth patterns of an individual or group, the most effective technique is to collect repeated measures on the same individual. These repeated measures constitute a longitudinal study (Lieberman, 1982). The results of a longitudinal study provide information not only on status, but also on the rate of growth. Because the data are measured at specific intervals over time, information on change and rate of growth can be estimated.

Both cross-sectional and longitudinal data have their uses, but they do not give identical information and cannot be handled in the same way. Cross-sectional surveys are cheaper and quicker than longitudinal surveys, and usually include much larger numbers of children (Harrison et al., 1988). However, cross-sectional studies are limited in that the only information that they provide is an indication of growth status. They do not provide any information about individual increments from one year to the next (i.e., about rate of growth) (Eveleth and Tanner, 1990). They do provide an estimate of the mean rate of growth within a population; however, they do not reveal anything about the variability around this mean. Such information is important, especially in a clinical context, to assess the velocity or rate of growth of individual children (Eveleth and Tanner, 1990). Growth curves that are derived from cross-sectional studies tend to be smooth, and mask the wide range of individual variability. This is because cross-sectional growth curves are plotted against chronological age, rather than against the time of maximum velocity (Harrison et al., 1988).

The growth curves that are observed from longitudinal data incorporate the speed and intensity of growth. These curves are plotted against a measure which arranges individual children according to how they have progressed along their course of development--according to their true developmental or physiological status (Harrison et al., 1988). Consequently, longitudinal studies accurately reveal the growth patterns of individuals. They enable researchers to evaluate changes in growth velocity and the patterning of a sequence of events, such as the eruption of teeth and the development of secondary sexual characteristics (Lieberman, 1982). However, the main disadvantages of longitudinal studies concern their duration and costs. A birth-to-maturity longitudinal study requires the participation of the subjects from birth until an age of about 20 years. Such studies require a well-organized logistical team to keep the subjects motivated. Because of other problems, such as mortality and normal attrition, it is difficult to carry out a longitudinal study on a sample that is sufficiently large to be truly representative of a population (Malina and Bouchard, 1991; Lieberman, 1982).

A mixed-longitudinal study provides a compromise between cross-sectional and longitudinal designs. In such a study, children enter and leave at different ages, giving varying degrees of longitudinality. Thus, a mixed-longitudinal study combines data for individuals who were measured on all occasions, and for some who were measured on only a few occasions. This type of growth study provides information on both status and rate of growth (Malina and Bouchard, 1991).

1.8 Objectives and Hypotheses

The first objective of this study is to describe the patterns of growth among the Evenki reindeer herders of Central Siberia and to compare these growth patterns to U.S. normative data (National Centre for Health Statistics). It is hypothesized that the Evenki will show reduced growth rates when compared to the U.S. normative data.

In tandem with the first objective, there will also be an assessment of how these growth patterns among Evenki infants, children, and adolescents have changed over a four-year period, since the fall of the Soviet Union in 1991. More specifically, the objective is to demonstrate that human growth is extremely sensitive to the environment. Since changes in anthropometric measures are largely mediated through nutrition, the following hypotheses also reflect, by inference, the changing nutritional and health status of these members of the Evenki population. The following hypotheses have been proposed:

a) During the ages of 0 - 5 years, rates of growth are most rapid; consequently, at this time, the child is especially sensitive to the surrounding environment (Johnston, 1986).

Hypothesis: overall growth will be compromised more in the age group 0 - 5 years than it will be in any other age group.

b) Males are more easily thrown off their growth pathway by environmental adversities, such as malnutrition and disease (Bielicki, 1986). However, up until the first year of life, no differences in growth between the sexes are expected, since infants are still being breast-fed. The differences appear, at least in most developing countries, once the introduction of weaning and complementary foods occurs (Martorell and Habicht, 1986).

Hypothesis: the growth of males (from the age of 1 year and up) is expected to be more compromised than that of females.

c) Stunting is the product of a cumulative history of episodes of stress, and is therefore indicative of long-term processes that have led to a reduction in stature. However, weight is far more ecosensitive than height. It can decrease or increase over time, and therefore relates more to recent nutrition and health status (Bogin and Loucky, 1997).

Hypothesis: the mean differences in Z scores for weight (WAZs) are expected to be significantly greater over the four-year period than the mean differences that are observed for Z scores for height (HAZs).

d) Leonard et al. (1997) have noted greater cardiovascular disease risk among Evenki women. These authors report that circulatory diseases appear to be emerging as the leading cause of death among Evenki women. These results are in striking contrast to most international data, which show higher cardiovascular deaths among men.

Hypothesis: females in this sample will show a greater distribution of subcutaneous fat over the trunk, rather than over the extremities, when compared to their male counterparts.

Finally, the growth patterns of the Evenki subadults will also be compared to growth data from other indigenous high-latitude populations. Because of similarities in environment and closeness in genetics, it is hypothesized that the mean differences in growth measures between the high-latitude samples will be significantly lesser in magnitude than those differences observed between the Evenki and the U.S. normative data.

Chapter 2: Background: the Evenki, Siberia, and Russia

2.1 Ethnographic and Historical Background on Evenki

2.1.1 Orientation

Today, the Evenki reindeer herders are one of the most numerous aboriginal groups of Central Siberia, with settlements widely scattered over the northern boreal forest (*taiga*) . There are approximately 30,000 Evenki presently living in this region, with most of them (79.8%) occupying isolated rural areas (Fondahl, 1994; Indian and Northern Affairs Canada, 1991). The Evenki inhabit a huge area, stretching from west of the Yenisei River to the sea of Okhotsk and northern Sakhalin Island, and from the base of the Taimyr Peninsula in the north to the Amur River in the south (Figure 2.1) (Uvachan, 1975).

Agriculture is difficult to maintain in this area, as the soil is too thin and the growing season too short. However, the forest lands and marshes are covered with mosses, lichens, shrubs, and dwarf willows, which all provide food for reindeers. The winters are very long and are very cold. Within the Evenki Autonomous District (Okrug) in central Siberia, January temperatures average -36°C and can fall as low as -80°C. In the summer, the temperatures average 16°C and can reach as high as 36°C. Snow cover is usually anywhere between 50 to 80 centimeters (Fondahl, 1994).

The Evenki language of central Siberia belongs to the Tungus division of the Tungus-Manchu group language family, and the Evenki themselves are thus related to the Manchu who conquered China in 1644. In 1979, 43 percent of the Evenki considered Evenki to be their first language, while most others spoke either Yakut or Russian (Fondahl, 1994).

Prior to the sixteenth century, Siberia was predominantly occupied by indigenous groups who had very little contact with Russians. Contact with the Russians intensified in AD 1540 with the conquest by Cossak Ermak (Vasilevich and Smolyak, 1964). Because of the difficulty of the terrain, penetration by the Russians into central Siberia was very slow. Consequently, the first contact between Russians and the Evenki was not until AD 1606. By 1623, the Russians had managed to impose a fur tax upon all Evenki clans (Vasilevich and Smolyak, 1964). Economic conditions for the Evenki under the tsarist government were very harsh, and these conditions worsened with great impoverishment and increased mortality rates among the Evenki over the period prior to the Great October Revolution in 1917 (Vasilevich and Smolyak, 1964).

Figure 2.1. Map showing the geographical distribution of the Evenki. Boxed area indicates specific area of study (modified from Fondahl, 1995)

2.1.2 Settlements

Formerly, the primary occupation of the Evenki was hunting, while reindeer breeding and fishing were subsidiary activities. In order to provide food for the reindeer, herders would travel over vast areas in search of new pastures. In the very short summers, the herds would be led through the forest and marshlands in search of food. Herds were brought back to the forest during the winters. This nomadic lifestyle meant that the reindeer herders needed to live in temporary housing. They lived in conical tents, which were made of hide in the winter or bark in the summer. More recently, however, canvas has been used instead of hide and bark (Uvachan, 1975; Fondahl, 1994).

The most important aim of the Soviet Union's social policies in the 1930s regarding its indigenous peoples was to change their lifestyle to a sedentary one. The direct result of this was that the Evenki, along with other indigenous groups, were forcibly reorganized into cooperative settlements and herder groups called *brigades* (Forsyth, 1992; Leonard et al., 1994b). Women, children, and the elderly were encouraged or forced to move into these settlements, while most men of working age continued to herd and hunt (Fondahl, 1994).

2.1.3 Economy

Before contact with the Russians, the indigenous populations subsisted on a diet of limited carbohydrates (bread, cereal) and vitamins (vegetables, fruit, butter). The development of ties with the Russians introduced bread as a main component of the Evenki diet. Before this, the primary foods of the Evenki were fish and meat. The latter was usually unseasoned and boiled, and consisted mainly of elk, wild reindeer, and bear (Vasilevich and Smolyak, 1964). In addition to their main diet, they also had reindeer milk. However, reindeer milk, while sweet and creamy, is low in butterfat. As well, the most milk that a female reindeer will provide in a day is less than a pint (Fondahl, 1994; Service, 1971). Wherever available, berries, field onions, and wild garlic were used as food (Vasilevich and Smolyak, 1964).

Reindeer husbandry and hunting are the main source of livelihood for the Evenki, with approximately 30 to 50 percent of the population engaged in these activities. Others work as unskilled physical laborers, while a growing number of Evenki also work in the health care, education, or administrative sectors (Fondahl, 1994).

Traditionally, hunting and trapping were the principal day-to-day activities of the Evenki. Men's activities largely involved hunting, the manufacturing of most implements, the loading of pack animals, slaughtering and skinning, and the cutting of firewood, among other arduous tasks. Women would dress the skins and make clothing and tent covers; they would also herd and milk the reindeers, cook food, and tend to their children as well as to the camp. However, older men who were unable to go on hunts would also help out around the camp with cooking and many other household tasks (Service, 1970; Fondahl, 1994).

Recently, there has been a tendency among Evenki women to seek white-collar jobs, more so in larger villages or urban areas. Evenki men, for the most part, remain predominantly employed in rural physical labor (Fondahl, 1994; Indian and Northern Affairs Canada, 1991).

2.1.4 Kinship and Family

In the past, the patrilineal clan was the predominant kinship group in Evenki society. The clan served mainly as an administrative body, determining the use and allocation of territory, as well as the determination of punishment for crimes. Marriage was exogamous, and was usually arranged by the clan leaders. Clans tended to be paired for the purpose of marriage. Although the family served as the basic economic unit, it was identified by its clan name. A clan could include up to 100 or more small families (Fondahl, 1994).

Under the tsarist government, the clan system began to disintegrate, so that by the beginning of the twentieth century, clan organization was no longer the basic unit of social organization. Consequently, most younger Evenki today do not know to which clan they belong (Uvachan, 1975; Fondahl, 1994).

With the establishment of boarding schools in the 1930s, Evenki children began to spend much of their time away from their families. Parents now complain that their children no longer learn how to live in the taiga, and that they are dependent on non-Evenki school personnel for their needs (Fondahl, 1994).

In Traditional Evenki society health care needs were met by the shaman. For less serious problems, the Evenki used a number of herbal cures, while more serious maladies involved a number of taboos and rituals. The Soviet state provided polyclinics to serve the Evenki and ensured free access to, as well as free travel to and from, these facilities. However, the level of health care in rural areas is still very primitive, and among most Siberian indigenous groups, mortality remains high and life expectancy low. The consumption of cheap vodka (or the tsar's "firewater," as indigenous groups called it) has been an increasing problem since first contact. Alcohol-related deaths are a huge problem among most Siberian indigenous groups (Fondahl, 1994).

2.2 Recent Political and Economical Changes in Russia and Their Effects:

2.2.1 The Health of the Russian Population

The collapse of the Soviet Union in 1991 marked the end of the Cold War and set in motion profound social and economic changes in the newly independent states, including the Russian Federation. The sudden imposition of market reforms, the collapse of free trade among the former Soviet republics, declining productivity, and unstable currencies have led to commodity shortages, increasing inflation, and rapid increases in government deficits (Toole and Serdula, 1996). Consequently, the already poor conditions of the health-care system have been exacerbated by these changes. One result is that the management of the health care system has become highly decentralized, with funding being derived from taxation of local industry; consequently, there has been an overall decline in funding to health care.

The practice of routine checkups has stopped, considerable reductions in hospital beds have occurred, and physicians are now paid less than factory workers (Wyon, 1996).

The effects of all these changes are starkly illustrated by most of the demographic data coming out of Russia. The yearly number of deaths in Russia, for instance, is estimated to have increased between 1989 and 1993 by over half a million. In fact, for the first time since World War II, the death rate was higher than the birthrate in Russia. By 1994, experts looking at the health data were talking about "Russian genocide." The Russian Academy of Sciences warned that the population of Russia could decrease by half in fifty years. The Academy reported that one million fewer Russians were born in 1993 than were born in 1992, and that by the year 2001, the present population of 148.4 million would decrease to 146.5 million (see Randolph, 1996:156-157). The *New York Times* reported that the number of children that were born in 1994 was 1.4 million, and that this number is believed to be less than half the number of abortions performed in the same year (Tulchinsky and Varavikova, 1996a). Respiratory, infectious, and parasitic diseases are the main causes of death among infants, accounting for more than 50% of deaths. The rate of adult deaths from infectious diseases is 10 times higher in Russia than it is in other western countries (Barr and Field, 1996). Wylon (1996) notes that there have been serious increases in the number of deaths among young adults in Russia between 1960 and 1995, particularly since 1990 and predominantly among males. Most of these deaths are due to accidents, homicide, suicide, and poisoning.

Infectious diseases that were once under strict control have again begun to plague Russia since 1991. The number of cases of diphtheria doubled in 1992, while cases of syphilis and respiratory tuberculosis increased 80% and 11% respectively. The situation worsened in 1993, reaching epidemic proportions in some cases. During the first five months of 1993 there were approximately 3,000 cases of diphtheria (100% increase over the previous year), 45,000 cases of measles (280% increase), and 20,000 cases of tuberculosis (24% increase) reported. Although no numbers are provided for syphilis and gonorrhea, it is reported that these diseases increased by rates of 150% and 70% respectively during 1992 (Tulchinsky and Varavikova, 1996b; UNICEF International Child Development Centre, 1993).

These social, political, and economic changes and the effects that they have had on the health-care and social welfare system have some experts concerned about the health of large numbers of economically-vulnerable citizens, such as children, pregnant and lactating women, and the elderly (UNICEF International Child Development Centre, 1993; Toole and Serdula, 1996; Rush and Welch, 1996). Preliminary research among the elderly has reported consistently poor standards of health, nutritional status, diet, and social conditions, and that these poor conditions are linked to recent weight loss, as well as insufficient money to buy foods (Rush and Welch, 1996).

The present situation of Russian children is disturbing. The infant mortality rate in Russia for 1990 was reported to be 17.4 per 1,000 live births. However, for the first half of 1993, it was 18.8. If WHO standards are applied to the Russian figures, infant mortality would have increased by 20% to 25% per 1,000 births in 1994 (Barr and Field, 1996). One in four children are deemed healthy by Russian standards, and the figure gets worse (one in five) when international standards are applied. A youth expert from the Soviet Health Ministry's branch on young people noted that fewer than one in 10 school children showed normal physical development. The current health status of Russia's children is succinctly summarized by Nina Ivanora, a pediatrician:

> We have the most frightening problem of all--our children. [They] are growing weaker. I have seen our children for over sixty years, and what I witnessed now is something terrible that is happening to them. The health of our children is now very poor, due to ecological problems, our air, our water, our food. Most of our children have some kind of allergy, respiratory problems, asthma. It's becoming worse and worse. Thirty years ago we saw single cases. Now, it is a pandemic problem. (Randolph, 1996:154)

The high death rate among infants and children is mainly due to respiratory infections and parasitic diseases. These are no doubt the result of Russia's poor sanitation standards. Russia's Environmental Protection and Natural Resources minister recently declared that almost half of the nation's tap water is unfit to drink (Randolph, 1996). To exacerbate this problem, Russia's health ministry reported in 1993 that 42% of hospitals had no hot water, and that another 12% had no running water.

The net result of these declining health conditions in Russia is that life expectancy (a determinant of a nation's overall health) has steadily decreased since 1991 (Figure 2.2). The life expectancy for men in 1995 was 57.3 years (compared to 72 years for American men) and 71 years for women (compared to 79 years for American women).

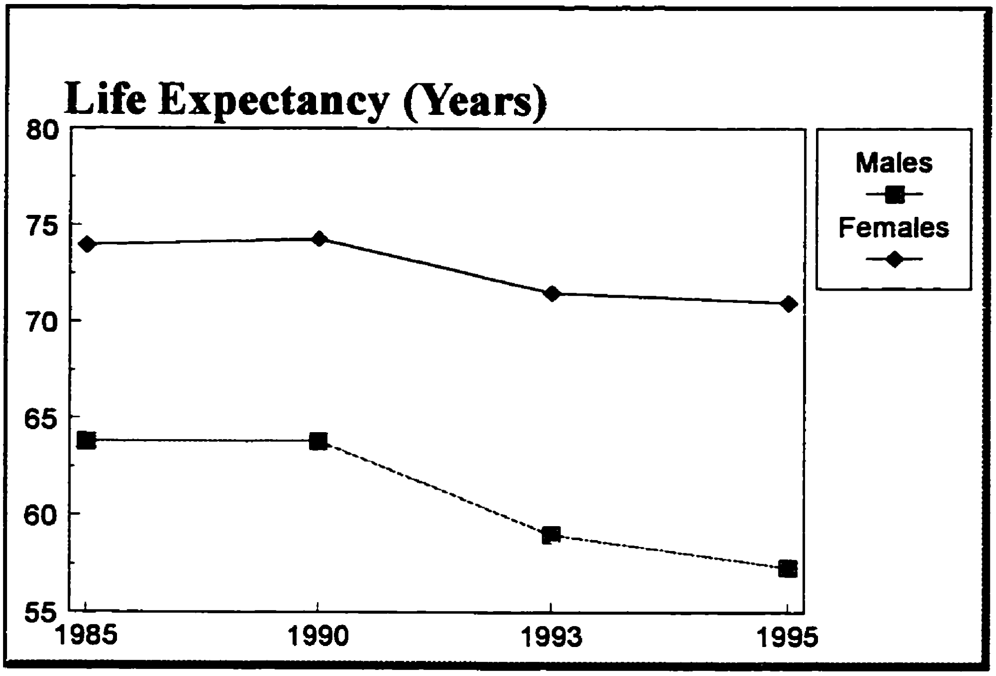

Figure 2.1. Life Expectancy (Years) at Birth for the Russian Federation, selected Years, 1985 through 1995 (Sources: Tulchinsky and Varavikova, 1996; Randolph, 1996)

2.2.2 The Health of Indigenous Peoples in the Russian North

Indeed, it is safe to assume that no other region of Russia has experienced the consequences of the collapse of the former Soviet Union more dramatically than the Russian North (Poelzer, 1995). There are two reasons for this assumption. Up to 1991, Russia's indigenous peoples were strongly promoted and massively subsidized by the Russian state. However, the State no longer has the resources to sustain that commitment. The second reason concerns the devolution of power from the center to the regions. Although this has been a long-awaited event by most indigenous groups of the north, it has also meant the weakening of the capacity of the center to intervene constructively in the development of the indigenous peoples (Poelzer, 1995). While both these points are very important ones, it is perhaps the second that will hurt the indigenous people the most. This weakening of the center's capacity is reflected in the breakdown of the delivery of supplies to the north. For example, by August of 1994, the north had received only half of the supplies that were needed to sustain it throughout the winter. From the words of a native: "The problem [northern shipping] lies not only in the scarcity of the financial resources earmarked by the state for the region. More importantly, the system of life support for the northern territories that evolved over decades has gone to pieces" (Poelzer, 1995: 210).

Consequently, rising food prices have left shelves in most small villages empty, except for alcoholic beverages. Rising prices for transport, especially air transport, has essentially isolated those villages that are not connected to a road network or on navigable waterways from the outside world for months at a time. The implication of these conditions is that the system of health care in the north has been seriously compromised. Medical evacuations from remote areas to the more developed regional centers have substantially decreased; medical centers in the very remote areas struggle to remain open, and fail to offer their patients the basics of running water and indoor plumbing (Fondahl, 1995).

As a result, the very limited data coming from these areas offers a frightening picture when we consider that, by the end of the Soviet period, the indigenous peoples of the north suffered from a life expectancy that was almost ten years less (43 years for males, and 47 years for females) than the already low Russian average, a suicide rate three times that of the Russian average (Fondahl, 1995; Marshall and Soule, 1993), and much higher rates of infant mortality (48.2 deaths per 1,000 births among the Evenki, compared to approximately 19 deaths per 1,000 births in Russia before 1990) (Fondahl, 1995; Marshall and Soule, 1993). Reporting on data from the Chukotka region, Finkler (1995) notes that, since the collapse of the former Soviet Union, health problems in this area have become acute. He notes that birth rates have declined to 9.9 per 1,000 population, with an even greater decline recorded for the aboriginal population; the mortality rate increased to 7.5 per 1,000 population, with the rate for the aboriginal population being three times higher; mortality from infectious diseases doubled in 1993, relative to 1992; mortality from alcohol doubled between 1991 and 1993, with a sixfold increase among the aboriginal population; during 1990-1993, tuberculosis increased by 43.5 percent, with a threefold increase among children, and was 5.4 times higher among the aboriginal population; and there has also been overall increase in the rate of infectious diseases (Finkler, 1995: 240-241).

