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GROWTH STATUS AND PHYSICAL FITNESS OF PRIMARY SCHOOL CHILDREN IN AN URBAN AND A RURAL COMMUNITY IN OAXACA, SOUTHERN MEXICO

By

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ABSTRACT

GROWTH STATUS AND PHYSICAL FITNESS OF PRIMARY SCHOOL CHILDREN IN AN URBAN AND A RURAL COMMUNITY IN OAXACA, SOUTHERN MEXICO

By

Maria Eugenia Peña Reyes

This study considered the growth status and physical fitness of primary school children in a rural and an urban community in the Valley of Oaxaca, southern Mexico, in 1999-2000. The prevalence of growth stunting, wasting, and overweight and obesity were also considered. The sample included 700 school children 6 to 13 years of age, 361 from the rural community (177 males, 184 females) and 339 from the urban community (173 males, 166 females). Anthropometric dimensions included body size, segment lengths, skeletal breadths, limb circumferences and skinfolds. The body mass index (BMI), leg length, arm and calf muscle circumferences, sum of skinfolds, and a trunk/extremity skinfold ratio were derived. Physical fitness items included motor-and-health-related tests: right and left grip strength (muscular strength), 35 yard dash (32.3 meters, speed), standing long jump (explosive power), sit-and-reach (flexibility), timed sit-ups (30 seconds, abdominal strength and endurance), and a distance run (8 minutes in grades 1-3 and 12 minutes in grades 4-6, cardiovascular endurance).

Height, weight, sitting height, estimated leg length and skeletal breadths on the trunk were significantly larger in urban than in rural school children. The BMI, sitting height/stature ratio, skeletal breadths on the extremities, limb and estimated limb muscle circumferences, subcutaneous fatness and relative fat distribution did not consistently differ by age group and sex between urban and rural children.

Urban children tended to perform better in the sit and reach, sit-ups and standing long jump, but results were not consistently significant. Rural children 6-9 years tended to perform better in the dash. There were no urban-rural differences in grip strength, but strength per unit body mass was greater in rural children. Rural children in grades 1-3 performed better in the distance run, but results in older children were not consistent.

The prevalence of stunting was about twice as great in rural than in urban children, but the prevalence of wasting was very low in both communities. The prevalence of overweight was significantly greater in urban than in rural children, but he prevalence of obesity was low.

Rural children, boys more than girls, reported more frequent daily participation in household-related activities classified as moderate and moderate-to-vigorous in intensity compared to urban children. Urban boys reported more household-related activities of light or very light ntensity. Urban and rural girls did not differ in reported frequencies of daily household activities classified of light and very light intensity. Urban children reported more diversity in diet, specifically at breakfast and dinner, than rural children. Animal protein represented in meats and meat derivatives were rather limited in the diets of rural children.

The results of the comparisons of growth status, physical fitness, daily activities and diet of urban and rural primary school children reflect, to a large extent, the contrast of living conditions and access to resources in the urban and rural communities.

Dedication

To my mother and father whose faith in my dreams never declined

To my family, their energy and happiness help make sense of my life

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Chapter 1

Introduction

The present study is developed within the context of quality of life and health related outcomes in two communities of the state of Oaxaca, in southern Mexico. It focuses on an aspect of a broader study designed with the purpose of evaluating secular changes in growth status, physical fitness, and living conditions in two communities in the Valley of Oaxaca, which were initially studied in 1968 and 1972 and again in 1999-2000 (Malina et al., 1972, 1980a; Malina and Selby 1982; Malina, 1999).

Deficits in nutrition and a high prevalence of infectious and parasitic diseases are major stresses that characterize the long term living conditions of the populations of interest. The growth status of children is highly sensitive to the quality of life in a community and particularly to marginal nutritional conditions. The main focus of the overall study is secular change (Malina, 1999). Positive secular changes in height during childhood and in adulthood are indicative of improved nutritional, health and socioeconomic circumstances, all of which are interrelated. The present study concentrates on urban-rural comparisons of growth and physical fitness as related to contrasting living conditions in the two communities.

Historically, Mexico has experienced uneven regional development, largely influenced by inequitable distribution of resources among areas. This is reflected in the economy as a whole and on living conditions for the population. The ongoing transformation, beginning in the 1950s, was intended to integrate rural areas into the market economy of the nation. The main strategies included construction of new roads and establishment of an irrigation infrastructure to make rural communities more accessible. Several years later, the strategy shifted to the development of urban areas and industrial parks whose objective was to attract the population into productive roles and in turn, encourage economic growth. At the same time, other programs attempted to enhance rural development (Palma-Cabrera, 1993). The cases for Oaxaca and several other states (Chiapas and Guerrero) are somewhat singular because these states did not seemingly benefit from the progress experienced by the other states of Mexico.

Agricultural policies that characterized the land reform of the Cardenas administration (1934-1940) contributed to the emergence of a large number of small land owners under the ejido system (i.e., collectively owned land). The owners of these small holdings had to deal with a lack of resources and general poor land quality, associated with erosion over time and single crop cultivation. These in turn placed consistent demographic pressures on the lands and affected productivity. The conditions in Oaxaca were further exacerbated by the local geography (i.e., mountainous terrain), limited construction of roads and thus access to markets, and lack of basic infrastructure for electricity, potable water, education and public health. These factors had their greatest impact on small, rural communities which dominate the state of Oaxaca. Further, by shifting national emphasis from agriculture to industry, capital investments tended to be concentrated in the southern areas of the state of Oaxaca. These include Tuxtepec and the Isthmus, areas which were oriented towards exchange with the states of Veracruz and Puebla instead of the capital, Oaxaca de Juarez and other communities the Valley of Oaxaca. The net result was reduced sources of work opportunities and in turn income for the local population, which contributed to the marginalization of living conditions for the more traditional, largely indigenous, rural communities. The prevalence of poverty increased and it was associated with illiteracy, high fertility and high infant and preschool mortality compared to more developed regions of the country (Arellanes, 1988; Gonzalez-Garcia and Monterrubio-Gomez, 1993).

Living conditions as assessed by the health and nutritional status of children and adults provide useful information to estimate the impact of social and environmental factors on the quality of life of members in a given community. The state of Oaxaca has gone through significant agricultural transformation in the past three decades, although the outcomes are not as positive in terms of economic growth as they have been for northeastern states such as Sinaloa, Sonora, or Baja California. The critical transformation in the agricultural sector, following inclusion of the country in the open market economy, brought serious challenges for local economies to maintain food availability in light of increasing costs associated with buying rather than producing foods to meet basic human needs.

Small scale farmers and landless agricultural workers in regions where technological change has taken place are at greater risk for limited access to food (Dewey, 1985; Diskin, 1991; Enge and Martinez-Enge, 1991; Food and Agriculture Organization (FAO), 1996; Stonich, 1993; Whiteford and Ferguson, 1991). Farmers who do not have access to the resources needed to acquire technology, primarily for irrigation, are relatively worse-off. Adoption of new technology affects intra-household allocation of labor for production and processing activities. In a parallel manner, women have been forced to work in agricultural production, but without being paid at the same rate as male wage laborers. This trend has the added disadvantage for intra-family needs and relationships, which require the efforts of women for family subsistence at the household level (Mebrahtu et al., 1995).

Although significant changes have occurred in the state of Oaxaca over the past three decades, the state still lags behind other states of Mexico in social, economic and health indicators. Several trends in demographic, economic, education and health indicators for 1999 and 2000 are summarized in Table 1.1. Among other states of Mexico, Oaxaca has the lowest growth rate, due in part to a relatively high rate of out-migration. The state of Oaxaca is unique among Mexican states in that 55% of its localities (municipios) have <2500 inhabitants, which is the highest percentage in the country. These municipios are located in rural areas. The state of Oaxaca also ranks among the highest in the percentage of its population <15 years of age (38%) and ≥65 years of age (6%), but overall the state has a relatively young median age (20 years).

From an economic perspective, the state of Oaxaca ranks lowest in the country (32^{nd}) in GDP per capita, but in midstream for GDP as a fraction of the total GDP for Mexico (1.5%, 19^{th}). The minimum wage is also slightly lower in Oaxaca compared to the national estimate.

The state of Oaxaca also ranks high in illiteracy and the percentage of individuals with an incomplete primary school education, 3^{rd} and 2^{nd} in the country, respectively, and low in the percentage of population with post-primary school education, 31^{st}.

The demographic, economic and education figures are consistent with marginal status of the state of Oaxaca for health-related indicators. The state of Oaxaca ranks among the highest in Mexico for overall death rate and deaths from intestinal and respiratory infections. On the other hand, the state ranks among the lowest (30^{th}) in physicians per 10,000 population. The state of Oaxaca has a relatively high birth rate among Mexican states, and an estimated infant mortality rate that is relatively low (11.1/1000 live born). This is somewhat puzzling given the high prevalence of intestinal and respiratory infections in the state. However, infant mortality for the state of Oaxaca and other largely rural states in Mexico must be tempered with caution. These states have a history of a high rate of underreporting birth and infant mortality statistics (Cordero, 1968; Aguirre and Camposortega, 1980; Canales et al., 1980).

Overall, the demographic, economic, education and health indicators suggest marginal conditions in the state of Oaxaca compared to the country of Mexico as a whole. The conditions are exacerbated by the high percentage of the population living in small, rural communities, and high mortality from intestinal and respiratory infections. The low GDP per capita for Oaxaca reflects in part the inequitable distribution of economic resources in the country and within the state. These conditions are the substrate within which children grow and mature, and the growth status of children is commonly viewed as reflecting the health and nutritional conditions in a society (World Health Organization, 1995, see below).

The growth status of children in developing countries, based primarily on anthropometric indicators such as weight, height, weight-for-age, height-for-age and weight-for-height, is accepted as an indicator of the overall health and nutritional status of a community (World Health Organization, 1995). Health is… "a human condition with physical, social and psychological dimensions, each characterized on a continuum from positive to negative poles. The positive health is associated with a capacity to enjoy life and to withstand challenges not only absence of disease, the negative health is associated with morbidity and taken to the extreme with premature mortality"… (Bouchard et al., 1997, p. 99). Primary concern with unfavorable living conditions, particularly chronic mild-to-moderate undernutrition among children in many developing countries of the world, is related to potential long-term functional consequences that may jeopardize adult health and ability to earn an adequate daily living (Pollitt et al., 1996).

Although emphasis is placed on growth status as an indicator of health and nutritional conditions in a society (Bielicki, 1986, 1999), there is increasing interest on overweight in some developing countries (Popkin et al., 1996). The estimated prevalence of overweight (defined as weight-for-height more than two standard deviations above international reference medians) among children under five years of age in developing countries range from about 5% in Latin America and the Caribbean to 3% in Africa and 2% in Southeast Asia (World Health Organization, 1995; de Onis and Blossner, 1997, 2000). There is, however, variation among and within countries. Better developed countries within a geographic region and more affluent sectors of society within a country have a higher prevalence of overweight. In general, as the prevalence of overweight increases, the prevalence of wasting (defined as weight-for-height more than two standard deviations below the international reference) within a country decreases. However, both overweight and wasting of preschool children are common in many countries. Stunting (defined as height-for-age more than two standard deviations below the international reference) is an additional nutritional concern in many developing countries. Growth in height reflects, to a large extent, the individual's nutritional history, and stunting is attributed to chronically poor or marginal nutritional circumstances during the preschool years. This suggests an epidemiological paradox – persistent undernutrition (wasting and stunting) in the presence of increasing overweight as countries go through an economic and nutrition transition (Popkin et al., 1996).

The prevalence of overweight and/or obesity has increased among urban school children in Mexico (Rangel et al., 1993; Siegel, 1999; Peña Reyes et al., 2002). Corresponding information for school children in rural areas and in rapidly growing urban slums (see below) are not presently available. Issues related to overweight and obesity among children from rural and marginal urban circumstances in developing countries has received relatively little attention because the prevalence of chronic undernutrition is still a major concern due to the relatively large proportion of children affected.

Major cities in Latin American have experienced rapid growth associated with rural to urban migration. In Mexico, for example, at the beginning of the 20th century only 10% of the total population lived in urban areas whereas the remaining 90% lived in widely distributed rural communities of <15,000 inhabitants. Subsequently, a shift in population occurred, at first gradually and then more rapidly, so that by 1990 approximately 58% of the population lived in urban areas (about 46,700,000 inhabitants) and 42% lived in rural areas (34,500,000 inhabitants), including many small communities. Living conditions in urban and rural settings are often markedly contrasting in the context of access to health services, quality of schools, unstable food supplies, and so on. The present study is set in the context of urban-rural contrasts.

Research Questions

The present study is set within the context of three questions:

1. How do current samples of urban and rural school children 6-13 years of age in Oaxaca, southern Mexico, compare in growth status?
2. How do current samples of urban and rural school children 6-13 years of age in Oaxaca, southern Mexico, compare in physical fitness?
3. How do current samples of urban and rural school children 6-13 years of age in Oaxaca compare in the estimated prevalence of growth stunting and wasting?
4. How do current samples of urban and rural school children 6-13 years of age in Oaxaca compare in the estimated prevalence of overweight and obesity?

The following hypotheses will be tested:

1. Urban school children have better growth status assessed with height, weight and other anthropometric indicators than rural school children.
2. Urban school children perform better on tests of physical fitness than rural school children.
3. Rural school children have a higher prevalence of growth stunting and wasting than urban school children.
4. Urban school children have a higher prevalence of overweight and obesity than rural school children.

Limitations

The study is based on cross-sectional surveys of two communities in the Valley of Oaxaca, one a rural indigenous community where the Zapotec language is spoken, and the other an urban colonia, which is now subsumed in the capital city of Oaxaca

(Oaxaca de Juarez). The Valley of Oaxaca is intermontane and includes many rural populations. However, the urban population is rapidly growing. Rural communities are characterized by relatively little or slow development, lack of adequate public utilities and health services, associated poverty, marginal agricultural productivity, and often relatively poor agricultural land. On the other hand, the urban settlements, largely on the perimeters of major cities, have developed as a consequence of consistent migration from rural villages. The process of migration observed in areas such as Oaxaca shows that migrants congregate in irregular settlements located at the periphery of cities, resulting in what are called "colonias populares." Health and nutrition conditions associated with migration to cities are generally poor in these marginal areas (Selby and Murphy, 1979; Murphy et al., 1991).

The two communities in the present study were studied initially about 30 years ago. The rural, Zapotec-speaking community was studied in 1968 and then again in 1978 and 1979 (Malina et al., 1972; 1980a; Buschang, 1980). The urban community was studied initially in 1972, when the growth status of school children in several urban and rural communities was surveyed (Malina et al., 1976, 1980b). The present study did not attempt to locate members of the communities who participated in the earlier surveys because the demographic dynamics of the communities are characterized by a relatively high rate of out-migration. This would make it difficult to trace families and individuals who participated in the earlier surveys (see Malina et al., 1982).

Significance

Living conditions in the urban colonia and the rural Zapotec-speaking community are reasonably typical of corresponding communities in the Valley of Oaxaca. Based on earlier studies in Oaxaca (Malina et al., 1981; Malina, 1983) and a recent national survey of primary school children including samples in Oaxaca

(Instituto Nacional de Salud Publica, 2000), it is reasonable to assume that the children from the two communities are representative of public primary school children in other communities in the Valley of Oaxaca. They are probably different from children of the same age who are from economically better-off families and attend private schools in the city of Oaxaca.

The growth status of children is a valuable, direct indicator of the health and nutritional conditions of communities in developing countries. The results will reflect rural-urban contrasts in overall quality of life.

Chronic mild-to-moderate undernutrition is a risk factor for several functional impairments. However, there is at present limited information for Mexico that assesses this relationship, apart from earlier studies by Malina and colleagues. Other available data from Mexico focus more often on the relationship between severe protein-energy undernturition early in life and functional status in preschool children. This is well documented in the work of Chavez and Martinez (1984) and Cravioto (1980, see also Cravioto and Arrieta, 1986). Compared to preschool children, school age children are unique in many parts of Mexico and other developing countries. They represent the survivors of a rigorous selection process that involves chronic undernutrition and infectious diseases, and associated morbidity and mortality. School children will be, to a large extent, the next generation of economically active adults.

Overview of Previous Studies in the Communities of Interest

Previous studies conducted by Malina and colleagues in the Valley of Oaxaca began in 1968 in Santo Tomas Mazaltepec, a Zapotec-speaking community of about 1250 individuals in the mid-1960s. The initial study focused on the growth status of the primary school children, 6-14 years, and foods consumed at the household level in a single rural community. In 1971 and 1972 the study expanded to include primary school children in several contrasting communities in the Valley of Oaxaca, including an additional Zapotec-speaking community (Magdalena Teitipac), two urban colonias (Benito Juarez, San Juan Chapultepec), and two rural Ladino communities (Rojas Cuauhtemoc, San Francisco Telixtlahuaca). The combined sample from 1968 to 1972 was approximately 1450 primary school children (Malina et al., 1980b).

A ten-year follow-up of Santo Tomas Mazaltepec was undertaken in 1978 (Malina et al., 1980a, Malina and Selby, 1982). The study included a village census (approximately 1700 inhabitants), and the growth status and motor fitness of school children 6-14 years of age. The study also included food items consumed at the household level, status quo and retrospective menarcheal data, and anthropometry of adults. In 1979 a one-year follow-up of the school children was undertaken to estimate velocity of growth (Buschang, 1980).

Summary of Findings of Previous Studies

Growth status in the combined sample from 1968 to 1972 included 1450 children 6-16 years of age from two rural Zapotec-speaking communities, two rural Ladino communities and two colonias populares. Mean statures were consistently below the 5th percentile of U.S. (NCHS) reference values. A delay in the adolescent spurt was suggested by the deviation of stature below the 5th percentiles after 11-12 years. Body weights of girls, on average, fell between the 5th and 10th percentiles whereas those of boys were close to the 5th percentile from 6-11 years and fell below the 5th percentile subsequently (Malina, 1982, 1983). Weight-for-stature in boys and girls, on the other hand, corresponded to medians for prepubertal U.S. children (NCHS). Although they are absolute shorter and lighter, the school children of Oaxaca have appropriate weight-for-stature.

In a more specific study of the Zapotec-speaking community (STM) in 1978, the school children were grouped on the basis of an economic index derived from landholdings, household goods and occupation. Within this seemingly single class rural community boys from higher socioeconomic status (SES) households had better growth status. The same trend was evident for girls, but the results were not significant (Malina et al., 1985). Evidence of early growth deficits was suggested in the estimated growth velocities based on 1978 and 1979 surveys. Estimated velocities of growth in height did not differ between children from high and low SES households (Little et al., 1988). Growth rates of school children from STM, including body weight, stature, sitting height and estimated leg length, when compared to corresponding data for well nourished children of similar age, also suggested that the growth deficits affecting stature and estimated leg length in Zapotec children occurred during early childhood (Buschang, 1980; Buschang and Malina, 1983; Buschang et al., 1986).

The growth of Oaxaca children was compared to middle class children of Mexico City (Ramos Galvan and Luna Jaspe, 1964), to reference values for well-off Mexico City children (Ramos Galvan, 1975), and to children from low economic conditions (Perez Hidalgo et al., 1965). Children from Oaxaca tended to be even smaller than the children from poor socioeconomic conditions (Malina et al., 1972; Malina, 1982, 1983).

The rural-urban comparison of Oaxaca school children showed that the rural Zapotec children were smaller than rural Ladino and urban colonia children. The rural Zapotec children also had smaller estimated mid-arm muscle circumferences than both rural Ladino and urban colonia children (Malina et al., 1980b).

Children from the rural Zapotec community also had lower absolute levels of strength and motor fitness compared to well-nourished children of the same age and sex. However, per unit body size, grip strength was appropriate, running and jumping performances were less, and throwing performance was better than expected (Malina and Buschang, 1985; Malina et al., 1987).

There was no secular change in stature, weight, arm and estimated mid-arm muscle circumferences, the triceps skinfold, and grip strength of school children in Santo Tomas Mazaltepec over the 10-year interval between 1968 and 1978 (Malina et al., 1980a). Diet estimated from the foods consumed at the household level also indicated little change between 1968 and 1978 (Peña et al., 1995). The lack of secular trend change over the short term (1968-1978) appeared consistent with lack of secular change in height among Zapotec adults between 1899 and the1970s (Malina et al., 1983). In this context, it was concluded that more time was perhaps needed before improvements in indicators of public health, such as easier access to health care and a decline in infant mortality, among others, may be reflected in improved growth status of school children (Malina and Selby, 1982).

The present study is concerned with urban-rural contrasts in growth and physical fitness, and in the prevalence of stunting, wasting and overweight/obesity. Data collected for the present study provide the basis for a more comprehensive comparison of changes in growth status between 1968/1978 and 2000, which is the major focus of the broader study (Malina, 1999). The analysis of secular change in the growth status of school children indicates a major increase in height (approximately 6 cm) over the past 30 years or so. Since there was no short term secular change between 1968 and 1978, the major increase in height has thus occurred over the past 20 years (Malina, 2002). Consistent with the secular change literature (Bielicki, 1986, 1999), the improved growth status of the primary school children in Oaxaca can be viewed as reflecting improved health and nutritional conditions.

Chapter 2

Review of Literature

The present study is concerned with urban-rural contrasts in growth and physical fitness, and in the prevalence of stunting, wasting and overweight/obesity of school children in the Valley of Oaxaca in southern Mexico. The review first considers presently available comparisons of the growth status and physical fitness of urban and rural children in different parts of the world. It then focuses on urbanization in Mexico and related issues, and then more specifically on the demographic characteristics of the population in the state of Oaxaca, including recent trends in migration. Urban-rural contrasts in the growth status of Latin American children and specifically those in Mexico are then considered. Finally, the functional consequences of chronic undernutrition, including effects on motor performance and physical fitness are reviewed.

Urban-Rural Contrasts – General Considerations

The significant changes that accompany the transition from agricultural to urban industrial societies have greatly impacted the social and biological transformation of populations worldwide. The urbanization process, however, occurs under different circumstances among countries. In the case of Europe, for example, urbanization has been a long term process, directed largely by individual interests and needs. In contrast, the process of urbanization in most developing countries of the world has been dictated by worldwide economic demands and constraints (Valladares and Coelho, 1993).

Living Conditions

Urbanization in Europe was characterized by consistent improvements in the economy which clearly favored nutrition and child care. The favorable conditions associated with urbanization in Europe included a regular supply of goods and services, and relatively easy access to health care and related service institutions (Tanner and Eveleth, 1976). Children in the cities benefited from sanitation and health services, large medical institutions, and educational, recreational and welfare facilities. In contrast, rural dwellers generally did not have equivalent services, and even worse, often lacked food during critical periods of growth. Other problems in rural areas which impacted the nutritional and health status of children were related to lack of adequate food storage facilities and inequitable distribution of resources. In addition to environmental differences, a more diverse genetic background probably resulted from migration and subsequent admixture in urban settings. This genetic heterogeneity may be an additional factor, which influences growth status.

Accelerated urbanization in developing countries at present has reduced the time that is needed to adjust to changes and, therefore, has affected not only lifestyle but also the local ecology, often with serious consequences for health. Urbanization has taken different paths depending on demographic profile, health status, natural resources and economic conditions, among many other factors (Schell et al., 1993).

Urban-Rural Contrasts in Growth

Data from Europe that span the past 100 years or so consistently indicate that, within a specific country or cultural group, children in urban areas have greater size and mature earlier than their peers in rural areas. In many countries, the urban-rural differences persist in studies of adults (Bielicki, 1986). The differences in size and maturity among children and adolescents in urban and rural areas are often attributed to beneficial changes in public health and nutrition and in general living conditions associated with urbanization.

Meredith (1979, 1982) has reported comprehensive reviews of studies of selected somatic characteristics of children and adolescents living in urban and rural areas in various parts of the world. Data for the period from 1870 to 1915 showed that children and youth of European ancestry residing in urban centers were generally shorter and lighter than rural children. In contrast, data for the period 1950 to 1980 indicated that urban children were taller and heavier than rural children (Meredith, 1979, 1982). Data for the period between 1915 and 1950 are not as extensive but it appeared that by the 1930s in Europe and the United States, the rural-urban contrast was reduced and/or reversed (Malina et al., 1981).

At present, there are no significant urban-rural differences in the growth status of children and adolescents in the United States, Canada and most western European countries (Hamill et al., 1972; van Wieringen et al., 1971; Eveleth and Tanner, 1976, 1990). On the other hand, some European countries, especially in eastern Europe (e.g., Poland, Romania) and the Mediterranean area (e.g., Greece) continue to show an urban-rural gradient in growth and maturity (Bielicki, 1986). Studies of 19 year old Polish conscripts best illustrate the urban-rural differences because they account for factors, which may potentially confound the comparisons. Among young adult male conscripts surveyed in 1986, heights of those from rural areas were about 173 cm compared to 177 cm for those in larger urban centers, respectively (Bielicki et al., 1992; see also Bielicki and Waliszko, 1991). Corresponding mean heights in 1995 were about 174 cm for conscripts from rural areas compared to about 179 cm for conscripts from large cities (Bielicki et al., 1997). The trends for Polish conscripts suggest that the urban-rural contrast in young adult height has not changed over time from 1965 to 1995. Rural Polish girls also attain menarche later than urban girls, although the difference between mean ages has declined from about 1.0 year to 0.6 year in surveys between 1955 and 1988 (Hulanicka and Waliszko, 1991).

Urban-rural contrasts are also evident among Han children and adolescents in China (Han are the dominant ethnic group in China). Differences between mean heights of urban and rural Chinese boys 7-18 years range from 2.9 to 5.7 cm;

corresponding differences for urban and rural girls range from 2.1 to 5.6 cm (Lin et al., 1992a). The urban-rural contrast is also reflected in later ages at menarche in rural girls (Lin et al., 1992b). Similar urban-rural contrasts are evident in the growth and maturity status of children and adolescents in parts of Africa (Spurgeon et al., 1984; Cameron et al., 1992; Pawloski, 2002).

Urban-rural differences in growth and maturation reflect to a large extent the inequitable distribution of and access to resources within a country. These include economic, educational, nutritional and health-related resources. Such resources are often concentrated in urban centers and are limited in the extent to which they filter into the rural areas of some countries.

Urban-Rural Contrasts in Physical Fitness

In contrast to available data on comparisons of the growth and maturity status of urban and rural children, corresponding data are limited for comparisons of physical fitness. Studies from the 1960s and 1970s indicate negligible differences in the physical fitness of urban and rural children in several European countries (Shephard, 1978). Studies of Polish youth 7-15 years of age in the 1960s and 1970s, in contrast, indicate consistent urban-rural differences in tests of motor fitness – vertical jump, medicine ball throw for distance, dash, agility (Miernik, 1965; Pilicz and Sadowska, 1973). The differences in motor fitness may reflect the contrasting lifestyles of rural and urban populations in Poland in the 1960s and 1970s because size differences (height and weight) between the samples compared were rather small (Pilicz and Sadowska, 1973). The same may explain variation in aerobic fitness between youth 12-15 years of age resident in alpine villages and midland urban centers in Switzerland (Buchberger, 1979).

Among Japanese primary school children 4-5 years of age, children residing in an island community were more flexible and had better motor coordination than urban children, but the latter performed better in tests of motor ability – standing long jump,

ball throw, agility, dash (Munetaka et al., 1971). Data for Japanese elementary school children and adolescents are variable (Tamura, 1975). Rural adolescents of both sexes tend to have higher levels of aerobic power (ml/kg/min) and the urban-rural difference increases with age. On the other hand, corresponding urban-rural contrasts for motor performances vary among prefectures in Japan, but in many instances urban children showed higher levels of motor ability. The rural-urban difference in endurance was attributed to the fact that the rural children walked relatively long distances to school and spent more time in physical activity (Tamura, 1975). This is consistent with the positive association between indicators of physical activity and energy expenditure and measures of cardiovascular endurance. On the other hand, the proficiency in motor ability among urban children was attributed to better access to school physical education and sport programs.