Leonard et al. (1997) have found similar trends among the Evenki from the Baykit District of Central Siberia. Here, they found that improvements in mortality rates during the 1980s were wiped-out during the 1990s, as rates returned to the high values of the early 1980s. In fact, Poelzer (1995) notes that for the first time in the Russian Far East, the mortality rate exceeds the birth rate. Fertility rates that were increasing throughout the 1980's have since rapidly declined, reaching their lowest point of less than 20 births per 1,000 individuals in 1993.

As in the case of the urban center of Russia, children in the Russian north are being severely affected by these changes. Almost all publications on the subject note that infant mortality is increasing at an alarming rate and that steps are needed to address this problem (Anderson, 1995; Finkler, 1995; Poelzer, 1995). Also of concern are the increasing rates of infectious disease, such as measles, pertussis, diphtheria, and tuberculosis. Anderson (1995) notes that sanitary conditions are a major problem and that polluted water is perhaps the major source of contamination for children.

2.3 Previous Research Among the Evenki
2.3.1 Physical Growth of the Evenki

In 1994, Leonard et al. presented the first detailed report on the growth and nutritional status of an indigenous Siberian population: the Evenki. Anthropometric dimensions were taken on a sample of 478 individuals (247 males; 231 females) ranging in age from 1 month to 76 years. Their findings revealed that the Evenki are small in stature and body weight, and that they grow slowly, particularly during late childhood and adolescence. Evenki boys and girls closely approximate the U.S. 15th percentile up to about adolescence, at which point they fall below the U.S. 5th percentile, where they remain throughout adulthood. After ruling out food shortage as a possible explanation for this compromised growth, the authors assert that seasonal energy imbalances may be responsible for the stunted growth and short stature of the Evenki, arguing that elevated resting and total metabolic demands, especially during the winter months, would limit the amount of energy that can be allocated to growth (Leonard et al., 1994b; Leonard et al., 1996).

Evenki women are relatively heavier and fatter than the Evenki males, and this weight and fatness increases with age. Analysis of the skinfold data shows that Evenki women preferentially distribute fat on their trunk. In fact, their subscapular skinfolds, on average, exceed the U.S. median for adult females. The authors explain that these sex differences might be a direct result of the lower activity patterns of women, the lower fertility levels of the Evenki since collectivization (thus, the lower metabolic cost of pregnancy and lactation), or a possible adaptation of Evenki women to cold stress (Leonard et al., 1994).

2.3.2 The Health of the Evenki

Leonard et al. (1997) note that the health status of the Evenki men is superior to that of the women, and that this difference in health status reflects a greater negative impact of acculturation and lifestyle change on women. The above information reveals that the Evenki women have lower activity levels, lower cardiorespiratory fitness, higher levels of obesity, and higher total and LDL cholesterol levels than men.

In fact, demographic records from the Baykit District of central Siberia indicate that circulatory diseases are emerging as the leading cause of death among Evenki women, accounting for one-third of the deaths among aboriginal women. Violence and accidents are the leading causes of death among men, accounting for over half the number of male deaths (56%). Violence and accidents account for approximately 31% of female deaths. The higher rate of female deaths from circulatory diseases is opposite to what is reported in most international data, where the death rates among men are usually higher (Leonard et al., 1997). However, this observation of a greater number of female deaths from circulatory diseases is not unique to the Evenki. The Indian and Northern Health Services of Canada have reported similar findings among registered Native Indian women (Indian and Northern Health Services of Canada, 1995).

Respiratory disease was the leading cause of infant mortality among the Evenki between 1982 and 1994, accounting for 90% (or 18 out of 20) of these deaths. Violence, accidents and respiratory problems were the primary causes of mortality for individuals below the age of 17 years (Leonard et al., 1997). Evers et al. (1985) report similar findings of high levels of respiratory disease among infants and young children in Canadian aboriginal populations.

During the 13-year period that was studied, Leonard et al. (1997) found that crude mortality rates in the Baykit District fluctuated for both the aboriginal and Russian populations, but more so for the aboriginal population. Overall, there was a steady decline in crude death rates among the aboriginal population, reaching a nadir during the 1990s as death rates returned to the levels that were observed in the early 1980s. These researchers argue that the increases that are observed in the 1990s are most likely the result of the greater availability of alcohol and the increasing isolation and economic marginalization within the district, associated with the fall of the Soviet Union in 1991 (Leonard et al., 1997: 413).

2.3.3 Diet and Nutritional Status of the Evenki

According to Leonard et al. (1994b), there does not appear to be a problem concerning shortage of food among the Evenki. The Evenki control large animal herds, and thus have access to a large amount of reindeer meat. The Evenki diet is also supplemented with non-local foods, such as flour, noodles, sugar, and tea. These products are brought in by helicopter from regional centers (Leonard et al., 1994).

Based on 24-hour recalls, the Evenki diet consists largely of carbohydrates (approximately 59%), followed by fat (approximately 23%) and then protein (approximately 18%). Animal products, primarily those derived from reindeer, wild game, and fish, make up a substantial portion of the Evenki diet. A smaller component of the diet comes from foraged foods, such as wild blueberries and pine nuts (Galloway, 1996; Leonard et al., 1994b; Leonard et al., 1996). The mean daily intake in adult males is approximately 3,200 Kcal/day, as compared to approximately 2100 Kcal/day in females. Leonard et al. (1994b) note that these values represent an adequate calorie intake during the late summer months, but that they may also present an overly-favorable representation of their dietary status, since the data represent only one season. The dietary status of the Evenki might be poorer in the winter months, when it is more difficult to obtain foods from the regional centers (Leonard et al., 1994). Leonard et al. (1996) argue that, despite the adequate caloric intakes in the summer, it is likely that the Evenki experience energy constraints during the winter months. In the summer, per capita energy demands for the population are about 8.6 MJ/d, while per capita consumption is around 9.0 MJ/d. Assuming a moderate elevation (of approximately 10%) in resting metabolic demands associated with cold stress, as well as a moderate increase in subsistence activity, the above numbers become 9.85 MJ/d and 9.5 MJ/d, respectively. Even if food availability were to remain constant throughout the year, it requires only small metabolic shifts to push this population into a state of negative energy balance (Leonard et al., 1996) .

Biochemical analyses have also been done to examine the variation of serum cholesterol (total HDL and LDL) and tryglyceride levels among the Evenki. The results from this study show that the Evenki have low cholesterol and tryglyceride levels, compared to both United States standards and those of other indigenous arctic and herding populations. This fact is attributed to a very low fat intake (despite a diet with large amounts of meat) and to high levels of energy expenditure. The results also show that Evenki men have much better lipid profiles than women, who have higher total and LDL cholesterol levels. These differences are attributed to the more active lifestyle of the men. Brigade/village differences were also observed, but these differences were significant for males only. That is, male villagers had higher total and LDL cholesterol levels than their brigade counterparts. However, the authors are unsure of the cause of this difference, noting that it might be alcohol-related (Leonard et al., 1994a).

2.3.4 Energetics of the Evenki

The metabolic adaptation of the Evenki to their environment has been studied. Katzmarzyk (1993) used the flex heart rate (HR) method of heart-rate monitoring to investigate the metabolic adaptation of the Evenki; this method estimated the total daily energy expenditure of Evenki men to be 2762 ± 731 kcal (11.6 MJ) and women to be 2083 ± 432 kcal (8.7 MJ). Comparisons of the Evenki TDEE to those of other selected populations show that their TDEE is high, but not as high as would be expected in an energy-limited environment, such as the central Siberian taiga. The difference in TDEE between males and females is significant, and is a product of the division of labor between the sexes.

In the same study, Katzmarzyk (1993) found that resting metabolic rates (RMR) were higher for individuals in the brigades than for those in the village. Since the RMRs for villagers were not significantly different from those for temperate populations, he argues that these results point to a strong environmental influence on the metabolic rate of the Evenki. Thus, the elevated metabolic responses among individuals from the brigades (or herding groups) represent a short-term physiological adaptation, and not a genetic one.

Physical activity levels (PAL) classify the Evenki as being "moderately" active. As well, the aerobic capacity of the Evenki is similar to that of other semi-subsistent populations and closely approximates the 50th percentile for Canadian adults (Katzmarzyk, 1993; Katzmarzyk et al., 1996; Leonard et al., 1996).

Galloway (1996) used open-circuit indirect calorimetry to monitor basal metabolic rates (BMR) in the Evenki, in order to determine if the Evenki possessed a metabolic adaptation to the cold stress of the taiga. The results revealed that the BMRs for individuals in the brigades were significantly higher than those for villagers and Russians living in the same area. Galloway (1996) alludes to diet, physical activity, and exposure to cold as possible explanations for the higher BMRs of the brigaders. When sex differences were investigated, BMR differences were observed in the older age cohorts, but not in the younger cohorts. Galloway (1996) explains that this is due to the fact that older men engage more in traditional activities (such as going out to hunt, or herding in the brigades), while the younger men have not yet fully started to participate in these activities and thus have activity patterns similar to those of their female counterparts.

Chapter 3: Methods

3.1 Study Population

This project is part of a larger project aimed at examining the ecology, health, and genetic diversity of the Evenki, which was initiated in 1991. The work presented here is aimed at assessing the influence of ongoing social and economic changes on the biology and health of the Evenki. The data that are analyzed here represent anthropometric data that were collected from fieldwork in 1991, 1992, and 1995. The data from all three years were collected during July to September of each year; research was focussed upon the Evenki of the Tunguska region from the cooperative settlements of Surinda and Poligus, and eight of their associated herding brigades. These settlements are located in the Stony Tunguska region of Central Siberia (63° N latitude; 97° E longitude), on and along the Tunguska River (Figure 2.1). The mean monthly temperatures in this region range from -32.5° C in January to a high of +15° C in July (Leonard et al., 1994). Census data indicate that as recently as 1994, the populations of Surinda and Poligus numbered approximately 613 and 481 people respectively (Galloway, 1996).

3.2 Sample and Measures

All anthropometric measurements were taken by a single, experienced observer, William Leonard, in each of the three years. A total of 226, 323, and 453 individuals were measured in 1991, 1992, and 1995, ranging in age from 1 month to over 70 years. From these larger samples, all individuals below the age of 17 years were chosen for this study. A total of 116 individuals from 1991, 158 from 1992, and 195 from 1995 were selected in the initial subsample. Using a multiple factorial analysis, it was found that there were no statistically significant differences for any of the anthropometric variables between the 1991 and 1992 data sets. Consequently, the data from these two years were pooled to form cohort 1, while the 1995 data are referred to as cohort 2. As a result of the pooling, there were 21 cases in which the same individual appeared in both years. In order to make the data independent, a program using randomly generated numbers (of 1's and 2's) was used to eliminate the repeaters. Ten repeaters were removed from the 1991 data set, and eleven were removed from the 1992 data set. Table 3.1 shows the final age and sex distribution of the sample, which consist of 253 individuals in cohort 1 and 195 individuals in cohort 2.

Three distinct age groups are used in this study. The first, which comprises infants and younger children, is identified as *0-5* years. This group consists of all infants below the age of 1, and children up to the age of 5.9 years old. The second age group comprises of older children, and is identified as *6-10* years. This group includes all children up to the age of 10.9 years. The final age cohort (*11-17* years) consists of adolescents up to the age of 17.9 years.

The anthropometric measurements used in this study are stature, weight, triceps skinfolds, subscapular skinfolds, and mid-arm circumference. Standard protocol, as outlined in Weiner and Lourie (1981) and Lohman et al. (1988), was followed for all measurements. All subjects were measured in light clothing without shoes. Stature was measured to the nearest 0.1 cm using a Harpenden portable field anthropometer, while weight was measured to the nearest 0.2 kg using a hanging scale (ITAC Corporation) for children under 2 years, and a standing scale (SECA Corporation) for older subjects. Skinfold measurements were measured to the nearest 0.5 mm, using Lange calipers.

One derived index was calculated: upper muscle arm area (UMA). Estimated UMA was calculated using the steps outlined in Frisancho (1990): $UMA = (C - T\pi)^2 / 4\pi$. Where C = mid-arm circumference (cm), T = triceps skinfold (cm).

Birth dates were obtained for each subject. Where children were too young to provide their own birth dates, this information was obtained from their parents. Where possible, birth dates were verified against demographic records that were kept by the cooperative. In cases where there were discrepancies in this information, the dates from these records were used (Leonard et al., 1994 and 1996).

Table 3.1. Age and Sex Distribution of the Sample of Evenki Children for Cohorts and 2

	Cohort 1		Cohort 2	
Age(years)	Males	Females	Males	Females
0	2	6	5	4
1	1	7	4	6
2	4	11	3	3
3	8	12	3	9
4	16	6	3	9
5	13	18	6	2
6	12	12	10	10
7	7	10	10	7
8	9	8	11	7
9	9	10	7	13
10	7	7	4	8
11	7	5	3	6
12	5	4	4	4
13	2	4	1	10
14	3	4	-	5
15	1	1	2	5
16	6	6	1	3
17	4	6	1	6
Total	116	137	78	117
	253		195	

3.3 Analytical Measures and Statistical Analysis

Standardized measures of growth and nutritional status were obtained by calculating z-scores for stature, weight, and weight-for-height, relative to the age and sex-specific U.S. reference data compiled by the National Center for Health Statistics (NCHS) (Hamill et al., 1979). As well, z-scores for skinfolds and UMA were also calculated, relative to those age and sex-specific U.S. norms compiled by Frisancho (1990).

The Evenki's stature and weight were also compared to that of indigenous groups from other high-latitude populations, as well as to those of a Russian sample and another Siberian indigenous group (both between the ages of 7 and 14 years). The three indigenous high-latitude populations represent the following groups: Northwestern Alaskan Eskimo, the Eskimo (Inuit) from the Foxe Basin region of Canada, and Finnish Lapps (Auger et al., 1980). The other Siberian indigenous sample represents 366 Nanai children between the ages of 7 and 14 years. The Nanai children were from the Nanai district of Khabarovsk region, which is located in Eastern Siberia (130° N latitude; 48° W longitude). The Russian sample represent 811 children, also between the ages of 7 and 14 years from the Khabarovsk region (Ostroushko et al., 1990) .

Statistical comparisons of the Evenki growth data to that of the above five groups was made possible through the use of the modified log odds (MLO) discriminant method (Hoff and Blackburn, 1981). This technique allows for a statistical comparison of growth data between two groups in situations where the data from one group (in this case, the data from the five comparative samples) is only available in the form of means and standard deviations for specified age groups. This technique has two steps. First, the Evenki's anthropometric measurements (in this case, stature and weight) are standardized as z-scores, relative to the five reference populations. Second, F-ratios are then calculated from these standardized scores. The F-statistic provides a conservative estimate of the statistical differences between the populations being compared (Hoff and Blackburn, 1981).

The normality of the data was tested using the Shapiro-Wilk statistic. All anthropometric variables had to be normalized at some point throughout the analysis. For example, while HAZ had to be normalized in the analysis of the 0-5 age group, no normalization was needed for this variable in the analysis of the 6-10 age group. Improbable z-score values were identified using the fixed exclusion range method outlined by the World Health Organization (1995). Essentially, all values more than 4 z-score units from the observed mean z-score are likely to be errors, and are thus treated as missing values. Using this method, three z-scores for height were treated as missing values (-7.50, a 17- year-old female; +5.63, a 4-year-old female; and +5.47, a 5-year-old male), as were two z-scores for weight (-4.71, the 17-year-old above; and +5.30, the 5-year-old male above) and one for weight-for-height (-4.89, another 5 year old male). All these values were also identified as outliers through the normality procedure mentioned above.

Analysis of covariance (ANCOVA) using a three factor-factorial design was used to examine the overall cohort effect of the different anthropometric measures, after adjusting for sex, age, location (for separate analyses), and the interaction among these factors. Upon finding any significant F-tests, pairwise multiple comparisons (T-tests) were then performed. Regression analyses were also used to examine the relationship between age and the various anthropometric measures.

All statistical analyses were performed on SAS version 6.12 (SAS Institute Inc., 1990).

Chapter 4: Results

4.1 Overall Physical Growth Patterns of Evenki Children

The pattern of linear growth in the Evenki is one of slow growth, especially from mid-childhood into adolescence. Both Evenki males and females show very good linear growth before the age of 2 years, as they very closely approximate (and in some cases surpass) the U.S. 50th percentile (Figure 4.1 and Figure 4.2). After this point, males fall below the 50th and remain slightly above the 5th percentile, until about age nine, when they fall below the 5th percentile and remain there throughout adolescence. Females fare somewhat better, approximating the U.S. 5th percentile right up to the age of 14 years, where individuals in cohort 1 fall below the 5th (Figure 4.2). Females in cohort 1 appear to have a better linear growth status up until the age of 9 years, when the stature of females in cohort 2 exceeds the stature of females in cohort 1. However, there is no clear pattern in the cohort differences among males.

The pattern of growth for body weight is similar to that of stature. In both sexes, body weight surpasses the U.S. 50th percentile in early infancy and remains mostly around the 5th percentile for boys, falling below in a few instances (Figure 4.3). Females show superior growth status, as they remain between the 50th and 5th, while at no time falling below the 5th percentile (Figure 4.4). In both sexes, body weight in cohort 1 is greater than that in cohort 2 until about the age of 6 years, at which point cohort 2 surpasses cohort 1, and even approximates the U.S. 50th percentile in females at 16 years of age.

The Evenki show considerable variation in fatness throughout their growing years, and this variation is more pronounced in males than in females (Figure 4.5). Overall, the Evenki show profiles in fatness that are more similar to their U.S. peers than measures of body size (both linear and weight). Again, as with stature and body weight, Evenki children fall above the U.S. median (for fatness) in early infancy up to age 3 years, as indicated by sum of skinfolds. Both males and females remain above the U.S. 5th percentile throughout their growing years. Females do, however, show a much better profile, as they surpass the U.S. median a few times in adolescence (Figure 4.6). It is also clear from both Figures 4.5 and 4.6 that energy reserves seem to be declining, as the skinfold measurements in cohort 2 are much lower than those in cohort 1.

The Evenki children show similar patterns of muscular development as they do for fat development. Both females and males track between the 5th and 50th percentiles (Figures 4.7 and 4.8). Again, the profiles for the females appear to be superior to those of the males, as the males are closer to the 5th percentiles than are the females, who fall at a more intermediate level between the 5th and 50th percentile. In fact, muscularity falls below the 5th percentile for adolescent males in cohort 1, a pattern not observed in females. Unlike the skinfold measurements, estimates of upper-arm muscle area have improved in cohort 2, as compared to cohort 1. This improvement is more pronounced in females up to the age of 8 years and in males up to 7 years of age, as the children within the group tend to approximate the U.S. median.

Overall, there is a significant decline in weight in cohort 2 as compared to cohort 1 (-1.49 vs. -1.70; $P < 0.05$), while the height in the two cohorts shows a greater similarity (-1.91 vs. -2.01; n.s.) (Table 4.1). This difference in weight is most likely the result of female weight changes, as the females in cohort 2 are significantly lighter than the females in cohort 1 (-1.21 vs. -1.47; $P < 0.05$). Note as well that there are no differences between the sexes for height, within or between cohorts (Figures 4.9 and 4.10).

Indeed, as can be seen in table 4.1, the decline in fatness is very significant (-0.43 vs. -0.63; $P < 0.0001$). Males and females in cohort 2 show significant declines in fatness, as compared to their respective peers in cohort 1 ($P < 0.01$ for males and $P < 0.001$ for females) (Figure 4.9). Significant sex differences are also noticeable within cohorts, with males showing more compromised growth in fatness in both cohorts.

Despite the overall decline in the anthropometric measures for weight, height, and fatness, the Evenki show significant improvement in muscularity, as estimated by upper-arm muscle area (-0.96 vs. -0.60; $P < 0.001$). This improvement is also seen in both sexes. Males in cohort 2 are significantly more muscular than their counterparts in cohort 1 (-1.12 vs. -0.82; $P < 0.001$), while females in cohort 2 show substantial improvements over the females in cohort 1 (-0.80 vs. -0.38; $P < 0.001$). Again, there are significant differences between the sexes within cohorts, and again, these differences show that females show superior muscular development over their male peers (Figure 4.9).

Table 4.1. Mean z-scores of selected anthropometric measures for the Evenki children and adolescents (0-17 years) for cohorts 1 and 2.

Entire Sample					
Cohort	WAZ[a]‡	HAZ[b]	WHZ[c]‡	ZSF[d]§	ZAM[e]§
1*	-1.49 ± 0.16[f]	-1.91 ± 0.16	-0.20 ± 0.13	-0.43 ± 0.31	-0.96 ±0.15
2*	-1.70 ± 0.14	-2.01 ± 0.14	-0.59 ± 0.11	-0.63 ± 0.27	-0.60 ±0.14

[a]Weight-for-age z-score.
[b]Height-for-age z-score.
[c]Weight-for-height z-score (only children 0-9 years).
[d]Z-score for sum of triceps and subscapular skinfolds.
[e]Z-score for upper arm muscle area.
* Differences between cohorts significant at: ‡P <0.05; †P <0.01; §P <0.001.

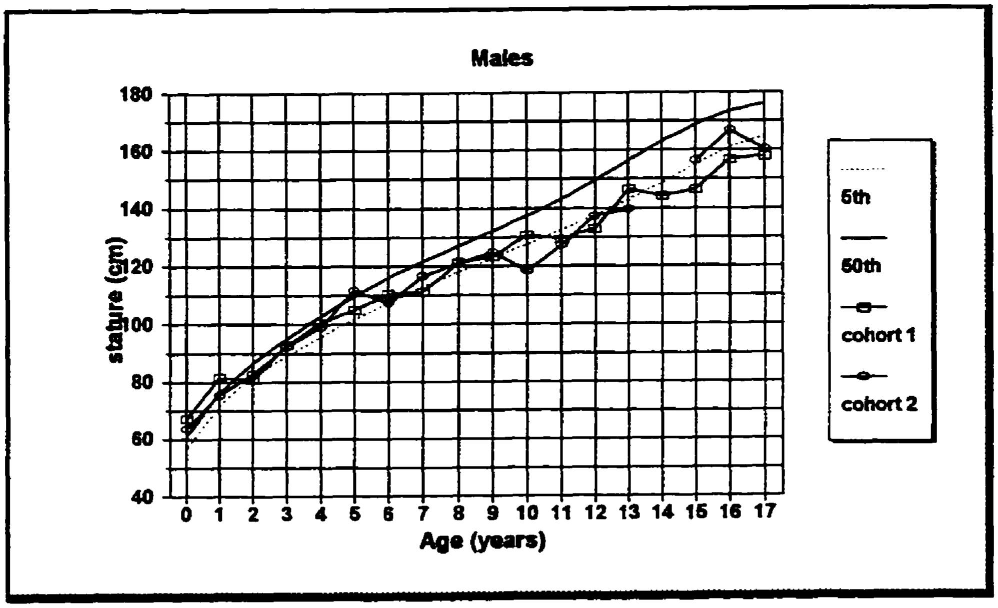

Figure 4.1. Comparison of height-for-age in Evenki males to the U.S. 5th and 50th percentiles from Hamill et al., (1979).

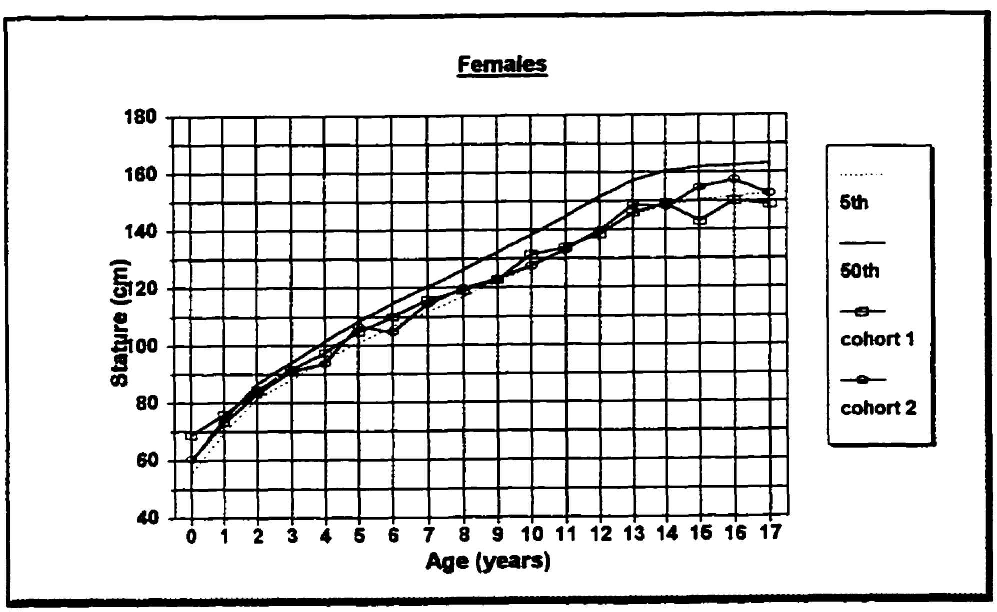

Figure 4.2. Comparison of height-for-age in Evenki females to the U.S. 5th and 50th percentiles from Hamill et al., (1979).

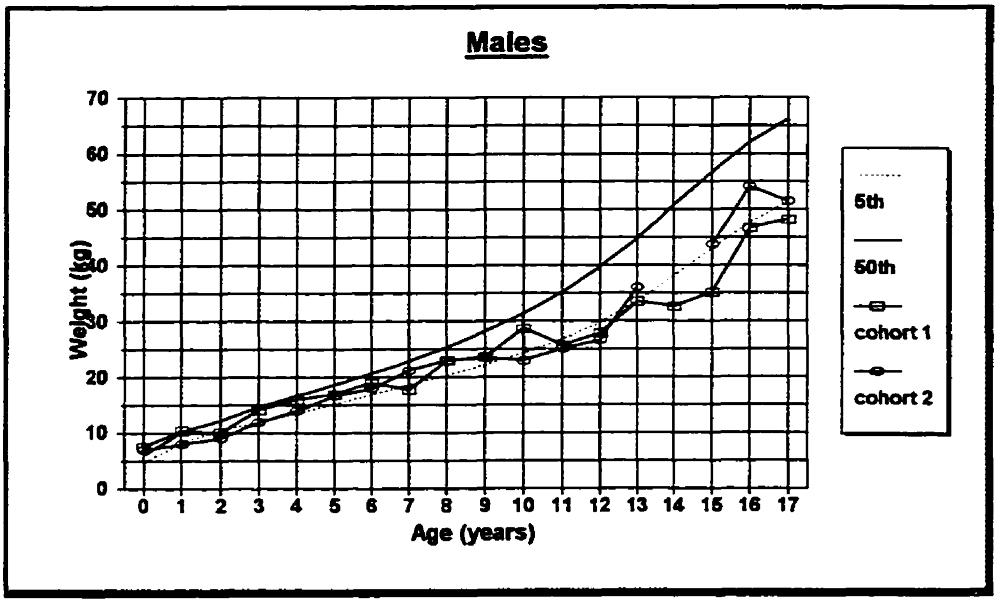

Figure 4.3. Comparison of weight-for-age in Evenki males to the U.S. 5^{th} and 50^{th} percentiles from Hamill et al., (1979).

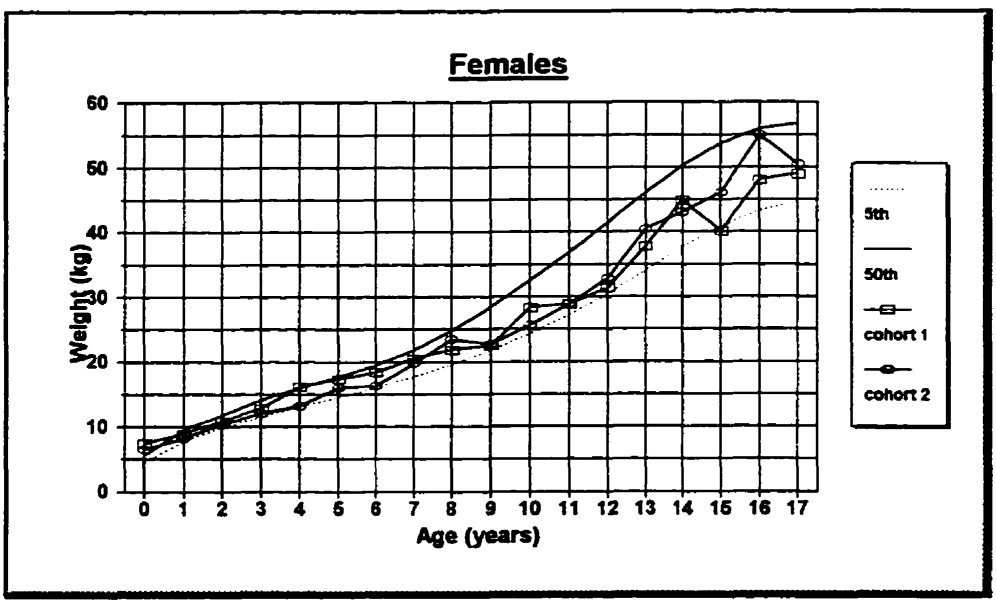

Figure 4.4. Comparison of weight-for-age in Evenki females to the U.S. 5^{th} and 50^{th} percentiles from Hamill et al., (1979).

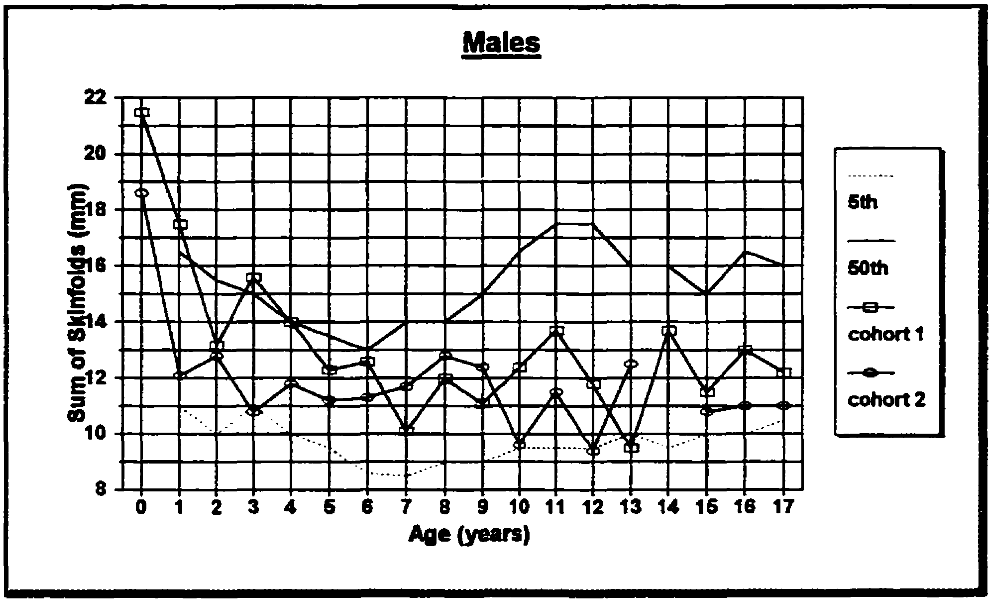

Figure 4.5. Comparison of the sum of triceps and subscapular skinfolds in Evenki males to the U.S. 5th and 50th percentiles from Frisancho (1990).

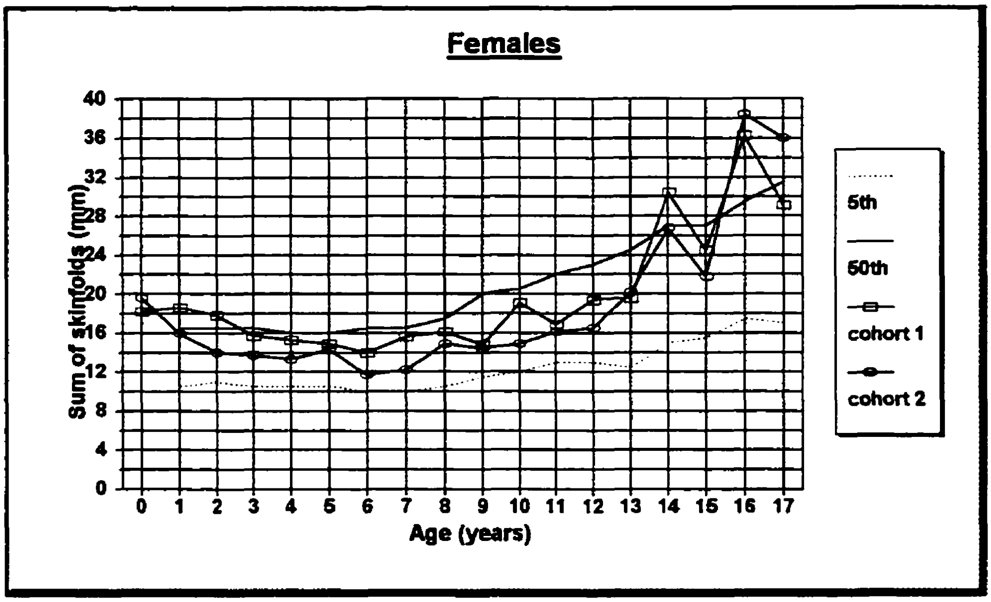

Figure 4.6. Comparison of the sum of triceps and subscapular skinfolds in Evenki females to the U.S. 5th and 50th percentiles from Frisancho (1990).

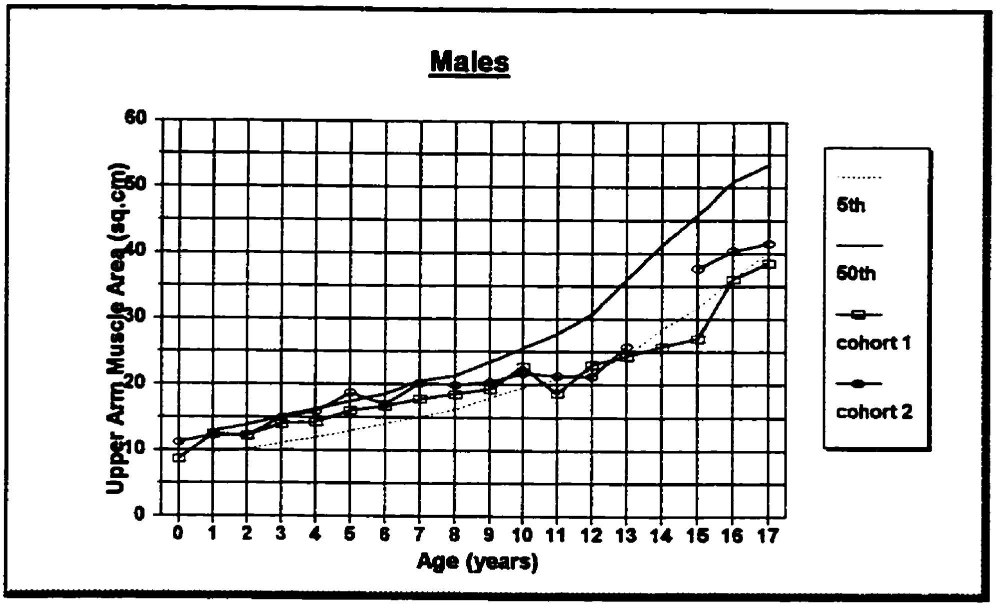

Figure 4.7. Comparison of estimated upper arm muscle area in Evenki males to the U.S. 5th and 50th percentiles from Frisancho (1990).

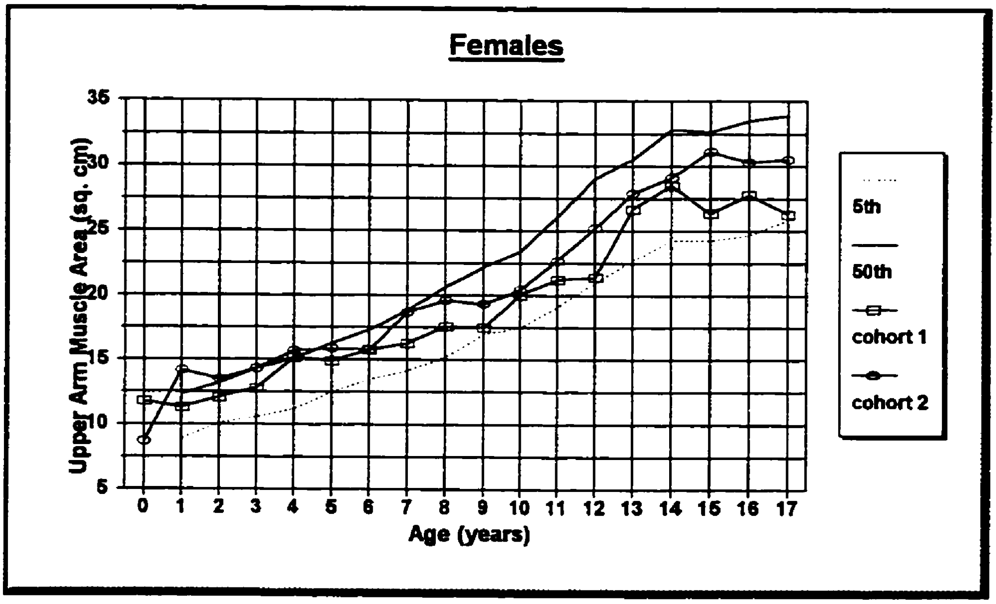

Figure 4.8. Comparison of estimated upper arm muscle area in Evenki females to the U.S. 5th and 50th percentiles from Frisancho (1990).

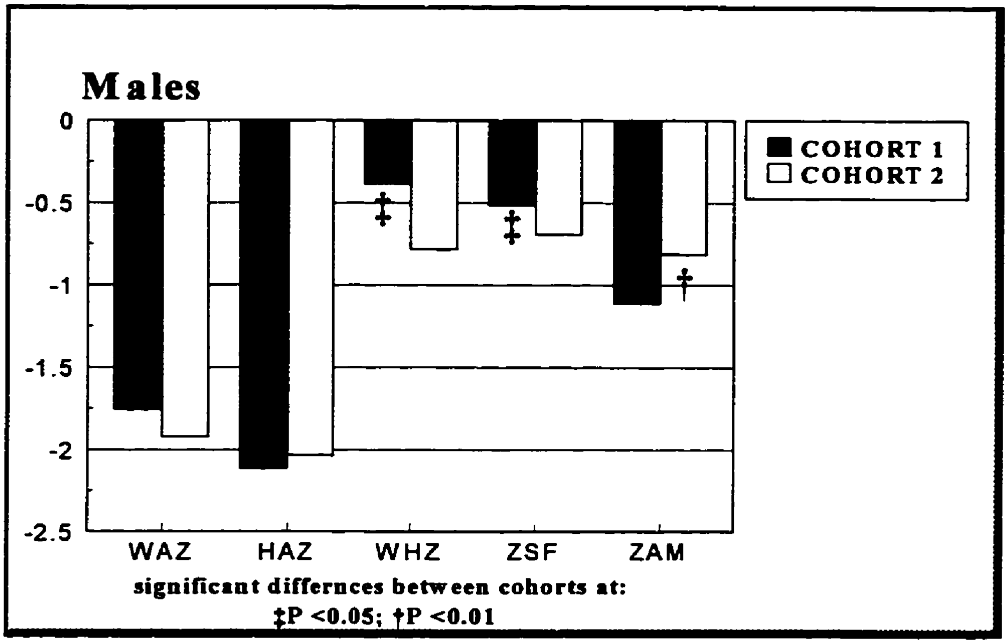

Figure 4.9. Differences between cohorts for anthropometric measures for the entire sample of males (0-17 years).

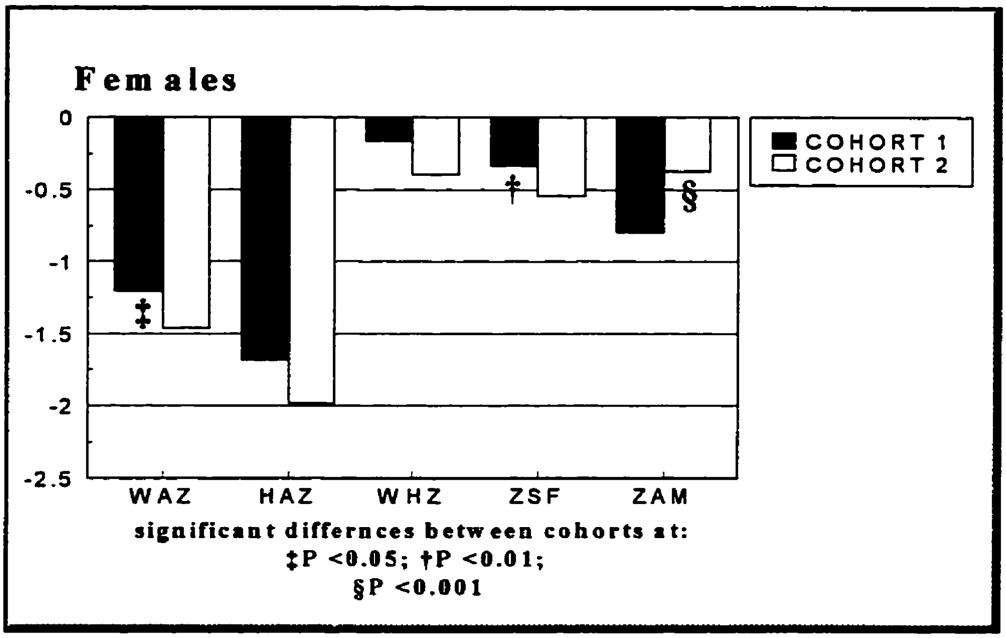

Figure 4.10. Differences between cohorts for anthropometric measures for the entire sample of females (0-17 years).

4.2 Infants and Preschool-age Children (0-5 year olds)

Pooled-sex differences. Table 4.2 shows that, in four of the five anthropometric measures, infant and preschool-age children show a significant decline over the three-year period. Only for z-scores of UMA is there statistically significant improvement. As a group, the children in 1995 are significantly shorter and lighter in body weight than their 1991/1992 peers. As is indicated by z-scores for the sum of skinfolds, they are also more likely to be deficient in energy reserves and to show signs of wasting, as is evident by the significant decline in WHZ. The magnitude of the difference is greatest for height, which is more than one standard deviation. The magnitude of the difference for weight is the next largest at approximately 0.8 standard deviations. Those for weight-for-height and sum of skinfolds are similar, at 0.55 and 0.47 respectively.