It is of interest that urban-rural comparisons of indicators of physical fitness has not received much attention in the auxology and sport science literature in the 1980s and 1990s. This is perhaps due to the reduction of differences in lifestyle and in access to health resources in urban and rural areas associated with economic development during this time. Urban-rural comparisons of the performance of contemporary American children are not available. A comparison early in the 20th century indicated negligible differences in lung capacity, grip strength and speed of limb movement between urban and rural children in Missouri (Pyle, 1920).

Urban-rural comparisons in developing areas of the world are of limited utility due to the generally marked socioeconomic and nutritional contrasts between communities (Malina, 1990). Nevertheless, results in some studies are variable. For example, rural children in South Africa of low socioeconomic status tend to have lower grip strength compared to urban children of high socioeconomic status, which probably reflects, to some extent, the reduced body size of the rural children. In contrast, comparisons of neuromuscular reaction time and pulse rate before and after exercise show no consistent rural-urban differences (Henneberg and Louw, 1998).

Urbanization in Mexico

By the beginning of the 20th century in Mexico, it was estimated that only 10% of the total population lived in urban areas. The other 90% lived in rural areas comprising widely distributed in towns of less than 15,000 inhabitants. By the year 1990, about 58% of the population lived in urban areas (46.7 million inhabitants) and the remaining 42% were in rural areas (34.5million inhabitants), including many in small communities. Thus a major shift in the population distribution has occurred. A rather large sector of the population was displaced from rural to urban settings.

The change in the population distribution in Mexico during the 20th century had several trends. Early in the century, the state with the most population was Jalisco, followed by Guanajuato, Puebla, Veracruz and Oaxaca. In contrast, the state of Mexico was 6th and Mexico City was 10th in population size. Between the 1980s and 1990s, there was a complete change in order and distribution of the population. The state of Mexico, which surrounds the Federal District (Mexico City), is now the most highly populated state in the country, approaching 10 million inhabitants, and the Federal District (Mexico City) is now in second position. Guanajuato and Oaxaca moved down in rank to the 6th and 10th positions, respectively (Cabrera-Acevedo, 1993).

Economic policies and structural changes contributed to better living conditions, which in turn influenced demographic changes. The internal gross national product doubled between the end of the 1940s and the beginning of the 1970s. Improvements in living conditions and increases in social investments, education and health were considered a social priority. Nevertheless, social inequalities were prevalent and persisted. Disparities between social groups as reflected, for example, in average mortality rates, varied to the extent that the difference in life expectancy between extreme social groups was about 12 to 15 years (Cabrera-Acevedo, 1993).

The economic goals for the country by the 1970s relied on industrialization with corresponding impacts on population mobility and geographic distribution. Migration from rural to urban areas, primarily to Mexico City, was dramatic. Mexico City absorbed 50% of the total migration from different states, whereas the northern cities of Guadalajara and Monterrey received another 10%. Baja California, in the northwest of the country, was an important point for out-migration given its proximity to the United States (Cabrera-Acevedo, 1993).

Agricultural reforms between 1934 and 1940 benefited a large sector of the rural population of Mexico. Agricultural modernization and irrigation were part of the so-called "green revolution," which had major results in the north of the country, whereas the opposite was the case for the economy in the center and south of the country. From the mid-1940s through the 1950s, agriculture was adequate for food production and economic resources (money stock) for the growing urban and industrial economy.

The industrial sector experienced a rapid growth from the 1940s to the1970s, which eventually proved to be the main influence for participation in work-related activities in urban areas and in turn urbanization of the population. Industries were located in the major cities, Mexico City, Monterrey, Puebla and Guadalajara. Private and government investments stimulated the development of the basic infrastructure for support of the oil, electricity, steel and iron industries, and in turn growth of the labor force. Government support for industrialization also included commercial policies, which included protective tariffs and import permits, that assured a protected market for local industries in addition to tax exemptions and subsidized credits to promote investment. The labor force experienced a considerable increase in that segment of the population between 15 and 64 years of age, and a growing participation of women in the work force.

Within the decade of 1930 to 1940, under the government of Lazaro Cárdenas, there was a significant agricultural reform along with industrialization, which together with demographic growth promoted better living conditions (well-being), increased birth rates, and decreased mortality rates resulting in population growth. Increased population mobility became a clearly recognizable social phenomenon, and was a key factor in the increase in population size in the federal capital and surrounding urban area (labeled Mexico City). It became the main destination for migrants from other geographic areas of the country. As a result of this demographic growth, social, economic and political problems emerged in rapidly expanding cities.

Social policies also played an important role in urban growth, among them being investments in basic services such as education, sanitation and transportation. The social security system (Instituto Mexicano del Seguro Social, IMSS) was implemented in 1943, and by 1970, about one-fourth of the population was covered, although benefits were limited largely to urban areas.

On the other hand, government policies directed towards legalization of irregular settlements on the periphery of large cities, i.e., colonias populares, had the purpose of meeting the housing needs of the rapidly growing urban population. Subsidies for basic products, including energy, were largely directed towards regulation of the national food supply. Most strategies had an urban bias, and, to a large extent, benefited the low-income sector of the urban population (Alba, 1993).

This accelerated economic development and demographic growth eventually came to an end by the late 1970s when social policies (i.e., birth control, public health, education, etc.) changed. Although the "green revolution" provided food self-sufficiency to the country by the late 1970s, agricultural production stopped growing. Education made rather impressive advances, but the large numbers of illiterate individuals did not decrease. Accumulation of human capital was also slowing, and the labor force had, on average, only four years of education. Many did not complete six years of primary school. Therefore, employment expectations of both the rural and urban sectors became uncertain, and at this point, the advantages of urbanization were seriously questioned (Alba, 1993).

In the context of changing conditions, the Consejo Nacional de Población (1998) developed an index of marginalization (índice de marginación) to quantify inequities within the country. Marginalization was defined as persistent inequities that prevent individuals and communities from enjoying progress and associated benefits. The index includes four components: (1) Education – percentage of literacy in the population 15 years of age and older; percentage of people who did not complete elementary school; (2) Housing – percentage of households without drainage and electricity; percentage of people living in crowded households, household without potable water, and houses with dirt floors; (3) Population distribution – populations living in localities less than 5000 inhabitants; and (4) Income -- percentage of working age individuals earning up to two minimum wages. Indices were estimated for the municipal level using the 1990 census as a base and then a population update based on the 1995 Conteo de Población. The index for the state of Oaxaca was 1.85 (very high marginalization). Indices for other states were 0.80 for Yucatan (high marginalization), 0.00 for Durango (medium marginalization), -0.85 for Sonora (low marginalization, -1.27 for Baja California Norte (very low marginalization) and -1.74 for the Federal District (very low). Most of the municipios in the state of Oaxaca were classified as having a very high index of marginalization (Consejo Nacional de Población, 1998).

Urbanization and Migration

Ecological changes and in some cases deterioration brought about by intensive farming, crop failures, and limited assets contributed to rising debts, food insecurity and reduction in good farm land, which were primary contributing economic factors underlying rural to urban migration. An important question was, "What degree of food deprivation is needed to trigger out-migration?" Failure of economic policies to stop poverty is characteristic of agricultural modernization. It limits work opportunities by offering low wages and growing underemployment in the form of informal activities. These factors underlie out-migration from rural indigenous communities (Wilson, 1993).

Impoverished living conditions resulting from uneven regional development in rural economies are among the main reasons behind migration in search of improved family income. According to community-based observations, people with more years of education have limited opportunities for jobs in the region. Young adults, particularly in the age range 20 to 34 years, are the workers who most often seek jobs outside of their respective communities. The type and duration of migration varies through time. Until 1950, indigenous migration was limited to temporary agricultural work in relatively close geographical areas (Molina, 1991). The work generally involved cash-crops, such as coffee and sugar cane, which required heavy physical work. After the work season, the workers usually returned to their communities to carry on farming of their own lands and the social and religious traditions of their respective communities. After 1960, however, temporal farming production was no longer adequate to meet community needs, and working outside of the community gradually became a prolonged absence and often permanent migration involving the whole family.

The progressive detrimental impact of migration on a community takes different forms which start with reduced participation in the local economy for a short period and eventually leads to a demographic impact on the community by reducing the number of economically active adults. In many cases, migration of young adult males demands a reorganization of farming strategies as the work now has to be carried on by women, children and older individuals. Associated changes are an increase in supplementary income generating activities, such as handcrafts, hunting and fishing.

There are thus two faces of migration. One is positive by providing economic input to the community by sending funds to support small-scale agricultural production that benefits the local economy. The negative side is the occupational mobility that often breaks-up family structures. It becomes more severe when migration is long term and when women, children and older people must undertake the essential subsistence agricultural labor tasks.

Migration and Demographic Characteristics of Oaxaca

The state of Oaxaca is characterized by high overall marginalization, economically, socially and politically. According to the National Population Council (CONAPO, 1996, cited by Iraizos-Bravo, 1999), 70% of the inhabitants of the state lived in communities of less than 5000 inhabitants and about 80% of the work force (población economicamente activa [PEA]) had incomes below two minimum wages [a minimum wage is the lowest salary paid for one working day, as regulated by law]; the level of income to provide enough for living is estimated at least two times the minimum wage (Iraizos-Bravo, 1999). In 1999, the minimum wage was about 34.5 pesos per day for Mexico City and 30.0 pesos per day for the state of Oaxaca [corresponding to about 3.7 and 3.2 U.S. $, respectively] (INEGI, 2000). The state of Oaxaca ranked second in illiteracy (just after Chiapas); this included 20% of the population older than 15 years of age in 1997 (INEGI, 2000). About 25% of the population in the state of Oaxaca older than 15 years of age did not complete elementary school. Further, about 45% of households in the state of Oaxaca lacked sewage disposal and 32% lacked potable water. Sewage disposal and potable water are minimum indicators of the local infrastructure.

About 51% of the economy in the state of Oaxaca is dependent upon agricultural activity. However, low wages earned by agricultural workers have forced many families to have women and children in the agricultural work force.

Statistics on the work force in Oaxaca for the 1995-1996 sugar cane harvest, Zafra, Programa Nacional de Jornaleros Agricolas (cited by Iraizos-Bravo, 1999), indicated that 23,000 migrant workers in Sinaloa, in the north of Mexico, were younger than 14 years of age. They represented 45% of total wage labor force, and the largest contingent of the young workers came from Oaxaca. The earnings of youth are thus becoming a critical component for the family's economy. However, the adverse working conditions and inadequacy of health care and education for working youth places them at high risk with a progressive deterioration in quality of life and little hope for a better adult life (Arboleda-Ramirez, 1999).

Comparative data on living conditions in Oaxaca between 1980 and 2000 are shown in Table 2.1. The data indicate rather slow improvement in living conditions for the state. However, when the same indicators are observed within specific communities, the range of inequality is magnified. For decades, the state of Oaxaca suffered, to a large extent, from ups and downs related to government agricultural and social policies and strategies that offered the hope of progress, economic improvement, and better quality of life for the area. The state has experienced significant changes in forms of production and resource allocation, but none of the strategies have apparently succeeded in offering enough resources to families to earn a decent living. It is not an accident that, given the heavy reliance of the state of Oaxaca on agriculture, its population has been struggling to survive the attacks of land reform and economic measures that have created the conditions that prevent the population from reaching food autonomy, reliability, and sustainability. Therefore, analysis of nutritional deficits in the population and its functional consequences are of central importance (Arboleda-Ramirez, 1999).

Urban-Rural Contrasts in Mexico and Latin America

Urban-rural contrasts in many developing countries of Africa, Asia and Latin America are magnified by chronic nutritional problems in the rural areas, in addition to marked economic inequities. In the more developed countries of these regions, the urban-rural contrast in growth and maturity reflects SES variation, i.e., the larger size and earlier maturity of urban children reflects the better-off economic circumstances and access to resources of city residents (Eveleth and Tanner, 1990).

Urban-rural comparisons of the growth status of Mexican children date to the 1960s. Vega-Franco and Robles-De la Vega (1962) estimated the nutritional status of urban school children from Durango (north central Mexico) with height and weight. A sample of 11,406 children, 6 to 12 years of age from public schools (5,917 males and 5,489 females) was measured in 1961. Adequate nutritional status corresponded to a height within ±5% and weight within ± 10% of Mexican reference data (Ramos Galván, 1960). There was a deficit in weight that increased with age in males and females, beginning at 7 and 8 years, respectively, which lead to an increase of first-degree undernutrition in males and first and second undernutrition degree in females (Gomez criteria, see below). Height was normal in 74% of males and 68% of females.

Perez-Ortiz and Mora (1967) assessed the growth status of a sample of school children, 7 to 14 years, from rural community in Tlaltizapán, Morelos, between 1962 and 1963. The sample was characterized by having low weight and most of the children were classified as having first degree undernutrition according to Gomez classification, which is based on weight-for-age. In the Gomez protocol, nutritional status is determined as follows: (actual weight / ideal weight for age X 100). The Gomez scale has the following categories: (1) overweight > 110%, (2) adequate 91-100%, (3) first degree undernutrition 76-90%, (4) second degree undernutrition 61-75%, (5) third degree undernutrition <60% (Gomez, 1946, 1956).

Weight and height were almost equally affected in the rural children from Morelos, and females were more affected than males. On the other hand, males had more weight-for-height from 9 to 11 years, which suggested a tendency towards overweight for these groups.

Table 2.2 compares the mean weights and heights of urban children from Durango with the corresponding values for rural children from Morelos. Although the children are from different geographic regions, both series date to the early 1960s, and may represent the trend for urban-rural differences at this time. Weight differences were larger in boys (2.5 to 3.5 kg) than in girls (0.8 to 3.3 kg). Height differences were also greater in boys (4.5 to 7.0 cm) than in girls (3.0 to 7.0), except at 10 years when the difference between urban and rural girls was greater than the difference between boys. This probably represents sampling variation in the cross-sectional samples.

Perez Hidalgo and colleagues (1965) compared the growth status of urban boys, 7-14 years of age, in Mexico City from high (n=1067) and medium (n=505) socioeconomic status (SES) and a sample of boys from a rural community close to Mexico City (n=425). Children of urban medium SES were taller and heavier than rural children at all ages. However, compared to U.S. reference values (University of Iowa charts), the Mexican children of high SES had an average height that was 15% lower and an average weight that was close to the median for U.S. children. Comparison of the urban and rural children in Table 2.3 also indicates smaller urban-rural differences than those in the Durango-Morelos comparison (Table2.1). Mean differences for weight were 0.5 to 3.3 kg at ages 7 to 12 years of age and reached 4.8 kg at 13 years. Differences for stature fluctuated between 2.0 cm and 5.2 cm.

Comparative studies for the 1970s are based on urban-rural and high-low SES samples. Pryor and Thelander (1972) compared the growth of 382 urban and 439 rural school children, ages 6 to 15 years, from southern Mexico (Oaxaca and Chiapas) to American children from California. Among Mexican children, there was very little difference between heights of the urban and rural samples until adolescence, although urban children were slightly taller at most ages. Beginning at age 10 in girls and 11 in boys, consistent differences showed that urban children became taller than rural children. Compared to Californian children, Mexican boys and girls had heights that were one standard deviation below the mean from 6 to 9 years and then 1.5 standard deviations below the mean from 10 to 12 years. Unfortunately these data are reported only graphically and the actual values are not available (Thelander personal communication to R.M.Malina).

A comparative study of urban school children from high SES (162 females, 156 males) and low SES (275 females, 226 males) in Mexico City (Villanueva, 1979) showed considerable differences between the groups. The difference between high and low SES children reached, on average, up to 4 cm for height and 2 kg for weight. The samples were also compared to middle class Mexican children (Faulhaber, 1976), to high SES Mexican children (Ramos-Galvan, 1975), and to British reference data (Eveleth and Tanner, 1976). Boys and girls from high SES compared well to the average heights of high SES Mexican children (Ramos-Galvan) and British children (Eveleth and Tanner), but were above the urban middle class Mexican children (Faulhaber). The high SES girls were heavier than girls from lower SES and the middle class sample (Faulhaber), but were lighter than British and high SES Mexican children. In contrast, high SES males were consistently heavier than their lower SES peers and the middle class sample, but were similar to reference values for British children and the high SES Mexican reference between 7 and 10 years; subsequently, their weights were heavier. The differences in height and weight between high and low SES Mexican children are shown in Table 2.4. Differences in weight ranged from 0.7 to 3.3 kg in males and from 1.2 to 3.5 kg in females, but did not follow a pattern across age groups. The differences in height ranged between 3.5 to 5.7 cm in males and from 3.4 to 6.3 cm in females. The largest difference occurred at 10 to 11 years of age in girls, which was interpreted as reflecting earlier sexual maturation (Villanueva, 1979).

The growth of 554 school children, 6 to 15 years of age (287 males and 267 females) from Indian communities from Chiapas was reported by Aréchiga and Serrano (1981). Heights and weights of rural children were considerably below the urban Mexican reference for high SES children (Ramos Galvan) and middle SES children (Faulhaber) at most ages in both sexes (Table 2.5). The differences in height and weight were considerably larger than indicated in the comparisons cited above, reflecting the impoverished circumstances in rural indigenous communities in southern Mexico. However, the urban-rural differences were of similar magnitude in boys and girls.

Nutritional status and food intake were assessed in three rural villages of Guanajuato, a north central state of Mexico, by Eastwood-Garcia et al. (1990) with the purpose of identifying patterns of food intake and growth stunting in preschool children (33 to 60 months of age). The observational study collected data on 45 children (24 males and 21 females). Stunting corresponded to height-for-weight below three standard deviations of reference values. The children had experienced a reduction of linear growth due to past insults, but were not currently overly thin. Although the children were beyond the period of greatest vulnerability, it was apparent that catch-up growth did not occur.

Butte et al. (1993) followed the weights and heights of infants in Capulhuac, a rural farming community in the northern Mexico, at monthly intervals from birth to 6 months. Growth faltering was evident at 6 months. Assessment of energy expenditure indicated that energy utilization was impaired as a result of malabsorption and/or micronutrient deficiencies, and possibly illness. More importantly, the energy intake was not appropriate to support catch-up growth.

Lagunas-Rodriguez and Jimenez-Ovando (1995) conducted a study of Otomi youth, 6 to 20 years of age, living in the northwest part of the state of Mexico. The cross-sectional sample of 518 males and 489 females was studied between 1978 and 1987. Although living conditions in the Otomi region were slightly better than those that were common in Chiapas, a similar growth pattern was apparent upon comparison with to the urban middle class sample of Faulhaber (1976). The differences increased with age and ranged from 6.4 to 15.5 cm for height in males and from 4.0 to 10.4 cm for height in females. The largest differences occurred at 13 year in males and at 12 years in females (Table 2.6). Unfortunately, body weights were not reported.

Lopez-Alonso (1995) reported on the growth of children in three North Sierra communities in the state of Puebla in late 1970s and the late 1980s. The samples were from Zacapoaxtla (n=374) and Caxhuacan (n=332), which are predominantly Nahuatl-speaking communities. The third community was Mecapalapa (n=383), a Totonaco-speaking community. The sample included youth 8 to 18 years of age. The particular interest in the groups was related to isolation resulting from geographic barriers since they lived in the Sierra Madre region. Growth in height and weight was compared to the urban middle class samples of Faulhaber (1976, 1989) using z-scores. At 8 years, both males and females from Zacapoaxtla and Mecapalapa had heights slightly below the urban reference, but with increasing age males from Zacapoaxtla lagged behind the reference by –0.5 to -1.5 SD units from 9 to about 15 years of age. The Caxhuacan samples presented a poorer picture; boys had heights that varied between –1.5 and –2.5 SD units between 8 and 15 years of age, and girls showed heights more than –3 SD units at most ages. Body weights showed a similar pattern, but deficits were not larger than –2 SD units. The results indicated a greater effect on height than on weight. The apparent sex difference in the magnitude of the deficit was attributed mainly to preferential treatment of males influenced by local rearing practices.

Cities in many developing countries of the world are currently expanding as a result of continuous rural to urban migration. Estimates for the year 2000 showed that Latin America appeared to be the most urbanized region of the developing world. Latin America urbanization has been associated with high rates of population growth, and until the 1960s, the urban population was highly concentrated in the main cities as in the cases of Montevideo, Buenos Aires, Mexico City, Caracas, Santiago, Lima, San Jose and Panama City (Valladares and Coelho, 2000). Although the rural-urban migration later shifted to medium-sized cities, population mobility continues to be a challenge when recession, scarcity of resources, and poverty are highly prevalent in urban settlements characterized by poor living conditions.

Quite commonly, migrants from rural areas form irregular settlements on a city's edge. Such neighborhoods are variously labeled in the literature, but a common term appears to be "shanty towns." Names for such neighborhoods in Latin American countries include favelas, barriadas, pueblo jovenes, and colonias populares. Health and nutritional conditions associated with migration are generally poor (Malina et al., 1980b; Malina, 1990).

Malina et al. (1981) considered the growth status of children from six communities in the Valley of Oaxaca in southern Mexico in the 1970s: two rural indigenous, Zapotec-speaking communities, two rural Ladino communities (more westernized and progressive), and two urban colonias. Boys in the colonias were slightly, but consistently, taller and heavier than boys in rural indigenous communities, but girls in the communities did not differ in height and weight. In contrast, children from the rural Ladino communities were slightly better off in height and weight compared to those in the colonias and rural Zapotec communities. Urban colonia and rural girls also did not differ in age at menarche (Malina et al., 1981). Of interest, rural to urban migration (i.e., children in the colonias) did not necessarily result in improved growth status since the differences between rural Ladino and urban children were small (about 0.5 kg for weight and 2 cm for height). On the other hand, the comparison clearly indicates the relatively poor nutritional status of children from rural indigenous communities (see Malina, 1990).

Graham et al. (1979, 1980) noted generally similar results for Peruvian children. Differences in height and weight were small between rural children from northern villages and poor urban children from the capital city of Lima. Rural boys were slightly shorter, but no differences were observed for rural and urban comparisons of stature in girls. Height and weight ratios suggested that, on average, rural children carried less weight-for-height than urban children.

Given the relatively high rate of migration from rural to urban areas in Latin American cities (as well as in other parts of the developing world), the need for ongoing studies of the growth status of children who migrate with their families is highlighted. With a longer duration of residence in urban areas, growth status may improve compared to children in rural areas.

Urban-rural differences in growth can be summarized as showing two different trends, one for developed and the other for less developed countries. In the case of United States and most European countries, the earlier advantage of rural children over urban children was reversed from the 1950s to the 1980s, resulting in taller and heavier children in urban compared to rural areas settings. Afterwards, no urban-rural differences are observed, which appears to indicate that living conditions for both urban and rural population are very much alike. In contrast, in some European countries as well as in Latin American countries an urban-rural difference that favor living conditions for urban children involve not only growth but also maturity. These trends are evident among children and young adults in the case of Poland, children and adolescents in China, and, especially children, adolescents and adults in Africa and Latin America.

The rationale for emphasis on the urban-rural gradient for populations where such differences exist is their common origin, i.e., most differences result from unequal access to economic resources that negatively impact quality of life. In general, the high concentration of economic resources, facilities and health services in cities of less developed areas of the world makes urban dwellers a privileged sector of the population. At the same time, this kind of urbanization raises physical and economic barriers that prevent children living in rural areas from having access to adequate living conditions and, therefore, for reaching they full growth potential. In the case of Mexico, the urban advantage over rural living conditions has prevailed for more than three decades, if not more, which indicates that not enough has been done to improve the living conditions and quality of life in rural areas. This is especially evident in two well studied rural, indigenous populations such as the Maya of the Yucatan (McCullough, 1982) or Zapotecs of Oaxaca (Malina et al., 1980, 1983). Both

Yucatecan Maya and Oaxaca Zapotecs have showed very little or no improvement for most of the 20th century, at least through the 1970s.

Such conditions are comparable in the Totonaco-speaking and the Nahua-speaking communities studied by Lopez-Alonso (1995). Quality of life also has not improved for indigenous communities in Chiapas, one of the most marginalized areas of the country, which is experiencing recent social movements demanding better use of natural resources to improve their lives. The rural populations, living under the more difficult conditions are, to a large extent, indigenous. The Otomi population studied by Lagunas-Rodriguez and Jimenez-Ovando (1995) is slightly better-off, though with weights and heights that still fall below those of urban populations. It is possible that one of the advantages of this group is its relative proximity to Mexico City, which may translate into easier access to better resources. Therefore, when they are compared to those who have both economic and the geographic disadvantages which set them farther away from major urban centers, living conditions then appear to be better off than other indigenous groups.

There is then a need for more precise and up-to-date information on the health and growth status of children in rural communities of Mexico. Promotion of health and nutritional programs to improve living conditions of marginalized people at present has to start with the knowledge of the extent of rural-urban differences and with more precise information of how they affect children, and, moreover, to what extent they affect the ability of adults to obtain daily living resources. The ability to develop such basic information required to implement adequate nutrition, health and education programs that respond equally to the needs of urban and rural populations may be expected to reduce the gaps that presently exist.

Functional Consequences of Undernutrition

Risk factors for growth retardation associated with chronic undernutrition include seasonal changes in food availability, disease, poverty, and overall deprivation. Frequent infections may also contribute to reduce rates of growth in length and weight. Although improvements in sanitation and health care help to reduce the risk of some diseases, recovery from infections increases the nutritional demands on the organism. An adequate diet must account for the dietary requirements for catch-up after a bout with infection.

Because undernutrition affects a large sector of the population in developing countries, it is a major, worldwide public health concern. Nutritional deficiencies can have long term consequences at different levels, ranging from poor mental development, to impaired physical growth (stunting), to limited physical working capacity (Allen, 1993; Pollit et al., 1996; Scrimshaw, 1996).

The association between changes in weight-for-height and linear growth in children from poor environments is considered a response to marginal dietary intakes over time, which allows overall growth to proceed but at a reduced rate without the children becoming wasted. This mechanism appears to insure proportionate growth under critically low energy and nutrient intakes.

Marginal nutritional status, sometimes labeled mild-to-moderate undernutrition, is presently highly prevalent in developing countries more so than more severe forms of undernutrition. The World Health Organization (Onis et al., 1993), based on surveys conducted from 1980 to 1992, reports that most countries in Latin America have a low to moderate prevalence of underweight among preschool children (birth to 5 years of age). However, there is considerable variation in estimates among countries and within specific countries.

Cognitive and Behavioral Consequences of Undernutrition

Studies that focus on the impact of early undernutrition on cognitive development were mainly concerned with its potential influence on mental development, and over the long-term, reduction of opportunities for success in school. For adults, such persistent conditions would affect the development of skills necessary to earn a living.

Mild-to moderate undernutrition is recognized as a developmental risk factor in this regard (Pollitt et al., 1996; Winick, 1993).

Effects of undernutrition on social and emotional development have received limited attention. Several studies have shown that social and emotional development are sensitive to undernutrition, so that marginal nutrition can affect a child's ability to adapt to his/her social and educational environments (Espinosa et al., 1992; Gardner and Grantham-McGregor, 1990; Grantham-McGregor et al., 1991).

Information on the consequences of deficient nutrition on behavior has been derived from intervention studies of nutritional supplementation in poor communities. Among these, the Jamaican study provides valuable information to understand distinct levels of response to limitations imposed by food scarcity (Grantham-McGregor et al., 1991; Powell et al., 1985, 1995; Walker et al., 1996). The initial study examined the relationship of background variables such as nutritional status and socioeconomic conditions, on developmental level. Limited stimulation in the home environment was presumed to explain the observed decline and gender differences favoring girls over boys, since girls tended to perform better in school than did boys. The study also suggested that mental development was more likely to be affected when malnutrition was experienced for longer periods. Nutritional supplementation had beneficial effects on the mental development of stunted children. The beneficial effect of supplementation continued for about six months, whereas the simple stimulation effect diminished faster. The findings supported the hypothesis that at least part of the deficit in behavioral development was attributable to undernutrition.