Within-sex differences. Figure 4.11 and 4.12 illustrate the changing growth status for each sex. There are no significant changes detected in height and muscularity for males over time. However, significant declines exist in weight-for-age (-1.53 vs. 2.25; $P < 0.01$), weight-for-height (-0.51 vs. -1.25; $P < 0.01$), and sum of skinfolds (-0.34 vs. -0.89; $P < 0.001$) (Figure 4.11). Females also show significant declines in weight-for-age (-1.14 vs. -1.96; $P < 0.001$), and fatness (ZSF) (-0.13 vs. -0.89; $P < 0.05$). There are no significant changes for females for weight-for height between the two cohorts (Figure 4.12). However, the improvement in muscularity for females is significant (-0.51 vs. +0.08; $P < 0.001$).

Between-sex differences. There are no significant differences between the sexes in cohort 1, for any of the anthropometric measures (Figure 4.13). However, in cohort 2, females show significantly better weight-for-height and sum of skinfolds measures. Females also show better profiles for muscularity and weight, but these differences are not significant (Figure 4.14). While females were taller than males in cohort 1, males had surpassed them in cohort 2.

Age-related differences. Table 4.3 shows age-specific z-scores for each of the anthropometric measures. There are significant changes in all variables, except HAZ for 3-year-olds. In general, it appears that the growth status of infants and children between the ages of 1 and 4 is unstable, as most of the changes occur in this age range. All the changes in z-scores for upper-arm muscle area represent improvements. Although these improvements are statistically significant only for 1, 3, and 5-year-olds, there is also an improvement for the other ages within this group. Perhaps the most striking observation in this group relates to changes in the z-scores for weight-for-height at all ages. These children are very thin, and thus are more likely to show evidence of wasting than their peers in cohort 1. The most severe retardation in growth status is observed in 2-year-olds, and their condition has deteriorated since 1991.

Table 4.2. Mean z-scores of selected anthropometric measures for the Evenki infants and children (0-5 years) for cohorts 1 and 2.

Infants and Children (0-5 years)					
Cohort	WAZ§	HAZ†	WHZ†	ZSF§	ZAM§
1*	-1.34 ● 0.31	-1.59 ± 0.39	-0.37 ● 0.20	-0.24 ● 0.28	-0.60 ± 0.28
2*	-2.10 ● 0.30	-2.63 ± 0.37	-0.92 ± 0.15	-0.71 ± 0.28	-0.12 ± 0.28

* Differences between cohorts significant at: †P <0.01; §P <0.001.

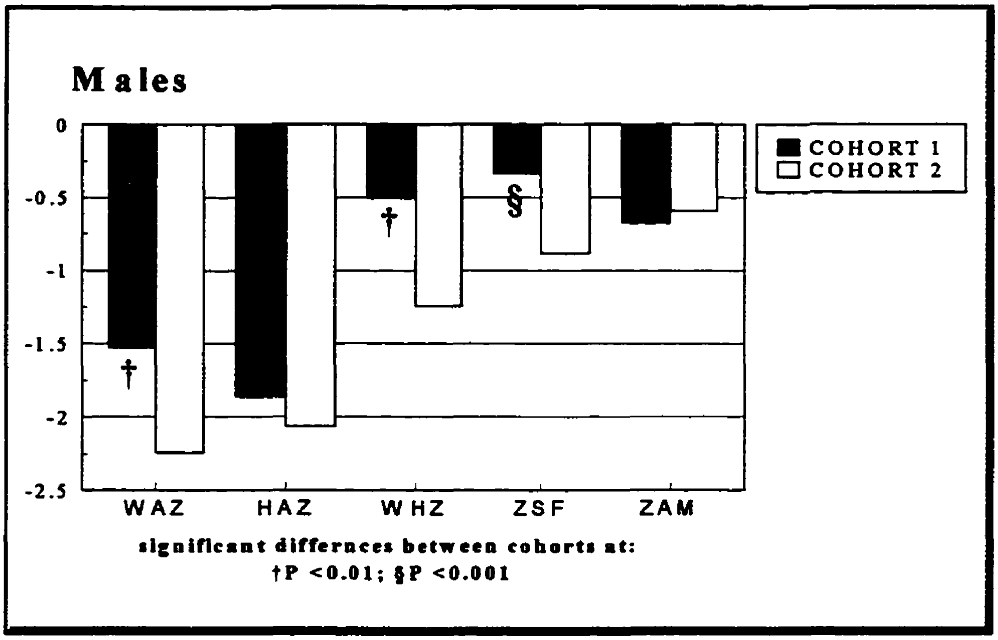

Figure 4.11. Differences between cohorts for anthropometric measures for male infants and children (0-5 years).

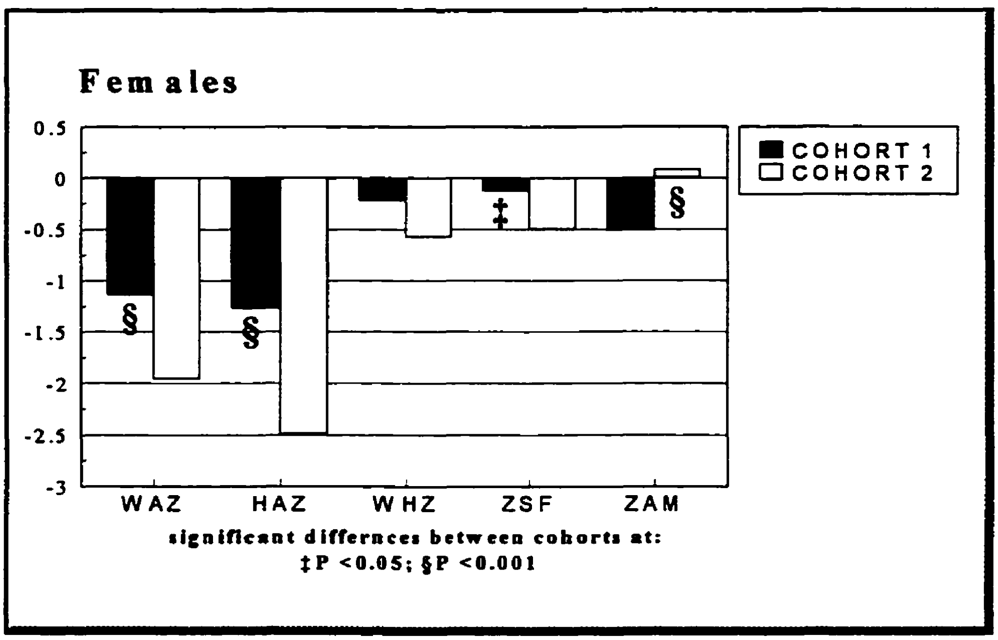

Figure 4.12. Differences between cohorts for anthropometric measures for female infants and children (0-5 years).

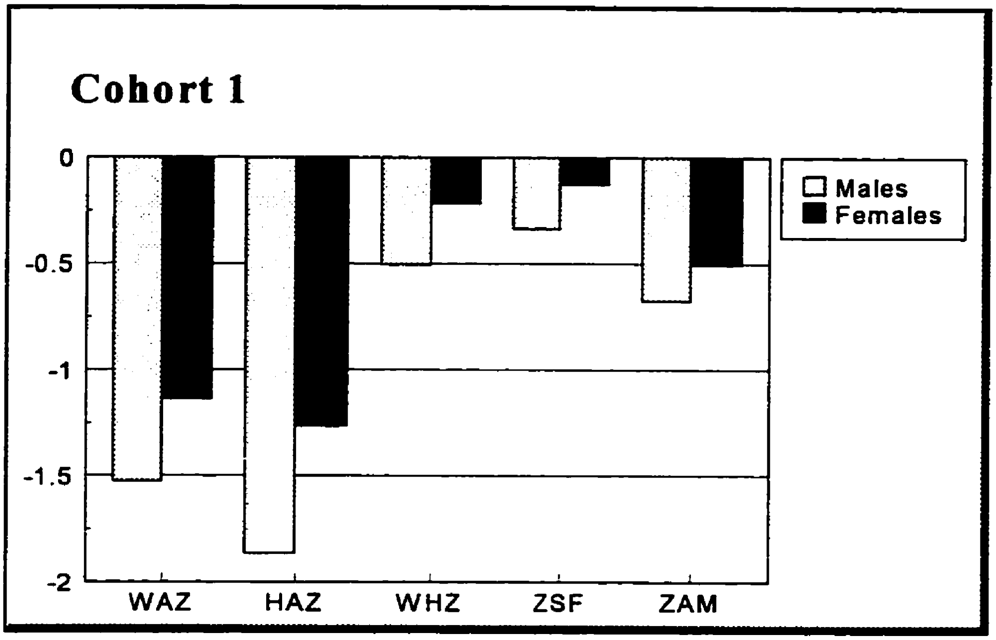

Figure 4.13. Differences between males and females in cohort 1 for infants and children (0-5 years)

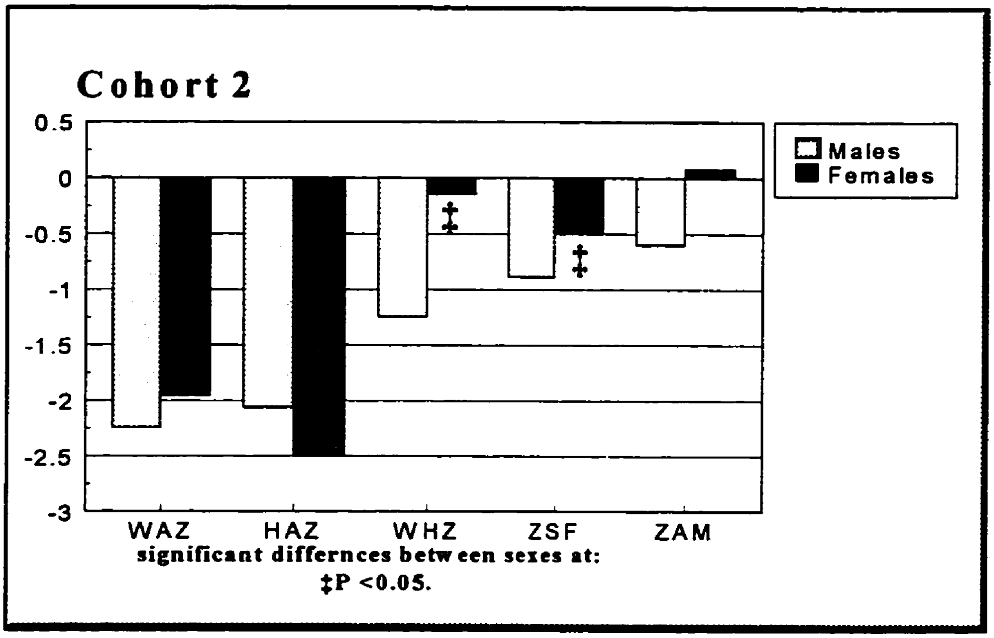

Figure 4.14. Differences between males and females in cohort 1 for infants and children (0-5 years)

Table 4.3. Age-specific differences for all anthropometric variables between cohorts 1 and 2.

Infants and Children (0-5 years)			
AGE*	MEASURE	COHORT 1	COHORT 2
0	WAZ	-1.29 ±0.28	-1.34 ± 0.27
	HAZ‡	-1.44 ± 0.57	-3.10 ± 0.39
	WHZ	-0.47 ± 0.20	+1.05 ± 0.18
	ZSF	–	–
	ZAM	–	–
1	WAZ	-1.85 ± 0.31	-2.41 ± 0.25
	HAZ	-1.57 ± 0.57	-2.17 ± 0.37
	WHZ‡	-0.54 ± 0.23	-1.66 ± 0.19
	ZSF†	+0.20 ± 0.42	-0.81 ± 0.28
	ZAM‡	-0.71 ± 0.31	+0.10 ± 0.25
2	WAZ‡	-1.98 ± 0.27	-2.91 ± 0.24
	HAZ	-2.03 ± 0.43	-2.58 ± 0.37
	WHZ	-0.94 ± 0.19	-1.78 ± 0.17
	ZSF	-0.41 ± 0.28	-0.73 ± 0.27
	ZAM	-0.65 ± 0.25	-0.36 ± 0.24
3	WAZ‡	-1.24 ± 0.27	-2.15 ± 0.28
	HAZ	-1.61 ± 0.36	-2.05 ± 0.38
	WHZ§	-0.23 ±0.18	-1.31 ± 0.17
	ZSF§	-0.15 ± 0.30	-0.91 ± 0.27
	ZAM	-0.55 ± 0.25	-0.07 ± 0.28
4	WAZ§	-0.67 ± 0.28	-2.15 ± 0.28
	HAZ‡	-1.44 ± 0.42	-2.59 ± 0.38
	WHZ‡	-0.04 ± 0.19	-0.97 ± 0.17
	ZSF	-0.27 ± 0.33	-0.68 ± 0.31
	ZAM	-0.49 ± 0.28	-0.21 ± 0.28
5	WAZ	-0.82 ± 0.28	-1.41 ± 0.26
	HAZ	-1.56 ± 0.39	-1.23 ± 0.37
	WHZ	-0.06 ± 0.17	-0.42 ± 0.19
	ZSF	-0.40 ± 0.28	-0.51 ± 0.28
	ZAM‡	-0.60 ± 0.28	-0.01 ± 0.25

*** Differences between age and between cohorts are significant at: ‡$P < 0.05$; †$P < 0.01$; §$P < 0.001$.**

4.2.1 Abnormal Anthropometry in the 0-5 age group

Tables 4.4-4.6 show the prevalence (%) of low height-for-age, weight-for-height, and weight-for-age in both cohorts. Abnormal anthropometric values are defined as those below -2 standard deviation or above +2 standard deviation, relative to the reference mean (WHO, 1995). Overall, the prevalence of stunting is more than twice as great in cohort 2 (49% vs. 24%)(Table 4.4). The most obvious difference is seen in the 0-year olds, where the prevalence of stunting has increased quite dramatically from 17% in cohort 1 to 88% in cohort 2. Similarly, patterns of increased stunting are observed for ages 1, 2, and 4.

The prevalence of wasting is very low in both cohorts: only 1% in cohort 1 and 9% in cohort 2 (Table 4.5). Nevertheless, the increase in cohort 2 is quite substantial. Wasting is observed in only 8% of 2-year-olds for cohort 1. However, the situation becomes worse in cohort 2 , where wasting is now observed in 1, 2, and 3-year-olds (with a prevalence rate of 20%, 17%, and 17%, respectively).

Only 10% of the children are underweight in cohort 1, and this number is more than tripled for cohort 2, as 34% of the children now show significant deficits in weight (Table 4.6). For all ages, except 5-year-olds, the prevalence of children who are underweight increases in cohort 2.

Table 4.4. Prevalence (%) of low height-for-age ("stunting") **among children under 6 years in cohorts 1 and 2**

Height-for-Age		
Age	Cohort 1	Cohort 2
0	16.7	87.5
1	20	50
2	30.8	66.7
3	36.8	33.3
4	19	50
5	19.4	14.3

For sample sizes, see table 3.1

Table 4.5. Prevalence(%) of low weight-for-height ("wasting") **among children under 6 years in cohorts 1 and 2**

Weight-for-Height		
Age	Cohort 1	Cohort 2
0	0	0
1	0	20
2	7.7	16.7
3	0	16.7
4	0	0
5	0	0

For sample sizes, see table 3.1

***Table 4.6. Prevalence(%) of low weight-for-age* among children under 6 years in cohorts 1 and 2**

Weight-for-Age		
Age	Cohort 1	Cohort 2
0	0	11.1
1	25	60
2	20	66.7
3	25	33.3
4	4.5	33.3
5	0	0

For sample sizes, see table 3.1

4.3 School-age Children (6-10 years)

Pooled-sex differences. While there is reduction in growth status for height and weight among 6-10-year-old children (in marked contrast to the 0-5 age group), none of these differences are significant (Table 4.7). There is a very slight improvement in z-scores for weight-for-height, but this improvement is not statistically significant. The skinfold measurements in this age group show a significant reduction (-0.52 vs. -0.65; $P < 0.01$), while z-scores for upper-arm muscle area again show a significant improvement (-0.83 vs. -0.58; $P < 0.001$).

Within-sex differences. In this age group, there is very little change in the anthropometric measures of each of the sexes over time. Males in cohort 2 show significantly more muscularity than males in cohort 1. Males in cohort 1 and 2 show no difference in any other anthropometric measure (Figure 4.15). Exactly the same trend is seen in females, except that, in cohort 2, the females have significantly less fat than those in cohort 1 (Figure 4.16).

Between-sex differences. There are no significant differences between the sexes for any of the anthropometric measures for children (6-10 years) in cohort 1 (Figure 4.17). Generally, the same pattern of growth is evident in cohort 2. However, males in this cohort are significantly fatter than the females (Figure 4.18).

Age-related differences. The age-specific z-scores for this group (Table 4.8) reveal that, for the most part, there is very little change in the overall growth status of the varying ages that make up this group. The-six-year olds in this group show a significant decline in linear growth and in overall energy reserves (z-score for sum of skinfolds), while the ten-year-olds show a significant decline in both weight and skinfold measurements. Seven, eight, and nine-year-olds all show significant improvement in musculature.

Table 4.7. Mean z-scores of selected anthropometric measures for the Evenki children (6-10 years) for cohorts 1 and 2.

Children (6-10 years)					
Cohort	WAZ	HAZ	WHZ	ZSF†	ZAM†
1*	-1.19 ± 1.0	-1.58 ± 1.0	-0.11 ± 0.87	-0.52 ± 0.19	-0.83 ● 0.19
2*	-1.38 ± 0.84	-1.79 ± 1.0	-0.08 ● 0.87	-0.65 ± 0.19	-0.58 ● 0.19

* Differences between cohorts significant at: †P <0.01.

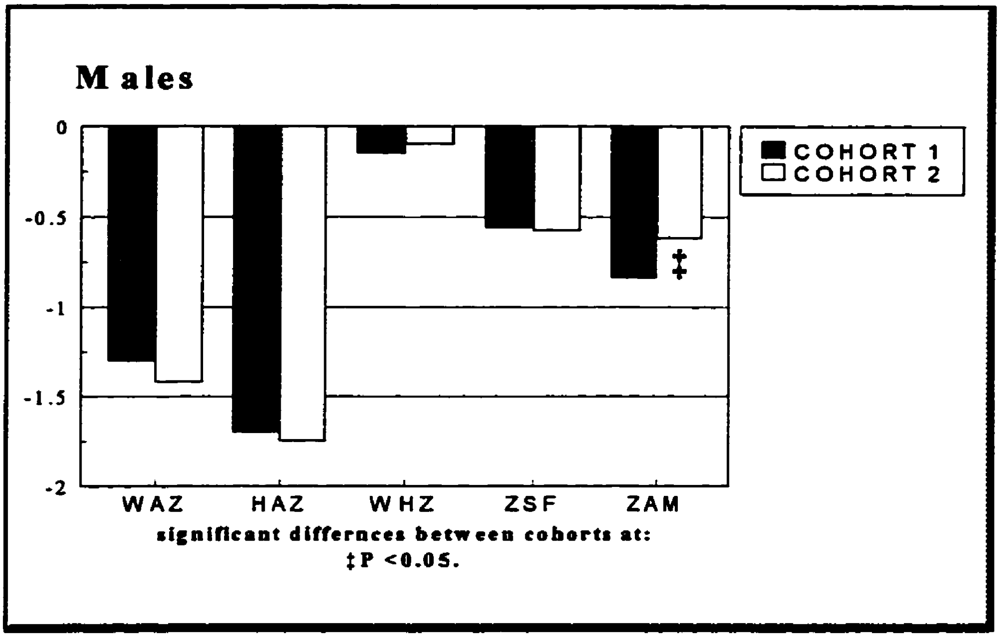

Figure 4.15. Differences between cohorts for anthropometric measures for male children (6-10 years).

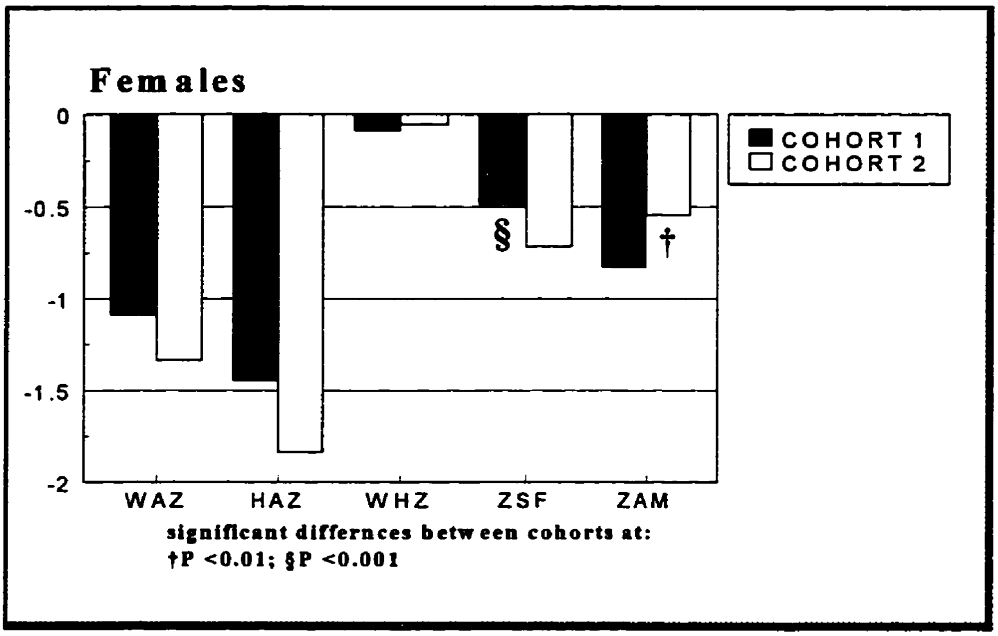

Figure 4.16. Differences between cohorts for anthropometric measures for female children (6-10 years).

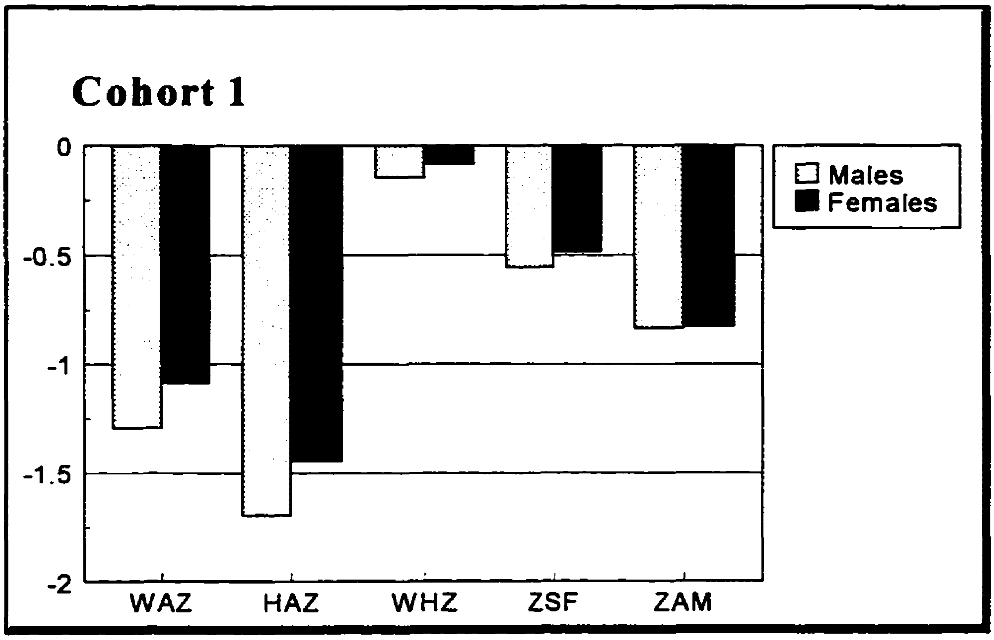

Figure 4.17. Differences between males and females in cohort 1 for children (6-10 years).

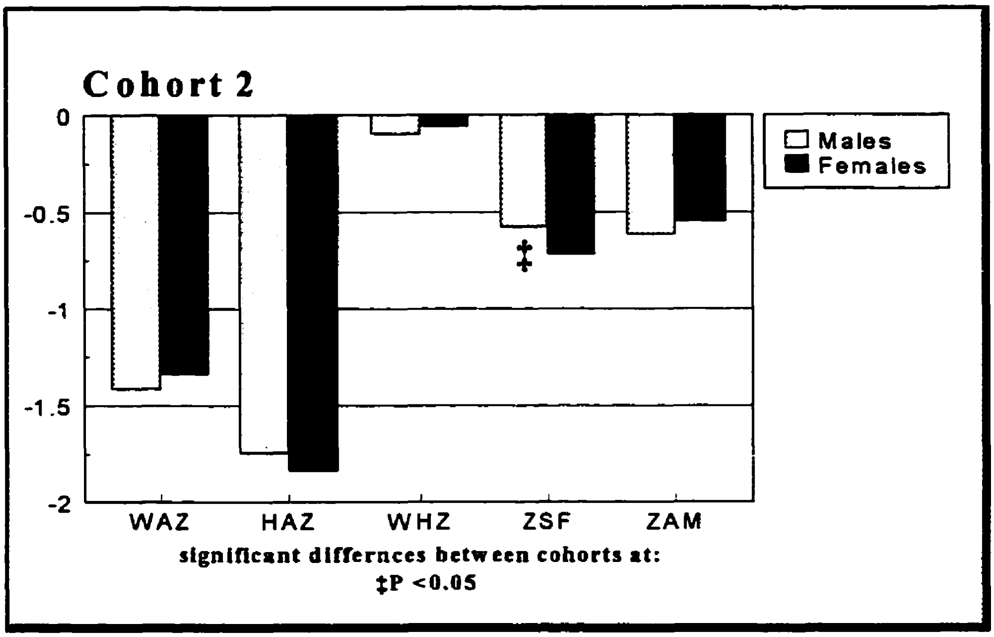

Figure 4.18. Differences between males and females in cohort 2 for children (6-10 years).

Table 4.8. Age-specific differences for all anthropometric variables between cohorts 1 and 2.

Children (6-10 years)			
AGE*	MEASURE	COHORT 1	COHORT 2
6	WAZ	-0.94 ± 0.78	-1.58 ± 0.80
	HAZ†	-1.40 ± 0.98	-2.29 ± 0.89
	WHZ	-0.06 ± 0.88	-0.18 ± 0.89
	ZSF‡	-0.40 ± 0.20	-0.64 ± 0.22
	ZAM	-0.69 ± 0.15	-0.59 ± 0.13
7	WAZ	-1.41 ± 0.76	-0.96 ± 0.78
	HAZ	-1.72 ± 1.0	-1.41 ± 0.99
	WHZ	-0.07 ± 0.88	-0.04 ± 0.91
	ZSF	-0.51 ● 0.23	-0.67 ± 0.21
	ZAM‡	-0.71 ± 0.15	-0.21 ± 0.16
8	WAZ	-1.13 ± 0.78	-1.07 ± 0.81
	HAZ	-1.50 ± 0.82	-1.65 ± 1.0
	WHZ	-0.10 ± 0.87	+0.25 ± 0.89
	ZSF	-0.51 ± 0.21	-0.47 ± 0.21
	ZAM	-0.80 ± 0.16	-0.48 ± 0.17
9	WAZ	-1.51 ± 0.78	-1.50 ± 0.80
	HAZ	-1.84 ± 0.96	-1.69 ± 1.0
	WHZ	-0.24 ± 0.87	-0.35 ± 0.89
	ZSF	-0.65 ± 0.21	-0.60 ± 0.22
	ZAM‡	-1.13 ± 0.17	-0.81 ± 0.18
10	WAZ‡	-0.99 ± 0.79	-1.79 ± 0.80
	HAZ	-1.42 ± 1.0	-1.92 ± 1.1
	WHZ	–	–
	ZSF†	-0.53 ± 0.21	-0.84 ± 0.21
	ZAM	-0.80 ± 0.14	-0.79 ± 0.17

* Differences between ages and between cohorts are significant at: ‡P <0.05; †P <0.01; §P <0.001.

4.4 Adolescence (11-17 years)

Pooled-sex differences. Table 4.9 shows that there are no significant changes in overall growth status for this group, as there are no significant changes in any of the anthropometric variables.

Within-sex differences. This set of analyses reveals that there is very little change in the anthropometric status of male adolescents over time, as there are no significant changes in any of the anthropometric variables (Figure 4.19). Adolescent females, however, in cohort 2, are both significantly taller and more muscular than they are in cohort 1 (Figure 4.20).

Between-sex differences. Adolescent females in cohort 1 are significantly heavier in body weight , but they are also significantly more muscular than their male peers, relative to the U.S. norms (Figure 4.21). These females are also fatter and taller than their male counterparts, but these differences are not significant. Exactly the same results are seen in cohort 2 (Figure 4.22).

Table 4.9. Mean z-scores of selected anthropometric measures for the Evenki children (11-17 years) for cohorts 1 and 2.

Children (11-17 years)				
Cohort	WAZ	HAZ	ZSF	ZAM‡
1*	-1.78 ± 0.98	-2.36 ± 1.1	-0.52 ± 0.30	-1.30 ± 0.69
2*	-1.58 ± 1.1	-1.99 ± 1.3	-0.60 ± 0.30	-0.97 ± 0.79

* Differences between cohorts significant at: ‡P <0.05.

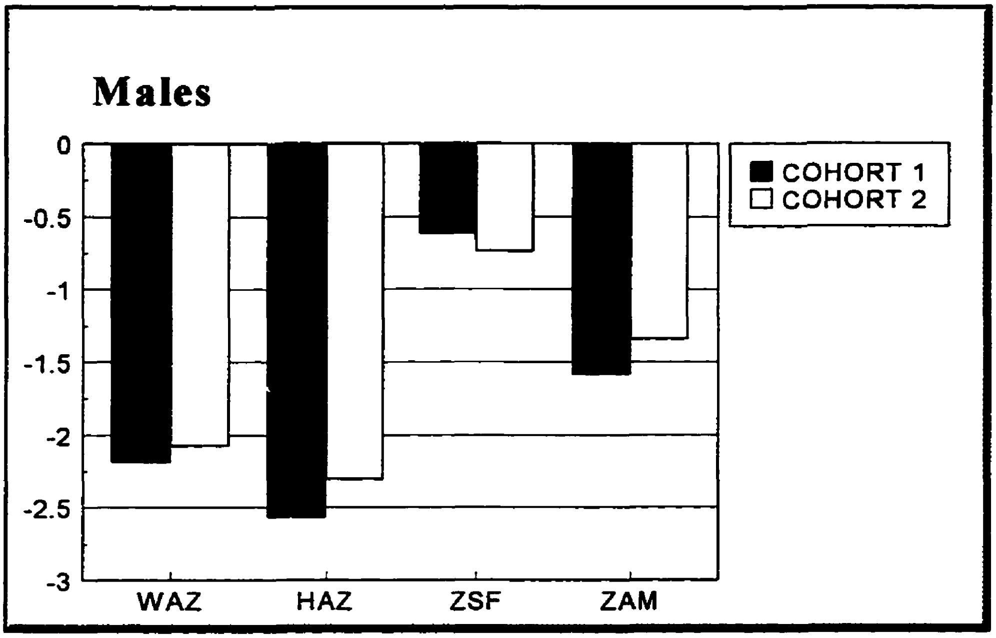

Figure 4.19. Differences between cohorts for anthropometric measures for male adolescents (11-17 years).

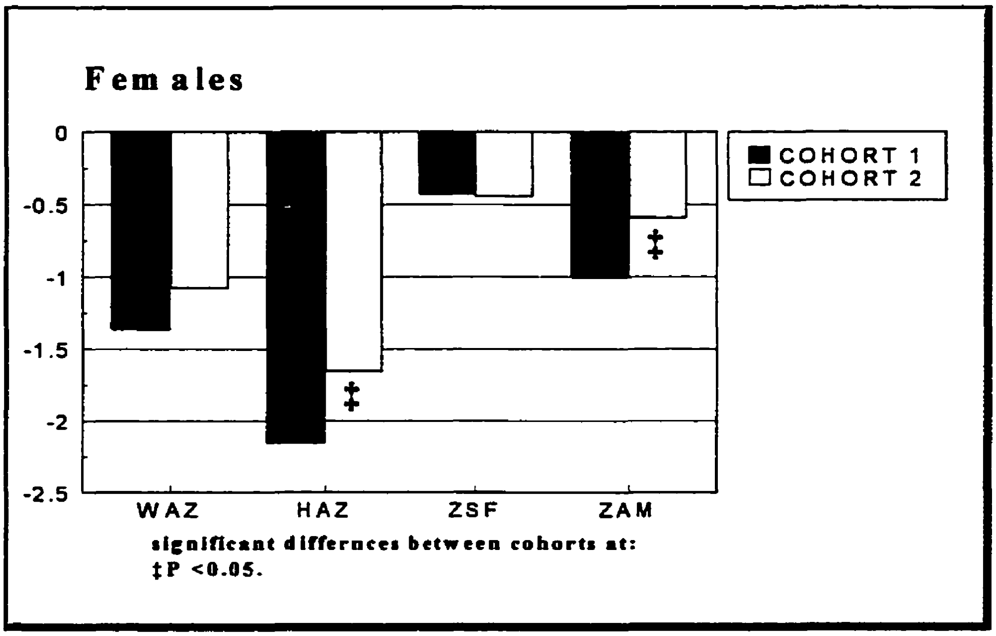

Figure 4.20. Differences between cohorts for anthropometric measures for female adolescents (11-17 years).

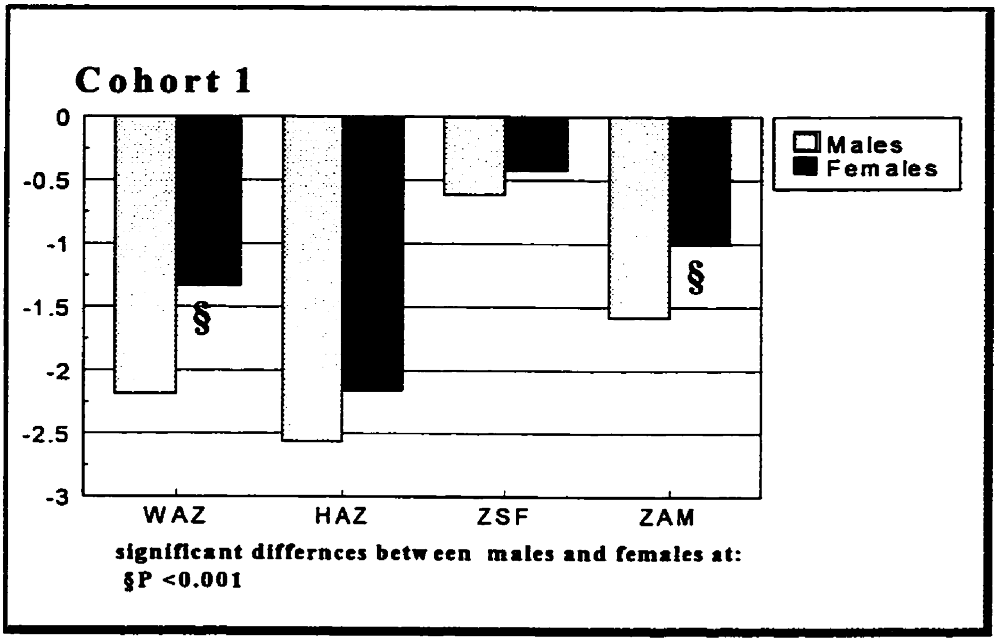

Figure 4.21. Differences between males and females in cohort 1 for adolescents (11-17 years).

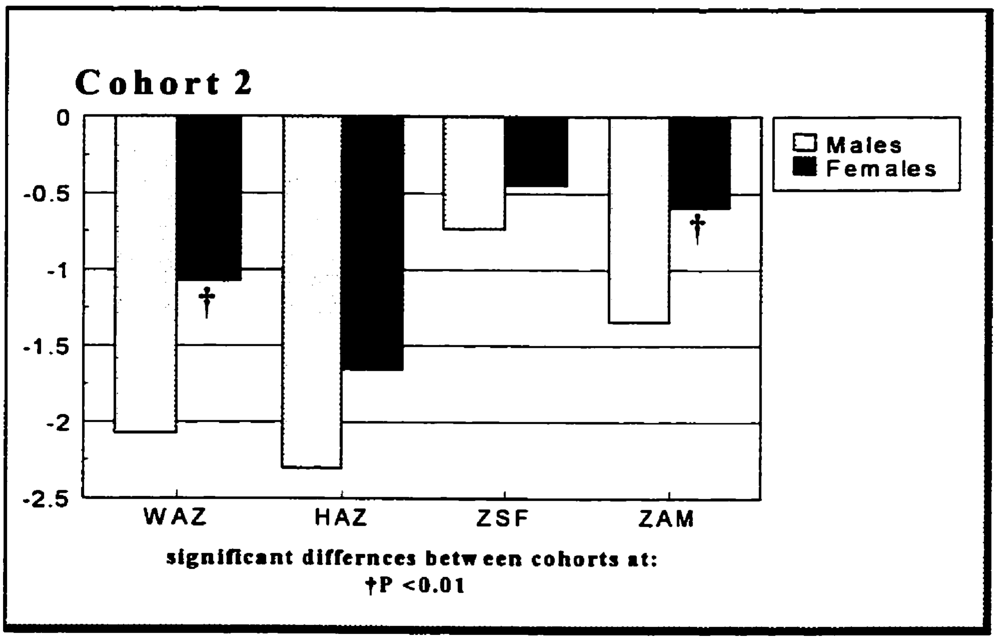

Figure 4.22. Differences between males and females in cohort 2 for adolescents (11-17 years).

4.5 Sex Differences

Differences between male and females z-scores in each cohort are shown for the three age groups in figures 4.23-4.25. For infants and preschool children (0-5 years), the male vs. female differences are greater in cohort 2 for weight-for-height, sum of skinfolds, and upper arm muscle area. This suggests that the nutritional status of these infants and children is poorer, at least, for these anthropometric measures in the 1995 cohort (Figure 4.23).

There is very little change in the male vs. female differences in either of the cohorts for children between the ages of 6 and 10 years (Figure 4.24). The magnitude of the male vs. female differences in this age group is very small, when compared to the other two groups. In this group of children the range of the differences is 0.2 to 0.25 SD units, while that for the youngest group is 0.18 to 0.67 SD units. The range for the adolescents is 0.2 to 1 SD units.

In the latter, the mean differences between males and females are largest for all the anthropometric measures in cohort 2. The greatest difference between the sexes is observed for weight-for-age, while the least amount of difference is observed for sum of skinfolds (Figure 4.25). In general, the results suggest that adolescents in 1995 have much poorer measures of nutritional status than their counterparts in the 1991/1992 cohort.

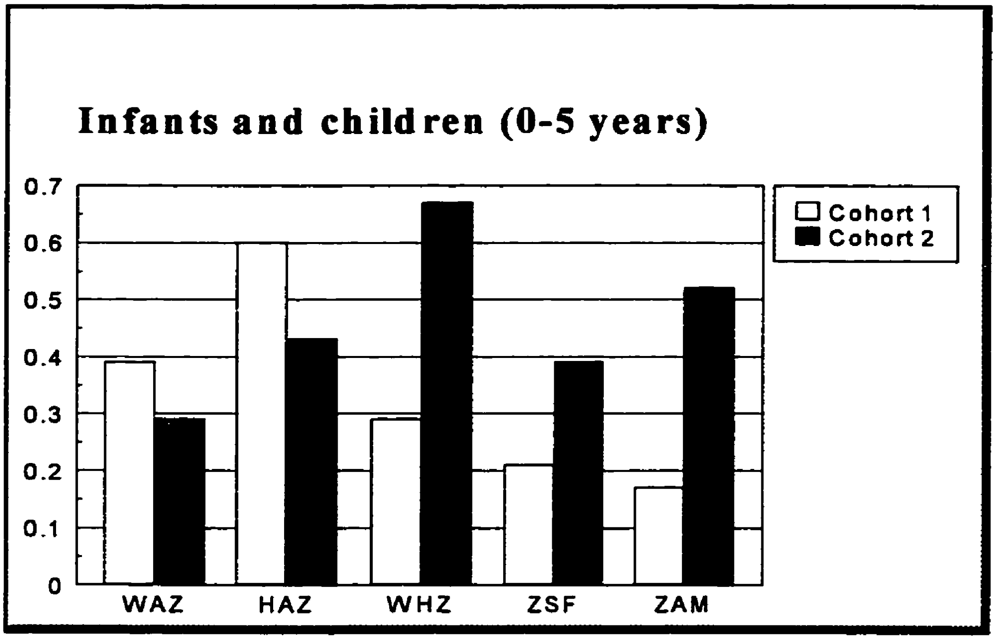

Figure 4.23. Differences between male and female mean z-scores in each cohort for infants and children (0-5 years).

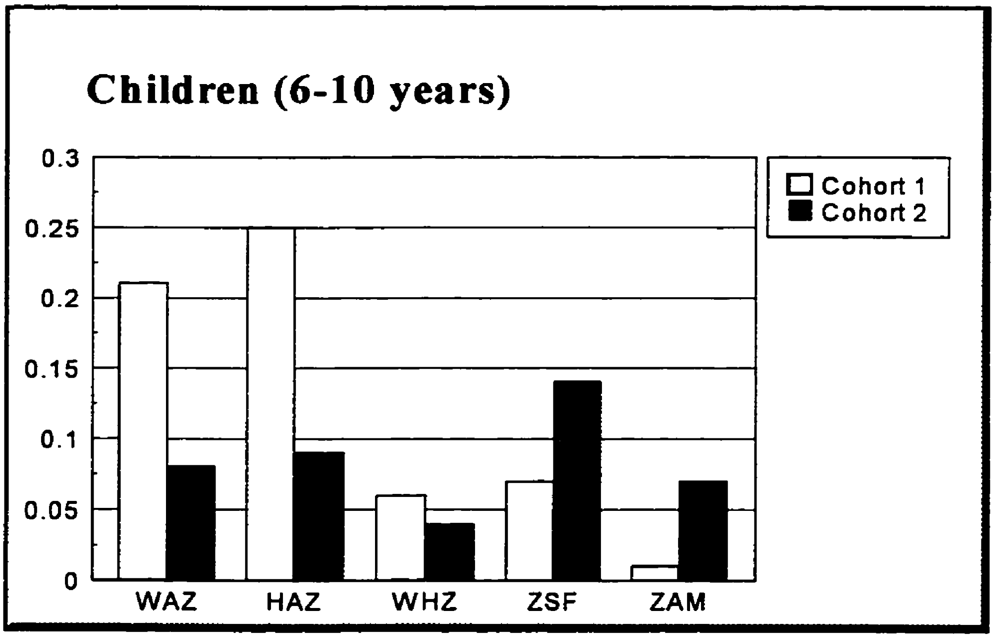

Figure 4.24. Differences between male and female mean z-scores in each cohort for children (6-10 years).