The Nutrition Collaborative Research Support Program (CRSP) was conducted in three different countries (Egypt, Kenya, Mexico) with contrasting diets to determine the relationships between energy intake and several outcome variables, including growth status, psychological development, pregnancy, lactation, behavior and morbidity (Allen, 1993). Food intake was measured at the household level by collecting information on food preparation and consumption inside and outside of the household. Food availability was considered adequate in Egypt since animal products provided, on average, 18% of energy (compared to approximately 40% for children in the United States). The communities in Kenya had serious deficiencies in production that were reflected in the poorest nutritional situation; preschool children obtained only about 8% of energy intake from animal products. In the Mexican communities, only 12% of the energy intake came from animal products and 60% from carbohydrates (Allen, 1993).

Measures of cognitive and behavioral development were administered to infants at three and six months of age, to preschool children at 18, 24 and 30 months of age, and to school-age children at the time of school entrance. Neurobehavioral performance in infants and preschool children was estimated with the Bayley scales of motor and mental development. The cognitive and behavioral outcomes suggested that growth stunted children of all ages performed less well than non-stunted children. Infants whose mothers consumed more animal products and had better quality diets, smiled more often. Maternal status for micronutrients (iron and vitamin B 12) was positively associated with infant performance on the Bayley motor and mental scales at three and six months of age. Observations of Mexican preschool children also showed that those whose growth was stunted because of poor quality diets had behavior characterized by apathy, long periods of time of doing nothing and crying, and reduced interactions with others. In contrast Egyptian and Kenyan children whose diets had more animal products played and verbalized more often, and used symbolic play, which is predictive to some extent of later cognitive development.

Data from an earlier study in Mexico (Chavez and Martinez, 1984) of supplemented and non-supplemented children in a small agricultural community considered relationships between food consumption and behavior early in life. No differences were detected in direct observations of activity, behavior, and mother-child interactions in the first eight months of life, with several significant exceptions. Children who received the supplement were more active than the unsupplemented children.

Play behaviors from six months to one year of age also varied between the groups. Children who were shorter and had less weight, i.e., undernourished, showed reduced verbal interactions by about 50%, reduced imaginative play by about 20%, and an increased tendency to cry more often than better nourished children. Overall, chronic undernutrition depressed physical activity and interpersonal interactions with the parallel consequences of limited stimulation during the first year or two of life.

The long-term effects of early protein-energy malnutrition were described by Cravioto (1980) in a follow-up study of 18 severely malnourished infants in another rural Mexican community. Children who were severely malnourished and hospitalized during the first two years of life and subsequently rehabilitated, were followed and compared to children in the same community who were not undernourished early in life. Motor development scores during the first three years of life (Gesell scales) declined with age. About 28% of the variation in the motor development scores at one year and 45% at two years could be explained by body weight, whereas the proportions of variance in motor development scores explained by length at one and two years were 18% and 38%, respectively. At school age, the motor performances of the severely malnourished children after nutritional recovery were poorer compared to control children in the community. The differences were especially marked for coordination, agility and balance.

The CRSP study cited previously (Allen, 1993) also included school-age children who were tested on Raven's progressive matrices as a measure of overall intellectual ability. Energy intake remained a significant predictor of intellectual ability when socioeconomic status, maternal anthropometry, gender and sanitary conditions in the communities were statistically controlled. Energy intake was a significant predictor of performance on the Raven task. The association between dietary patterns and attained body size and growth in school children showed that better nutrition (diet quality but not energy intake) was a strong predictor of weight, height and weight gain in Mexican children, while in Kenya the diet predicted only weight gain. Data for Egypt where meat consumption was higher, showed that the influence was on height gains. Morbidity also explained some degree of growth failure in all three countries, since toddlers consumed less food during illness, falling to lower levels in Mexico and Kenya. The results suggest that chronic undernutrition places children at risk for lower levels of attention, difficulties in learning, poor school attendance, and achievement. Thus, a process that begins early in life in many communities in the developing world has a toll at school age (Pollit et al., 1996).

Richardson et al. (1972) analyzed the long-term consequences of severe malnutrition in early childhood at school age in 74 Jamaican boys who were hospitalized during the first two years of life for marasmus, kwashiorkor, or both. The children were about 6 to 10 years at the time of follow-up. Teachers assessed behaviors in the school setting. The index boys, i.e., previously malnourished boys, were less able to pay attention in class than classmates, but did not differ from unaffected siblings, i.e., their siblings in the same household who were not hospitalized for malnutrition during the first two years of life. The previously malnourished boys were significantly less cooperative, showed fewer social interactions, and tended to be isolated and withdrawn, or to be more often disliked by peers in school. There was no systematic association between age at hospitalization during the first two years of life and the degree of behavioral impact, but this may reflect lack of information on maternal conditions during pregnancy or both maternal and familial conditions after hospitalization. Nevertheless, social domains and interactions at school age were affected by severe malnutrition early in life.

Physical activity levels, emotional states and social behaviors of children from Kenya who had mild-to-moderate undernutrition were described by Espinosa et al.

(1992). Food intake was assessed during behavioral observations and by direct measurements, and social behaviors were directly observed in unstructured settings. Information on socioeconomic status, parental literacy, duration of schooling, and school attendance were also considered. Playground observations were conducted during regular school breaks and included activity levels (classified as high and low), emotional states, and social interactions (peer involvement, no peer interactions, aggression, leadership). Observations were conducted during 40-minute school breaks for each child over 6 to 8 months. Weight-for-age and weight-for-height were significantly associated with higher activity levels at the beginning of the study. Better-fed children also showed more positive affect. Overall, playground behaviors of school children appeared to be related more to the adequacy of caloric intake than to specific nutrients; in contrast, fat and animal protein intakes appeared to be more closely related to the cognitive development of children followed up to 5 years. The results suggest that an adequate level of energy intake is essential to maintain levels of physical activity on the playground, whereas a diet of higher quality (i.e., balance of protein and energy) is essential for the development of cognitive skills. Cognitive skills at school age were also influenced by previous nutritional status.

Martorell (1995) summarized the Institute of Nutrition Central America and Panama (INCAP) study of early supplementary feeding and cognition in adolescence. The study was based on data collected in two periods, nutritional supplementation during pregnancy and the first seven years of life in four rural communities in Guatemala (1969-1977) and a cross-sectional follow-up of former participants during the teen-age years. The study assessed the differential effect of two supplements with different proportions of energy and protein (163kcal/682kJ and 11.5g protein vs. 59kcal/247 kJ and 0g of protein) made available to mothers, infants and young children. Performance during adolescence was assessed on a battery of educational and information processing tasks. The participants who received the protein supplement between birth and three years of age scored significantly higher than adolescents who were given the non-protein supplement. The previously protein supplemented adolescents had especially faster reaction times in information processing tasks. The supplementary protein feeding provided during the first three years of life also had a long-term influence on academic performance in adolescence (reading, vocabulary, and mathematics).

Reaction time was also assessed in a study of 85 undernourished, Indian rural school children, 11-14 years of age, who were randomly selected using as a reference their nutritional status during the first five years of life (Agarwal, 1998). Assessments with audio-visual reaction time (RT) and electromyography were performed. Early malnutrition was associated with prolonged RT compared to controls with adequate nutrition during the first five years of life. Total pre-motor and motor RT for audio as well as visual stimuli were affected in the previously undernourished children, and RT also increased with the severity of current nutritional status. An additional observation was that the children who suffered undernutrition during early childhood but who achieved normal nutritional status at school age remained slow in processing auditory and visual information compared to children with normal nutritional status. This study suggested that undernutrition early in life affects perceptual abilities, information processing and analytical capabilities at school age, but also that current nutritional status was an additional factor (Agarwal, 1998). Nevertheless, the persistence of impaired perceptual and information processing abilities suggests a functional deficiency associated with early malnutrition that is unlikely to recover.

In an earlier study, Agarwal (1993) assessed the effect of long-term, chronic malnutrition in rural Indian children. Two age groups were studied, 0-3 and 6-8 years. Functions such as immediate memory, reasoning, language and comprehension were negatively affected by undernutrition. Motor coordination was significantly affected in early childhood, but was somewhat improved at school age, which suggested that the school environment may have provided stimulation to offset earlier effects and lead to improved motor function. On the other hand, the undernourished children showed poorer attainment in personal independence, individual responsibility, self-sufficiency and language development. It is important to note these characteristics influence the child's overall social interactions which also affect subsequent development. In a sub-sample of wasted and stunted children (i.e., severely undernourished), observations of neurological deficits were also noted in performances on measures of finger tapping and arm pronation-supination.

Nutritional Consequences for Motor Performance

The acquisition of basic movement patterns and skills takes place largely during early childhood so that most fundamental motor patterns (walk, run, jump, hop, kick, throw) are developed by 6 to 8 years. Afterwards there is, more or less, rather continuous improvement of such abilities in more complex performances, i.e., motor skills improve with age from childhood into adolescence (Malina and Bouchard, 1991).

Chronic undernutrition is associated with impaired motor performances as expressed in low scores in tests of static strength, running speed, jumping, and throwing. Measures of motor performance are, therefore, of interest in the evaluation of health status in developing areas of the world where chronic undernutrition is common. Performance–related physical fitness refers to…"those components of fitness that are necessary for optimal work, motor and sport performance. It is commonly defined in terms of motor abilities and performance using standardized tests"… (Bouchard et al., 1997, p.89). Because performance-related fitness is a multifactorial outcome, depending on specific motor skills, aerobic and anaerobic power, body size and composition, motivation, and nutritional status, it applies to highly skilled elite athletes as well as the general population, and to the child in learning to run, or jump, or to aging adults whose movement activities are declining (Bouchard et al., 1997).

Assessment of the performances of children must consider that physiological demands are higher for children than they are for adults, such as the oxygen cost of walking or running, which per unit of body weight is higher in children and may be related to proficiency in motor skills (Malina et al., 1987). Different aspects of performance are affected under chronic protein-energy malnutrition (PEM) in children. Rocha-Ferreira et al. (1991), for example, considered the functional characteristics of 8 year old low SES Brazilian children with a history of mild-to-moderate undernutrition (61 girls, 84 boys). Performance items included the standing long jump, shuttle run, 50m dash, 9-min run, and grip strength. Current nutritional intake was estimated from information provided by parents (intake at home) and school records (intake at school). There were low-to-moderate positive correlations between body size and proportions and indicators of performance. When age and weight were statistically controlled, stature was positively correlated with jumping, agility and 9-minute run scores.

In a study of Senegalese children 10-13 years of age, Benefice (1993) emphasized physical activity as an important component of daily energy expenditure (EE). It was estimated that physical activity represented 31% of total EE in boys and 25% in girls. Benefice also considered the effects of nutritional status on the physical activity and motor performances of this sample of Senegalese youth 10-13 years of age. Physical activity was estimated from direct observation, and performance tasks included the 35 m dash, a submaximal step test, the standing long jump, hand grip strength, an overall ball throw, and vital capacity. The Senegalese children had deficits in height and weight that were associated with lower performances than observed in well-nourished children.

The strength and motor performances of school children 6-14 years of age from a rural indigenous community in the Valley of Oaxaca, Mexico (Santo Tomas Mazaltepc) were studied by Malina and Buschang (1985) and Malina and Little (1985). The mild-to-moderately undernourished school children had absolutely lower levels of strength and motor fitness compared to well-nourished children. However, when body size was controlled, i.e., per unit height or weight, grip strength was commensurate with their small body size, but running and jumping performances were less than expected. In a subsequent study, the performances of these rural Mexican children were compared to school children of the same age from an island community in Papua New Guinea (Malina et al., 1987). Grip strength and the same motor tasks were measured in both studies. The growth status of the two samples approximated the 5th percentiles of U.S. reference data, which suggested that the samples as a whole probably experienced chronic mild-to-moderate nutritional stress during infancy and early childhood. The performances of the rural Mexican children were below those of the Papua New Guinea children and a corresponding sample of American children the same age and sex. When expressed per unit body size, the performances of the Papua New Guinea children compared favorably to those for the American children, but those of the Mexican children did not, especially for the dash and standing long jump. Interestingly, performance on a ball throw for distance per unit body size was better in the Mexican and Papua New Guinea samples than in the American sample. The throwing performances were likely related to patterns of life style observed in both communities compared to those of the American children.

Nutritional Status and Physical Working Capacity

The long-term effect of chronic undernutrition on physical working capacity has been a matter of debate in terms of quality of life and economic productivity. Smaller individuals appear to require less food to live and to move, and seemingly perform well in activities that demand low level of energy expenditure. On the other hand, many studies show that small body size is disadvantageous in conditions of moderate-to-heavy work (Allen, 1990; Buzina et al., 1989: Calloway, 1982; Desai, 1984; Ferro-Luzzi, 1985; Satyanarayana et al., 1979; Spurr et al., 1983; Spurr and Reina, 1988, 1989).

Physical working capacity (PWC) represents the individual's ability to perform submaximal or maximal muscular work. PWC is measured via submaximal or maximal power output, submaximal oxygen consumption, or maximum oxygen consumption (VO_2max, peak VO_2). PWC is often used as an indicator of health status in adults in societies with economies that depend upon physical labor in agricultural or industrial production. Deterioration of PWC is often observed in populations where chronically marginal nutritional conditions are common. Moreover, when the compromised nutritional status also involves iron deficiency, which has an important role in oxygen transport, PCW is more affected (Buzina et al., 1989). Therefore, the concern for poor nutrition is not restricted to energy and protein, but also to macronutrients and micronutrients that are known to affect physiological functions essential to physical work, immunological competence, behavior and cognition. Although causes vary from country to country, economic deprivation and disease are generally central to the issues at hand.

Despite of the general assumption that in developing areas physical work capacity is of prime importance to obtain resources for survival, energy requirements vary with degree of complexity in each society (Ferro-Luzzi, 1985). As an example, subsistence economies of modern hunter-gatherers require rather moderate physical effort to meet their needs, whereas agricultural communities demand more work from their members. A peasant farmer in a pre-industrial system represents the next level of intensity of energy input and his energy expenditure is considered in the high range without taking into account intermediate periods of activity. In terms of the necessary adjustments to carry on physical work, it has been suggested that the upper limit of work that can be tolerated for an 8-hour shift corresponds to a level of physical activity that approaches 35% to 40% of an individual's VO_2max. The malnourished individual with reduced PWC responds either by working at a higher proportion of VO_2max or by producing less than the well-nourished person performing the same work task.

Several studies have observed association between marginal nutritional status and physical work performance in youth from different populations. Satyanarayana et al. (1979), for example, considered the physical working capacity of boys who were observed between 1 and 5 years of age and then observed again at about 15 years of age. Physical working capacity was measured on bicycle ergometer as power output at a heart rate of 170 beats per minute (PWC_{170}). The boys were classified by their nutritional status during early childhood, expressed as standard deviation scores for height (i.e., degree of growth stunting). The boys who were most severely stunted in growth during early childhood were at a significant disadvantage compared to nutritionally normal boys (based on height standard deviation scores during early childhood) in PWC_{170}. They also had to work at a higher rate to achieve the same power output.

Desai et al. (1984) measured the effect of marginal nutritional conditions on the physical working capacity of adolescent offspring of agricultural migrant workers in Southern Brazil. Nutritional status was estimated by 24-hour dietary recall. Body size, biochemical data (lactic acid levels), and PWC (heart rate and oxygen consumption during a submaximal bicycle ergometer work) were measured. Well-off Brazilian boys of the same age served as a control group. Physical growth and estimated fatness and muscle mass of the adolescent offspring of migrant workers were low. Although oxygen consumption of the migrant children at submaximal work loads (0, 25, 50, 75w) was similar to that of the controls, the former worked at a higher percentage of their maximum work capacity as indicated by significantly higher heart rates for the same oxygen consumption. Higher blood lactic acid levels in the migrant adolescents suggested that considerable physiological stress was experienced. PCW 170 was significantly reduced by about one-third in the migrant adolescents, 643 ± 62 kpm/min vs. 905 ± 345 kpm/min. The differences were attributed to reduced body mass, which represented the effect of chronically compromised nutritional conditions during childhood on both PWC and growth.

Spurr (1990) summarized a series of studies on the effects of nutritional status on PWC and productivity in adult males and of nutritional status and growth on the PWC in school aged children 6-16 years of age in Cali, Colombia. Well-nourished and marginally undernourished children were included in the study. The undernourished group had reduced growth and subcutaneous fatness, and a significantly delayed growth spurt and sexual maturity. Absolute VO_2 max values were significantly lower, with larger differences for girls than for boys. However, per unit body mass, VO_2max was generally similar between the marginally undernourished and well-nourished children.

An estimate of daily energy expenditure among Colombian children was based on heart rate. Heart rate was used to estimate daily energy expenditure and energy expenditure in physical activity. To answer the question of how undernourished boys would respond to increased levels of energy expenditure, physical activity was intentionally modified. Fourteen nutritionally normal and 19 marginally undernourished boys 10-12 years of age participated in a summer day camp. During the sport activities of the day camp, the undernourished boys could not keep up with the nutritionally normal boys as reflected in consistently lower estimated levels of energy expenditure during the morning session. After a hot meal was served for lunch, the undernourished boys were able to keep-up with the nutritionally normal boys for about one hour, but then consistently lagged behind in energy expenditure. The morning observations probably reflect a combination of a history of chronic, marginal undernutrition and lack of breakfast, whereas the afternoon observations probably reflect the provision of a hot lunch.

In contrast to the preceding studies, Haas et al. (1995) considered the physical working capacity of Guatemalan adolescent boys who had received different nutritional supplements during the first three years of life. Boys who had received the protein supplement (see Martorell, 1995, discussed earlier in this section) had a greater VO2 max per unit body weight and per unit fat-free mass than boys who had received only a calorie supplement. The direction of results was the same for protein supplemented and calorie supplemented girls, respectively, but the differences were not significant.

The preceding discussion has focused on children and adolescents. In developing areas of the world, however, there is major concern for the functional efficiency of adults who were chronically undernourished as children. Among adults, there is a need to differentiate between working capacity and work productivity (Martorell, 1989). Whereas work capacity is a measure of biological potential to do work, productivity is an economic term that is expressed in terms of goods produced per unit time. Some studies show that reduced muscle mass in stunted adult men is associated with diminished work capacity. However, some farming and industrial activities do not demand extremely high levels of physical work. Instead, more sedentary occupations are more likely to require cognitive abilities, skill, dexterity, motivation, good sight, etc., as important determinants for adequate work performance.

Summary

Urban-rural contrasts in growth and physical fitness in different populations show variable results. In most developed countries, urban-rural differences in growth and fitness are negligible. In areas where such contrasts persist, e.g., parts of Eastern Europe and Latin America, the urban-rural differences largely reflect inequitable distribution of resources. In contrast to Eastern Europe, the urban-rural contrast in Latin America also reflects major differences in nutritional and health status. The rapid growth of urban centers and slums in Latin American cities is an additional problem. These areas are inhabited largely by migrants from rural areas and health and nutritional conditions are quite different from other areas of urban centers. The present study contrasts the growth status and physical fitness of children resident in a marginalized urban area with those of children resident in a subsistence agricultural rural community. Two areas are separated geographically by about 25-30 km.

Chapter 3

Methods

The present study considers the growth status and physical fitness of school children living under contrasting conditions in two communities, one urban and one rural, in the Valley of Oaxaca, southern Mexico. It is a part of a broader study of secular change in growth status and physical fitness of school children in the Valley of Oaxaca (Malina, 1999).

The state of Oaxaca has one of the poorest economies in Mexico. Rural lifestyle in Oaxaca is more traditional, based on kinship, and communities are commonly endogamous. The economy in rural communities is based on small scale farming of relatively small plots of individually owned land.

In contrast, urban lifestyle is characterized by more recently established, colonias populares, which were described by Selby and Murphy (1979) as a heterogeneous mix of classes and ethnic groups that, despite of having some urban advantages, do not show improved health and nutritional status compared to the economically better-off segments of the urban population.

The two communities which are the focus of the present study, Santo Tomas Mazaltepec and San Juan Chapultepec, were chosen because they represent the contrasting living conditions that may influence growth and physical fitness of school children. Figure 3.1 shows the geographic location of communities. Moreover, both communities were studied systematically approximately 30 years earlier, thus permitting a unique secular perspective. Thus, reasonably extensive information on growth status and living conditions is available from earlier studies. These earlier contacts also facilitated access to both communities for the present study.

Conditions in the Valley of Oaxaca

The Valley of Oaxaca includes the largest area of the altiplano of Oaxaca. It includes the state capital, Oaxaca de Juarez, and the Monte Alban and Mitla archeological sites. The valley is divided into four areas, the Etla, Tlacolula and Zimatlan valleys, and the Ocotlan, Ejutla and Mihautlan areas. The major source of water is the Atoyac River, which starts northeast of Oaxaca. It collects water draining from the mountains and also from the Tlacolula River which passes through Mitla. For most of the year, the water level in the Atoyac River is rather low by the time the river reaches the Valley of Oaxaca. Water levels change dramatically during the rainy season, May through September. The river also contains relatively high levels of pollutants derived from drainage of the city of Oaxaca, chemical from the wood industry, and agriculture. Additional factors affecting water levels in the river are water extraction from wells and deforestation. The Atoyac River and its branches influence agricultural production in the Etla, Tlacolula and Zimatlan valleys (Rios Morales, 1995).

The Valley of Oaxaca depends mainly upon agriculture and mostly on a single crop, rain-fed maize. Because the crops depend on precipitation, droughts cause frequent harvest failures, whereas flooding during the rainy season often destroys seemingly fine harvests. However, gradual improvements in transportation and greater access to tractors, fertilizers and irrigation pumps during the last 25 years have brought new possibilities to the potential agricultural market, but conditions are inequitable among members of farming communities.

Agricultural production experienced a significant decline in the Valley of Oaxaca in the 1960 and persisted for some time. At this time, the economy was developing in Tuxtepec and the Istmo, which attracted migrant workers from communities in the Valley of Oaxaca. These two areas also were involved in greater exchange with the states of Veracruz and Puebla rather than with the capital city of Oaxaca. This contributed to reductions in jobs and modifications of natural resources associated with the economic transformation process, and forced many of the poor in the region, including the unemployed, to look for work opportunities in the economic developing areas of the state and even areas out of the state (Winter et al., 1988).

The rainy season in the Valley of Oaxaca begins during April and May, peaks during June, and continues through July and August, although it is highly variable (Dilley, 1993). Rain-fed agriculture is possible from June to September. During drought years such as 1982, the rain-fed agriculture became impossible even during the rainy season. Although the Valley of Oaxaca has two or three growing seasons, 95% of agricultural production takes place during the summer months (Dilley, 1993). Maize is the most important crop, accounting for 87% of the total summer agricultural production and 64% of the value of summer production. Almost all summer maize is rain-fed (88%) and grown almost exclusively for human consumption. Variation in maize production affects the region's food supply.

Dilley (1993) emphasizes that even in good years, the Valley of Oaxaca is not self-sufficient in maize production. The deficit is supplemented by imported maize. Since 1970, the Valley-wide production, on average, was 100 kg of maize per capita per year, whereas the average consumption was estimated as 160 kg per capita.

At present, land quality, in particular access to water, is a major factor in determining who participates in the growing agricultural market economy. Irrigation is necessary to ensure success for cash crop cultivation. Irrigation has increased in the Valley due to the use of gasoline and electric pumps, with a corresponding impact in socioeconomic structure of the community.

Both state and national governments promote cash crop cultivation and adoption of new agricultural technology in the Valley of Oaxaca. Credits are given to access farm equipment, chemical fertilizers, alfalfa cultivation and livestock acquisition. According to Dilley (1993), the state of Oaxaca authorized $1.3 million U.S. for agroindustries, $4.5 million for irrigation works and $1.2 million for federal and rural roads in 1990 for the Valley. The modern profile of agricultural economy shows investments in new technologies for successful cash-cropping becoming an integral part of the economy. Therefore, irrigation pumps play a very important role and chemical fertilizers are commonly used. Another important component of the new economic strategies is growing demand on dairy products that has doubled cattle production in the Valley region over the last four decades (Dilley, 1993).

The Valley floor varies in altitude from 1420 to 1740 meters and is surrounded by mountains (Kirkby, 1973). The mean annual temperature is around 20°C, with a difference of 5°C between the mean temperatures of the hottest and coldest months. As noted, the Valley receives about 85% of its annual rainfall during the five month period from May through September, the "rainy season." The interval from October through April receives minimal rainfall and is considered the "dry season" (Kirkby, 1973). Thus, "Fall" and "Winter" in the Valley of Oaxaca are dry seasons and are relatively warm.

The Communities

Santo Tomas Mazaltepec

At the time of this study in 1999-2000 the community of Santo Tomas Mazaltepec had a high proportion of Zapotec-speaking population. Despite the closeness to the Oaxaca city (about 23 km north), it is important to note that Santo Tomas was still lacking urban advantages such as sewage, potable water within each household, paved streets and public phones in 1999, when data collection of the present study began (October 1999). Significant changes have since taken place during the period 1999-2001. These represent benefits for the community which were achieved as a result of active participation of its members, among them works to develop street branches for sewage which began around January 1999 and was completed by November 2000. The major and most expensive investment had to do with a water treatment plant. The community had to put together essential resources for the land and construction. Construction was completed in December 2001 and it is expected that the water treatment plant will be operating sometime in 2002. Overall, the community has experienced major improvements during the three year term of the immediately preceding presidente municipal, who concluded his term in December 2001 (January 1999 through December 2001).

Water is brought to the community from two rivers that join each other at about 500 meters from the village, and become the Mazaltepec River. The river lacks water for most of the year, except for the rainy season from May to September when the level rises considerably. The river eventually runs through San Andres Zautla and into the Atoyac River. There is also a storage site for potable water obtained from deep wells located about 500 meters north of the village. A water pump is used to send the water from the storage site to the village.

Santo Tomas has a village president, who is elected to a three year term according to the traditions of the community. Activities of the municipal government are carried out in two units, the ayuntamiento and the comisariado de bienes ejidales (commision for the welfare of the community). The former consists of the municipal president, a sindico and alcalde (judge), a secretary, a treasurer, five regidores (councilmen), and the topiles (individuals in charge of running errands). The ayuntamiento meets every evening at the municipal building to address community issues and to take care of requests of people from the village. If there are important decisions to be made, the case is brought before the village assembly where only adult males participate. The ayuntamiento and the comisariado serve for a three year period. The presidente municipal is elected from among the older and responsible men in whom community members place their confidence. The individual elected is not from a specific political party, but usually has demonstrated commitment to the community and its welfare, rectitude, and experience from participation in communal activities.

Santo Tomas is located in the Etla district. According to the most recent update from the annual household survey conducted by the health center in the community, the population in 2001 was 2046 individuals (Martinez-Julian et al., 2001), although there is probably some degree of under-registration given the relatively constant out-migration that is characteristic of the village. Nevertheless, the estimated population size suggests limited population increase over the past 30 years since the population was 1423 in 1970. Table 3.1 shows the population distribution by age group, based on data from the health center for 2001 (the report for 2000 did not disaggregate the data by age). Differences between the community estimates and those for the 2000 census might be influenced by population mobility, as emigration is obviously a factor that needs to be considered. In this context, the annual report of the health center in the community probably provides a better indication of current conditions than the national census figures.

The community is rural. Most lands are community owned because lands are not productive enough to provide resources for family subsistence. Maize is the main crop.