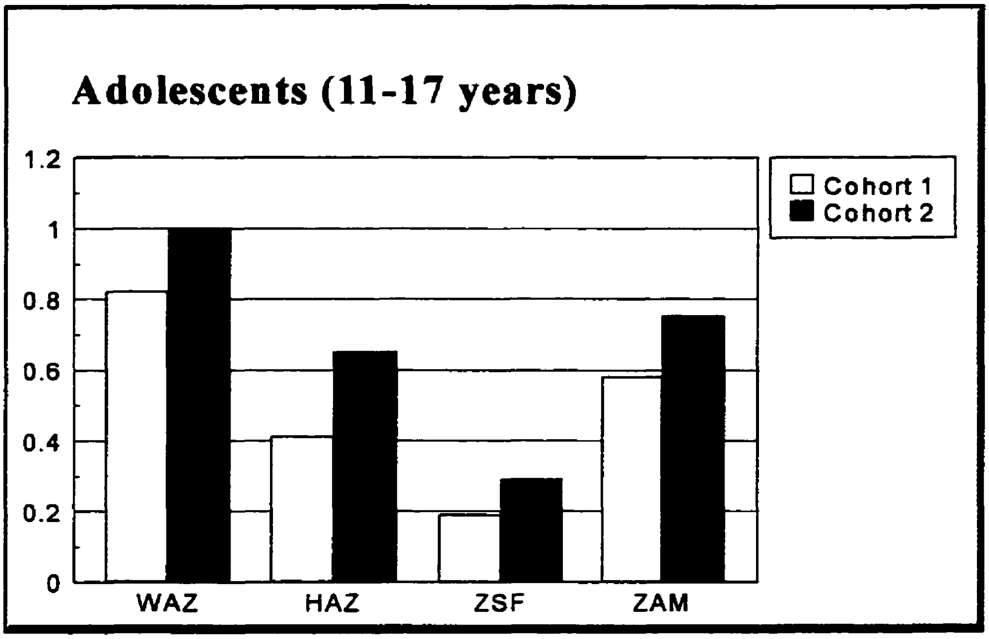

Figure 4.25. Differences between male and female mean z-scores in each cohort for adolescents (11-17 years).

4.6 Location Differences

Separate factorial analyses were done on each of the three age groups to determine how location might have affected the growth status of Evenki children and adolescents. Location is not a factor for any of the anthropometric variables in either the 0-5 age group or the 6-10 age group. In the 11-17 age group, location is significant only in the model for sum of skinfolds. Individuals in the brigades are likely to be significantly more compromised in energy reserves than their peers in Surinda, as is indicated by the lower z-scores for sum of skinfolds in the former (-0.58 [Surinda] vs. -0.83 [Brigades]; $P < 0.05$). There is also a three-way interaction involving cohort, sex, and location. Here, it was found that females in the brigades are significantly more compromised in cohort 2 than are the females from the brigades in cohort 1 (-0.40 [cohort 1] vs. -0.90 [cohort 2]; $P < 0.0001$). These same females in cohort 2 from the brigades are also significantly more compromised than their peers in Surinda, also from cohort 2 (-0.25 [Surinda] vs. -0.90 [Brigades]; $P < 0.001$). Overall, the nutritional status of individuals from Surinda are worse than the individuals from the brigades. This compromised nutritional status is seen in both cohorts (Figure 4.26). This compromised growth appears to have worsened in 1995, as is evident from weight-for-age, sum of skinfolds, and upper arm muscle area.

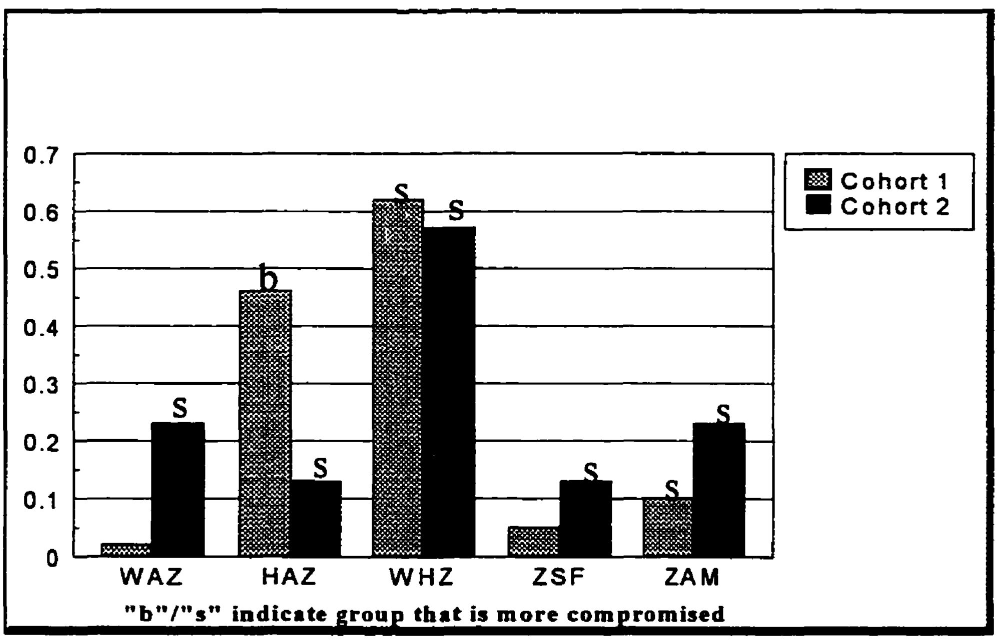

Figure 4.26. Mean z-score differences between individuals from Surinda and the brigades in each cohort.

4.7 Comparison to Other High-Latitude Populations Outside of Siberia

The Evenki are also small in both body weight and stature compared to other high-latitude populations. Up until the 5th year of life, Evenki males are similar in stature to the Alaskan Eskimo, Inuit from the Foxe Basin region of Canada, and the Lapps of Finland. However, after age 5, they lag behind all three groups (Figure 4.27). Statural growth in Evenki female children appears to be much better than that of the male children, relative to other high-latitude populations. As Figure 4.28 shows, Foxe Basin Eskimo, for the most part, lag behind all the other groups, including the Evenki. It is not until late adolescence that the Evenki females start to fall behind all three groups. Overall, the Alaskan Eskimo children, both males and females alike, appear to be the tallest of all three groups.

Table 4.10 shows mean z-scores of stature and weight for the Evenki children and adolescents (1-17 years), standardized against all three high-latitude groups. Both Evenki males and females are significantly shorter than their Alaskan peers, with the Evenki group being approximately 0.7 SD units away from the Alaskan group. The linear growth of the Evenki is also significantly more compromised than that of the Finnish sample, but this is not as severe a difference as it is with the Alaskan sample. Overall, the Evenki are relatively similar in stature to that of the Foxe Basin Inuit children.

The data from the Alaskan Eskimo, the Inuit, and the Finnish Lapps were collected in the 1960s and the early 1970s. It is possible that, like the Evenki, these groups have experienced increases in statural growth over the past thirty years.

Thus, it is quite possible that their small stature is exaggerated in the graphs that are presented here. Consequently, the Evenki may very well show more compromised growth (relative to these groups) than that which is depicted in figures 4.27 and 4.28.

As children and adolescents, the Evenki are lighter in body weight than all three groups (Figures 4.29 and 4.30). Both males and females show significant compromised growth in body weight, compared to all three groups (Table 4.10). Again, the compromised body weight is most severe when compared to the Alaskan group (-1.66 for males and -1.45 for females), and it is least severe relative to the Finnish sample (-0.61 for males and -0.42 for females). Evenki boys are lighter than their Foxe Basin peers by 1.25 SD units, while the females are approximately 0.9 SD units lighter than their female peers.

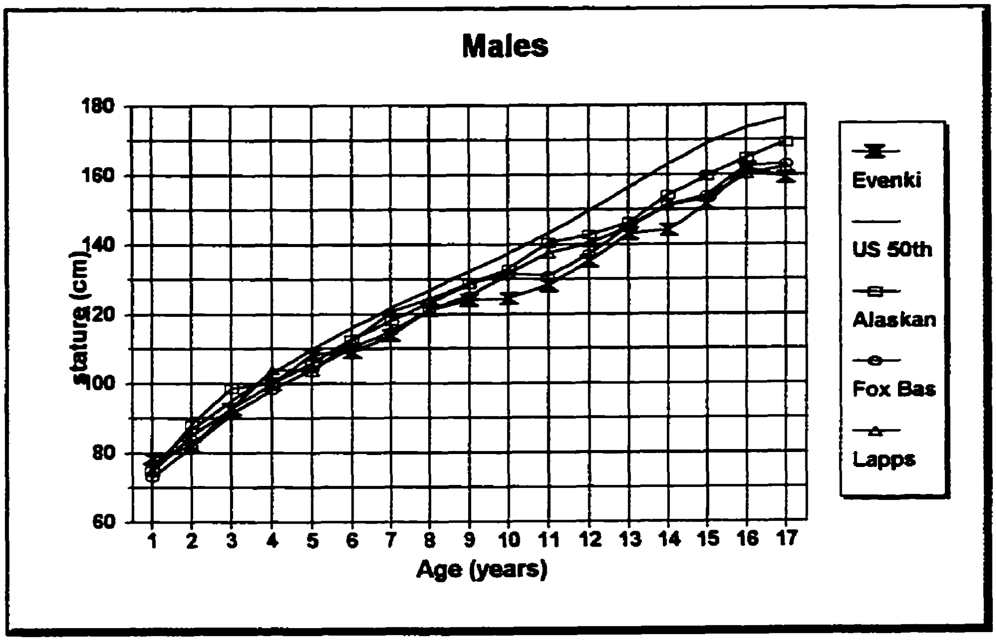

Figure 4.27. Comparison of linear growth in males of four indigenous high-latitude populations: the Evenki, Alaskan Eskimo, Foxe Basin Canadian Inuit, and Finnish Lapps. Comparative data taken from Auger et al. (1980).

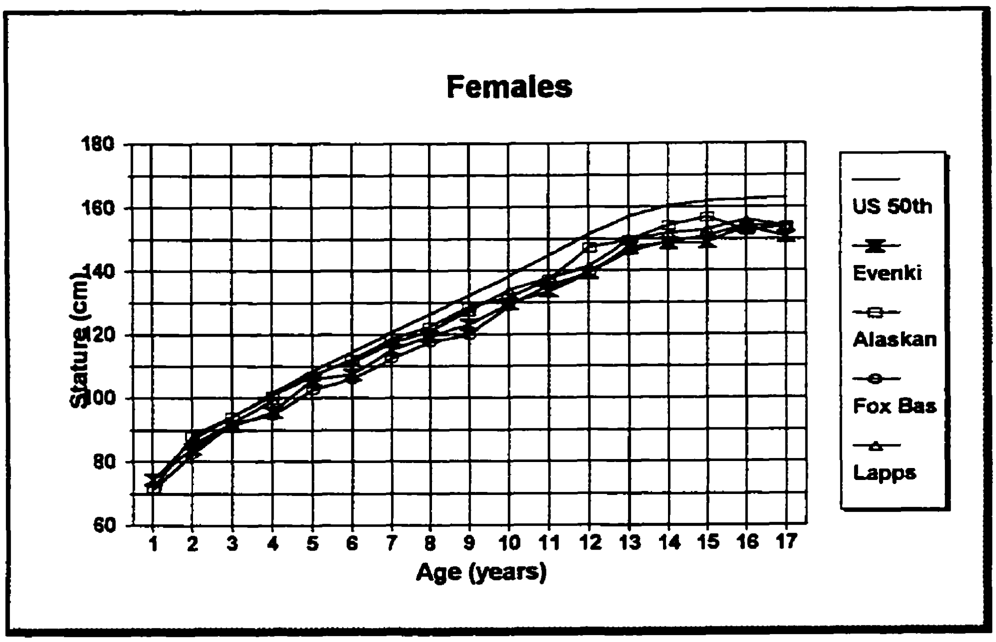

Figure 4.28. Comparison of linear growth in females of four indigenous high-latitude populations: the Evenki, Alaskan Eskimo, Foxe Basin Canadian Inuit, and Finnish Lapps. Comparative data taken from Auger et al. (1980).

Table 4.10. Mean z-scores of stature and weight for Evenki children (1-17 years) standardized relative to comparative data for the Alaskan Eskimo, Foxe Basin Inuit, and Finnish Lapps[1]

	Males (n=187)*				Females (n=244)*			
	Stature		**Weight**		**Stature**		**Weight**	
Comparative group	Z	SD	Z	SD	Z	SD	Z	SD
Alaskan Eskimo	-0.75§	1.69	-1.66§	1.49	-0.72§	1.54	-1.45§	1.07
Foxe Basin Inuit	-0.07	1.98	-1.25§	1.73	+0.33§	1.43	-0.91§	1.20
Finnish Lapps	-0.37†	1.91	-0.61§	1.58	-0.47§	1.43	-0.42§	1.29

[1]Comparative data taken from Auger et al. (1980)

*differences between the Evenki and the comparative sample are significant at: †P <0.01; §P <0.001.

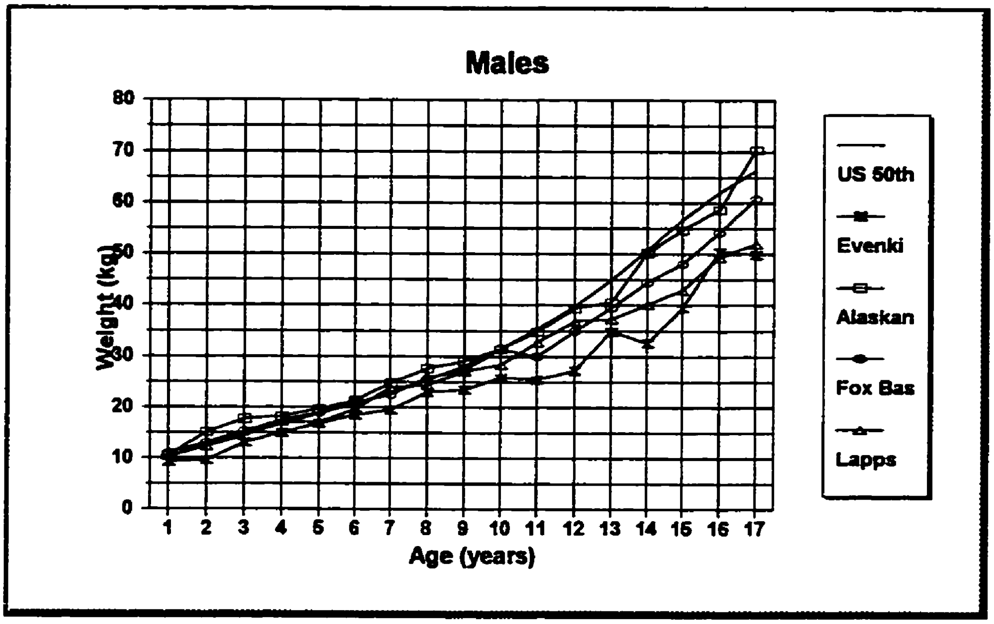

Figure 4.29. Comparison of growth in body weight in males of four indigenous high-latitude populations: the Evenki, Alaskan Eskimo, Foxe Basin Canadian Inuit, and Finnish Lapps. Comparative data taken from Auger et al.. (1980).

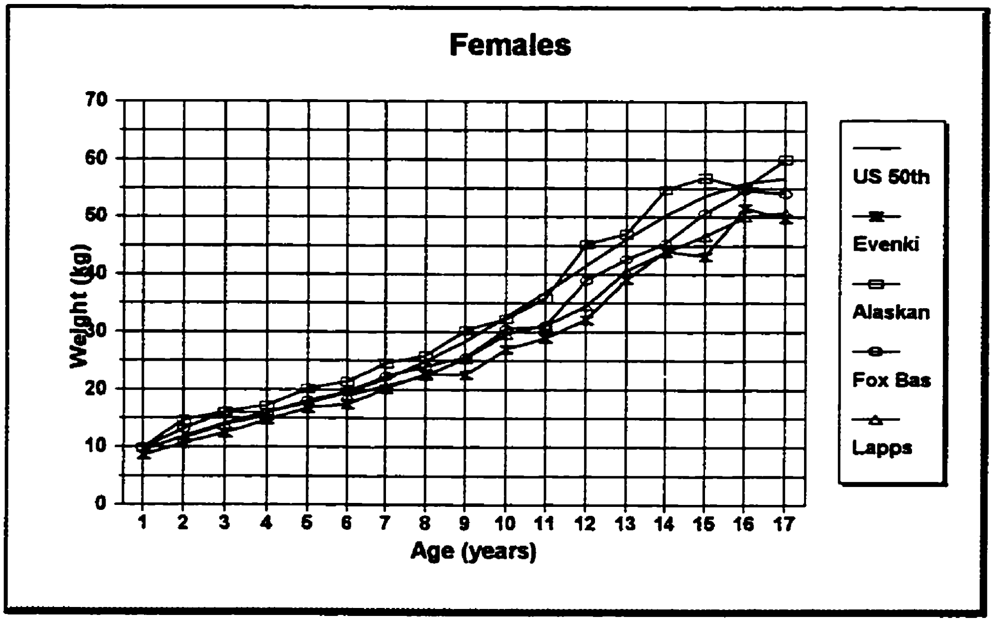

Figure 4.30. Comparison of growth in body weight in females of four indigenous high-latitude populations: the Evenki, Alaskan Eskimo, Foxe Basin Canadian Inuit, and Finnish Lapps. Comparative data taken from Auger et al.. (1980).

4.8 Comparison to a Russian Sample Living in Siberia and Another Indigenous Siberian Group

The Evenki children between ages 7 and 14 are substantially shorter and lighter than the Russian sample (Figures 4.31-4.33). In this subsample of Evenki children, males average more than 1 SD unit below their Russian peers for both stature and weight. The Evenki females in this subsample fare much better, as they average 0.8 SD units below the average Russian stature and 0.5 SD units below the average Russian weight (Table 4.11).

When the Evenki are compared to another Siberian indigenous group (the Nanai), the poor growth status of the Evenki males is accentuated. While the females very closely track their female Nanai peers for stature, and in some cases surpass Nanai females (Figure 4.32), the Evenki males track their peers less closely and at no point surpass the Nanai males in statural growth (Figure 4.31). This relationship is highlighted when the Evenki children are standardized against the Nanai children. The males are 0.3 SD units below their Nanai counterparts, while the females are almost equal to the Nanai females in their statural growth, being only 0.07 SD units lower.

Evenki males between the ages of 7 and 10 are very similar in body weight to their Nanai peers, but after this point, the Evenki males show a substantial decline in body weight in early adolescence (Figure 4.33). Females show a much different pattern when their body weight is compared to that of their Nanai counterparts. For the most part, Evenki females track very closely, showing a tendency to surpass their Nanai peers in early adolescence (Figure 4.34). On average, the Evenki males are about 0.5 SD units below their Nanai peers, while the females are very similar to their peers, being only 0.28 SD units below the Nanai (Table 4.11).

Table 4.11. Mean z-scores of stature and weight for Evenki children (7-14 years) standardized relative to comparative data for a Russian sample and a Siberian indigenous group[1]

	Males (n=89)*				Females (n=112)*			
	Stature		**Weight**		**Stature**		**Weight**	
Comparative group	Z	SD	Z	SD	Z	SD	Z	SD
Russian sample	-1.03§	1.41	-1.01§	1.31	-0.76§	0.79	-0.53§	0.67
Nanai sample	-0.32‡	1.40	-0.52§	1.11	-0.07	1.08	-0.28§	0.87

[1]Comparative data taken from Ostroushko et al. (1990)
*differences between the Evenki and the comparative sample are significant at: ‡P <0.05; †P <0.01; §P <0.001.

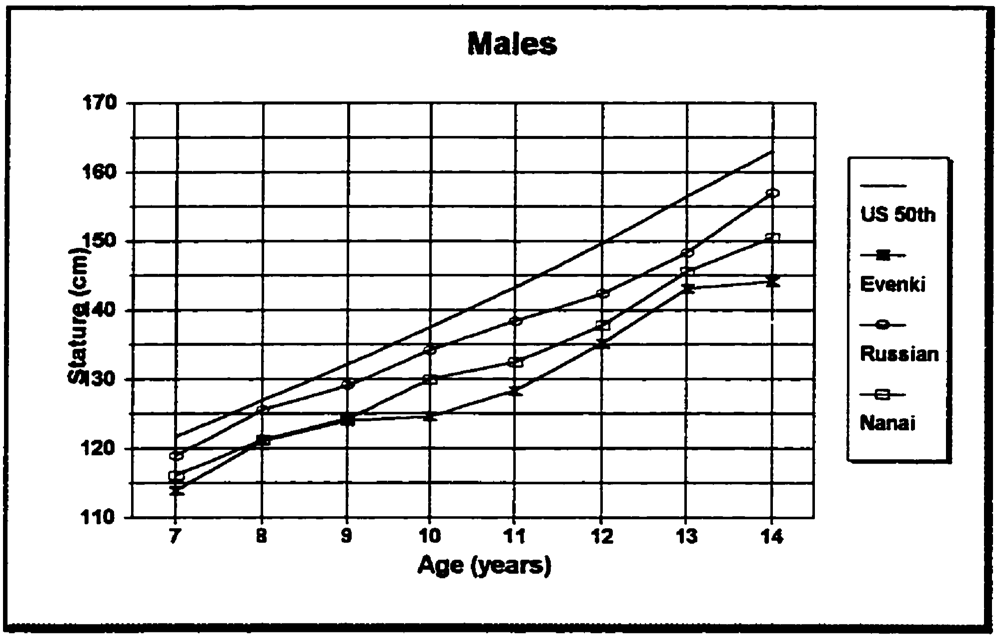

Figure 4.31. Comparison of linear growth in Evenki males (7-14 years) to that of another Siberian indigenous group and a Russian sample. Comparative data taken from Ostroushko et al. (1990).