The proportion of the population that is working, i.e., economically active (15 years of age and older), varies from year to year according to surveys of the community health center. Based on data for surveys from 1999 to 2001 (Lopez and Altamirano, 1999; Reyes-Castellanos et al., 1999, 2000; Martinez-Julian et al., 2001), economically active individuals represented, respectively, 68%, 53% and 68% of the population. The main occupational activities for the population also show variation by year. The proportions of campesinos (peasant farmers) was 32%, 25% and 28% for 1999, 2000, and 2001, respectively. Housewives represented, respectively, 17%, 26% and 32% of economically active individuals. It is important to emphasize that housewives generate an important source of income, largely through sale of tortillas. One-third of the mothers of the school sample indicated that they made their living from the preparation and sale of tortillas. School students (some from the primaria and others from the telesecundaria) often combine school activity with household- and farming-related chores that are essential components of the family routine. Hence, school age children over 15 years of age represent a small but significant percentage of the working population. The contributions of primary school children under 15 years of age are not reflected in the statistics for economically active individuals, although many contribute significantly to the economic activities of households by helping in field work, animal care and herding, and household chores related to family businesses. Other occupational activities for those 15 years and older include individuals classified as employees (4% in each of the three years) and comerciantes (traders, 7%, 17% and 11%, respectively, in the three years). Unemployed individuals represent a relatively small number (0.6%, 2.3% and 2.1%, respectively in the three years).

Data on average family income indicated that a large proportion of families had incomes lower than or equal to one minimum wage (minimum salary). The percentages were 86%, 84% and 65% for 1999, 2000 and 2001, respectively. At the time of the study was begun (1999), the minimum wage was about 34.5 pesos for Mexico City and 30.0 pesos for the state of Oaxaca, which corresponds, respectively, to about 1035 and 900 pesos per month (INEGI, 2000). Equivalents in United States dollars are $113 and $96, respectively. Income reached two times the minimum wage in 14%, 15% and 35% of the families in 1999, 2000 and 2001, respectively (Lopez and Altamirano, 1999; Reyes-Castellanos et al., 1999, 2000; Martinez-Julian et al., 2001). An average salary of two times the minimum wage is considered necessary to satisfy basic family needs.

At present, a number of men are employed as construction workers. Construction is an increasingly more common source of income due to an increase in the number of houses being remodeled or new construction in process. These improvements are largely the result of important economic contributions sent by migrant workers to their families. According to an informant in the community, the duration of a migrant's economic cycle is about three years before his/her family benefits from his/her earnings. The process is described as follows. For the first year away from the village, they send money to pay debts derived from the loans acquired to pay for the trip and expenses associated with settlement in the new location. During the second year, the resources help to improve the family living conditions in the new community. It is not until the third year that the resources are invested in household improvements in the parent community (Santo Tomas). It is interesting to note that during the interval of the study in the community (October 1999 to March 2000), there was a significant increase in household improvements which appeared to show that the regular flow of resources from migrant workers have had a positive influence on the quality of life in the community.

Information in the 1998 health diagnostic report prepared by the staff of the community health center (Lopez and Altamirano, 1999) indicated that about 93 individuals had emigrated from the community. Based on information derived from household survey interviews in 1999-2000, the estimated number of migrants was 98. The families surveyed indicated that more than one-half have one relative who emigrated, while 22% and 26% had three or more members who emigrated from the community. However, of these, only 3% had emigrated permanently.

The destination of the migrants was mainly Mexico City (about 60%), with a smaller proportion going to the United States (20%). Migrants are primarily males (79%). A small number are females (13%), who leave their children with their parents (i.e., grandparents). About 13% of the males who emigrated were fathers and 66% were sons. The duration of the migration period ranged from 6 months (7%) to 2-4 years (27%) to 5-10 years (30%). The emigrants leave their families in the village and return periodically for important community celebrations, such as dia de muertos (November 1-2) and fiesta del santo patrono del pueblo (village saint's day) which takes place on December 18. Few migrants married outside of the community and returned to the village after they had children 5-10 years later.

Social organization is still largely based on nuclear families, which represented 76% and 87% of the households in 1999 and 2000 (Lopez and Altamirano, 1999; Reyes-

Castellanos et al., 1999, 2000; Martinez-Julian et al., 2001). Education has continued to improve since the earlier surveys. In the 1970s, only 35% had completed between one and six years of school. Data for the 2000 census (INEGI, 2000, 2002) showed that among individuals under 18 years of age, 41% completed six years of school and about 37% completed secondary school. However, among individuals 18 years of age and older, only 7% completed high school and 4% had some college education. In the period 1999-2001, only 6% of the population was described as illiterate.

A secondary school which works under the national education television system (telesecundaria) is presently reaching a larger number of students of this level. About 100 students were enrolled in the telesecundaria at the time of the study. Significant improvements in the telesecundaria include a recent donation of computers for the purpose of retaining the students in the community rather than have them attend a secondary school in Etla.

There was one kindergarten building. The building for the primary school had six classrooms and enrolled a total of 367 students in morning and afternoon sessions in 1999-2000.

The community health center provides medical care on a daily basis. Attention is offered by one full time physician, who commutes from Oaxaca. She is helped by a nurse and a medical student who was under internship training. One of the most recent projects was to build a public library, which was opened for the community in March 2000.

The community is largely bilingual in Zapotec and Spanish (Lopez and Altamirano, 1999; Reyes-Castellanos et al., 1999, 2000; Martinez-Julian et al., 2001). Most people above 15 years of age speak Zapotec. Although children and adolescents are Spanish-speaking, they are generally able to understand Zapotec.

Based on the conditions described, it is clear that community living conditions have improved significantly in recent years. Paved roads are only available for two of the main streets in the village and 10 km away from the village. Transportation includes buses that run from Mazaltepec to Oaxaca City on regular basis every 40 minutes on weekdays and every hour on weekends. There is also a taxi service, but it is expensive and less frequent. There is only one public phone in the village; people usually go to Zautla (8 km) when they need phone service. However, the road from Santo Tomas to Zautla, and in turn to Etla is mostly paved (about 10 km).

The following housing construction characteristics were derived from the most recent health center. Roofs were made of tile (42%), concrete (44%), and laminated board (12%). The laminated board includes a light asbestos coating, which apparently represents a very low level of exposure (Asbestos Institute, 2002). Walls were made of concrete or brick (53%), adobe (40%), and wood and other materials (7%). The majority of houses (66%) presently have cement or concrete floors; the remainder have earthen floors.

Sanitary conditions in the village have improved relative to the earlier survey in the late 1970s. Potable water was available for 89% of the households in 1998 and to 98% in 2001. Disposal of human wastes was dependent upon latrines in 32% of households in 1998 and 47% in 2001. This improvement reduced the amount of open ground used for human excrement from 52% to 35%. The use of septic tanks also increased from 15% to 17% from 1998 to 2001.

The burning of waste materials is a persistent source of pollution, but it has decreased slightly from 61% in 1999 to 57% in 2001. And, in 2001, the municipal administration purchased a truck that collected waste throughout the community. Smoke from kitchens is a persistent problem as most women still use wood and carbon to cook tortillas.

Based on the health center report, acute respiratory conditions are relatively common. They represented 75% of requests for treatment in 1999, but only 25% in 2000 and 31% in 2001. Intestinal infections were the second most common complaint, 15%, 7% and 4%, respectively in 1999, 2000, and 2001 (Lopez and Altamirano, 1999; Reyes-Castellanos et al., 1999, 2000; Martinez-Julian et al., 2001).

San Juan Chapultepec

The urban community San Juan Chapultepec is located on the slopes of the hills west of the city of Oaxaca de Juarez. It is an old community which had a population of about 5000 in 1970 (Welte, 1973). This urban settlement has expanded considerably and its population continues to increase due to migration not only from rural areas but also by attracting people from other states who come to work to the city of Oaxaca. At present, the colonia is part of the city of Oaxaca, although its administration is based on a municipal agent who corresponds to a large extent to the presidente municipal at the villages.

It is difficult to obtain a precise estimate of demographic changes in San Juan over the past 25-30 years. San Juan is now incorporated into the city of Oaxaca (Oaxaca de Juarez). The following figures are estimates for the area, including several barrios. They are based on the 1990 and 2000 censuses using disaggregated information for the city of Oaxaca (INEGI, 1990, 1993, 2000, 2002). The 1990 census indicated an estimated population of 14,573, which increased to about 16,279 in 2000. Data for the area suggests slow, continuous demographic growth. Living conditions in San Juan are closely related to the resources and administration of the city of Oaxaca. The colonia has spread up and across the hillside which represents the newer and more crowded areas, or the so called barrios. There is still a dynamic participation of community members in activities of common interest, such as building facilities and maintaining public areas (schools, parks and sport facilities) or cleaning fields. Adults congregate on weekends to undertake this shared community work called "tequio". It represents the family contribution to community well-being.

Characteristics of the urban population resident in the colonia can be gleaned from a study in the mid-1970s (Graedon, 1976), the 1990 census (INEGI, 1990, 1993), the 1995 update (INEGI, 1995), and the 2000 census (INEGI, 2000, 2002). The population is basically Spanish-speaking. In the earlier survey, education was, on average, three years, and 20% of the heads of households were illiterate. In contrast, estimates in the 2000 census indicate that 82% of the San Juan Chapultepec population 15 years and older was literate and that they had an average of 8 years of schooling. About 20% of the adult population 18 years and older completed elementary school (primaria), about 20% completed secondary school (secundaria), and 18% reached high school (preparatoria) (INEGI, 2000, 2002). There are presently two kindergardens and three primary schools within the colonia. The schools work only as morning sessions. There is a television-based secondary school (telesecundaria) next to the agencia municipal in the colonia, and about 190 students were enrolled in 1999.

Average household size was six persons in the previous study in the mid-1970s (Graedon, 1976). The 2000 census indicated an average of 4.2 persons per household (INEGI, 2000). Time of residence in the colonia varied from 6 months to more than 20 years in the 1990 census (INEGI, 1990, 1993), which reflects the high mobility of the urban population. Data from the 2000 census indicated that 81% of the population resided in the colonia for five years or more (INEGI, 2000, 2002).

The 2000 census for the city of Oaxaca reported a working population of about 53%; the corresponding figure for San Juan was 40% (INEGI, 2000, 2002). About 18% of the working population declared household activities as a primary occupation compared to 17% in 2000 (INEGI, 1990, 2000). This sector represents mainly women who, despite not having a formal job, do various activities to bring resources to support the family. Examples include tortilla making or vending combined with household chores. About 33% of the Oaxaca population work as employees or in industry, and 40% works in the service sector (INEGI, 2000).

Data on average family income in 1990 indicated that less than one-half of families (40%) received between one and two minimum wages (minimum salary), 25% received less than one minimum wage, and one-third (33%) reported more the two minimum wages. In the 2000 census, about 15% of the working population in the San Juan Chapultepec area received less than one minimum wage, 31% received between one and two minimum wages, and only 23% reported income between two and five minimum wages (INEGI, 2002). Although the data indicate some improvement, the figures for 2000 still indicate generally limited resources to satisfy basic human needs.

A survey of 3360 households in the city of Oaxaca in the 1990 census (INEGI, 1993) indicated the following house characteristics. Roofs were made primarily of laminated cardboard (35%) and concrete (42%); walls were made of brick (57%), adobe (20%), and wood (4%); and almost 65% of houses had cement floors. Corresponding estimates for a survey of 3570 households in the San Juan area in 2000 (INEGI, 2000, 2002) indicated generally improved living conditions. Walls were made largely of concrete, cement or bricks (70%), while only 30% had light and/or precarious building materials for walls; about 81% of the houses had cement floors.

Sanitary conditions represented by potable water, sewage facilities and waste disposal indicated more favorable living conditions in 2000. Only 14% of houses had no sewage, while 76% were connected to street sewage and 6% to septic tanks. About 86% of houses had access to potable water (INEGI, 2000, 2002). There also was a regular service of municipal trucks to collect waste on a daily basis, although service is less frequent in the higher sections (i.e., near to top of the hill) of the colonia. Public transportation is provided by regular bus and taxis service to Oaxaca city.

Public transportation is provided by regular bus service to the central areas of the city of Oaxaca. Taxis are also available on a regular basis. The buses presently reach the barrios near the tops of the hills, although many individuals climb rather steep paths to negotiate the hilly environment of the colonia.

In the mid-1970s, the most common health problems in San Juan showed seasonal variation (Graedon, 1976). There was a high prevalence of gastrointestinal problems from March to April, which was attributed to water and environmental contamination. More recent data from the health center indicate a high prevalence of

respiratory and gastrointestinal infections as the main problems between 1995 and 1999 (Martinez-Morales, 1999). More specific information is limited to households that are located in the vicinity of the health center, which is located adjacent to the agencia municipal. It reaches less than 1000 inhabitants of the colonia. The attending physician and medical student in training also indicated the lack of accurate demographic and health data for this specific sector of the city (San Juan).

Although most streets are paved, there are many unpaved roads, particularly as one moves up the hillside. In addition, sanitary deficiencies increase as the barrios progress greater distances from the center. A physician and two nurses at a health center provide basic attention on daily basis, 8 hours a day. The closest hospital is about 5 km away from the colonia, but there are some private services provided by general practitioners and a private hospital. Given the proximity of San Juan to downtown Oaxaca, the population has relatively easy access to work opportunities and services such as health clinics, pharmacies, stores and markets.

Overview of Conditions in the Rural and Urban Communities

Indicators of social, economic, educational and living conditions in the two communities which are the basis of this study are summarized in Table 3.2. The information is derived from the 2000 national census (INEGI, 2002). Conditions in the rural community related to health and sanitation are generally inferior to those in the urban community. Rural households also have relatively fewer appliances with the difference most marked for refrigerators. This obviously has implications for the storage of foods. About one-half of the economically active population in the rural community has no regular wages, whereas about two-thirds of the economically active population in the urban community receives between 1 and 5 minimum wages. The urban and rural communities do not differ in the prevalence of literacy/illiteracy, but urban adults have slightly more years of schooling.

The characteristics of the urban community, San Juan, are generally similar to those for the city of Oaxaca, and are better than those for the state of Oaxaca as a whole. The characteristics of the rural community, Santo Tomas, vary compared to those for the state of Oaxaca. Indicators of health (sanitation, health insurance coverage) are relatively less available in Santo Tomas, and proportionally more economically active individuals receive no wages in Santo Tomas compared to the state as a whole. In contrast, proportionally more individuals 15+ years of age in Santo Tomas are literate compared to those in the state of Oaxaca.

Subjects

Study subjects were children enrolled in the primary school in each community. Attendance in primary (elementary) school is required in Mexico, and the focus of the study was children enrolled in school. The project was developed within the activities of the general project: "Secular change in size, strength and motor fitness in the Valley of Oaxaca, Mexico," with Robert M. Malina as principal investigator (Malina 1998). The project was approved by the University Committee for Research Involving Human Subjects at Michigan State University (Appendix I). After initial contacts with each community, permission for the study was granted by local authorities and school officials of each community. All activities were supervised by minicipal and school authorities in both communities.

There was a very good relationship with the presidente municipal and other members of the municipio's administration in the rural community. The research team contributed some books to the local library and some medicines to the health center. In addition, the team also assisted the administration in preparing a document about the village history. The latter was based on interviews with the oldest individuals in the community and discussions with archeologists who worked in the area. The document is presently available in the community library.

Informed parental consent in both communities was obtained after meeting with the parents at the respective schools. At these meetings, the purpose of the study was explained and a consent statement was distributed and read to the parents. Some of the parents were not able to read the approved form. Only those children whose parents provided informed consent to participate in the study were included.

Self-assent was obtained from older school children (10 years of age and older). The statement of participation in the study was read to them and they were informed that they could decide if they wanted to participate in the study and that they could withdraw from the study at any time.

The rural sample was comprised of the children enrolled at the primary school in Santo Tomas Mazaltepec. The school program included morning (8 a.m. to 12:30 p.m., with a one-half hour break 10-10:30 a.m.) and afternoon (1:30 p.m. to 6 p.m., with a one-half hour break, 4-4:30 p.m.) sessions. Children enrolled in both programs were included in the sample. The break is used in both sessions for children to get a meal. For the morning school, the meal was breakfast, since children generally leave home without eating a meal. For the evening session, the meal corresponded to lunch. A total of 367 children, 180 boys and 187 girls, in the 1st through 6th grades was measured and tested in the Fall 1999 and Spring 2000. According the school records, there were 372 children enrolled at the beginning of the school year, but several dropped out before the study was started.

The urban sample was drawn from one of three primary schools in San Juan Chapultepec. It was the same school studied previously (Malina et al., 1976). In contrast to Santo Tomas, San Juan had only a morning session. The duration of the session for the urban children was the same as in the rural community. A total of 341 subjects, 175 boys and 161 girls, in the 1st through 6th grades was measured and tested in the Fall 1999 and Spring 2000. Note that the total enrollment in the school at the start of the academic year was 342 children and one child was not in attendance during the time of the survey. Hence, the present sample represents the entire student body.

Chronological age of each child was based on the date of measurement and birth dates obtained from school records and corroborated by parents and teachers if necessary. When birth certificates were not available for children in Santo Tomas, dates were obtained from the municipal records in the community or the archives in Etla. Children were grouped into whole year age categories, i.e., 6.0 to 6.99 defined the 6 year age group, and so on. The distribution of subjects measured during the survey of each community by age group and sex is indicated in Table 3.3. The total sample surveyed was 708 school children 6 to 15 years of age, 367 (180 males, 187 females) in the rural community) and 341 (175 males, 166 females) in the urban community.

Data Collection Procedures

Anthropometric, menarcheal status and physical fitness data were collected at the respective schools during regular school hours in both communities. In addition, an activity and dietary questionnaire was administered in children in grades 4, 5 and 6. The data collection forms are given in Appendix II. The specific protocols for each type of data are described subsequently.

<u>Anthropometry</u>

A battery of anthropometric dimensions was selected to provide information on growth (size attained) and nutritional status. The growth status of children is universally accepted as an indicator of the overall health and nutritional status of a community (Waterlow et al., 1977).

Height and weight provide an indication of overall body size and in the form of the body mass index (BMI, wt/ht^2), provides an indication of underweight and overweight. Sitting height in conjunction with standing height provide an indication of segment lengths and proportions. Skeletal breadths and limb circumferences provide an indication of skeletal robustness and relative muscularity, and skinfold thicknesses provide an estimate of subcutaneous fatness and relative fat distribution (Malina, 1995a).

Measurements were taken following the procedures described in Lohman et al. (1988; see also Malina 1995a). Bilateral dimensions were taken on the left side (as were measurements in earlier studies done in Oaxaca). Anthropometric data were collected by MEPR. Six students of physical anthropology, who were specifically selected and trained for the study by the principal investigator, assisted in recording, fitness testing and anthropometry of adults (which is part of the broader study and is not considered in this study). The students were enrolled in the Escuela Nacional de Antropologia e Historia (ENAH) in Mexico, D.F.

Anthropometric dimensions were taken with calibrated instruments. The protocol was the same as used in the 1968 and 1978 surveys in Santo Tomas and the 1972 survey in San Juan. Weight was measured with a portable field unit (HealthOMeter) that was scaled to 100 grams. Stature and sitting height were measured with a GPM (Martin type) field anthropometer (Pfister Import-Export, Inc., Carlstadt, NJ), while skeletal breadths on the trunk were measured with the upper segment of the field anthropometer used as a sliding caliper. Skeletal breadths on the extremities were measured with a small sliding caliper (Martin type, 25 cm; Pfister Import-Export, Inc.). Circumferences were measured with a retractable fiber glass tape (non-stretchable, Grafco), and skinfolds were measured with a Lange caliper (Cambridge Scientifc Industries, Cambridge, MD). The skinfold caliper was regularly calibrated relative to the standardized wedge provided by the manufacturer.

Body mass (weight) was measured in kilograms using a portable scale and recorded to the nearest 100 grams. Weight was measured without shoes, but the children wore light clothing with all accessories removed (sweaters, sweatshirts, jackets, etc.).

Stature (standing height) was measured with the child standing erect posture, without shoes and with body weight evenly distributed between both feet. The heels were placed together and the arms were hanging relaxed at the sides. Height is the distance from the floor to the top of the head positioned in the Frankfort horizontal plane. Measurements were recorded to the nearest 0.1 centimeter.

Sitting height corresponds to the distance from the table (sitting surface) to the highest point at the top of the head (vertex). The individual sat erect on the table with the knees hanging freely and the hands positioned on the thighs. Sitting height was measured to the nearest 0.1 cm.

Biacromial breadth was measured as the distance between the left and right acromial processes of the scapulae with application of firm pressure. The measurement was taken from the rear and was recorded to the nearest 0.1 cm.

Bicristal breadth was measured as the distance between the most lateral points of iliac crests with application of firm pressure. The measurement was taken from the rear and was recorded to the nearest 0.1 cm.

Bicondylar breadth was measured as the distance across the most medial and most lateral points of the femoral condyles. The individual was seated with the knee flexed 90°. The measurement was recorded to the nearest 0.1 cm.

Biepicondylar breadth was measured as the distance between the epicondyles of the humerus with the elbow flexed 90°. The measurement was recorded to the nearest 0.1 cm.

Limb circumferences. Three limb circumferences were measured and recorded to the nearest 0.1 cm.

Relaxed arm circumference was measured at the level midway between the olecranon and acromial processes with the arm handing loosely at the side. The tape was placed in the horizontal position in contact with the skin but without compression of the underlying soft tissues.

Flexed arm circumference was taken at the same level as relaxed arm circumference, but the arm was flexed to a right angle at the elbow.

Calf circumference was measured as the maximum circumference of the calf with the subject in a standing position and body weight evenly distributed between both legs. The measuring tape was placed in a horizontal plane in contact with the skin but without compressing the soft tissues.

Four skinfolds were measured to the nearest 0.5 mm using a Lange skinfold caliper (as was used in the earlier studies in Oaxaca). A double fold of skin and underlying soft tissue was raised with the thumb and index finger of the left hand about one cm above the specific site for each fold and the caliper was applied to the site.

Triceps skinfold was measured on the back of the arm over the triceps muscle at the same level as relaxed arm circumference.

Subscapular skinfold was measured on the back immediately beneath the inferior angle of the scapula following the natural cleavage line of the skin.

Suprailiac skinfold was measured immediately above the iliac crest in the midaxillary line.

Calf skinfold was measured on the medial aspects of the calf at the same level as calf circumference.

During the field phase of the study with the school children, every tenth child was measured independently by MEPR on a second occasion to estimate intra-observer measurement variability. The replicates were taken about one month after the initial measurements (hence, there is the potential for a growth factor in the interpretation of measurement variability). The technical error of measurement (s_e) was calculated as follows:

$\sigma_e = \sqrt{\Sigma d^2 / 2N}$,

the square root of the sum of differences between replicate measurements squared divided by twice the number of replicates (Malina, 1995a). Intra-observer technical errors of measurement for the present study are summarized in Table 3.4. They compare favorably with errors based on within day replicates from an earlier survey in the rural community (Table 3.3) and with corresponding intra- and inter-observer technical errors in several national health surveys in the United States (Malina, 1995a).

The basic anthropometric dimensions were used to derive several additional variables:

1. The body mass index (BMI) was calculated as weight (kg) divided by height (m) squared (kg/m^2). It is used primarily as an indicator of overweight, but is also used as an indicator of underweight in developing countries.

2. The sitting height/standing height ratio expresses relative sitting height and provides an estimate of the relative contribution of the trunk or lower extremities to stature. The ratio was calculated as sitting height/standing height X 100.

3. Estimated leg (subischial length) was calculated as standing height minus sitting height.

4. Estimated mid-arm muscle circumference and area were derived from relaxed arm circumference (Ca) and the triceps skinfold (St) as follows (Malina, 1995a):

Upper arm muscle (cm) = Ca - (π St)

where Ca is arm circumference and St is the triceps skinfold (cm).

5. The trunk-extremity ratio (TER) was used as an estimate of relative subcutaneous fat distribution. The sum of the two trunk skinfolds (subscapular and suprailiac) was divided by the sum of the two extremity skinfolds (triceps and medial calf).

Age at Menarche

All girls were interviewed on menarcheal status by MEPR or a female assistant. They were first asked in Spanish and with culturally appropriate terminology whether or not menarche had occurred (status quo method, Malina and Bouchard, 1991). In the case of post-menarcheal girls, they were also asked to recall the age at which menarche was attained. Prompts were used to facilitate the recall process.

Physical Fitness

Physical fitness items included a combination of motor-and-health-related tasks. Four tasks were used in an earlier study in Santo Tomas – right and left grip strength, 35 yard dash, and standing long jump (Malina and Buschang, 1985). Several additional tasks were added for the current study.

Static grip strength of the right and left hand was measured with a Stoelting adjustable dynamometer. The subject held the dynamometer in the line with the forearm at the level of the thigh. Children were instructed to squeeze the dynamometer as vigorously as possible so as to exert maximum force. Three trials were administered for each hand, the protocol alternating trials between hands. The best trial with each hand was retained for the analysis (Malina and Buschang, 1985).

The 35-yard dash (32.3 meters), an indicator of running speed, was measured as the time elapsed from the starting signal to crossing the finish line. The children ran on a flat concrete surface on the respective school grounds. The elapsed time was recorded to the 0.1 second. Two trials were administered, and the better of the two was retained for the analysis. A sufficient rest period between trials was included in the protocol (Malina and Buschang, 1985).

The standing long jump, a measure of power, was measured as the distance from the take-off line to the point where the heels touched the ground. The distance was measured to the nearest cm. Three trials were administered and the best of the three was retained for the analysis (Malina and Buschang, 1985).

The 12 minute run/walk was used as a measure of cardiorespiratory fitness. The subjects ran or walked for 12 minutes in an area at the urban school or the central plaza of the rural community, which was previously laid out with posts marking the limits and distance covered. The number of laps was counted by the research assistants. A warm-up and cool-down was provided done before and after the test, respectively. Participants ran in groups of about five. The distance run was recorded to the nearest meter by the research assistants. After testing several first grade children, it was noted that younger children had a difficult time trying to complete the 12 minutes walk/run. Therefore, the test was modified for children in the younger ages, corresponding to children at the 1st to 3rdgrades. The walk/run time was reduced from 12 to 8 minutes. Only one trial was administered and the children were verbally encouraged throughout the test to complete the task.

The sit-and-reach, an indicator of lower back and upper thigh flexiblity, was measured as follows. Subjects were permitted to warm-up before the test by performing slow stretching movements. The subject removed his/her shoes and was seated at the test apparatus with the legs fully extended. The heels were approximately shoulder width apart and the feet were flat against the end board of the apparatus. The subjects were instructed to extend the arms forward as far as possible with the hands placed on top of each other. The subject leaned forward extending the finger tips, with palms facing downward, as far along the ruler as possible without jerking or bouncing. This effort pushed a sliding marker along the scale. The child stretched forward along the top of the box four times. On the fourth attempt, he/she held the stretch for at least one second. The score was the farthest point reached on the last stretch, which was recorded to the nearest centimeter (Safrit, 1995). Three trials were recorded and the best of the three was retained for the analysis.

Sit-ups, a measure of abdominal strength and endurance, were measured as follows. The subject was in a supine position with the knees bent at right angles and the feet approximately shoulder width apart. The hands were placed at the side of the head with the fingers over the ears and with the elbows pointed toward knees. The hands and elbows had to be maintained in this position for the entire duration of the test. The participant's ankles were held throughout the test by the appraiser to ensure that heels were in constant contact with the mat. The subject was required to sit up, touch the knees with the elbows, and return to the starting positions (shoulder touching the mat). Each subject performed as many sit ups as possible within 30 seconds. Subjects were permitted to pause for rest whenever necessary. Clear instructions were given. Bouncing was not allowed and the subject's buttocks had to remain in contact with the mat. In curling down after the sit up, the lower back had to be in contact with the mat before the upper back and shoulders touched. One trial was given.

Test Validity and Reliability

Grip strength, standing long jump and 35-yard dash are indicators of static strength, power (explosive strength) and running speed, respectively. The are commonly used indicators of performance-related physical fitness (Malina, 1995b). The tests require all out effort, and have face validity and good reliability (Fleishman, 1964; Simons et al., 1969).

The sit-and-reach, timed sit-ups and distance run are indicators of lower back and hamstring flexibility, abdominal strength and endurance, and cardiovascular endurance (aerobic capacity), respectively. They are indicators of health-related physical fitness (American Alliance for Health, Physical Education, Recreation and Dance, 1980). The validity of the sit-and-reach as an indicator of back flexibility is limited; the test is apparently a more valid estimate of hamstring flexibility. In contrast, the sit-and-reach has high reliability (Plowman and Corbin, 1994). The validity of sit-ups as a measure of abdominal strength and endurance is uncertain due to the lack of an agreed upon criterion measure. However, the test has moderate to moderate high reliability (Plowman and Corbin, 1994). Distance runs have moderate validity as indicators of aerobic capacity and moderate to high reliability (Cureton, 1994).

For fitness items with more than one trial in the present study (right and left grip strength, dash, standing long jump, sit and reach), repeated measures ANCOVA was used to estimated within day reliabilities (intraclass correlations). Results are summarized in Table 3.5. The intraclass correlations range from 0.85 to 0.95 and indicate good within day reliability of these fitness measures. Correlations were also were also calculated between first vs second trial, first vs third trial, best vs second best, second best vs third best, etc. The average of the correlations are summarized in Table 3.6. With two exceptions (r=0.71 and 0.77 for the dash in boys, all correlations range between 0.81 and 0.93, and indicate acceptable levels of reliability for group comparisons.

Activity and Diet Information for Older Children

Measuring habitual physical activity and recording dietary intake of children is a difficult task, especially in field settings where literacy levels vary and concepts of time and amounts may not be the same as in western cultures. To obtain an estimate of physical activities and foods consumed by the school children, students in the 4th through 6th grades were asked to complete an activity questionnaire and to write down a list of the foods that they ate at each meal the day before. The data provide a general description of activities and foods consumed by children in the upper primary school grades.

The activity questionnaire was administered in the classroom setting. The questions were read aloud for the group, and the children were given time to write their answers. The assistants walked around the classroom to provide assistance as needed, largely in the context of answering specific questions and providing explanations. The assistants collected the questionnaires, checked the responses, and clarified answers with children if necessary.

The children were asked to describe their daily routines and kinds of activities they did with their parents, caregivers, siblings and peers, including play activities during school and free time and work chores. The children were also asked to describe their activities during free time, specific games and/or sport activities, television viewing, and household chores.

To estimate diet, a short term 24-hour recall was used. The children were asked to indicate the different foods consumed within the past 24 hours. Amounts were not requested. A similar protocol was used in earlier studies (Peña et al., 1995). The information was compared to the list of foods consumed at the household level during interview. In previous studies in Oaxaca, the communities were characterized as having a relatively limited diet with a relatively small number of foods, according to previous surveys. A basic list derived from the earlier studies (Amdurer, 1976; Peña et al, 1995) was used with the children and households.

The purpose of the activity and dietary assessments of older school children was to provide an indication of habitual activities and foods consumed. They are a complement to the anthropometric and fitness data, and provide background information on dietary intake and activity behaviors of primary school children in the urban and rural settings. The data are presented in a descriptive manner as community- and sex-specific frequencies and percentages.

Preparatory Activities for the Field

Prior to going into the field, preparatory activities were undertaken in three phases. First, potential field assistants (students enrolled in Escuela Nacional de Antropologia e Historia, ENAH) in Mexico City were identified and interviewed by the co-principal investigator and field coordinator (MEPR). Six assistants were eventually selected. All were students of physical anthropology and had previous experience with anthropometry.

Second, a working session was conducted in the Anthropometry Laboratory of ENAH. This session provided more detailed information about the project and specific training about the field protocols for anthropometry, physical fitness testing, and interviewing school children. A preliminary activity questionnaire was developed during this session. This session took about one week.

Third, standardizing sessions were conducted for anthropometry and fitness testing. For the former, the specific dimensions were described and demonstrated and then the assistants practiced taking the measurements on each other, and also on other adults and children who visited the laboratory at ENAH. All anthropometric dimensions were taken under the supervision of the field coordinator (MEPR). The protocol for the administration of the hand grip strength tests was also standardized at this time. This phase took about two weeks.

After the anthropometric phase, the second part of the standardizing process concerned physical fitness testing. The assistants first work in the laboratory to familiarize themselves with the tests, equipment, test procedures and sequence, instructions for children, and recording. The tests were performed initially by the assistants outdoors on a basketball court at ENAH. Then, the tests were administered to a group of six children, 8-12 years of age. This phase took about one week.

The final phase of the standardization process involved the preparation and field testing of the activity questionnaire. The development of the activity questionnaire was based on the following guidelines: (1) What activities do school children do in three different settings: at home, at school, and outside of school; and in the context of several social interactions - by themselves, with peers, with teachers, with adults (relatives, caretakers, others)? (2) What are the children's responsibilities to their respective households, i.e., work-related activities for the family - food preparation, animal care, wood gathering, field activities, and others, as well as family business activities, e.g., tortilla sales. (3) What do school children do during after school time (and on weekends), with a specific emphasis on physical activities related to work-related chores and leisure? (4) What kind of games and organized activities are they involved in and what is the level of involvement? The students administered the activity questionnaire to each other and then to several other students at ENAH. After group discussion and evaluation, modifications were made as needed. This took about one week.

After the standardization sessions, a pilot study was conducted. The instruments were tested on a group of urban school children in Cuernavaca, Morelos. The entire battery, including anthropometry, physical fitness tests and activity questionnaire, was applied to a group of children. Subsequently, adjustments and/or modifications were made as needed, and the recording forms were finalized. Further adjustments were made in the field as needed, e.g., modifying the 12 minute run to an 8 minute run to accommodate children in grades 1 through 3.

Statistical analysis

Given the small number of children 14 and 15 years of age (6 in the rural community and 2 in the urban community), they were not retained for the analyses. Thus, the analysis is limited to school children 6 through 13 years of age. Sample sizes by age group and sex, and means and standard deviations for chronological age for the rural and urban school children retained for the analyses are indicated in Table 3.7. The total sample thus includes 700 school children 6 to 13 years of age, 361 from the rural community (177 males, 184 females) and 339 from the urban community (173 males, 166 females). By sex, the overall sample includes 350 males (177 rural, 173 urban) and 350 females (184 rural, 166 urban).

The analysis followed several directions. First, descriptive statistics (means, standard deviations and medians (where appropriate) for all variables were calculated by age group and sex in each community. Second, to establish the current growth status of the rural and urban children, mean heights, weights, and BMIs were plotted relative to the new United States growth charts or reference data (Centers for Disease Control and Prevention, 2000). Third, the descriptive statistics for all variables were plotted by age to illustrate general trends in comparisons of the rural and urban males and females, respectively, in the anthropometric (measured and derived) and physical fitness characteristics. Given the small numbers among 12 and 13 years old children, graphic presentation of the data was limited to children 6 through 11 years of age.

The subsequent analyses focused on the specific study questions.

1. How do current samples of urban and rural school children 6-12 years of age in southern Mexico compare in growth status?

Analysis of covariance (ANCOVA) with age as the covariate was used to test the significance of differences in height, weight and other anthropometric indicators between urban and rural school children. The data were analyzed in two age groups separately for each sex: 6-9 and 10-13 years. As noted earlier, numbers of older children (14+ years) were too limited for the analysis. The samples were combined into two age groups to approximate earlier (6-9 years) and later (10-13) ages of middle childhood. These groupings were valid from two perspectives. First, the younger age group (6-9) is probably prepubertal. All girls 6-9 years were pre-menarcheal. This is also an age group in which children are nearing mature movement patterns for fundamental motor skills. Second, the older age group (10-13) probably includes children who have begun the transition into adolescence, which influences body dimensions and physical fitness. Six rural and 5 urban girls 11-13 years of age were already post-menarcheal (Table 3.8). A level of $p<0.05$ was accepted.

The following hypothesis was tested in the context of this research question: Urban school children have better growth status assessed with height, weight and other anthropometric indicators than rural school children. This hypothesis was deemed reasonable based on earlier studies in Oaxaca and in other areas of Mexico.

2. How do current samples of urban and rural school children 6-12 years of age in southern Mexico compare in physical fitness?

Analysis of covariance (ANCOVA) with age as the covariate was used to test the significance of differences in six tests of physical fitness between urban and rural school children. The raw scores of each test were used in the comparisons. The data were analyzed in two age groups separately for each sex: 6-9 and 10-13 years (see above). A level of $p<0.05$ was accepted.

The following hypothesis was tested in the context of this research question: Urban school children perform better on tests of physical fitness than rural school children. As noted in Chapter 2, data comparing the physical fitness of urban and rural children are limited. The available data, however, suggest generally better levels of fitness in urban samples.

3. How do current samples of urban and rural school children in southern Mexico compare in the estimated prevalence of growth stunting and wasting?

Growth stunting was estimated using the criteria of the World Health Organization (WHO, 1995), in which stunting is defined as low height-for-age relative to internationally acceptable reference data. A height below two standard deviations of age- and sex-specific reference values is classified as stunted. Heights of individual children were converted to z-scores using the protocol and reference values of the new United States Growth charts (Centers for Disease Control and Prevention, 2000). A z-score below –2.0 was defined as stunting. Note that the original recommendation of the WHO was based on the earlier United States Growth Charts (Hamill et al., 1977).

The sex-specific prevalence (and 95% confidence intervals) for growth stunting was calculated for each age group (6-9, 10-13 years) and the total sample (6-13 years). Sex-specific comparisons of the prevalence of stunting in the two age groups and the total sample of urban and rural children were tested with the chi-square statistic.

Many developing areas of the world include an epidemiological paradox, a continued presence of undernutrtion in the face of an increasing prevalence of overweight/obesity. Wasting is a form of undernutrition that indicates low weight-for-height (World Health Organization, 1995). Wasting was defined as a BMI below the 5th percentiles of age- and sex-specific reference data for the United States (Centers for Disease Control and Prevention, 2000).

The sex-specific prevalence (and 95% confidence intervals) for wasting was calculated for each age group (6-9, 10-13 years) and the total sample (6-13 years). Sex-specific comparisons of the prevalence of wasting in the two age groups and the total sample of urban and rural children were tested with the chi-square statistic.

The following hypothesis was tested in the context of this research question: Rural school children have a higher prevalence of growth stunting and wasting than urban school children.

4. How do the current samples of urban and rural school children in southern Mexico compare in the estimated prevalence of overweight and obesity?

Overweight was defined relative to the internationally recommended criteria (cut-off points) based on six national samples (Cole et al., 2000). The recommended cut-off points for the international criteria are based on pooled data from six nationally representative cross-sectional growth surveys – Brazil, Great Britain, Hong Kong, the Netherlands, Singapore, and the United States (excluding the most recent national health examination survey, 1988-1994, NHANES III). In establishing the cut-off points, a BMI of 25 kg/m^2 at 18 years of age was considered overweight and a BMI of 30kg/m^2 at 18 years of age was considered obese. Curves were then mathematically fit to the pooled BMI data from 2 years of age on so that they passed through a BMI of 25 kg/m^2 and 30 kg/m^2 at 18 years of age (retro-fitting). The values at each half year from 2 to 18 years of age are the respective cut-off points for overweight and obesity (Cole et al., 2000).

The sex-specific prevalence (and 95% confidence intervals) of overweight and obesity was estimated for each age group (6-9, 10-13 years) and total sample (6-13 years). The sex-specific comparison of the prevalences of overweight and obesity in the two age groups and the total sample of urban and rural children was tested with the chi-square statistic. The following hypothesis was tested in the context of this research question: Urban school children have a higher prevalence of overweight and obesity than rural school children.

The reported daily activities and foods consumed by the 4th, 5th and 6th grade children in the urban and rural communities were summarized in frequencies and percentages. The activities were divided into those related to recreation and those related to household chores. Time spent viewing television and intensity of household-related activities was also estimated. The ten most commonly reported food items for each meal of the day (breakfast - desayuno, lunch - comida, dinner - cena) were listed separately for rural and urban children.

Chapter 4

Results

Descriptive statistics by age group and sex in the urban and rural communities are given in Appendix III, Tables III.1 through III.14. The data are plotted in Figures 4.1 through 4.25. As noted earlier, the plotted data are limited to ages 6 through 11 due to small numbers at 12 and 13 years. Results of the analyses of covariance, with age as the covariate, and age-adjusted means and standard errors are summarized in each of the following sections dealing with body size, segment lengths and proportions, skeletal breadths, limb circumferences and estimated muscularity, subcutaneous fatness and relative fat distribution, and physical fitness. Prevalences and 95% confidence intervals and results of the chi square analyses for stunting, wasting and overweight in the two communities are then compared. A descriptive comparison of the recreational and household activities of 4th, 5th and 6th grade children closes the chapter.

Anthropometry

Body Size. The growth status of the sample relative to U.S. reference values (Centers for Disease Control and Prevention, 2000; Kuczmarski et al., 2000) is shown in Figures 4.1 through 4.6. On average, the heights of urban boys and girls fall at or above the 10th percentiles and approach the 25th percentiles at several ages, whereas the heights of rural boys and girls fluctuate between the 5th and 10th percentiles (Figures 4.1 and 4.2). Mean weights of urban children of both sexes tend to be above the 25th percentiles of the reference values. In contrast, mean weights of rural boys and girls are at or below the 25th percentiles (Figures 4.3 and 4.4). The trends for mean heights and weights suggest elevated weight-for-height in both the urban and rural samples. This is reflected in the BMI, which, on average, falls between the 25th and 75th

percentiles of the reference data at most ages (Figures 4.5 and 4.6). The urban-rural contrast is more apparent among 10-11 year old boys and 6-9 year old girls.

Mean heights, weights and BMIs of the urban and rural samples are illustrated in Figures 4.7 to 4.9, while results of the ANCOVA, with age as the covariate, are summarized in Table 4.1. In the two age groups within each sex, urban children are significantly taller and heavier than rural children. The BMI does not significantly differ between urban and rural males 6-9 years and females 10-13 years, but is significantly higher in urban than in rural females 6-9 years and males 10-13 years.

Segment Lengths and Proportions. Mean sitting heights and leg lengths of urban and rural children are illustrated in Figure 4.10, while mean sitting height/standing height ratios are shown in Figure 4.11. On average, sitting height and leg length are significantly longer in urban than in rural children of both sexes in each age group (Table 4.1). This reflects the greater standing height of urban children. Although absolute sizes of the two components of height are larger in the urban sample, there are no urban-rural differences in relative proportions. This is shown in the ratio of sitting height to standing height (Figure 4.11). The ratio does not differ between urban and rural children.

Skeletal Breadths. Age-for-age, the two skeletal breadths taken on the trunk (biacromial and bicristal breadths) are, on average, larger in urban than in rural children within each sex (Figure 4.12). Shoulder (biacromial) and hip (bicristal) breadths are significantly larger in urban than in rural boys and girls in each age group (Table 4.2). This likely reflects the larger overall size of the urban sample. In contrast to skeletal breadths of the trunk, the skeletal breadths taken on the extremities (biepicondylar and bicondylar) do not consistently differ between urban and rural children (Figure 4.13). Results of the ANCOVA (Table 4.2) indicate that the two extremity skeletal breadths are significantly larger in urban than in rural boys with the exception of biepicondylar breadth at 6-9 years. Among girls, both extremity breadths are significantly larger in urban than in rural children 6-9 years, but do not differ between urban and rural children 10-13 years. It should be noted, however, that although the differences between urban and rural children are statistically significant in some cases, the absolute differences in extremity skeletal breadths are quite small.

Limb Circumferences and Estimated Muscularity. Age trends in arm and calf circumferences are shown in Figure 4.15, while corresponding trends in estimated arm and calf muscle circumferences are shown in Figure 4.16. Age-adjusted mean circumferences based on the ANCOVAs (Table 4.2) are generally larger in urban than in rural children. However, the differences are significant only in girls 6-9 years and in boys 10-13 years. Among boys 6-9 years, arm circumference and estimated midarm muscle circumference do not differ between the urban and rural samples, whereas calf and estimated calf muscle circumferences are significantly larger in the urban sample. Among 10-13year old girls, on the other hand, the urban-rural contrasts in arm and calf circumferences and in estimated muscle circumferences are not significant.

Subcutaneous Fat and Relative Fat Distribution. Age trends in the four skinfold thicknesses are shown in Figures 4.16 to 4.19, while corresponding data for the sum of the four skinfold thicknesses and the trunk-extremity ratio are shown in Figures 4.20 and 4.21, respectively. Results of the ANCOVA are summarized in Table 4.3. The thickness of each skinfold and the sum of the four skinfolds do not differ between urban and rural boys and girls 6-9 years and between urban and rural girls 10-13 years. On the other hand, urban boys 10-13 years have significantly thicker skinfolds (individual skinfolds and sum of four skinfolds) than rural boys of the same age. The same trends are apparent in the trunk-extremity ratio, indicating no urban-rural differences in relative subcutaneous fat distribution (Figure 4.21), with the exception of urban boys 10-13 years of age have proportionally more subcutaneous fat on the trunk (higher ratio) than rural boys of the same age.

Hypothesis. Urban school children have better growth status as assessed with height, weight and other anthropometric indicators of growth than rural school children. This hypothesis was partially supported. Absolute body size (height and weight), trunk (sitting height) and estimated leg length, skeletal breadths on the trunk (biacromial and bicristal breadths) are significantly larger in urban than in rural school children. Urban-rural constrasts in skeletal breadths on the extremities (biepicondylar and bicondylar breadths), limb circumferences, estimated limb muscle circumferences, and subcutaneous fatness are not consistently significant by age group and sex.

Physical Fitness

Comparisons of mean values for right and left grip strength, the sum of right and left grip strength, and strength per unit body mass are illustrated in Figures 4.22 to 4.25. Results of the ANCOVA of the urban-rural comparison are summarized in Table 4.4.

Right grip, left grip and the sum of right and left grip strength do not differ significantly between urban and rural boys and girls 6-9 and 10-13 years of age. However, strength per unit body mass (sum of right and left grip/body weight) is significantly greater in rural girls 6-9 years and in rural boys 10-13 years. On average, strength per unit mass is also greater in rural boys 6-9 years and in rural girls 10-13 years, but the differences are not significant.

Age trends for each of the other physical fitness variables (trends are by grade for the distance run) are illustrated in Figures 4.26 through 4.30. Comparisons of the age-adjusted means (ANCOVA, Table 4.5) indicate several trends by age group, although the significance of the differences is not consistent across items and age groups. Among children 6-9 years of age, urban boys and girls perform, on average, better in the sit-and-reach ($p<0.01$ males, NS females), sit-ups ($p<0.001$ males and females), and standing long jump ($p<0.001$ males and females), whereas rural boys and girls perform, on average, better in the dash (NS males, $p<0.05$ females). The same trends are evident in children 10-13 years of age. On average, urban children perform better in the sit-and-reach (NS males, $p<0.01$ females), sit-ups ($p<0.01$ males, $p<0.001$ females), and standing long jump

($p<0.001$ males and females). In contrast to the younger age group, urban children 10-13 years of age also perform better, on average, in the dash ($p<0.05$ males, $p<0.01$ females).

Performance in the distance run was evaluated by grade (Figure 4.30, Table 4.5). In grades 1-3, rural children of both sexes run significantly greater distances in 8 minutes than urban children ($p<0.001$ males and females). In grades 4-6, rural boys run a greater distance in 12 minutes than urban boys but the difference is not significant, whereas urban girls run significantly farther than rural girls ($p<0.05$).

Hypothesis. Urban school children perform better on tests of physical fitness than rural school children. This hypothesis was partially supported. Urban children, on average, tend to perform better in the sit and reach, sit-ups, standing long jump and dash (10-13 years only), but results are not consistently significant. Rural children 6-9 years perform better in the dash. There are no urban-rural differences in grip strength, although strength per unit body mass tends to be greater in rural children. Rural children in grades 1-3 perform better in the distance run. Rural boys in grades 4-6 also perform better in the distance run, but the difference is not significant. On the other hand, urban girls in grades 4-6 perform significantly better in the distance run.

Stunting

The prevalence of growth stunting (and 95% confidence intervals) in the rural and urban samples is summarized in Table 4.6. Differences are small and not significant between age groups in each community (all χ^2 are <1.0). On the other hand, the prevalence of stunting is about two times higher in rural than in urban children. The trend is consistent in each age group but significance levels vary in the older group due to the smaller samples sizes, 6-9 (males $\chi^2 = 7.48$, $p<0.01$; females $\chi^2 = 6.45$, $p=0.01$) and 10-13 years (males $\chi^2 = 3.27$, $p=0.07$; females $\chi^2 = 2.83$, $p=0.09$). Across the total age range, 6-13 years, the rural-urban difference in the prevalence of stunting is significant in both boys ($\chi^2 = 10.62$, $p<0.01$) and girls ($\chi^2 = 9.26$, $p<0.01$).

Hypothesis. Rural school children have a higher prevalence of growth stunting than urban school children. This hypothesis was supported.

Wasting

In contrast to growth stunting, wasting is relatively rare among the urban and rural school children in this study (Table 4.7). The estimated prevalence is about 2% in rural children and 1% in urban children, and there is no sex difference. The urban-rural difference is not significant (boys, χ^2=0.63, NS; girls, χ^2=0.49, NS).

Hypothesis. Rural school children have a higher prevalence of wasting than urban school children. This hypothesis was not supported.

Overweight and Obesity

The prevalence (and 95% confidence intervals) of overweight and obesity, based on the internationally recommended criteria or cut-off values (Cole et al., 2000) are summarized in Tables 4.8 and 4.9 for boys and girls, respectively. Across the entire age range (6-13 years), the prevalence of overweight is greater in urban than in rural boys (11% vs 5%, respectively, χ^2 = 4.49, $p<0.05$) and girls (14% vs 8%, respectively, χ^2 = 4.43, $p<0.05$). The prevalence of overweight is especially higher in urban (14%) than in rural (3%) boys 10-13 years of age (χ^2 = 5.70, $p<0.05$). Among boys 6-9 years, the urban-rural contrast in the prevalence of overweight is smaller, 9% vs 6%, respectively (χ^2 = 0.68, NS). The opposite trend is apparent among girls. The prevalence of overweight is higher in urban than in rural girls 6-9 years of age, 16% vs 7%, respectively (χ^2 = 4.35, $p<0.05$). Corresponding percentages for urban and rural girls 10-13 years of age are 12% and 8%, respectively (χ^2 = 0.47, NS).

In contrast to overweight, the prevalence of obesity in the urban and rural samples is low, with the exception of urban boys 10-13 years of age. Among 6-9 year old children, only 2 urban boys and 2 rural boys are classified as obese (χ^2 = 0.003, NS), whereas among 10-13 year old children, 5 urban boys (8%) and no rural boys are classified as obese ($\chi^2 = 6.00$, $p<0.05$). Among girls, only 2 rural girls (one in each age group) and 4 urban girls (2 in each age group) are classified as obese ($\chi^2 = 0.52$, NS; $\chi^2 = 0.62$, NS).

Hypothesis. Urban school children have a higher prevalence of overweight and obesity than rural school children. This hypothesis was partially supported. The prevalence of overweight is significantly greater in urban than in rural children, specifically when the data are considered across the entire age span, 6-13 years. Within ages groups 6-9 and 10-13 years, the prevalence is greater in urban children, but the results are not consistently significant. The prevalence of obesity in urban and rural school children is low, and is significantly greater only in urban boys 10-13 years.

Activities of 4th, 5th, and 6th Grade Children

Self-reported daily activities were obtained from children in the 4th, 5th and 6th grades. A structured questionnaire was used. The activities were divided into those classified as recreational and those related to household chores. Time spent viewing television and intensity of household-related activities was also estimated.

Household Activities. Household activities of urban and rural school children are summarized in Table 14.10. Overall, rural boys report least involvement in house-related activities. About two-thirds of urban boys and urban and rural girls report house cleaning chores (62-67%) in contrast to 42% of rural boys. Urban boys and urban and rural girls also report making the bed (26-33%) compared to only 12% of rural boys. Urban (52%) and rural (60%) girls report cleaning dishes than urban (23%) and rural (1%) boys. In contrast to urban girls (12%), more rural girls (25%) report doing laundry. Few boys (3-4%) report doing laundry.

There are major differences between urban and rural children in food- and animal-related activities. Relatively few urban children, 2% of boys and 6% of girls, report involvement in cooking. More rural girls than rural boys report involvement in food-related activities. About 64% of rural girls report activities related to the making of tortillas compared to 13% of rural boys, and 14% of rural girls report cooking compared to no rural boys. On the other hand, more rural boys report gathering wood (13%) and getting water (12%) than rural girls (6% report getting water).

Rural children, specifically boys, report daily involvement in animal-related activities, caring for animals (70%) and getting animal feed from the pasture (69%). Smaller percentages of girls report these activities, 8% and 9%, respectively. Small percentages of urban children report daily care for pets, 8% boys and 3% girls.

Small percentages of rural boys (4%) and girls (2%) report involvement in farming activities, most often described as clearing ground. More rural girls (12%) than rural boys (4%) reported assisting with a family business, primarily selling tortillas. Rural and urban girls also report more involvement in caring for siblings than rural and urban boys.

Recreational Activities. Recreational activities are summarized in Table 4.11. Basketball is the most commonly reported sport activity of urban and rural boys, followed by football (soccer). Basketball is also the most commonly reported sport activity of rural girls, whereas basketball and volleyball are reported about equally among urban girls. Smaller percentages of children of boys and rural girls report participation in volleyball. No rural children report participation in baseball compared to small percentages of urban boys and girls.

Games of chase are reported more often by girls (urban 58%, rural 47%) than boys (urban 35%, rural 10%). Urban and rural girls also report more involvement in games of hide and seek, 30% and 32%, respectively, compared to urban and rural boys, 9% and 7%, respectively.

Bicycling is reported by small numbers of children. Small numbers of urban boys and girls report skating (7) and karate (4), whereas one rural boy and one rural girl report dancing.

Light/sedentary activities indicate a sex difference. More girls report playing with dolls and more boys report playing with cars and marbles. More boys also report playing videogames, 12% urban and 5% rural, in contrast to only one urban girl.

Television Viewing. Children were asked to indicate how much time they spent viewing television. Results are summarized in Table 4.12. Overall, about 11% of children in the 4th, 5th and 6th grades report either not having a television and/or no television viewing. Urban-rural contrasts in viewing television less than one hour and between 1 and 2 hours are small. About 47% of boys and 37% of girls report less than one hour, and about 21% of boys and 26% of girls report watching television 1 to 2 hours. Relatively more urban boys (28%) report watching television for more than 2 hours per day than rural boys (13%); in contrast, similar percentages of urban (27%) and rural (23%) girls report viewing television for more than 2 hours per day.

Intensity of Activities. An attempt was made to estimate the intensity of the activity reported before and after school by the 4th, 5th and 6th grade children. Activities were classified as follows:

Very light – includes activities involved in making the bed, doing dishes and running errands close to home (and requiring a short period of time),

Light – includes housecleaning (sweeping, mopping), shucking corn, removing grains from cobs, assisting with family business, cooking,

Moderate – includes feeding, cleaning and herding animals; milking cows/ goats; washing clothes; grinding corn; making, delivering and/or selling tortillas; gathering chapulines,

Moderate-to-vigorous – clearing farm ground, carrying water, cutting and gathering wood, cutting and carrying feed for animals.

Results are summarized in Table 4.13. Rural children, boys more so than girls, report daily participation in household-related activities classified as moderate and moderate-to-vigorous in intensity compared to urban children. Urban boys, on the other hand, report more household-related activities that are very light or light in intensity. Urban and rural girls do not differ markedly in reported frequencies of daily participation in household-activities classified a very light and light.

Activities During School Break. The daily school schedule includes a 30 minute break for lunch. Activities during the break reported by 4th, 5th and 6th children are summarized in Table 4.14. During this time, many boys are involved in physical activities. About equal percentages of rural and urban boys report involvement in games of running and chasing (35% rural, 31% urban), and in sport (56% rural, 48% urban). Basketball ball is the preferred sport of rural boys and soccer in urban boys. On the other hand, relatively more urban (20%) than rural (9%) boys report sedentary activities during the break – sitting, eating, chatting.