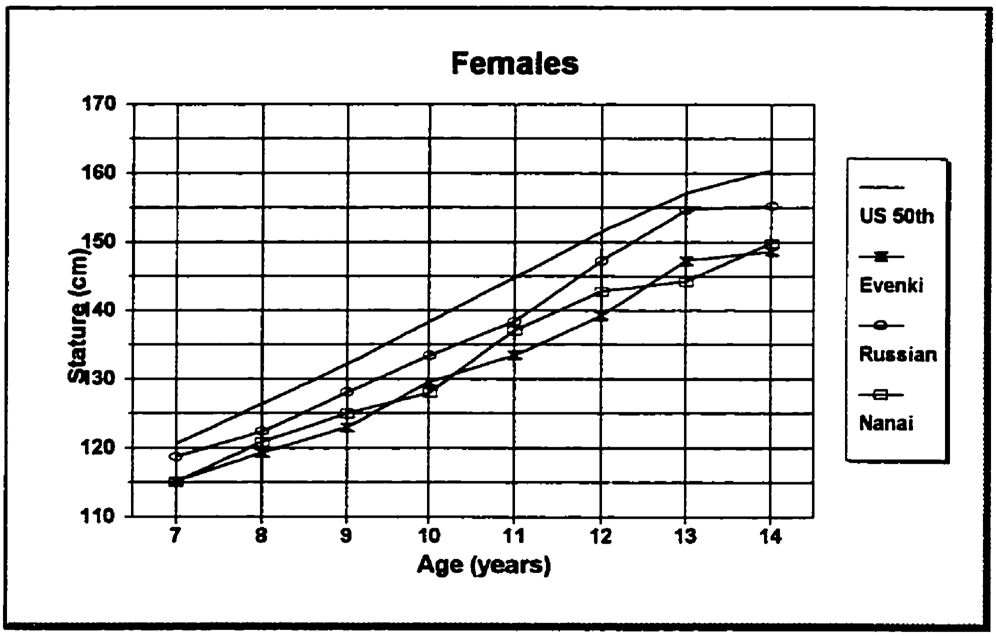

Figure 4.32. Comparison of linear growth in Evenki females (7-14 years) to that of another Siberian indigenous group and a Russian sample. Comparative data taken from Ostroushko et al. (1990).

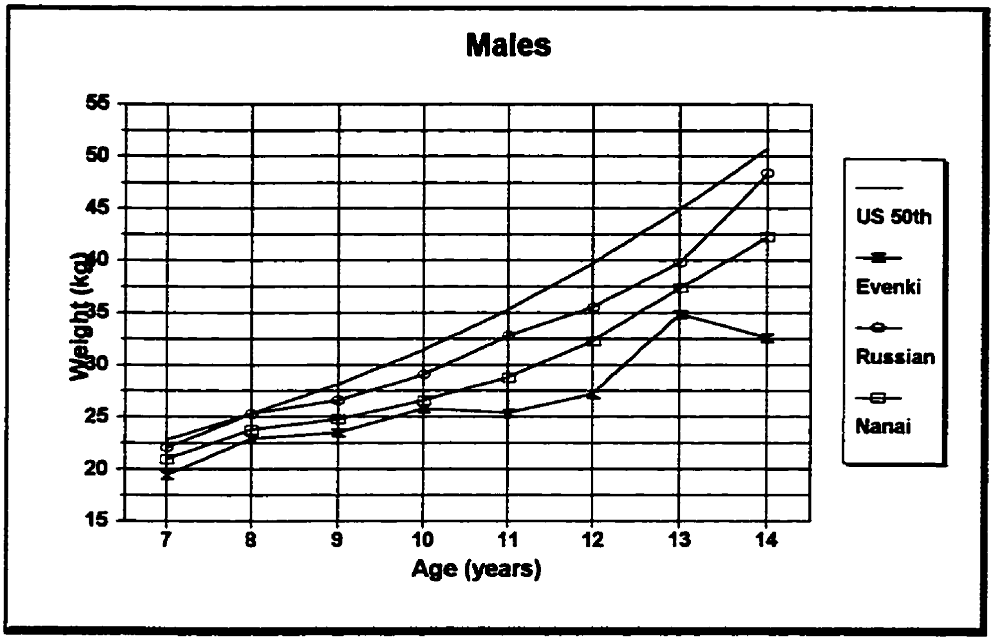

Figure 4.33. Comparison of growth in body weight for Evenki males (7-14 years) to that of another Siberian indigenous group and a Russian sample. Comparative data taken from Ostroushko et al. (1990).

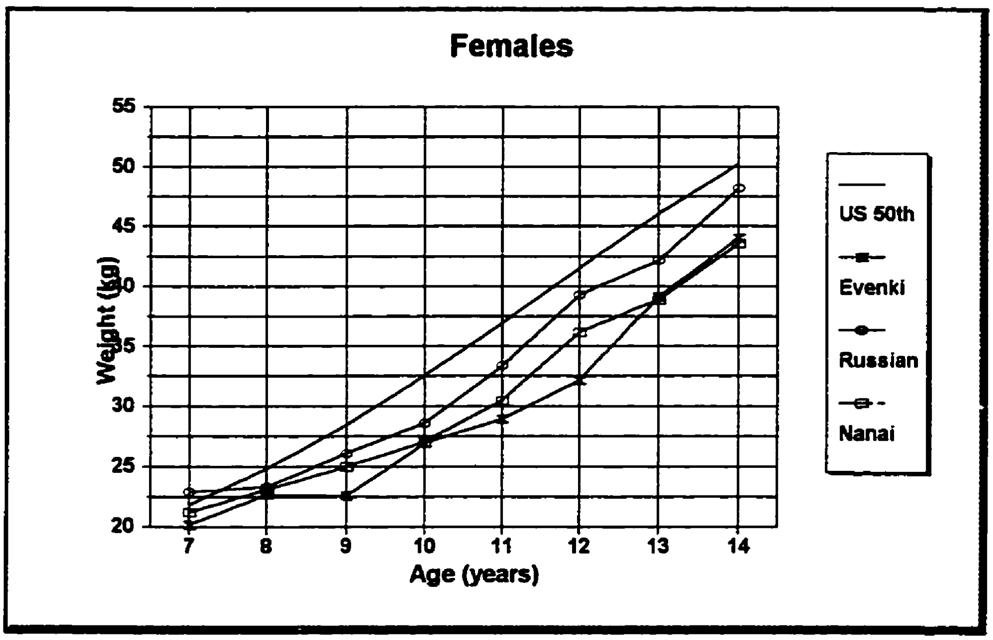

Figure 4.34. Comparison of growth in body weight for Evenki females (7-14 years) to that of another Siberian indigenous group and a Russian sample. Comparative data taken from Ostroushko et al. (1990).

Chapter 5: Discussion

5.1 Patterns of Physical Growth Among The Evenki

The Evenki are small in stature and body weight. Their diminutive size is most pronounced during adolescence, since both males and females in this group consistently fall below the U.S. 5th percentile for stature. The body weight of adolescent males tends also to track very closely to the U.S. 5th percentile. Although the females are also lighter in body weight, they show better profiles than their male counterparts, as they consistently fall above the U.S. 5th percentile.

Similar patterns of slow growth have been consistently reported for other circumpolar groups. Shephard and Rode (1995 and 1996) compared Inuit children (from an Igloolik community in the Baffin island region) 5 - 20 years of age to the NCHS norms. These authors found that the males consistently tracked the U.S. 10th percentile up to the age of 15, and fall below thereafter. However, they found that the Igloolik females consistently tracked the U.S. 10th percentile. Despite their short stature, these Inuit children had better growth in body weight, as they were close to the 50th percentile. Zammit et al. (1993) examined 100 Labrador Inuit youth 5-18 years and also compared them to the NCHS norms. They found that the height of the Labrador Inuit males tracked very closely to the U.S. 10th percentile, while females fell between the 10th and 50th percentiles of the U.S. norms, until about age 12, from which point they tracked closely to the U.S. 10th percentile. Better growth in body weight (compared to stature) was also evident in these Labrador Inuit children, as both males and females fell between the U.S. 50^{th} and 75^{th} percentiles. As observed in the Evenki, the more pronounced slow growth during the adolescent years is also apparent in both the Igloolik and Labrador samples.

Compared to other circumpolar groups, the Evenki also appear to be small. The data presented here show that both the adolescent boys and girls are smaller in stature than the Alaskan Inuit, the Inuit of the Foxe Basin region of Canada, and the Lapps of Finland. At all ages, the Evenki boys and girls are also consistently lighter than their peers in all three groups. Even when they are compared to another indigenous Siberian group, the Evenki are both smaller and lighter.

Why are the children and adolescents of the Evenki (and those from other circumpolar regions as well) so short? It has been argued that the Asian heritage of many indigenous populations is the reason why individuals from these populations appear to be small, relative to the U.S. norms. Indeed, in Eveleth and Tanner's (1990) *Worldwide Variation in Human Growth*, Asiatics are reported as being smaller and lighter than Europeans. These authors note that *the term Asiatics* refers to the groups of people originating from the Far East, of which the Arctic Inuit are included. Recently, Leonard et al. (1994 and 1996) have suggested that the energy demands that result from being exposed to the stresses of a high-latitude ecosystem might be responsible for the compromised physical growth of the Evenki (and hence, of other circumpolar populations). The high levels of resting and the total energy expenditure of the Evenki possibly restrict the amount of energy and nutrients that can be allocated to growth, and that perhaps their small body size is not the result of limited food availability (Leonard et al., 1996).

The dramatic compromised growth that has been observed between 1991/1992 and 1995 shows the strong influence of environmental factors on the physical growth status of the Evenki. This evidence suggests that, during the last three years, nutrition, health, and other social and economic variables have played primary role in shaping the growth of the Evenki children and adolescents. However, one can certainly envision seasonal energy imbalances playing a secondary role that will no doubt serve to exacerbate the impact of compromised nutritional status and declining health on overall physical growth. Anthropometric data on the Evenki has provided some evidence of improved nutritional status (since collectivization started in the 1930s), as a secular trend in stature was observed among adult males (Leonard et al., 1996). These results indicate that present conditions in Russia and Siberia are not conducive to an increasing secular trend in stature. In fact, as will be shown in the subsequent discussion, the results that are presented here suggest that, if conditions remain the same for the Evenki, the positive secular trend that has been observed since the 1930s will be reversed.

5.2 Age-related Differences in Anthropometric Measures of Nutritional Status

Age differences in children's growth status are quite notable in the present samples. Changes in the anthropometric measures of nutritional status between 1991/1992 and 1995 show that, as a group, the physical status of the youngest children (0 - 5 years) is demonstrably worse than that of the other two groups. The data suggest significant deterioration in the overall nutritional status (height-for-age, weight-for-age, weight-for-height, and z-scores for sum of skinfolds). Together, these results indicate that, in 1995, Evenki children are more likely to show signs of long-term malnutrition and poor health (height-for-age), signs of being wasted and/or stunted (weight-for-age), signs of being wasted, due to recent deficits in current nutritional status (weight-for-height), and deficits in energy reserves (z-score for sum of skinfolds) (Gibson, 1990). In contrast, older children (6 - 10 years) only show deficits in energy reserves, while the adolescents show no deficits in nutritional status. Ironically (especially for the youngest group), all three groups showed improvement in protein nutritional status, as indicated by z-scores for the arm-muscle area.

These dramatic changes in the nutritional status of infants and young children are further highlighted by the increased prevalence of stunting and wasting among these children. Stunting, as indicated by height-for-age z-scores < -2 SD units, more than doubled in prevalence, from 24.2% in the 1991/1992 cohort to 49.1% in the 1995 cohort. Similarly, wasting is almost non-existent in the first cohort (1%), but its prevalence increases to 9% in the second cohort. While stunting is present among all ages within the 0 - 5 age group, wasting is only present among 1, 2, and 3-year-olds in the 1995 cohort. The highest prevalence of stunting in the 1995 cohort is seen among 0 year olds, at approximately 90%.

The prevalence of stunting increases with age, rising from about 10% below age 1 to as high as 70% between 2 and 3 years. The two most common causes of stunting are malnutrition (or insufficient food intake) and continued and repeated infections, especially of the gastrointestinal tract (Keller, 1988; Nabarro et al., 1988). Wasting is normally most common during the second year of life, just at about the time when weaning begins. In terms of wasting, the results from the Evenki infants and younger children concur to some degree with the latter point. However, the results for stunting do not agree with the literature, which claims that stunting should peak at about 3 years of age. As was mentioned above, the Evenki results show the highest prevalence at age 0 years. The youngest 0-year-old is 5 months, and the oldest is 11 months. This dramatic decline in the length of 0-year-olds in cohort 2, as compared to those of cohort 1, suggests that they may have had longer exposure to malnutrition, perhaps beginning in *utero*. As well, it might be that mothers have changed their feeding behavior; for example, they may be feeding infants less than they did in the past. It should also be pointed out that this high prevalence of stunting for 0-year-olds might be an artifact of a very small sample size.

Unfortunately, dietary data are not available for subadults in this population. Dietary analyses on selected Evenki adults reveal that the Evenki have more than adequate caloric and protein intakes, at least during the late summer months. Using standard 24-hour recalls, it was estimated that the mean daily intake in adults was approximately 2650 Kcal/day in males and 2,800 Kcal/day in females. These values suggest that Evenki males achieve 106% of their energy needs, while females only achieve 135% (relative to predictive levels of energy expenditure).

However, at this juncture, I would add two caveats. A diet that is adequate for energy and protein is not necessarily entirely adequate as a diet. Many other nutrients have an influence on growth and development, such as iodine, iron, copper, vitamin D, vitamin C, and manganese, to name only a few (Golden, 1988; Malina, 1987). In fact, in his investigation of dietary adequacy and its relationship to anthropometric status in a highland Equadorian community, Berti (1996) found that, although energy and protein were distributed equitably within households, in the younger group (0-10 years) there was a higher prevalence of inadequacy of zinc, vitamin A, and vitamin B-12. Second, even if the diet were quite adequate, information taken from a dietary analysis that was conducted on adults is certainly not representative of the diet of the subadults within the same population. There are clear processes connected to demographic factors within populations that dictate the differential flow of energy among individuals. For example, Payne (1985) notes that in a longitudinal study of food allocation in a Bangladeshi village, the effects of seasonal fluctuations in food supply are reflected in changes in consumption among individual members of families, with evidence of regular hungry seasons. He notes that young children also suffer a reduction in intake during such seasons. In their study of intra-household food distribution among Guatemalan families, Engle and Nieves (1993) observed food distribution patterns which favored adults. They found that male and female heads of households received a relatively higher proportion of the family's protein and calories.

With these caveats in mind, to what extent can we generalize from information about adult diet to reach a conclusion on the diet of the subadults? In general, it can be concluded that the nutritional status of younger Evenki children is probably extremely compromised, while that of the older children and subadults is sub-optimal. Both Evenki men and women exceed their daily energy requirements (by 6% for men and 35% for women). However, if Evenki subadults have a suboptimal diet relative to the adults, perhaps the high energy cost that is needed for growth would be enough to push them into a negative energy balance, thus compromising growth.

The increase in protein reserves for all the subadults may be explained through patterns of diet and activity. Leonard et al. (1994b) point out that the Evenki control much larger animal herds than do most pastoral populations; consequently, they have access to substantial amounts of animal foods. However, as was pointed out in an earlier section, rural areas in Siberia have become increasingly more isolated since 1991. The high cost and limited availability of fuel have greatly reduced the number of helicopter flights that usually bring in food and medical supplies from the cities (Finkler, 1995; Fondahl, 1995; Leonard et al., 1997). Leonard et al. (1997) note that the greater isolation of indigenous settlements is promoting a return to a traditional lifestyle. Consequently, this shift to a more traditional lifestyle, coupled with the shortages of non-local foods (mainly grains and cereal products) has meant that the Evenki have probably become more reliant upon animal foods, hence the overall increase in musculature.

Eating more meat alone will not lead to a substantial increase in muscle mass. Physical activity is needed to stimulate muscle tissue hypertrophy. The move to a traditional lifestyle has most likely meant that the physical activity patterns of the Evenki have increased, due to do a greater reliance on hunting and other traditional means of subsistence.

5.3 Sex Differences in Anthropometric Measures of Nutritional Status

Among all three groups, there are marked differences in anthropometric measures between Evenki boys and girls. In general, Evenki girls tend to be relatively fatter and heavier than their male counterparts, and both the weight gain and fatness increases with age in this population. Among the 0 - 5 age group, Evenki girls show, on average, better nutritional status than their male counterparts for all anthropometric variables and in both cohorts, with the exception of males in cohort 2, who are closer to the U.S. population for stature than the females in this cohort. The males in the 0 - 5 age group appear to be undergoing progressive declines in nutritional status. Ironically, this overall poorer nutritional status among the boys is not supported by the data for wasting. Both boys and girls have the same prevalence rate (9%) for wasting in cohort 2, while approximately 7% more males showed wasting in cohort 1 (28% for males and 21% for females). The situation was reversed in cohort 2, where approximately 6% more females showed wasting (46% males vs. 52% females). Again, the same general poorer nutritional status is seen in boys in the 6 - 10 age group. However, there does not appear to be any progressive differential decline in nutritional status for any of the sexes, as there are no significant differences between their means for any of the anthropometric variables.

The sex differences become even more prominent for the 11 - 17 age group, with females again possessing more superior nutritional status than their male counterparts. Furthermore, adolescent males also show progressively significant declines in nutritional status relative to their female peers.

The results presented here show that the growth status of Evenki boys has been more sensitive to the recent and ongoing negative social and economic changes that have taken place since the fall of the Soviet Union. Indeed, a large body of literature indicates that males are more easily diverted from their growth pathway by environmental adversities, such as malnutrition and infections, and that they show a stronger response to environmental improvements, as well (Bielicki, 1986; Tanner, 1962). If nutritional conditions are, in fact, getting worse, not only would we expect to see an overall decline in z-scores, but we would also expect to see the rate of decline getting relatively worse for males than for females. The test of this hypothesis is determined by the differences between males and females in each cohort. If there has been an overall improvement in conditions, it is predicted that the male vs. female differences will be less in the 1995 cohort, relative to the 1991/1992 cohort. However, if there has been an overall decline, it is expected that the male vs. female differences will be greater in the 1995 cohort, as compared to the 1991/1992 cohort.

These male/female differences from each cohort are shown in Figures 4.23-4.25. In general, the information provided here suggests an overall decline in nutritional conditions for the infants and younger children. As well, all the indicators which suggest a decline in nutritional conditions are all short-term indicators of nutritional status (Gibson, 1990; Santos and Coimbra, 1991). The information also suggests that conditions seem to have remained stable for older children. For adolescents, the mean differences for all the measures are greater in the 1995 cohort. Thus, the gap between males' and females' anthropometric status has also increased.

The information on muscularity does not actually represent a decline in nutritional status; instead, it represents the failure of the Evenki males to improve at the same magnitude as their female counterparts.

The anthropometric measures for the other circumpolar groups consist of weight and stature. In both these measures, all the circumpolar groups (Alaskan Eskimo, The Foxe Basin Canadian Inuit, and the Finnish Lapps) show this trend of superior female growth. Both males and females in these three groups fall intermediate to the U.S. 5^{th} and 50^{th} percentiles throughout growth. However, the adolescent females in all three groups are much closer to the U.S. 50^{th} percentile than their male peers. The difference between males and females for body weight is even more pronounced than that seen for stature. For example, while adolescent males from the Alaskan Eskimo sample closely approximate the U.S. 50^{th} percentile for body weight, their female peers surpass it.

As has been seen in both cohorts, the apparently poor nutritional status of the Evenki males (especially the adolescents, being more reduced in fatness, as well as muscularity) has meant that the degree of sexual dimorphism in arm-muscle area, as well as in overall body size, is considerably less than that seen in Western populations. These findings are consistent with what other studies have reported-- that human populations living under varying degrees of stress exhibit significant reductions in sexual dimorphism (Stini, 1972 and 1975; Leonard, 1991) .

Researchers have argued that this reduced sexual dimorphism is the product of reproductive adaptive strategies, differential dietary habits between the sexes, and work patterns (see section 1.3). As was indicated previously, the dietary data for the Evenki does suggest differential dietary adequacy between the sexes. The amount of energy (~2650 Kcal/day) that is consumed by men is about 1.8 times their basal requirements, while that consumed by women (~2800 Kcal/day) is approximately 2.3 times their basal requirements, and is also significantly higher than that of the males (Figure 5.1) (Galloway, 1996). Relative to predicted daily energy needs based on heart rate monitoring, men exceed their daily energy requirements by an average of 6%, whereas women have intakes that are more than 35% greater than predicted needs. Since the males have a relatively small energy balance in the summer, it is likely that their energy adequacy during the winter months might be compromised, thus resulting in intakes that are inadequate to support their activity levels.