About equal percentages of rural and urban girls report involvement in games of running and chasing during the break (48% rural, 49% urban), but relatively more rural (38%) than urban (6%) report involvement in sport during the break. Basketball is the preferred sport of rural girls, whereas small but equal numbers of urban girls report participation in basketball and football (soccer). More urban (42%) than rural (14%) report sedentary activities during the break. The sex difference in sedentary activities during the school break is more marked in urban than in rural children.

Dietary Information of 4th, 5th and 6th Grade Children

Children in the 4th, 5th and 6th grades were asked to list the foods that they consumed at each meal in the past 24 hours. Complete records were provided by 67 rural children and 97 urban children. Overall, urban children reported a greater number of individual food items at the three meals than to rural children, 66 compared to 47, respectively. The total number of foods and the ten foods reported most often by the children at breakfast (desayuno), lunch (comida) and dinner (cena) are listed in Tables 4.15, 4.16 and 4.17, respectively. Urban children reported more diversity in diet, specifically at breakfast and dinner. The total number of foods reported at lunch was similar in rural and urban children. Animal protein represented in meats and meat derivatives were, in general, rather limited in the diets of rural children.

Rural and urban children reported 25 and 34 different food items at breakfast, respectively. However, the frequencies of food items reported at breakfast were 165 among the 67 rural children and 129 among the 97 urban children, which suggests 2.5 items per child among rural children and 1.3 items per child among urban children. Bread, chocolate, milk and coffee were the most commonly reported breakfast foods among both rural and urban children. The five most commonly reported breakfast foods also included cereal and milk shakes in urban children, and tortillas in rural children.

The number of food items reported at lunch was reasonably similar in rural (38) and urban (44) children. The frequencies of food items reported at lunch were 152 among the 67 rural children and 149 among the 97 urban children, which translates to 2.3 items per child among rural children and 1.5 items per child among rural children. There was, however, a major rural-urban contrast. The three most frequently reported items among rural children were soft drinks, orange juice and a fruit drink (agua frutas), which were reported by 30%, 22% and 18% of the children, respectively. The next three most commonly reported food items among rural children were bread, tortillas and sauces (salsa), each of which was reported by 16% of the children. Lunches of urban children were more substantive: chicken, beans, rice, chicken broth, and eggs, which were reported by 10% to 14% of the children. Other food items among the ten most often reported by urban children were pasta (noodle) soup, meat broth, and meat. Only 8% of urban children reported soft drinks among the ten most common items at lunch.

Almost twice as many food items were reported for dinner among urban children (43 items) compared to rural children (23 items). In contrast to breakfast and lunch, soft drinks and fruit drinks were not among the ten most often reported food items among rural children. The frequency of food items was 76 among the 67 rural children, which suggests that only one item was consumed per child (1.1) at the evening meal. Five of the ten most frequently reported items were animal derivatives, i.e., animal protein sources. Except for eggs and chicken, reported by 6% and 5% of the children, respectively, dinner items reported by urban children were largely starch-based. The frequency of food items for dinner reported by the 97 urban children was 131, which suggests that 1.4 items were consumed per child at the evening meal.

Overall, the diets reported by 4^{th}, 5^{th} and 6^{th} grade children in the rural and urban communities are rather limited, specifically in animal protein. Somewhat surprisingly, tortillas and beans, often reported as staples of the Mexican diet, are relatively lacking among the food items reported by the urban children. Among rural children, 20%, 25% and 25% reported consuming tortillas and beans at breakfast, lunch and dinner, respectively.

Chapter 5

Discussion

The present study considered the growth status and physical fitness of primary school children, 6-13 years of age, living under contrasting conditions in two communities, one urban and one rural, in the Valley of Oaxaca, southern Mexico. The sample can be viewed as generally representative of the public primary school population in rural areas and in expanding colonias of Oaxaca, not of the more affluent segment of the population whose children tend to attend private schools. The sample was divided into two age categories, 6-9 and 10-13 years. The analysis was set in the context of four questions and hypotheses dealing with growth status, physical fitness, the prevalence of stunting and wasting, and the prevalence of overweight and obesity. Activities and foods consumed by 4th, 5th and 6th grade children were also described.

Growth Status

It was hypothesized that urban school children would have better growth status as assessed with height, weight and other anthropometric indicators than rural school children. The hypothesis was partially supported. Absolute body size (height and weight), trunk (sitting height) and estimated leg length, skeletal breadths on the trunk (biacromial and bicristal breadths) are significantly greater in urban than in rural school children. Urban-rural contrasts in skeletal breadths on the extremities (biepicondylar and bicondylar breadths), limb circumferences, estimated limb muscle circumferences, and subcutaneous fatness do not consistently differ by age group and sex.

The data for weight, height, sitting height and estimated leg length in urban and rural children of Oaxaca are generally consistent with data for school children in several European countries (Bielicki, 1986), Africa (Spurgeon et al., 1984; Cameron et al., 1992), and China (Lin et al., 1992a) in showing more favorable growth status in urban compared to rural children. Most studies, however, are limited to height and weight. Similar contrasts have been reported in several studies of Mexican children dating to the 1960s. The studies in Mexico have generally compared the growth status of a rural or urban sample relative to reference values for children in Mexico City or the United States. Results consistently indicate smaller body size in rural school children and in children from other urban centers in Mexio (Vega-Franco and Robles-De la Vega, 1962; Perez-Ortiz and Mora, 1967; Pryor and Thelander, 1972; Arechiga and Serrano, 1981; Lopez-Alonso, 1995). The data for Mexico also indicate marked differences in growth status of urban children when they are classified by socioeconomic status (Perez Hidalgo et al., 1965; Villanueva, 1979). More recent data from the 1990s indicate that primary school children from urban centers of Sonora and Veracruz (Peña Reyes et al., 2002) compare favorably in height to the commonly used reference data (Ramos Galvan, 1975) for Mexican children. However, the more recent samples are heavier and have a higher body mass index (BMI), which have implications for overweight and obesity.

Urban-rural contrasts in growth status reflect to a large extent the inequitable distribution of and access to resources within a country. These include economic, educational, nutritional and health-related resources. Resources are often concentrated in urban centers and are limited in the extent to which they filter into expanding areas of cities in Latin America and into the rural areas. The data for Latin America are also influenced by recent migrations to urban centers, which have lead to the expansion of urban developments (colonias in Mexico), many of which are slums with poor housing, marginal access to resources and limited employment opportunities.

Migrants do not ordinarily differ in physical characteristics from sedentes in their respective communities (Bogin, 1988), and this is also true of the growth status of eventual migrants and sedentes in Oaxaca (Malina et al., 1982). However, it is well documented that the growth status of offspring born to migrants to urban centers improve in their growth status compared to children in the home communities (Boas, 1912, 1922; Goldstein, 1943).

A question of interest in the present study is the growth status of children born in San Juan Chapultepec or the city of Oaxaca, and those born in other communities in the state of Oaxaca or in other states of Mexico. Information on the place of birth of all except four children in the sample of school children from San Juan Chapultepec was available: 75% of the children were born in San Juan or the city of Oaxaca, 18% were born in other areas of the state of Oaxaca, and 6% were born in other states of Mexico (including one child who was born in the United States). The heights, weights and BMIs of children born in San Juan or the city of Oaxaca, in other communities in the state of Oaxaca, and in other states of Mexico do not differ significantly (Table 5.1). Information was not available on the age of the child at the time of migration for children whose families moved into the colonia. However, about 75% of the families of the school children for whom information was available (236 of 317) lived in the colonia for 10 years of less.

Corresponding information for children in Santo Tomas Mazaltepec indicated that 87% of the children were born in the community while 4% were born in other areas in the state of Oaxaca and 7% were born in other states of Mexico. Information on place of birth was not available for 8 children. Boys born in the rural community and those who were born elsewhere did not differ in height, weight and the BMI. Girls born in other areas of Oaxaca (n=9) or other states of Mexico (n=15) were significantly heavier and had a larger BMI than girls born in the community, but the three groups did not differ significantly in height (Table 5.2).

Results of the present comparison for height and weight are consistent with a similar comparison of about 30 years ago between primary school children resident in two colonias of Oaxaca, one of which was San Juan, and two rural Zapotec-speaking communities, one of which was Santo Tomas (Malina et al., 1981). The earlier comparison also indicated no urban-rural difference in the thickness of the triceps skinfold for girls, but indicated a smaller estimated midarm muscle circumference in rural boys and girls. In the present study, the triceps skinfold did not differ between urban and rural girls and between urban and rural boys 6-9 years; however, urban boys 10-13 years had a thicker triceps skinfold (Table 4.3). Estimated arm muscle was significantly greater in urban boys 10-13 years and in urban girls 6-9 years, and did not differ between urban and rural boys 6-9 years and girls 10-13 years (Table 4.2). However, the age-adjusted means tended to be larger in urban children in the four age groups. The earlier study did not analyze the data by corresponding age groups.

Although urban children tend to be taller and heavier than rural children, both samples from Oaxaca are, on average, consistently shorter and lighter compared to United Stated reference data. On average, the heights of urban boys and girls fall at or above the 10^{th} percentiles but approach the 25^{th} percentiles at several ages, whereas the heights of rural boys and girls fluctuate between the 5^{th} and 10^{th} percentiles (Figures 4.1 and 4.2). Mean weights of urban children of both sexes tend to be above the 25^{th} percentiles of the reference values. In contrast, mean weights of rural boys and girls are at or below the 25^{th} percentiles (Figures 4.3 and 4.4).

The growth status of the current sample of Oaxaca children fares better relative to United States reference values than Oaxaca children surveyed between 1968 and 1972. A combined sample of rural and urban children, 6 to 13 years of age, in 1968-1972 had heights that were, on average, consistently below the 5^{th} percentiles of United States reference data and weights that approximated, on average, the 5^{th} percentiles of United States reference data (Malina, 1983). This comparison needs to be tempered with caution. Different reference values were used in the present (Centers for Disease Control and Prevention, 2000) and earlier (Hamill et al., 1977) comparative studies. Heights of national samples of American children in surveys carried out from the 1960s through 1994 have not changed significantly, although there have been major increases in body weight in the most recent national survey, 1988-1994. The increase in weight was of major public health concern and the body weights from the most recent survey were not used in the construction of the new growth charts (Kuczmarski et al., 2000). Allowing for these caveats in the United States reference data, the growth status of urban and rural school children in Oaxaca in 2000 has improved compared to that of urban and rural school children in 1968-1972.

Overweight, Obesity and Wasting

The urban girls 6-9 years and boys 10-13 years had a significantly larger body mass index (BMI) than rural children in the respective age groups, but the BMI did not differ between urban and rural girls 10-13 years and boys 6-9 years (Table 4.1). The trends in the BMI are generally consistent with the estimated prevalence of overweight and obesity in the urban and rural children (Tables 4.8 and 4.9). Across the age range 6-13 years, urban children show a higher prevalence in overweight than rural children, 11.0% and 5.1%, respectively, in boys (χ^2=4.49, $p<0.05$), and 14.5% and 7.6%, respectively, in girls (χ^2=4.43, $p<0.05$). In contrast, obesity is relatively rare in this sample of urban and rural children, 1.1% and 4.0%, respectively, in boys (χ^2=3.33, NS), and 1.1% and 2.4%, respectively, in girls (χ^2=1.10, NS).

The estimated prevalence of overweight and obesity in the present study was based on the internationally recommended criteria of Cole et al. (2000). These criteria were applied to several other samples of Mexican children to provide a comparative perspective: primary school children in urban centers of Sonora and Veracruz (Peña Reyes et al., 2002) and Mexico City (Siegel, 1999), and rural Tarahumara school in Chihuahua children in northern Mexico (Peña Reyes et al., in preparation). The estimated prevalences of overweight and obesity are summarized in Table 5.3. Rural Mexican primary school children from indigenous communities in Oaxaca and Chihuahua have a low prevalence of overweight, about 4% in boys and 8% in girls. Obesity in rural school children is relatively uncommon, about 1%. Urban boys in

Oaxaca have a lower prevalence of overweight (11%) and obesity (4%) compared to urban boys in other centers of Mexico (19-23% and 9-14%, respectively). The contrast among girls from different urban areas is less for overweight, 14% in girls from Oaxaca compared to 17-23% in girls from larger urban centers. On the other hand, obesity is relatively uncommon in urban Oaxaca girls (2%) compared to girls in other urban centers (6-9%). Corresponding data for other samples utilizing the internationally recommended criteria (Cole et al., 2000) are not presently available.

Estimates of overweight and obesity in a population are based on the BMI, and both conditions indicate excess weight-for-height. Overweight and obesity are sometimes referred to as forms of overnutrition, but chronically excessive energy intake is only one part of the equation. Chronic physical inactivity is another important factor in the etiology of overweight and obesity. The opposite extreme of overweight/ obesity is wasting, a form of chronic undernutrition that indicates low weight-for-height (World Health Organization, 1995). In the present study, wasting was defined as a BMI below the 5th percentiles of age- and sex-specific reference data for the United States (Centers for Disease Control and Prevention, 2000). The same criteria were applied to the data for the children from other areas of Mexico used in the comparisons of overweight and obesity (see above). Results are summarized in Table 5.4. Overall, wasting is relatively uncommon among rural and urban Mexican primary school children 6-13 years of age. Estimated prevalences are lowest in rural (2%) and urban (15) children in Oaxaca and rural Tarahumara children in Chihuahua (<1% boys, 2% girls). Estimates are 2% (boys) and 3% (girls) in Sonora, 3% (boys and girls) in Veracruz, and 6% (boys) and 4% (girls) in Mexico City. The somewhat higher estimates of wasting for primary school children in Mexico City are perhaps somewhat surprising. They may reflect more extreme conditions of poverty, or perhaps later onset of the adolescent growth spurt during which weight-for-height relationships change appreciably (Malina and Bouchard, 1991).

Stunting

In contrast to wasting, which indicates low weight-for-height, stunting refers to short stature or deficient linear growth. Growth in height is a record of a child's nutritional history, and a high prevalence of growth stunting, defined as a z-score below –2.0 relative to age- and sex-specific reference values, generally accepted as evidence of chronic undernutrition in a community (World Health Organization, 1995). Most stunting occurs during the preschool years when the rate of growth in height is especially rapid (Malina and Bouchard, 1991). Estimated rates of growth in height over a one year interval (1978-1979) suggest that the height of school children 6-13 years in Santo Tomas is more indicative of insults experienced during the preschool years than during the school ages (Buschang and Malina, 1983).

In the present study (Table 4.6), the prevalence of stunting is almost twice as great in rural (about 29%) than in urban boys and girls (about 15%). Corresponding data for other samples 6-13 years of age in Mexico are not available. Estimates of stunting (height more than two standard deviations below that expected for age) for first grade children at school entry in 1994 vary among states in Mexico (Secretaria de Salud, 1998). Estimates are highest in Chiapas (44.1%), Oaxaca (43.4%) and Yucatan (36.6%), all states with a high percentage of rural indigenous populations. Estimates for rural children 6-9 years of age in the present study are 27.4% in boys and 29.2% in girls, which are lower that the statewide estimate for rural children at entry to school (43.4%).

The prevalence of stunting was estimated for the sample of rural Tarahumara school children in Chihuahua using the same reference values (Centers for Disease Control and Prevention, 2000) as in the present study. The comparative data are summarized in Table 5.5. Among children 6-9 years, estimates of stunting are slightly lower in rural Zapotec in Oaxaca compared to rural Tarahumara in Chihuahua. Among older children 10-13 years, estimates of stunting a reasonably comparable in rural Oaxaca and Chihuahua. In contrast, estimates of stunting among urban children in

Oaxaca are about one-half of the estimates among rural children in Oaxaca and Chihuahua.

Physical Fitness, Physical Activity and Diet

It was hypothesized that urban school children would perform better on tests of physical fitness than rural school children. The hypothesis was partially supported. Urban children, on average, tended to perform better in the sit and reach, sit-ups, standing long jump and dash (10-13 years only), but results were not consistently significant. Rural children 6-9 years performed better in the dash. There were no urban-rural differences in grip strength, although strength per unit body mass was greater in rural children. Rural children in grades 1-3 and rural boys in grades 4-6 performed better in the distance run. On the other hand, urban girls in grades 4-6 performed significantly better in the distance run.

The urban-rural contrasts in physical fitness may reflect, in part, physical education in the respective schools and the pattern of daily activities. The rural school has one physical education period per week (30-45 minutes). The class is conducted by the classroom teacher. The first part of the period is spent marching around the patio of the central plaza of the community, followed by free play. Most children participate in sport, specifically basketball. There is little, if any, instruction and practice of specific motor skills. The urban school, in contrast, has a physical education teacher who offers formal classes (30-45 minutes) once per week. Time is usually devoted to the practice of specific motor skills and routines, which vary from grade to grade and throughout the school year.

Several of the fitness tests (e.g., standing long jump, sit-ups) appeared more familiar to the urban than to the rural children. This may contribute to some of the contrasts between the urban and rural samples, i.e., familiarity with the tests. Indeed, some of the younger rural children had difficulty with the protocol for the standing long jump.

In contrast to physical education, the rural children, especially boys, spend a good deal of time in household chores related to the care of animals (Table 4.10). These chores require muscular strength and moderate endurance in walking back and forth to the fields for animal feed (and carrying the feed back to the household) and for animal grazing. Gathering and carrying wood and carrying water are other household chores of many boys. This may contribute to the generally better distance run (endurance) performances and the better grip strength per unit body size in rural boys.

The chores of rural girls are largely involved with food preparation (Table 4.10). These activities include shucking corn, walking back and forth to the corn grinding mill (and carrying the maize), and occasionally assisting with the sale of tortillas, which involves considerable walking. The activities of girls also include some chores related to animal care (same as boys), carrying water, and gathering chapulines. All these activities require regular walking and carrying. Hence, this may contribute to the better grip strength per unit body size in rural compared to urban girls. Although rural girls are seemingly more active in walking and carrying tasks, this does not necessarily translate into better endurance (distance run performance). It may reflect the observation that many of the activities of rural girls take place relatively close to home and with age, older rural girls are generally more homebound than older urban girls. Rural girls 6-9 years perform better in the distance run than urban girls, but urban girls 10-13 years perform slightly better in the distance run than rural girls.

The strength and motor fitness of children in Santo Tomas were also studied in 1978. Performances in the dash, standing long jump, ball throw for distance, and grip strength were consistently poorer than those of American children. When performances were adjusted for body size differences between the samples, the performances of the rural Zapotec children were generally commensurate to their smaller body size, especially 6 through 9 years of age, although the rural children tended to throw better than expected for their small body size (Malina and Buschang, 1985). Comparison of the mean performances of children in Santo Tomas in 2000 with those of the sample in 1978 indicates several trends. The recent sample of boys and girls is stronger in grip strength, probably reflecting their larger body size. Differences between the 2000 and 1978 samples in the 35 yard dash (32.3 m) are small and inconsistent across the age range. In contrast, the standing long jump performance of the 2000 sample is, on average, consistently poorer than the performances of the 1978 sample in both sexes (Malina, 2002).

Urban-rural comparisons of physical fitness are rather limited, but suggest variable results depending on fitness tests being used. The physical fitness of Japanese children and adolescents varies by item and among prefectures. In Kyoto, for example, rural elementary school children (about 7-12 years) performed better in muscular strength (grip, back), motor ability (50 m dash, standing long jump, ball throw for distance), and muscular endurance (chinning), but urban children performed better in agility (continuous hopping). On the other hand, urban boys 9-18 years in the Gifu prefecture performed better than their rural peers in muscular strength (back) and motor fitness (50 m dash, standing long jump), but urban and rural boys did not differ in grip strength. Urban girls had better motor fitness than their rural peers, but there were no urban-rural differences in muscular strength (grip, back). Both rural boys and girls had better maximal aerobic power than their urban peers (Tamura, 1975).

Observations on rural and urban children in Oaxaca are reasonably similar to those for Japanese children. The rural children tended to perform better in the endurance task (8 and 12 minute run), with the exception of girls 10-13 years, whereas there were no differences in muscular strength. The urban children also performed better in the standing long jump, but urban-rural differences were not consistent for the dash.

Data from Poland in the 1960s indicated better performances in the vertical jump and agility by urban boys 7-13 years of age, but no consistent differences in the performances of urban and rural boys in a dash, medicine ball throw and grip strength (Miernik, 1965). On the other hand, 10 year old urban Polish boys and girls performed better than their rural peers in a 30 m dash, a 1 kg medicine ball throw, the vertical jump, squat thrusts (muscular endurance), and an agility run (Pilicz and Sadowska, 1973).

Urban-rural comparisons of physical fitness in some areas of the world must be tempered by contrasts in socioeconomic and nutritional status. Rural, low socioeconomic status children in South Africa, for example, have poorer grip strength than urban, high socioeconomic status children, but rural-urban contrasts in neuromuscular reaction time and pulse recovery after exercise (cardiovascular endurance) are inconsistent (Henneberg and Louw, 1998).

A question of interest is the physical fitness status of the Oaxaca children compared to healthy, well nourished children. Reference values for several indicators of physical fitness permit several comparisons. The Fitnessgram (Cooper Institute for Aerobic Research, 1994) provides "healthy fitness zones" for several components of health-related physical fitness, including the BMI and percentage fat (predicted from skinfolds). Mean BMIs of rural and urban children in Oaxaca fall well within the "healthy" zone. The percentage body fat of Oaxaca children was predicted from the sum of the triceps and medial calf skinfolds following the protocol of the Fitnessgram (Lohman, 1994). Mean estimated percentage fat of the rural and urban children fall towards the low end of the "healthy fitness zone" in both sexes. The recommended low ends of the "healthy fitness zone" are 10% fat in boys and 17% fat in girls. Mean estimates for rural and urban boys 6-9 years are 12.3% and 12.7%, respectively, and for rural and urban boys 10-13 years are 12.6% and 14.9%, respectively. Estimated means for rural and urban girls 6-9 years are identical, 15.8%, and are below the low end of the "healthy fitness zone," while those for rural and urban girls 10-13 years are 17.7% and 17.0%, respectively.

The sit-and-reach is scored on a pass-fail basis in the Fitnessgram. Mean values for the sit-and-reach performance of the rural and urban Oaxaca children exceed the passing levels (20 cm in boys, 23 cm in girls). The mean sit-and-reach performances of Oaxaca children approximate the medians for the reference sample of the American

Alliance for Health, Physical Education, Recreation and Dance (1980). The Fitnessgram includes modified sit-ups (curl-ups), but it is not a timed test. Rather, children are instructed to perform the curl-ups at a slow and controlled pace of about 20 per minute. Hence, the data are not comparable to values in the present study.

Reference data for the distance run and/or walked in 8 and 12 minutes are not available. The American Alliance for Health, Physical Education, Recreation and Dance (1980) provide reference values for the distance run (yards) in 9 minutes. Expressing the medians and means as yards per minute and meters per minute, respectively, provides an indirect comparison. Allowing for the differences in measurement units, the distance run performance of rural and urban Oaxaca children, estimated as meters per minute, is quite similar to the reference. The aerobic performance of the Oaxaca children is perhaps more impressive in the context of their smaller body size, specifically leg length, which is related to stride length. This would suggest better aerobic fitness in the Oaxaca children.

The three remaining items in the physical fitness battery used in the present study include static strength (grip strength), explosive strength (standing long jump) and running speed (35-yard dash). The three items are highly correlated with body size (Malina, 1975, 1994a). Hence, given the smaller body size of the Oaxaca children, one would expect lower performances in these three tasks. Reference values for healthy, well-nourished children are not available with the exception of the standing long jump. Tests of running speed use different distances. Comparisons of grip strength are limited by variation in the type of dynamometer. Estimates of strength based on different dynamometers are not directly comparable.

Data for a mixed-longitudinal sample of Philadelphia children 6-13 years of age tested in the mid-1960s include the standing long jump, the 35-yard dash and grip strength (Malina, unpublished). The jumping and running protocols are the same as used in the present study. Grip strength was measured with a Narragansett dynamometer in the Philadelphia study, whereas an adjustable Stoelting dynamometer was used in the present study. Mean performances of rural and urban Oaxaca children on the standing long jump and 35-yard dash are consistently lower than corresponding age- and sex-specific values for the mixed-longitudinal sample of Philadelphia children. Allowing for differences in type of dynamometer, the grip strength of Oaxaca children is also consistently lower than that of Philadelphia children.

Urban and Rural School Children in Oaxaca – An Overview

The growth status of children is often viewed as a mirror of conditions in society and as specifically reflecting the overall health and nutritional status of a community. The growth status of the urban and rural school children can be viewed as reflecting conditions in the state of Oaxaca and specifically in the Valley of Oaxaca, which are influenced by economic development in the area and by an increasing proportion of small land owners who are abandoning rural communities in search of jobs closer to or in the more attractive urban areas (Ruiz-Cervantes, 1988). The larger heights and weights of the urban sample probably reflect improved health and nutritional conditions in the city of Oaxaca compared to rural areas. Improved conditions are reflected in indicators as sewage disposal and potable water, better housing, access to outpatient clinics, better schools, and availability of a regular food supply.

Although it is difficult to specify direct contributions of these factors to the growth status given the complexity of the cellular processes that underlie growth, this interpretation is consistent with an index of nutritional deficits (indicadores de desnutrición) developed by the National Institute of Nutrition (Roldan et al., 2000). The variables used to derive the index include primarily health and social indicators so that the index might be more appropriately labeled social undernutrition (desnutrición social): height deficit at school entrance, infant mortality, school age mortality, percentage of deaths related to respiratory disease, percentage of deaths related to diarrhea, percentage of indigenous population, and the index of marginalization (índice de marginación, described earlier, Chapter 2). The index of marginalization was based on education, housing, population distribution and income (Consejo Nacional de Poblacion, 1998). Based on these indicators, nutritional grades were classified as follows:

Indices ≤15 – low deficits

Indices 15.1 to 20.0 – moderate deficits

Indices 20.1 to 30.0 – important deficits

Indices ≥30.1 – severe deficits.

The nutritional index for the state of Oaxaca was 35.78; the corresponding indices for the city of Oaxaca and rural communities in the state were 11.53 and 41.81, respectively. Indices for the rural areas fell in the severe range. By way of comparison and as examples, the nutritional index was 7.18 for Baja California Norte, 7.28 for the Federal District, 7.90 for Sonora, 17.19 for Durango, and 30.33 for the Yucatan (Roldan et al., 2000).

If the index of marginalization is treated separately, the index for the state of Oaxaca places the state in a very high of level marginalization. Corresponding classifications for other states are very low marginalization for the Federal District and Baja California Norte, low marginalization for Sonora, medium marginalization for Durango, and high marginalization for Yucatan.

The indices of nutritional deficit and marginalization highlight the relatively poor conditions of life in small, rural communities in the state of Oaxaca in contrast to the better conditions characteristic of urban centers. It is such marginal conditions that contribute to the urban-rural contrast in growth status observed in the present study and to the greater prevalence of stunting in rural children. However, the urban sample from Oaxaca is consistently shorter than primary school children from other urban centers in Mexico (Peña Reyes et al., 2002).

Although the growth status (size attained) of urban children is better than that of rural children, both samples are shorter compared to reference values recommended by the World Health Organization. The World Health Organization (1995) recommended the use of reference data for United States children. The reference values, or "growth charts," for United States children have been recently revised (Centers for Disease Control and Prevention, 2000). Compared to the new reference values, urban children in Oaxaca tend to approximate the 10th percentiles but approach the 25th percentiles at several ages, whereas the heights of rural boys and girls fluctuate between the 5th and 10th percentiles. In contrast to the present sample, rural and urban primary school children surveyed in Oaxaca in 1968-1972 have mean heights that approximated or were below the 5th percentiles of United States reference data.

Thus, the growth status of urban and rural Oaxaca children has improved over the past 30 years or so (Malina, 2002). Urban boys 6-13 years of age in 2000 are about 5.1 cm taller and 4.9 kg heavier than urban boys in 1972. Similarly, rural boys 6-13 years of age in 2000 are about 6.6 cm taller and 4.3 kg heavier than rural boys in 1968. The magnitude of the urban-rural differences in height, weight and the BMI in 2000 are smaller than the corresponding differences in 1968/1972 among boys 6-9 years, but the opposite is true among boys 10-13 years, i.e., the magnitude of the urban-rural difference in height, weight and the BMI in 2000 is greater than in 1968/1972. The difference in older boys is especially marked in body weight. The urban-rural difference among 10-13 year old boys in 1968/1972 was 2.3 kg, while the corresponding difference in 2000 is 5.7 kg. This is reflected in the significantly greater prevalence of overweight/obesity in the current sample 10-13 year old urban boys compared to rural boys of the same age (Table 4.8). The corresponding estimates among younger boys 6-9 years did not differ between urban and rural boys.

Generally similar trends are apparent among the urban and rural girls over the past 30 years. Urban girls 6-13 years of age in 2000 are about 7.0 cm taller and 5.4 kg heavier than urban girls in 1972. Similarly, rural girls 6-13 years of age in 2000 are about 5.7 cm taller and 3.8 kg heavier than rural boys in 1968. In contrast to boys, the magnitude of the urban-rural differences in 2000 are greater for weight and the BMI compared to the corresponding differences in 1968/1972 among girls 6-9 years; the magnitude of the urban-rural difference for height was about the same in 1968/1972 and 2000. Among girls 10-13 years, the magnitude of the urban-rural difference in height, weight and the BMI in 2000 is greater than in 1968/1972, which is similar to the trend in boys 10-13 years. In contrast to boys, the prevalence of overweight/obesity among the current sample of urban girls is greater in both younger (6-9) and older (10-13) year old girls (Table 4.9).

The improved growth status of primary school children in Oaxaca probably reflects better health and nutritional conditions compared to those of 20-30 years ago. Although growth status has improved, a significant percentage of urban and especially rural primary school children are stunted in growth (Table 4.6). The estimated prevalence of stunting is about twice as great in the rural children (about 30%) compared to the urban children (about 15%). Growth stunting is generally viewed as reflecting nutritional insults during infancy and early childhood. Hence, significant numbers of urban and rural children have probably been reared under poor conditions. The growth and fitness characteristics of stunted and non-stunted children are currently under study.

While mean heights of primary school children have increased, on average, over time, mean weights have increased proportionally more, particularly in the urban population. This is reflected in a significantly greater prevalence of overweight in the urban than the rural samples. Nevertheless, the prevalence of overweight and obesity among urban primary school children in Oaxaca is less than corresponding estimates in school children from other, larger urban centers in Mexico (Table 5.3).

Taken together, the data for primary school children in Oaxaca present a picture labeled as the epidemiological paradox – an increasing prevalence of overweight/obesity in the face of persistent chronic undernutrition. This is a characteristic of countries, or areas within a country, that are experiencing an economic and nutrition transition (Popkin et al., 1996). Rapid urbanization is a characteristic of the transition, and the urban population of the state of Oaxaca has increased from 32% in 1980 to 43% in 2000 (Table 2.1). Migration to cities has influenced the demographic make-up of rural communities, often contributing to economic disparities between the areas. For example, about 29% of the urban population of Oaxaca has an income corresponding to 1 or 2 minimum wages compared to only 16% of the rural population. And, about 34% of the urban population has an income corresponding to 2 to 5 times the minimum wage in contrast to 15% of the rural population. On the other hand, about 49% of the rural population received no income compared to only 6% of the urban population (INEGI, 2000, see Table 3.2). Although these figures are estimates, they affect the purchasing power of families which influence living conditions, including habits related to diet and physical activity, and in turn the health and nutritional status of children.

Although the observations on the physical activities of 4th, 5th and 6th grade children in the urban and rural communities are limited, they suggest less regular physical activity among the urban children, which may be a contributory factor to the increasing prevalence of overweight and in some cases obesity. In contrast, the rural children are more regularly involved in activities of moderate intensity, and in some instance activities of moderate-to-vigorous intensity. These activities are related largely to household chores and subsistence needs, e.g., gathering wood, carrying water, caring for animals, and so on. Regular involvement in such activities involving walking and carrying loads, may contribute to the observed rural-urban difference in cardiovascular endurance (distance run) and muscular strength per unit body mass. Although methods of classifying youth as active and less active vary among studies, there is a reasonably consistent observation that more active youth are generally more fit in measures of cardiorespiratory endurance. On the other hand, results for other components of health-related physical fitness are somewhat inconsistent among studies, suggesting that habitual physical activity is only one of several factors that influences fitness (Malina, 1994b).

Although limited to reports of 4th through 6th grade children, urban children indicate a more varied diet as reflected in a greater number of individual food items reportedly consumed at the three meals, breakfast (desayuno), lunch (comida) and dinner (cena), in the past 24 hours, 66 versus 47 food items, respectively. This suggests that the urban children have access to a greater variety of foods. However, the dietary items reported by these older primary school children in the rural and urban communities are rather limited, specifically in animal protein. Urban children report more food items of higher quality animal protein (eggs, red meat). Eggs and red meat are listed on 10% of the entries of urban children compared to 5% of the entries of rural children. Somewhat surprisingly, tortillas and beans, often reported as staples of the Mexican diet, are lacking among the food items reported by the urban children and are indicated rather infrequently by the rural children. Only 4%, 15% and 6% of urban children reported consuming tortillas, and beans at breakfast, lunch and dinner, respectively. Tortillas have been largely replaced by bread in the urban diet. In contrast, among rural children, 20%, 25% and 25% reported consuming tortillas and beans at breakfast, lunch and dinner, respectively.

Chapter 6

Summary and Conclusions

The present study considered the growth status and physical fitness of school children living in two communities, one urban and one rural, in the Valley of Oaxaca, southern Mexico, in 1999-2000. The two communities, Santo Tomas Mazaltepec and San Juan Chapultepec, were chosen because they represented the contrasting living conditions that may influence growth and physical fitness of school children.

Santo Tomas is a rural community with a high proportion of Zapotec-speaking population. It is largely a subsistence agricultural community. Community lands are generally not high quality to produce adequate resources. Hence, many women are economically active, largely through the sale of tortillas.

San Juan is an urban colonia located on the slopes of the hills west of the city of Oaxaca de Juarez. At present, the colonia is part of the city of Oaxaca. The population is basically Spanish-speaking. The majority of the population of the colonia works as employees or in industry, and in the service sector of the city of Oaxaca.

Study subjects were children enrolled in the primary school in each community. The project was developed within the activities of the general project: "Secular change in size, strength and motor fitness in the Valley of Oaxaca, Mexico," with Robert M. Malina as principal investigator. A total of 367 children, 180 boys and 187 girls, in the 1st through 6th grades was measured and tested in the rural community in the Fall 1999 and Spring 2000, and a total of 341 children, 175 boys and 161 girls, in the 1st through 6th grades was measured and tested in the urban community in the Fall 1999 and Spring 2000. Given the small number of children 14 and 15 years of age (6 in the rural community, 2 in the urban community), the analysis was limited to school children 6 through 13 years of age. The total sample included 700 children 6 to 13 years of age, 361 from the rural community (177 males, 184 females) and 339 from the urban community (173 males, 166 females).

Anthropometric and physical fitness data were collected at the respective schools during regular school hours in both communities. The anthropometric battery included measures of body size (height and weight), segment lengths (sitting height and estimated leg length), skeletal breadths (biacromial, bicristal, biepicondylar, bicondylar), limb circumferences (arm and calf), and skinfolds (triceps, subscapular, suprailiac, medial calf). The body mass index (BMI), the sitting height/stature ratio, estimated arm and calf muscle circumferences, sum of skinfolds, and the trunk/extremity skinfold ratio were calculated.

Physical fitness items included motor-and-health-related tasks: right and left grip strength (muscular strength), 35 yard dash (32.3 meters, speed), standing long jump (explosive power), sit-and-reach (flexibility), timed sit-ups (30 seconds, abdominal strength and endurance), and a distance run (8 minutes in grades 1-3 and 12 minutes in grades 4-6, cardiovascular endurance).

An activity and dietary questionnaire was administered in children in grades 4, 5 and 6. Self-reported daily activities and food items consumed in the preceding 24 hours were obtained from children in the 4th, 5th and 6th grades. Activities were divided into those classified as recreational and those related to household chores. Time spent viewing television and intensity of household-related activities was also estimated. Variety of food items and foods consumed at breakfast, lunch and dinner were compared,

Chronological age of each child was based on the date of measurement and birth dates obtained from school records and corroborated by parents and teachers if necessary. Descriptive statistics (means, standard deviations and medians where appropriate) for all variables were initially calculated by age group and sex in each community. Children were grouped into whole year age categories, i.e., 6.0 to 6.99

defined the 6 year age group, and so on, but were divided in two age groups separately for each sex, 6-9 and 10-13 years, to address the four questions of the study.

Before systematically comparing the growth status and physical fitness of the urban and rural children, their mean heights, weights, and BMIs were the plotted relative to the new United States growth charts to establish the current growth status of the sample. On average, the heights of urban boys and girls fall at or above the 10^{th} percentiles but approach the 25^{th} percentiles of the reference values at several ages, whereas the heights of rural boys and girls fluctuate between the 5^{th} and 10^{th} percentiles. Mean weights of urban children of both sexes tend to be above the 25^{th} percentiles of the reference values. In contrast, mean weights of rural boys and girls are at or below the 25^{th} percentiles. The trends for mean heights and weights suggest elevated weight-for-height in both the urban and rural samples, which is reflected in the BMI. The BMI, on average, falls between the 25^{th} and 75^{th} percentiles of the reference data at most ages.

Results of rural-urban comparisons of the growth and performance variables are summarized in the context of the specific questions and hypotheses.

1. How do current samples of urban and rural school children 6-12 years of age in southern Mexico compare in growth status? Hypothesis. Urban school children have better growth status as assessed with height, weight and other anthropometric indicators than rural school children. The basic statistic was analysis of covariance (ANCOVA) with age as the covariate. This hypothesis was partially supported. Absolute body size (height and weight), trunk (sitting height) and estimated leg length, skeletal breadths on the trunk (biacromial and bicristal breadths) were significantly larger in urban than in rural school children. Urban-rural contrasts in skeletal breadths on the extremities (biepicondylar and bicondylar breadths), limb circumferences, estimated limb muscle circumferences, subcutaneous fatness and relative fat distribution were not consistently significant by age group and sex.

2. How do current samples of urban and rural school children 6-12 years of age in southern Mexico compare in physical fitness? Hypothesis. Urban school children perform better on tests of physical fitness than rural school children. The basic statistic was analysis of covariance (ANCOVA) with age as the covariate. The hypothesis was also partially supported. Urban children, on average, tended to perform better in the sit and reach, sit-ups, standing long jump and dash (10-13 years only), but results were not consistently significant. Rural children 6-9 years performed better in the dash. There were no urban-rural differences in grip strength, although strength per unit body mass tended to be greater in rural children. Rural children in grades 1-3 performed better in the distance run, but results for children in grades 4-6 were inconsistent. Older rural boys performed better than urban boys, although the difference was not significant, but urban girls in grades 4-6 performed significantly better than rural girls.

3. How do current samples of urban and rural school children in southern Mexico compare in the estimated prevalence of growth stunting and wasting? Growth stunting was estimated using the criteria of the World Health Organization (WHO, 1995), in which stunting is defined as low height-for-age relative to internationally acceptable reference data. A height below two standard deviations of age- and sex-specific reference values is classified as stunted. Heights of individual children were converted to z-scores using the protocol and reference values of the new United States Growth charts (Centers for Disease Control and Prevention, 2000). A z-score below –2.0 was defined as stunting. Wasting is a form of undernutrition that indicates low weight-for-height (World Health Organization, 1995). Wasting was defined as a BMI below the 5th percentiles of age- and sex-specific reference data for the United States (Centers for Disease Control and Prevention, 2000).

The sex-specific prevalences (and 95% confidence intervals) for stunting and wasting were calculated for each age group (6-9, 10-13 years) and the total sample

(6-13 years). Sex-specific comparisons of the prevalences of stunting and wasting in the two age groups and the total sample of urban and rural children were tested with the chi-square statistic. Hypothesis. Rural school children have a higher prevalence of growth stunting and wasting than urban school children. The hypothesis was partially supported. The prevalence of stunting was about twice as great in the rural compared to the urban children, but the prevalence of wasting was very low in both communities and did not differ.

4. How do the current samples of urban and rural school children in southern Mexico compare in the estimated prevalence of overweight and obesity? Overweight was defined relative to the internationally recommended criteria (cut-off points) based on six national samples (Cole et al., 2000). The sex-specific prevalences (and 95% confidence intervals) of overweight and obesity were calculated for each age group (6-9, 10-13 years) and total sample (6-13 years). The sex-specific comparison of the prevalences of overweight and obesity in the two age groups and the total sample of urban and rural children was tested with the chi-square statistic. Hypothesis. Urban school children have a higher prevalence of overweight and obesity than rural school children. The hypothesis was partially supported. The prevalence of overweight was significantly greater in urban than in rural children, specifically when the data were considered across the entire age span, 6-13 years. Within ages groups 6-9 and 10-13 years, the prevalence was greater in urban children, but the results were not consistently significant. The prevalence of obesity in urban and rural school children was low, and was significantly greater only in urban boys 10-13 years.

Activities and dietary items reported by rural and urban children in the upper grades showed several contrasts. Rural boys reported least involvement in house-related activities (cleaning, making the bed). About two-thirds of urban boys and urban and rural girls reported house cleaning chores in contrast to about 40% of rural boys. There were major differences between urban and rural children in food- and animal-related activities. Relatively few urban children (2-6%) reported involvement in cooking. About two-thirds of rural girls reported activities related to the making of tortillas compared to 13% of rural boys, and 14% of rural girls reported cooking compared to no rural boys. On the other hand, more rural boys reported gathering wood and getting water than rural girls.

Rural children, specifically boys, reported major daily involvement in animal-related activities, caring for animals (70%) and getting animal feed from the pasture (69%). Smaller percentages of girls reported these activities (8-9%). Small percentages of urban children reported daily care for pets (3-8%). Small percentages of rural children (2-4%) reported involvement in farming activities, most often described as clearing ground.

Basketball was the most commonly reported sport activity of urban and rural boys, followed by football (soccer). Basketball was also the most commonly reported sport activity of rural girls, whereas basketball and volleyball were reported about equally among urban girls. Games of chase and seeking (hide and seek) were reported more often by urban and rural girls than boys.

Light/sedentary activities indicated a sex difference. More girls reported playing with dolls and more boys reported playing with cars and marbles. Boys also reported playing videogames; in contrast, only one urban girl reported this activity.

Urban-rural contrasts in viewing television less than one hour and between 1 and 2 hours per day were small. Relatively more urban boys reported watching television for more than 2 hours per day than rural boys, but similar percentages of urban and rural reported viewing television for more than 2 hours per day.

An attempt was made to estimate the intensity of activities reported before and after school by the 4th, 5th and 6th grade children. Rural children, boys more so than girls, reported more frequent daily participation in household-related activities classified as moderate and moderate-to-vigorous in intensity compared to urban children. Urban boys, on the other hand, reported more household-related activities that were very light or light in intensity. Urban and rural girls did not differ markedly in reported frequencies of daily participation in household-activities classified a very light and light in intensity.

Urban children reported more diversity in diet, specifically at breakfast and dinner than rural children. The total number of foods reported at lunch were similar in rural and urban children. Overall, the diets reported by 4th, 5th and 6th grade children in the rural and urban communities were rather limited. Animal protein represented in meats and meat derivatives were, in general, rather limited in the diets of rural children. Somewhat surprisingly, tortillas and beans, often reported as staples of the Mexican diet, were lacking among the food items reported by the urban children. Tortillas and beans were reportedly consumed by about 25% of the rural children at breakfast, lunch and dinner, respectively.

The results of the comparisons of growth status, physical fitness, daily activities and diet of urban and rural primary school children reflect, to a large extent, the contrast of living conditions and access to resources in the respectively communities. Conditions in the colonia, though somewhat marginal, are closely related to the economic and social resources of the city of Oaxaca. These include access to jobs, better salaries, health care facilities, educational opportunities, and so on, all factors which are related to the improved growth status of children. Conversely, the increased prevalence of overweight in the urban compared to the rural community suggests a negative consequence of urban life, perhaps reflecting reduced physical activity and chronically excessive energy intake in contrast to a more physically active lifestyle among the rural children. Conditions in the rural community, though improving, reflect some degree of isolation from urban resources, specifically related to income and educational opportunities. Financial input from emigrants living in the Federal District or abroad has contributed to improved infrastructures related to health and quality of life in the rural community. However, the growth status of the current samples of urban and rural children has improved compared to the status of school children in earlier studies in the two communities about 30 years earlier (Malina, 2002).

TABLES

Table 1.1. Demographic, Economic, Education and Health Indicators for the State of Oaxaca relative to national statistics. Estimates are for 1999 or 2000. The rank (from highest to lowest) of the state of Oaxaca among the 32 federal entities is also indicated where available.[1]

Indicator	National	Oaxaca	Rank
Population			
Population	94.48 million	3.44 million	10
Population Growth Rate	1.85%	1.32%	32
In-migrants	4.4%	2.7%	
Out-migrants	4.4%	4.9%	
Population by Localities:			
<2500 inhabitants	25.4%	55.5%	1
≥15,000 inhabitants	61.0%	22.5%	32
Population by Age:			
<15 years	33.4%	37.8%	3
≥65 years	4.9%	5.9%	4
Median Age	22 yrs	20 yrs	30
Economic			
GDP/Total GDP		1.5%	19
GDP/capita			32
Minimum Wage	32pesos/day	30 pesos/day	
Education			
Illiteracy	9.5%	21.5%	3
Incomplete primary school	28.2%	45.1%	2
Post-primary school	51.8	33.3	31

Table 1.1 (continued)

Health			
Death Rate/1000 population	4.5/1000	5.1/1000	3
Deaths, intestinal infections	5.7/1000	14.6/1000	2
Deaths, respiratory infections	17.0/1000	23.4/1000	4
Birth Rate/1000 population	21.7/1000	24.3/1000	6
Infant Mortality/1000 live born	13.8/1000	11.1/1000	24
Physicians/10,000 population	120/10,000	86/10,000	30
Insured Population	40.1%	22.6%	30

[1]Based on estimates reported by INEGI (2001a, 2001b) and Direccion General de Estadistica e Informatica de la Secretaria de Salud, Mexico (2001).

Table 2.1. Living conditions in the State of Oaxaca, 1980-2000.[1]

Indicator	1980	1990	2000
Population	2, 369,076	3, 019, 560	3,438,765
Urban population	32.0%	39.5%	43.0%
Rural population	68.0%	60.5%	57.0%
Birth rate	44.2*	35.3*	23.3*
Mortality rate	10.1*	6.5*	5.5*
Infant mortality rate	39.9**	23.5**	16.3**
Life expectancy, years	58.0	62.1	75.3
Illiteracy	35.9%	27.5%	20.0%
Sewage disposal	14.6%	29.9%	78.1%
Potable water	44.2%	58.1%	71.3%

[1]Data for 1980 and 1990 are from the XI Censo General de Poblacion y Vivienda (INEGI, 1990); data for 2000 are from the 2000 census (INEGI, 2000).

*Births and deaths per 1000 inhabitants

**Per 1000 live born; the most recent estimate of infant mortality is based on records for 1998. Specific information was lacking in the 2000 census.

Table 2.2. Mean weight (kg) and height (cm) for urban (Durango) and rural (Morelos) children in Mexico in the 1960s by age group (years).[1]

Age Group	Weight (kg) Durango	Morelos	U-R Diff	Height (cm) Durango	Morelos	U-R Diff
Boys						
6+	20.4			114.3		
7+	22.1	19.1	3.0	118.5	113.5	5.0
8+	24.3	21.5	2.8	124.0	119.5	4.5
9+	26.4	23.8	2.6	128.4	123.2	5.2
10+	29.2	26.3	2.9	133.5	128.0	5.5
11+	31.6	29.1	2.5	139.5	134.1	5.4
12+	34.9	31.4	3.5	145.5	138.5	7.0
Girls						
6+	19.8			113.9		
7+	21.2	20.2	1.0	118.3	115.3	3.0
8+	23.6	21.5	2.1	123.4	119.0	4.4
9+	26.2	23.9	2.3	128.5	123.4	5.1
10+	28.9	26.9	2.0	137.0	129.2	7.8
11+	31.6	30.8	0.8	139.9	136.0	3.9
12+	37.2	33.9	3.3	145.0	141.7	3.3

[1]Adapted fromVega-Franco and Robles-De la Vega (1962) and Perez-Ortiz and Mora (1967) for Durango and Morales, respectively.

Table 2.3. Socioeconomic variation in the weight (kg) and height (cm) of urban boys in the Federal District and corresponding data for low socioeconomic status rural boys from a community close to the Federal District by age group (years).[1]

	Socioeconomic Status			
Age Group	Urban High	Urban Medium	Rural Low	Medium-Low Difference
Weight (kg)				
7+	23.9	19.5	19.0	0.5
8+	26.3	23.1	21.1	2.0
9+	29.5	26.3	23.1	3.2
10+	32.9	28.2	25.2	3.0
11+	36.6	30.2	28.2	2.0
12+	38.7	33.7	30.4	3.3
13+	45.2	38.6	33.8	4.8
14+	50.6	42.2	40.9	1.3
Height (cm)				
7+	122.5	115.6	113.0	2.6
8+	127.8	120.7	117.6	3.1
9+	132.2	127.1	121.9	5.2
10+	137.6	130.4	126.3	4.1
11+	142.3	134.7	132.7	2.0
12+	146.7	140.5	136.3	4.2
13+	154.0	147.8	141.7	6.1
14+	160.9	153.0	151.6	1.4

[1]Adapted from Pérez-Hidalgo et al.(1965).

Table 2.4. Socioeconomic variation in the weight (kg) and height (cm) of urban boys and girls in the Federal District by age group (years).[1]

Age	Weight			Height		
Group	High SES	Low SES	Diff	High SES	Low SES	Diff
Boys						
6-7	22.9	20.9	2.0	120.4	116.2	4.2
7-8	25.8	23.2	2.6	125.0	121.0	4.0
8-9	29.0	25.7	3.3	131.8	126.1	5.7
9-10	30.8	30.1	0.7	135.3	131.8	3.5
10-11	37.7	31.2	6.5	141.3	135.9	5.4
11-12	41.2	38.2	3.0	148.4	142.7	5.7
Girls						
6-7	22.6	20.4	2.2	120.9	115.7	5.2
7-8	24.5	22.8	1.7	125.0	120.7	4.3
8-9	28.4	26.3	2.1	131.3	126.7	4.6
9-10	30.5	27.9	2.6	135.1	130.5	4.6
10-11	35.5	32.0	3.5	142.9	136.6	6.3
11-12	36.9	35.7	1.2	145.3	141.9	3.4

[1]Adapted from Villanueva (1979).

Table 2.5. Mean weight (kg) and height (cm) of indigenous Tojolabal children from Chiapas by age group (years).

Age Group	Weight	Diff[1]	Height	Diff[2]
Boys				
6+	16.5	3.2	104.2	8.6
7+	18.1	4.4	107.9	11.1
8+	18.7	6.7	113.0	11.9
9+	21.2	7.4	117.4	12.5
10+	29.9	1.2	119.6	14.8
11+	26.3	7.8	125.3	13.9
12+	29.5	7.5	127.8	15.5
13+	31.8	12.5	134.1	18.2
14+	35.4		135.7	
15+	39.3		141.6	
Girls				
6+	17.2	2.2	103.1	8.0
7+	18.0	3.8	107.1	10.0
8+	19.9	4.4	110.0	12.4
9+	21.7	5.2	115.6	12.3
10+	22.8	7.9	118.8	14.6
11+	25.4	8.8	125.2	13.8
12+	26.7	11.8	130.1	16.2
13+	30.9	14.9	133.6	18.3
14+	33.9		136.2	
15+	37.7		141.6	

[1]Adapted from Arechiga and Serrano (1981).

[2]The difference refers to the growth status of indigenous children relative to reference values for urban children in the Federal District (Faulhaber, 1976).

Table 2.6. Mean height (cm) of a sample of indigenous Otomi children and a sample of urban middle class children by age group (years).[1]

	Males			Females		
Group	Otomi	Urban	Diff	Otomi	Urban	Diff
6+	106.4	112.8	6.4	107.1	111.1	4.0
7+	111.3	118.9	7.6	111.9	117.1	5.2
8+	117.9	124.9	7.0	117.2	122.4	5.2
9+	121.8	130.0	8.2	121.6	127.9	6.3
10+	125.2	134.3	9.0	126.0	133.4	7.4
11+	130.2	139.2	9.0	131.2	138.9	7.7
12+	134.8	143.3	8.5	134.8	146.3	11.5
13+	136.8	152.3	15.5	141.5	151.9	10.4

[1]Adapted from Lagunas-Rodriguez and Jimenez-Ovando (1995)

Table 3.1. Population distribution of Santo Tomas Mazaltepec by age group and sex in 2000.[1]

Age Group, yrs	Males	Females	Total
0-4	100	109	209
5-9	138	150	288
10-14	127	146	273
15-19	94	119	213
20-24	48	70	118
25-29	59	89	148
30-34	48	70	118
35-39	56	73	129
40-44	49	51	100
45-49	38	56	94
50-54	36	36	72
55-59	29	28	37
60-64	31	28	59
65+	90	78	168
Total	943	1103	2046

[1]Adapted from the community health report for Santo Tomas Mazaltepec for 2001.

Table 3.2. Indicators of social, economic, educational and health conditions in the rural and urban communities with comparative data for the city of Oaxaca and the state of Oaxaca based on the national census for 2000.[1]

	Santo Tomas (rural)	San Juan (urban)	City of Oaxaca	State of Oaxaca
Total population	1,939	16,279	256,130	3.4 million
Household Characteristics:				
Number of households	422	3,782	60,612	741,005
Sewage connected to street	1%	77%	78%	26%
Sewage to septic tank	14%	5%	6%	20%
No sewage installation	84%	18%	14%	54%
Radio	82%	90%	91%	71%
Television	71%	87%	89%	57%
Refrigerator	29%	61%	72%	37%
Male head of household	85%	73%	70%	77%
Female head of household	15%	27%	30%	22%
Income (% EAP):				
< 1 minimum wage	15%	15%	12%	20%
1 to 2 minimum wages	16%	29%	25%	24%
2 to 5 minimum wages	15%	34%	28%	18%
No wages	49%	6%	4%	28%
Health and Education:				
Insured population	6%	39%	48%	23%
Uninsured population	93%	59%	50%	76%
Number children/woman	3.1	2.2	1.9	2.1
Literate, 15+ years	91%	91%	94%	78%
Illiterate, 15+ years	9%	9%	5%	20%
Years of schooling	6 yrs	8 yrs	10 yrs	6 yrs
Did not complete primaria	22%	14%	11%	25%

[1]Adapted from INEGI (2002). EAP = economically active population.

Table 3.3. Numbers of school children surveyed in the rural and urban communities, 1999-2000, by age group and sex.

Age	Males		Females	
Group*	Rural	Urban	Rural	Urban
6	26	30	29	24
7	26	29	22	27
8	30	26	37	23
9	31	25	25	33
10	26	31	28	25
11	15	20	34	25
12	9	10	4	7
13	14	2	5	2
14	2	1	-	-
15	1	1	3	-
Total	180	175	187	166

*Age groups are whole year categories, i.e., 6 = 6.00 to 6.99 years, 7 = 7.00 to 7.99 years, etc.

Table 3.4. Intra-observer technical errors of measurement for anthropometric dimensions.