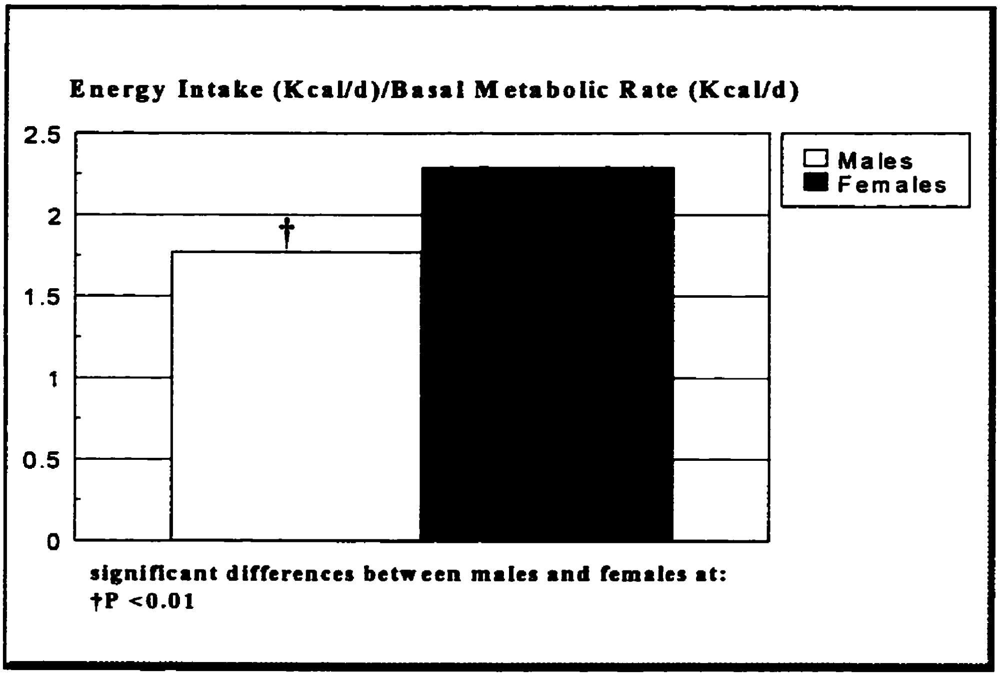

Figure 5.1. Energy Intake to BMR Ratio for Male and Female Evenki (modified from Galloway, 1996).

5.4 Body Size and Composition of the Evenki

The sex differences in fatness and fat patterning, especially those found among the Evenki adolescents, suggest that adolescent females have a higher risk of developing cardiovascular disease and hypertension (Cameron et al., 1994; Leonard et al., 1994b), since there is a high positive association between trunkal fat and these diseases. Szathmary and Holt (1983) have found that acculturation to Western society and "modernization" are associated with increased centralized (trunk) obesity and increased rates of maturity-onset diabetes among Dogrib Indians in Canada. The arrival of television to the Igloolik population has been blamed for the increased body fat, decreased muscle strength, and decreased aerobic power that have been observed among Igloolik children (Shephard and Rode, 1996 and 1995; Rode and Shephard, 1992) . Previous work among the Evenki shows that adult Evenki women do have poorer lipid profiles than their male counterparts (Leonard et al., 1994a), and that, indeed, the leading causes of death among Evenki women are from circulatory diseases (Leonard et al., 1997).

As was noted previously, daily heart-rate monitoring has indicated that Evenki women have significantly lower activity patterns than Evenki men. It is believed that, since collectivization, women no longer play an active role in the herding of reindeer, and consequently, their predominantly sedentary lifestyle has led to these negative health consequences (Leonard et al., 1994).

In discussing the age-related increases in adiposity that is apparent in this population (in particular, the adults), Leonard et al. (1994) note that this phenomenon may be associated with the relatively low fertility levels of the Evenki women. The authors note that a culmination of only 4 births on average, as well as a practice of early weaning by mothers, has meant that the metabolic costs of pregnancy and lactation are low in Evenki women, compared to women of other non-Western populations. However, the results presented here, for the subadults suggest that these factors might actually play a small role, since this trend appears before the child-bearing years. At present, it seems that the most plausible explanation is that which concerns the adoption of western lifestyles. Incidentally, then, one would expect a reversal of these trends (that is, a move away from the centralization of fat, and from the age-related increases in adiposity), since the present economic conditions have caused a return to more traditional activities. The extent to which this move to traditional activities will have impact on the sexes is unclear. It is more likely that these changes will affect males more than they will females, at least in the short term, as they probably mostly involve hunting and herding. The data presented here lend support to this hypothesis, as all the anthropometric variables for males show either a reversal or a reduction in the strength of their relationship with age, a pattern that is not observed among females.

One might expect that the readoption of traditional ways of life would also, at some point, start to reverse these westernized trends (of fat centralization and age-related increases in adiposity) in women. However, one subject of concern is the degree to which female domestic activities have been westernized. For example, the availability of food-preparation equipment, such as blenders and sophisticated cutting devices, will have an effect on the amount of activity that is needed to prepare meals.

5.5 Geographic Differences in Growth Status

It has been mentioned before that the Evenki and other Siberian aboriginal groups have started to rely more on traditional means of subsistence. This move to a reliance on traditional means of subsistence is very interesting in itself, and should provide interesting data for further research. Much of the research conducted among indigenous peoples around the world has been focused on the negative effects that acculturation to a western way of life has had on the health and culture of aboriginal peoples. The current situation in Siberia presents the opportunity to investigate the "catch-up" phenomenon. It also raises many interesting questions for future consideration. Is it possible to reverse the negative consequences of acculturation to a western way of life? If so, to what degree can this be accomplished? Perhaps most importantly, what are the negative consequences (if any) of this re-acculturation?

The information on locational differences should help to address the issue of a return to a traditional lifestyle. The two locations that were used in the analyses were Surinda and the brigades. Individuals from the brigades have always maintained a more traditional lifestyle, continuing to rely on herding and hunting

(Leonard et al., 1996). Thus, while those from Surinda also went off into the brigades at times, they tended to rely more on supplies from the city. Consequently, it is expected that the current problems in the Siberian north should have a differential effect on the nutritional status of the two locations. It was expected that individuals from Surinda would show more compromised growth than that seen in individuals from the brigades. That is, if indeed there is a move to a greater reliance on traditional activities, the magnitude of the difference for each anthropometric measure should be greater in cohort 2 than it is in cohort 1 for those individuals from Surinda, as compared to those from the brigades.

Indeed, the results suggest a greater degradation of growth for Surinda children (Figure 4.26). Although, in general, individuals from Surinda show greater declines in growth status than those from the brigades, their growth status does appear to be worsening. The magnitude of the differences between z-scores have grown larger in cohort 2, as compared to cohort 1, for weight -for-age, sum of skinfolds, and upper arm muscle area. In all these three cases, individuals from Surinda are worse off than their counterparts from the brigades.

Chapter 6: Conclusions And Suggestions For Future Research

6.1 Conclusions

The Central Siberian taiga poses a very challenging environment for human existence, and no doubt plays a crucial role in shaping the pattern of human growth for its residents. Among some of the environmental factors that influence childhood growth in this area are the seasonal and climatic changes (in which temperature plays an important role) and limited amount of energy, which is exacerbated by high metabolic requirements. The recent changes in Russia, brought about by the fall of the Soviet Union in 1991, have created massive social and economic changes in both Russia and, perhaps to a greater extent, Siberia. This has meant that there is limited access to medical care, rapid and significant increases in food prices, and significant reductions in air transport service to most rural areas, thus leaving these areas without food and health-care supplies. All these factors have underscored the precarious situation that exists among Siberian indigenous peoples, whose harsh living conditions have disproportionately created suboptimal health conditions among them.

Since the physical growth and development of children are sensitive indicators of the quality of the social, economic, and political environment in which they live, it was possible to examine the extent to which these recent changes in Russia have affected Siberian indigenous groups--more specifically, the Evenki reindeer herders of Central Siberia. In general, the Evenki are lighter in weight and smaller in stature, especially during late childhood and adolescence, as compared to their age-matched U.S. peers. This pattern of growth still holds when they are compared to other high-latitude groups, including another Siberian indigenous group. However, when compared to growth data from these other high-latitude groups, the mean differences in growth measures (height and weight) for the Evenki are, indeed, significantly less than those differences that are apparent between the Evenki and the U.S. normative data. These analyses with the other high-latitude groups suggest that the diminutive size of the Evenki is hereditary, as most of the groups tend to cluster together. As well, the differences between the groups indicate the environmental influence on growth.

The temporal analysis of cross-sectional anthropometric measures of nutritional status reveals that the Evenki children show significantly poorer growth in 1995 than they did in 1991 and 1992. As has been hypothesized, these differences are more pronounced in the youngest children--that is, in infants and younger children up to 5 years of age. These groups of children were more likely to show deficits in overall nutrition and energy reserves. Indeed, they showed a significantly higher prevalence of stunting and wasting than the children in the 1991 and 1992 sample. These findings suggest that human growth is extremely sensitive to the environment, especially in the first five years of life.

There are marked differences in the anthropometric measures of nutritional status between Evenki boys and girls, and even more interesting is the observation that there are marked sex differences in response to nutritional and environmental stress. For the most part, males (especially those in the 0 - 5 age range and those above 11 years old) show progressive declines in nutritional status, as compared to their female counterparts. The net result of this decline in nutritional status for the Evenki is that the degree of sexual dimorphism in arm-muscle area and overall body size is considerably less in this population, as compared to that seen in most Western populations. The most likely explanation for this difference in sexual dimorphism among the Evenki is differential dietary adequacy between the sexes. Thus, males are more easily diverted from their growth pathway by environmental adversities than are females.

It was expected that, due to the fact that weight is more ecosensitive than height, greater abnormal anthropometry would have been observed for weight measures than for height measures. However, this pattern was not observed. Prevalence of stunting was much higher than that of wasting for the youngest age group (0 - 5 years). It was also higher than the prevalence of abnormal weight-for-age measures. This pattern is also consistent for the older age groups. It is quite possible that cross-sectional measures of height-for-age are just as useful, if not more sensitive, than weight-for-age as an indicator of recent changes in social and environmental factors affecting child health (Begin et al., 1997). It should be noted that the low rate of wasting that has been observed among the Evenki does not necessarily indicate that wasting is not a problem in Evenki children. It probably indicates the absence of wasting at the time of measurement, and, in fact, the high-prevalence rate of stunting might be an indication of the amount of previous wasting, since it is believed that stunting lags behind wasting (Keller, 1988; Nabarro et al., 1988).

Evenki girls show a greater centralized (or trunkal) distribution of subcutaneous fat when compared to their male counterparts. This difference is accentuated in the adolescent group. Thus, it appears that from a very early stage in life, Evenki girls possess this pattern of fat distribution, which predisposes them to cardiovascular disease in their adult life.

6.2 Suggestions for Future Research

The first suggestion is derived from a limitation within the existing data. It is difficult to make conclusions about the patterns of human growth using cross-sectional data. In order to better understand the patterns of Evenki growth, it is necessary to use longitudinal data to obtain information on the magnitude and timing of the pubertal growth spurt among the Evenki. However, because of the logistical problems of conducting longitudinal surveys in circumpolar regions, semi-longitudinal data might at least allow for some crude calculations which are still not attainable with cross-sectional data. Such data should also include anthropometric data that represents the winter season.

The present anthropometric data lack supportive nutritional and socioeconomic data. Dietary information is needed on the subadult component of this population. Information is also needed on mothers' breastfeeding practices, as well as information on weaning. This latter information will help us to understand better the process of stunting and wasting in this population. Child growth and development is modeled along socioeconomic gradients. The availability of socioeconomic data (such as income, number of children in households, and perhaps the number of herds in each clan) will allow us to get at some of the subtle factors that play a role in influencing growth among Evenki children.

The energetic information on the adult population has allowed us to understand other pertinent information, such as activity patterns, energy flow, and nutritional adaptations in this semi-subsistence population. However, as is common with research in this area, there is a general lack of information on this topic with regards to children. However, information about the energetics of children, especially those in circumpolar regions, will help us to understand better the role that seasonal energy imbalances might play in shaping the overall growth of the Evenki.

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APPENDIX 1

Table A-1. Age-specific means and standard deviations of anthropometric variables for Evenki males in cohort 1

	Stature (cm)		Weight (kg)		Mid-arm circ. (cm)		Triceps skinfold (mm)		Subscap. skinfold (mm)	
Age (years)	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
0	67.2	1.6	7.6	0.6	14.1	1.1	11.5	0.7	10.0	1.4
1	81.5	-	10.5	-	15.5	-	9.5	-	8.0	-
2	80.9	5.4	10.1	1.8	15.0	1.7	8.3	2.9	4.8	1.0
3	92.8	4.3	14.2	1.8	16.3	0.9	9.8	1.4	5.8	0.9
4	100.6	4.5	16.0	2.4	16.1	0.8	8.6	1.8	5.5	1.4
5	105.1	4.7	17.0	1.4	16.5	0.9	7.4	2.1	4.9	1.1
6	110.5	5.3	19.0	2.7	16.9	0.9	7.6	1.2	5.0	1.2
7	111.2	5.3	17.7	3.1	16.9	0.3	6.3	0.8	3.8	0.3
8	121.3	10.1	22.9	5.8	17.4	1.7	7.1	2.1	4.9	1.3
9	123.3	6.9	23.6	1.4	17.7	0.3	6.8	1.4	4.4	0.6
10	130.8	11.0	28.7	5.6	19.1	2.2	7.3	0.8	5.1	0.5
11	129.4	4.0	25.7	3.5	17.8	1.4	7.9	2.9	5.9	1.5
12	133.0	5.5	27.9	3.2	19.1	1.7	6.8	2.2	5.1	1.2
13	146.6	7.0	33.6	4.2	19.2	2.2	5.5	0.0	4.0	0.0
14	144.2	9.3	32.6	7.2	20.5	0.3	8.0	1.5	5.7	1.3
15	146.5	-	35.2	-	20.3	-	6.0	-	5.5	-
16	156.9	9.6	46.8	10.7	23.4	3.1	7.0	2.4	6.0	1.4
17	158.0	7.8	48.3	10.1	23.7	2.6	5.7	2.2	6.5	0.9

For sample sizes, see table 3.1

Table A-2. Age-specific means and standard deviations of anthropometric variables for Evenki males in cohort 2

	Stature (cm)		Weight (kg)		Mid-arm circ. (cm)		Triceps skinfold (mm)		Subscap. skinfold (mm)	
Age (years)	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
0	63.7	2.9	7.1	1.2	15.2	1.2	10.9	4.9	7.8	2.4
1	75.4	3.9	8.1	1.0	14.7	1.3	7.1	1.9	5.0	0.8
2	82.9	6.1	9.1	1.1	14.9	0.5	8.2	0.8	4.7	0.6
3	92.3	5.9	11.9	1.2	15.6	1.2	6.2	0.8	4.7	0.8
4	99.1	2.7	14.0	1.1	16.3	0.8	7.0	1.3	4.8	0.3
5	116.8	17.1	19.9	8.0	17.2	1.6	6.3	1.4	4.8	0.3
6	107.5	4.9	17.9	2.6	16.7	0.8	6.6	1.1	4.7	1.2
7	116.7	6.7	21.2	2.6	18.0	0.9	6.7	1.9	4.9	1.2
8	121.0	5.7	22.9	2.6	18.1	0.9	7.6	2.9	5.2	1.3
9	124.8	8.5	23.4	1.9	18.3	0.8	7.2	1.8	5.2	1.6
10	118.4	24.1	22.9	6.3	18.3	1.2	5.6	2.1	4.0	0.8
11	127.3	10.2	25.1	6.1	18.5	1.8	6.8	2.4	4.7	0.6
12	137.4	6.3	26.6	2.1	17.9	2.3	5.5	1.1	3.9	0.9
13	139.7	-	36.1	-	20.2	-	7.0	-	5.5	-
14	-	-	-	-	-	-	-	-	-	-
15	156.4	5.2	43.8	4.5	23.6	1.6	5.8	0.4	5.0	0.0
16	166.9	-	54.2	-	24.1	-	5.0	-	6.0	-
17	160.4	-	51.5	-	24.4	-	5.0	-	6.0	-

For sample sizes, see table 3.1

Table A-3. Age-specific means and standard deviations of anthropometric variables for Evenki females in cohort 1

	Stature (cm)		Weight (kg)		Mid-arm circ. (cm)		Triceps skinfold (mm)		Subscap. skinfold (mm)	
Age (years)	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
0	68.9	5.5	7.5	0.9	15.3	1.1	10.1	2.3	8.1	3.6
1	75.9	5.6	8.9	1.3	15.3	1.2	10.9	2.3	7.7	2.6
2	84.6	4.6	10.9	1.6	15.5	0.9	10.5	1.6	7.2	1.8
3	91.5	4.8	12.8	1.4	15.7	0.7	9.6	1.9	6.1	1.9
4	101.6	11.4	16.2	4.3	16.7	0.8	9.1	1.1	6.3	2.0
5	104.9	7.6	17.4	2.3	16.4	0.7	8.8	1.5	6.1	1.7
6	109.9	5.4	18.4	1.9	16.8	0.9	8.6	1.3	5.4	1.3
7	115.9	4.0	20.5	1.9	17.4	1.1	9.8	1.9	5.8	1.1
8	119.0	5.1	21.9	1.4	17.9	0.8	9.7	2.5	6.4	1.5
9	122.8	5.2	22.5	2.6	17.6	1.2	8.9	1.8	5.8	1.1
10	131.5	3.5	28.4	2.1	19.4	1.9	11.5	3.1	7.8	2.1
11	133.9	7.0	28.9	4.7	19.4	1.2	10.1	1.6	6.9	1.8
12	138.7	7.9	31.4	7.9	19.9	1.7	11.1	2.6	8.3	3.8
13	145.9	1.6	37.8	4.3	21.7	1.7	10.8	3.9	8.9	2.5
14	149.2	2.4	45.0	7.2	24.3	2.5	17.1	4.9	13.4	3.9
15	142.9	-	40.2	-	22.3	-	13.0	-	11.5	-
16	150.2	3.4	48.1	4.7	24.7	1.6	19.2	2.6	17.2	3.8
17	143.3	14.5	44.3	13.2	22.4	5.1	14.9	4.9	14.2	5.6

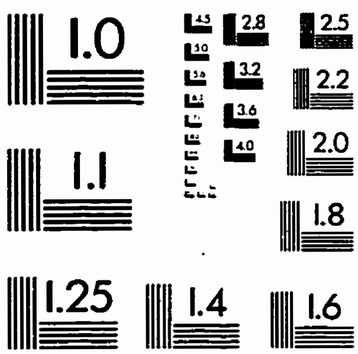
For sample sizes, see table 3.1

Table A-4. Age-specific means and standard deviations of anthropometric variables for Evenki females in cohort 2

Age (years)	Stature (cm) Mean	SD	Weight (kg) Mean	SD	Mid-arm circ. (cm) Mean	SD	Triceps skinfold (mm) Mean	SD	Subscap. skinfold (mm) Mean	SD
0	60.4	2.4	6.5	0.5	13.6	1.1	10.1	1.3	9.5	3.4
1	73.0	7.2	8.3	1.3	16.1	1.4	8.8	0.9	7.1	1.8
2	83.4	4.9	10.4	1.4	15.5	1.5	7.8	1.3	6.2	1.3
3	90.9	3.9	12.1	1.6	16.0	0.6	8.3	1.0	5.4	1.5
4	93.8	5.8	13.2	1.3	16.4	0.7	7.4	0.9	5.8	1.8
5	106.8	0.9	16.0	1.6	16.9	0.2	9.0	0.0	5.3	0.4
6	104.7	4.4	16.3	2.1	16.2	0.9	6.9	0.8	4.9	0.8
7	114.6	2.6	19.8	2.1	17.5	0.9	7.1	1.7	5.1	1.2
8	119.7	6.5	23.5	3.6	18.4	1.8	8.6	2.5	6.3	2.3
9	123.2	5.5	22.7	1.9	18.3	0.9	8.8	2.1	5.7	0.8
10	127.6	4.2	25.6	2.7	18.8	1.1	8.9	2.7	6.0	1.2
11	133.1	5.6	28.9	3.7	19.9	1.3	9.8	1.7	6.3	0.8
12	139.8	3.9	32.9	5.4	20.7	0.9	9.1	2.4	7.4	2.1
13	148.7	5.2	40.5	8.7	22.3	2.9	11.5	6.8	8.8	3.9
14	148.1	2.5	43.1	6.6	24.0	2.2	15.6	6.4	11.2	5.0
15	154.7	7.9	46.1	5.5	23.8	1.8	13.0	2.7	8.8	1.6
16	157.4	12.6	55.0	10.9	25.8	2.7	20.3	8.1	18.2	9.8
17	152.5	8.9	50.5	6.3	25.6	1.5	19.2	6.7	16.8	5.7

For sample sizes, see table 3.1

IMAGE EVALUATION TEST TARGET (QA-3)



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