Dimension	Present Study (n=36, one month apart)	Buschang (1980) (n=40, within day)
Weight	0.52 kg	
Height	0.32 cm	0.33 cm
Sitting Height	0.40	0.47
Biacromial br.	0.23	0.32
Bicristal br.	0.35	0.38
Bicondylar br.	0.12	0.13
Biepicondylar br.	0.09	0.12
Arm circ., rel.	0.29	0.21
Arm circ., flex.	0.29	
Calf circ.	0.21	0.19
Triceps skf.	0.83 mm	0.33 mm
Subscapular skf.	0.67	0.33
Suprailiac skf.	0.69	0.33
Medial calf skf.	0.63	

Table 3.5. Within day reliabilities for physical fitness items based in intraclass correlations derived from repeated measures ANCOVA with age as the covariate, sexes and rural and urban samples combined.

	Age Group		
Test Item	6 – 9	10 – 13	6 – 13
Right Grip	0.90	0.94	0.92
Left Grip	0.92	0.95	0.94
Sit and Reach	0.93	0.94	0.93
Standing Long Jump	0.91	0.93	0.92
35 Yard Dash	0.85	0.87	0.86

Table 3.6. Within day reliabilities for physical fitness items based on correlations between trials, rural and urban samples combined.[1]

	Test Items				
	Right Grip	Left Grip	Sit and Reach	35 Yard Dash	Standing Long Jump
Boys					
6-7	.81	.86	.82	.77	.88
8-9	.88	.90	.89	.83	.89
10-11	.91	.91	.90	.83	.91
12+	.87	.93	.92	.71	.89
Girls					
6-7	.81	.85	.84	.86	.88
8-9	.88	.86	.92	.84	.88
10-11	.91	.90	.91	.84	.92
12+	.91	.90	.91	.93	.92

[1]Correlations were calculated between trial 1 and trial 2, trial 2 and trial 3, etc., and between best trial and second best, etc.

Table 3.7. Sample sizes by age group and sex, and means and standard deviations for chronological age for the rural and urban children included in the analysis.

Age Group	n	Rural Mean	SD	n	Urban Mean	SD
Boys						
6	26	6.6	0.3	30	6.5	0.3
7	26	7.5	0.3	29	7.5	0.3
8	30	8.6	0.3	26	8.4	0.3
9	31	9.5	0.3	25	9.6	0.3
10	26	10.4	0.3	31	10.5	0.3
11	15	11.4	0.3	20	11.4	0.3
12	9	12.4	0.3	10	12.4	0.2
13	14	13.4	0.3	2	13.8	-
Girls						
6	29	6.5	0.3	24	6.6	0.3
7	22	7.4	0.3	27	7.5	0.3
8	37	8.6	0.3	23	8.5	0.3
9	25	9.4	0.3	33	9.5	0.3
10	28	10.5	0.3	25	10.5	0.3
11	34	11.5	0.3	25	11.5	0.3
12	4	12.6	0.3	7	12.3	0.1
13	5	13.6	0.2	2	13.3	-

Age groups are whole year categories, i.e., 6 = 6.00 to 6.99 years, 7 = 7.00 to 7.99 years, etc.

Table 3.8. Status quo menarcheal status of girls 9-15 years of age in the rural and urban communities.

Age		Rural			Urban	
Group	n	n No	n Yes	n	n No	n Yes
9	25	25	0	33	33	0
10	28	28	0	25	25	0
11	33	32	1	25	24	1
12	4	2	2	7	4	3
13	5	2	3	2	1	1
14	-	-	-	-	-	-
15	3	1	2	-	-	-

Information on menarcheal status was not available for one girl. There were no 14 year old girls in attendance at school in each community at the time of the survey, and there were no 15 year old girls in attendance at school in the urban community at the time of the survey (see Table 3.2).

Table 4.1. Age-adjusted means and standard errors for indicators of body size and proportions in rural and urban children 6-9 and 10-13 years of age.

	Males 6-9 Years					Females 6-9 Years				
	Rural		Urban			Rural		Urban		
Variable	Mean	SE	Mean	SE	p	Mean	SE	Mean	SE	p
Weight, kg	23.4	0.3	24.5	0.3	<0.05	23.2	0.4	25.4	0.4	<0.001
Height, cm	119.1	0.5	121.4	0.5	<0.001	119.3	0.5	122.5	0.5	<0.001
BMI, kg/m^2	16.4	0.2	16.5	0.2	NS	16.1	0.2	16.8	0.2	<0.01
Sit Ht, cm	65.3	0.3	66.4	0.3	<0.001	65.1	0.3	66.5	0.3	<0.001
Leg Lt, cm	53.8	0.3	54.9	0.3	<0.01	54.2	0.3	56.0	0.3	<0.001
St Ht/Ht, %	54.8	0.1	54.8	0.1	NS	54.6	0.1	54.3	0.1	NS

	Males 6-9 Years					Females 6-9 Years				
	Rural		Urban			Rural		Urban		
Variable	Mean	SE	Mean	SE	p	Mean	SE	Mean	SE	p
Weight, kg	31.6	1.1	37.1	1.1	<0.001	32.8	0.8	35.2	0.9	<0.05
Height, cm	135.1	0.8	138.6	0.8	<0.01	135.1	0.7	138.8	0.8	<0.001
BMI, kg/m^2	17.2	0.4	19.0	0.4	<0.001	17.8	0.3	18.0	0.3	NS
Sit Ht, cm	71.8	0.4	73.6	0.4	<0.05	72.2	0.4	73.7	0.5	<0.05
Leg Lt, cm	63.3	0.5	65.0	0.5	<0.05	62.9	0.4	65.1	0.5	<0.001
St Ht/Ht, %	53.2	0.1	53.2	0.1	NS	53.5	0.2	53.1	0.2	NS

Based on ANCOVA with age as the covariate. Sit Ht = Sitting Height, Leg Lt = Leg Length, St Ht/Ht = Sitting Height/Height Ratio

Table 4.2. Age-adjusted means and standard errors for skeletal breadths and limb circumferences in rural and urban children 6-9 and 10-13 years of age.

	Males 6-9 Years					Females 6-9 Years				
	Rural		Urban			Rural		Urban		
Variable	Mean	SE	Mean	SE	p	Mean	SE	Mean	SE	p
Biacromial, cm	27.3	0.1	28.1	0.1	<0.001	27.2	0.1	28.2	0.1	<0.001
Bicristal, cm	19.6	0.1	20.2	0.1	<0.001	19.6	0.1	20.6	0.1	<0.001
Biepicondylar, cm	4.8	0.0	4.8	0.0	NS	4.7	0.0	4.7	0.0	<0.05
Bicondylar, cm	7.5	0.0	7.7	0.0	<0.01	7.3	0.0	7.5	0.0	<0.001
Arm Circ, cm	17.6	0.2	17.8	0.2	NS	17.7	0.2	18.2	0.2	<0.05
Calf Circ, cm	23.7	0.2	24.3	0.2	<0.01	23.5	0.2	24.6	0.2	<0.001
EAMC, cm	15.2	0.1	15.4	0.1	NS	15.0	0.1	15.5	0.1	<0.01
ECMC, cm	21.2	0.1	21.7	0.1	=0.01	20.7	0.2	21.7	0.2	<0.001

	Males 10-13 Years					Females 10-13 Years				
	Rural		Urban			Rural		Urban		
Variable	Mean	SE	Mean	SE	p	Mean	SE	Mean	SE	p
Biacromial, cm	30.7	0.2	32.0	0.2	<0.001	30.9	0.2	31.6	0.3	<0.05
Bicristal, cm	21.6	0.2	23.4	0.2	<0.001	22.1	0.2	23.2	0.2	<0.001
Biepicondylar, cm	5.3	0.1	5.5	0.1	<0.01	5.2	0.0	5.2	0.1	NS
Bicondylar, cm	8.3	0.1	8.7	0.1	<0.01	8.1	0.1	8.1	0.1	NS
Arm Circ, cm	19.3	0.3	21.1	0.3	<0.001	20.2	0.2	20.6	0.3	NS
Calf Circ, cm	26.6	0.3	28.4	0.3	<0.001	27.0	0.3	27.7	0.3	NS
EAMC, cm	16.9	0.3	18.2	0.3	<0.01	17.1	0.2	17.7	0.2	NS
ECMC, cm	24.0	0.3	25.3	0.3	<0.01	23.5	0.2	24.4	0.2	NS

Based on ANCOVA with age as the covariate. Arm Circ – Arm Circumference, Calf Circ = Calf Circumference, EAMC = Estimated Arm Muscle Circumference, ECMC = Estimated Calf Muscle Circumference.

Table 4.3. Age-adjusted means and standard errors for subcutaneous fatness and relative subcutaneous fat distribution in rural and urban children 6-9 and 10-13 years of age.

	Males 6-9 Years					Females 6-9 Years				
	Rural		Urban			Rural		Urban		
Variable	Mean	SE	Mean	SE	p	Mean	SE	Mean	SE	p
Triceps, mm	7.6	0.2	7.8	0.2	NS	8.7	0.2	8.5	0.2	NS
Subscapular mm	6.4	0.2	6.4	0.2	NS	7.7	0.3	7.9	0.3	NS
Suprailiac, mm	8.3	0.3	8.9	0.3	NS	9.4	0.3	9.6	0.3	NS
Medial Calf, mm	7.8	0.2	8.1	0.2	NS	9.0	0.2	9.0	0.2	NS
Sum 4 Skf, mm	30.1	0.7	31.2	0.7	NS	34.8	0.8	35.1	0.9	NS
TER, %	94.9	1.8	96.5	1.9	NS	95.6	1.8	99.1	1.9	NS

	Males 10-13 Years					Females 10-13 Years				
	Rural		Urban			Rural		Urban		
Variable	Mean	SE	Mean	SE	p	Mean	SE	Mean	SE	p
Triceps, mm	7.7	0.3	9.2	0.3	<0.01	9.9	0.3	9.3	0.3	NS
Subscapular, mm	7.4	0.4	9.2	0.4	<0.01	10.1	0.4	9.4	0.4	NS
Suprailiac, mm	8.8	0.5	11.9	0.5	<0.001	12.2	0.4	11.6	0.4	NS
Medial Calf, mm	8.1	0.3	9.7	0.3	<0.01	10.9	0.3	10.3	0.3	NS
Sum 4 Skf, mm	32.0	1.4	40.0	1.4	<0.001	43.2	1.1	40.7	1.2	NS
TER, %	102.0	3.0	110.8	3.0	<0.05	107.0	2.3	107.3	2.5	NS

Based on ANCOVA with age as the covariate. Sum 4 Skf – Sum of the four skinfolds, TER = Trunk/Extremity Ratio (sum of the two trunk skinfolds/sum of the two extremity skinfolds)

Table 4.4. Age-adjusted means and standard errors for indicators of muscular strength in rural and urban children 6-9 and 10-13 years of age.

	Males 6-9 Years					Females 6-9 Years				
	Rural		Urban			Rural		Urban		
Variable	Mean	SE	Mean	SE	p	Mean	SE	Mean	SE	p
R Grip, kg	11.8	0.2	11.9	0.2	NS	11.1	0.2	11.3	0.2	NS
L Grip, kg	11.0	0.2	11.5	0.2	NS	10.1	0.2	10.5	0.2	NS
Sum RL, kg	22.8	0.4	23.4	0.4	NS	21.2	0.4	21.7	0.4	NS
Sum/Wt, kg/kg	0.98	0.02	0.96	0.02	NS	0.92	0.01	0.86	0.01	<0.01

	Males 10-13 Years					Females 10-13				
	Rural		Urban			Rural		Urban		
Variable	Mean	SE	Mean	SE	p	Mean	SE	Mean	SE	p
R Grip, kg	18.5	0.5	19.0	0.5	NS	17.2	0.4	17.1	0.4	NS
L Grip, kg	17.1	0.5	18.2	0.5	NS	15.6	0.4	16.2	0.4	NS
Sum RL, kg	35.6	1.0	37.2	1.0	NS	32.8	0.7	33.3	0.7	NS
Sum/Wt, kg/kg	1.13	0.02	1.02	0.02	<0.001	1.01	0.02	0.96	0.02	NS

Based on ANCOVA with age as the covariate. R Grip = Right Grip, L Grip = Left Grip, Sum RL = Sum of Right and Left Grip, Sum/Wt = Sum of Right and Left Grip/ Body Weight.

Table 4.5. Age-adjusted means and standard errors for indicators of physical fitness in rural and urban children 6-9 and 10-13 years of age.

	Males 6-9 Years					Females 6-9 Years				
	Rural		Urban			Rural		Urban		
Variable	Mean	SE	Mean	SE	p	Mean	SE	Mean	SE	p
SAR, cm	26.3	3.9	28.0	4.0	<0.01	27.1	4.2	27.8	4.4	NS
Sit-Up, n	7.5	0.4	11.3	0.4	<0.001	6.4	0.4	9.4	0.4	<0.001
SLJ, cm	90.3	1.7	106.2	1.7	<0.001	78.9	1.7	91.7	1.8	<0.001
Dash, sec	7.34	0.05	7.47	0.05	NS	7.94	0.06	8.13	0.07	<0.05
Dis Run, m	1195	14	1085	15	<0.001	1123	15	1039	16	<0.001

	Males 10-13 Years					Females 10-13 Years				
	Rural		Urban			Rural		Urban		
Variable	Mean	SE	Mean	SE	p	Mean	SE	Mean	SE	p
SAR, cm	27.0	6.5	26.9	6.6	NS	26.6	5.8	28.8	6.3	=0.01
Sit-Up, n	12.1	0.5	14.1	0.5	<0.01	8.1	0.5	11.2	0.6	<0.001
SLJ, cm	111.8	2.5	130.4	2.5	<0.001	90.1	1.8	109.9	2.0	<0.001
Dash, sec	6.66	0.06	6.47	0.06	<0.05	7.26	0.07	6.95	0.07	<0.01
Dis Run, m	1856	27	1828	26	NS	1637	23	1703	25	=0.05

Based on ANCOVA with age as the covariate. SAR = Sit and Reach; Sit-Up = Number of sit-ups completed in 30 seconds, SLJ = Standing Long Jump, Dash = 35 yard dash (32.3 meters), Dis Run = Distance run in 8 minutes in children in Grades 1-3 and in 12 minutes in children in Grades 4-6; ages approximate 6-9 in the former and 10-13 in the latter (see text).

Table 4.6. Prevalence [95% confidence intervals] of stunting in rural and urban children 6-13 years of age.

Age	Rural			Urban		
Group	n	f	% [95% CI]	n	f	% [95% CI]
Males						
6-9	113	31	27.4 [19.2 - 35.6]	110	14	12.7 [6.5 – 18.9]
10-13	64	20	31.3 [19.8 – 42.6]	63	11	17.5 [8.1 – 26.9]
6-13	177	51	28.8 [22.1 – 35.5]	173	25	14.5 [9.3 – 19.7]
Females						
6-9	113	33	29.2 [20.8 – 37.6]	107	16	14.9 [8.2 – 21.8]
10-13	71	21	29.6 [19.0 – 40.2]	59	10	16.9 [7.3 – 26.5]
6-13	184	54	29.3 [22.7 – 35.9]	166	26	15.7 [10.2 – 21.2]

Stunting was defined as a height below two standard deviations of age and sex specific reference data for healthy children (Centers for Disease Control and Prevention, 2000).

Table 4.7. Prevalence [95% confidence intervals] of wasting in rural and urban children 6-13 years of age based on the body mass index.

	n	f	% [95% CI]
Males:			
Rural	177	4	2.3 [0.01 – 4.5]
Urban	173	2	1.2 [-0.4 – 2.8]
Females:			
Rural	184	4	2.2 [0.0 – 4.4]
Urban	166	2	1.2 [-0.5 – 2.9]

Wasting was defined as a BMI <5^{th} percentiles (age and sex specific) of the United States growth charts (Centers for Disease Control and Prevention, 2000).

Table 4.8. Prevalence [95% confidence intervals] of overweight and obesity, using internatonal criteria, in rural and urban males 6-13 years of age based on the body mass index.

	n	Overweight f	Overweight % [95% CI]	Obese f	Obese % [95% CI]	Total f	Total % [95% CI]
Males:							
Rural							
6-9	113	7	6.2 [1.8 – 10.6]	2	1.8 [-0.6 – 4.2]	9	8.0 [3.0 – 13.0]
10-13	64	2	3.1 [-1.2 – 7.4]	0	0	2	3.1 [-1.1 – 7.4]
6-13	177	9	5.1 [1.9 – 8.3]	2	1.1 [-0.5 – 2.7]	11	6.2 [2.6 – 9.8]
Urban							
6-9	110	10	9.1 [3.7 – 14.5]	2	1.8 [-0.7 – 4.3]	12	10.9 [5.1 – 16.7]
10-13	63	9	14.3 [5.7 – 22.9]	5	7.9 [1.2 – 14.6]	14	22.2 [11.9 – 32.5]
6-13	173	19	11.0 [6.3 – 15.7]	7	4.0 [1.1 – 6.9]	26	15.0 [9.7 – 20.0]

International criteria are those of Cole et al. (2000). See text for the respective cut-off points for overweight and obesity.

Table 4.9. Prevalence [95% confidence intervals] of overweight and obesity, using internatonal criteria, in rural and urban females 6-13 years of age based on the body mass index.

		Overweight		Obese		Total	
	n	f	% [95% CI]	f	% [95% CI]	f	% [95% CI]
Females:							
Rural							
6-9	113	8	7.1 [2.4 – 11.8]	1	0.9 [-0.8 – 4.5]	9	8.0 [3.0 – 13.0]
10-13	71	6	8.5 [2.0 – 15.0]	1	1.4 [-1.3 – 4.1]	7	9.9 [3.0 – 16.8]
6-13	184	14	7.6 [3.8 – 11.4]	2	1.1 [-0.4 – 2.6]	16	8.7 [4.6 – 12.8]
Urban							
6-9	107	17	15.9 [9.0 – 22.8]	2	1.9 [-0.7 – 4.5]	19	17.8 [10.6 – 25.0]
10-13	59	7	11.9 [3.6 – 20.2]	2	3.4 [-1.2 – 8.0]	9	15.3 [6.6 – 24.5]
6-13	166	24	14.5 [9.1 – 19.7]	4	2.4 [0.1 – 9.1]	28	16.9 [11.2 – 22.6]

International criteria are those of Cole et al. (2000). See text for the respective cut-off points for overweight and obesity.

Table 4.10. Household activities reported by rural and urban school children in 4th, 5th and 6th grades: Frequencies reported and corresponding percentages.

	Males				Females			
	Rural (n=77)		Urban (n=83)		Rural (n=99)		Urban (n=77)	
Activities	f	%	f	%	f	%	f	%
House-Related								
House cleaning	32	42	56	67	66	67	48	62
Bed making	9	12	27	33	26	26	21	27
Cleaning dishes	1	1	19	23	59	60	40	52
Doing laundry	2	3	3	4	25	25	9	12
Food-Related								
Cooking	-		2	2	14	14	6	8
Making tortillas								
Corn cleaning	8	10	-		18	18	-	
Corn to mill	-		-		13	13	-	
Prepare dough/ cook tortillas	2	3	-		33	33	-	
Cut and gather wood	10	13	1	1	-		-	
Get water	9	12	-		6	6	-	
Gather chapulines	1	2	-		4	4	-	
Animal-Related								
Care for animals[1]	54	70	-		8	8	-	
Get feed from pasture[2]	53	69	-		9	9	-	
Pet care/play	-		7	8	-		2	3
Farm Activities[3]	3	4	-		2	2	-	
Assist Family Business	3	4	2	2	12	12	-	
Care for Siblings	1	1	2	2	7	7	2	3

[1]Includes feeding animals, taking them to pasture (grazing, herding), milking cows and goats, etc.

[2]Includes cutting and gathering of animal feed from pasture.

[3]Most commonly includes clearing ground.

Table 4.11. Recreational activities reported by rural and urban school children in 4th, 5th and 6th grades: Frequencies reported and corresponding percentages.

	Males				Females			
	Rural (n=77)		Urban (n=83)		Rural (n=99)		Urban (n=77)	
Activities	f	%	f	%	f	%	f	%
Sports								
Basketball	56	73	67	81	60	61	23	30
Football (soccer)	56	73	26	31	9	9	13	17
Volleyball	3	4	5	6	7	7	24	31
Basebakk	-		9	11	-		4	5
Miscellaneous								
Bicycling	3	5	4	5	2	2	2	3
Skating	-		4	5	-		3	4
Karate	-		3	4	-		1	1
Dancing	1	1	-		1	1	-	
Rope jumping	-		-		1	1	-	
Games								
Chase	8	10	29	35	47	47	45	58
Hide and seek	7	9	6	7	32	32	23	30
Others[1]	-		1	1	-		3	4
Light/Sedentary								
Play with toys								
Cars/marbles	10	13	2	2	1	1	-	
Dolls	-		2	2	9	9	15	20
Videogames	4	5	10	12	-		1	1
Music playing	2	3	-		2	2	-	
Music listening	-		-		3	3	-	
Table games[2]	-		4	5	-		7	9

[1]Swing, matatena, rondas

[2]Dominos, chess

Table 4.12. Time spent viewing television (hours per day) reported by rural and urban school children in 4th, 5th and 6th grades: Frequencies reported and corresponding percentages.

	Males				Females			
	Rural (n=77)		Urban (n=83)		Rural (n=99)		Urban (n=77)	
Activities	f	%	f	%	f	%	f	%
None or no TV[1]	10	13	7	8	11	11	9	12
≤ 1 hours	38	49	37	45	38	38	28	36
> 1 ≤ 2 hours	19	25	16	19	27	27	19	25
> 2 ≤ 3 hours	7	9	12	15	13	13	13	17
> 3 hours	3	4	11	13	10	10	8	10

[1]No television viewing reported or no television available at home; ncludes 8 children who did not complete this question; it was assumed that they did not have a television at home(2 rural males, 1 rural female, 3 urban males, 2 urban females).

Table 4.13. Frequency of household-related activities before and after school by estimated level of intensity reported by rural and urban 4th, 5th and 6th grade school children.

Males	Rural (n=77)		Urban (n=83)[1]	
	Before	After	Before	After
Intensity	f	f	f	f
No activities	21	7	38	6
Very light	12	10	15	18
Light	4	12	29	40
Moderate	35	32	1	8
Moderate-to-vigorous	6	18	-	-

Females	Rural (n=99)		Urban (n=77)[1]	
	Before	After	Before	After
Intensity	f	f	f	f
No activities	27	16	38	1
Very light	44	24	12	11
Light	3	26	20	54
Moderate	17	25	4	7
Moderate-to-vigorous	6	5	-	-

[1]Frequencies do not necessarily add to the total number because some children did not complete the respective questions and some indicated multiple activities

Very light – includes activities involved in making the bed, doing dishes and running errands close to home (and requiring a short period of time),
Light – includes housecleaning (sweeing, mopping), shucking corn, removing grains from cobs, assisting with family business, cooking,
Moderate – includes feeding, cleaning and herding animals; milking cows/goats; washing clothers; grinding corn; making, delivering and/or selling tortillas; gathering chapulines,
Moderate-to-vigorous – clearing farm ground, carrying water, cutting and gathering wood, cutting and carrying feed for animals.

Table 4.14. Recreational activities reported by rural and urban 4th, 5th and 6th grade children during the break period at school:Frequencies and corresponding percentages.

	Males				Females			
	Rural (n=77)		Urban (n=80)		Rural (n=90)		Urban (n=73)	
Activities	f	%	f	%	f	%	f	%
Eating, chatting, sitting	7	9	16	20	13	14	31	42
Walking	-		1	1	-		2	3
Running, chasing	27	35	25	31	43	48	36	49
Basketball	40	52	8	10	34	38	2	3
Football (soccer)	3	4	30	38	-		2	3

Table 4.15. The total number of foods reported and the ten foods reported most often at breakfast (desayuno) by rural and urban children in the 4th, 5th and 6th grades - percentages reporting consumption of each food item in the past 24 hours (sexes combined).

Rural (n=67)		Urban (n=97)[1]	
Foods	%	Foods	%
Total number of foods	25	Total number of foods	34
Ten most often consumed:			
Bread	60	Bread	24
Chocolate	49	Milk	16
Milk	28	Coffee	13
Coffee	19	Chocolate	6
Tortillas	16	Cereal	6
Eggs	9	Milk shake	6
Mole	9	Atole	5
Atole	6	Eggs	5
Soft drink (refresco)	6	Orange juice	4
Fruit drink (agua frutas)	4	Beans	4
Beans	4	Pasta (noodle) soup	4
Chicken	4	Sausage (chorizo)	4
Meat (beef)	4		
Cheese	4		
Pasta (noodle) soup	4		

[1]21 urban children did not report eating breakfast at home, but had their morning meal during the school break. It basically included a sandwich made of some type of meat, cheese or eggs and a drink (soft drink, juice or water).

Table 4.16. The total number of foods reported and the ten foods reported most often at lunch (comida) by rural and urban children in the 4th, 5th and 6th grades - percentages reporting consumption of each food item in the past 24 hours (sexes combined).

Rural		Urban	
Foods	%	Foods	%
Total number of foods	48	Total number of foods	44
Ten most often consumed:			
Soft drink (refresco)	30	Chicken	14
Orange juice	22	Beans	12
Fruit drink (agua frutas)	18	Rice	12
Bread	16	Chicken broth	10
Tortillas	16	Eggs	10
Mixed sauce (salsa)	16	Soft drink (refresco)	8
Memelitas[1]	15	Pasta (noodle) soup	8
Beans	9	Beef broth	6
Tamales	7	Meat (beef)	5
Sandwich	7	Dried meat (cecina/tasajo)	5

[1]A type of thick tortilla usually spread with beans and cheese with salsa on top.

Table 4.17. The total number of foods reported and the ten foods reported most often at dinner (cena) by rural and urban children in the 4th, 5th and 6th grades - percentages reporting consumption of each food item in the past 24 hours (sexes combined).

Rural		Urban	
Foods	%	Foods	%
Total number of foods	23	Total number of foods	43
Ten most often consumed:			
Tortillas	18	Coffee	24
Chicken broth	10	Milk	18
Bread	9	Bread	18
Coffee	7	Eggs	6
Beans	7	Chicken	5
Chocolate	6	Chocolate	4
Meat (beef)	6	Cereal	3
Chicken	6	Tortillas	3
Tamales	4	Beans	3
Meat broth	4	Rice	3
Mole	4		

Table 5.1. Age-adjusted means and standard errors based on ANCOVA with age as the covariate for indicators of body size in urban school children grouped by place of birth.

	Place of Birth							
	San Juan or City of Oaxaca (n=126, 128)[1]		Other Areas of State of Oaxaca (n=29, 31)		Other States of Mexico (n=15, 6)			
	Mean	SE	Mean	SE	Mean	SE	F	p
Males								
Height, cm	126.7	4.9	128.0	10.2	127.7	14.2	0.77	NS
Weight, kg	28.9	0.7	28.7	1.4	28.5	1.9	0.02	NS
BMI, kg/m^2	17.6	0.2	17.1	0.5	17.2	0.7	0.50	NS
Females								
Height, cm	128.7	5.3	128.0	10.7	127.3	24.3	0.27	NS
Weight, kg	29.5	0.5	27.9	1.1	28.2	2.4	1.00	NS
BMI, kg/m^2	17.5	0.2	16.6	0.4	17.3	0.9	1.88	NS

[1]The first number refers to the sample size for boys and the second to girls.

Table 5.2. Age-adjusted means and standard errors based on ANCOVA with age as the covariate for indicators of body size in rural school children grouped by place of birth.

	Place of Birth							
	Santo Tomas (n=159, 155)[1]		Other Areas of State of Oaxaca (n=5, 9)		Other States of Mexico (n=10, 15)			
	Mean	SE	Mean	SE	Mean	SE	F	p
Males								
Height, cm	125.7	0.4	121.5	24.9	124.8	17.5	1.50	NS
Weight, kg	26.7	0.3	25.4	2 0	27.1	1.4	0.27	NS
BMI, kg/m^2	16.6	0.1	16.9	0.8	17.3	0.5	0.72	NS
Females								
Height, cm	125.3	4.5	126.7	18.6	127.5	14.4	1.26	NS
Weight, kg	26.6	0.4	31.3	1.6	29.1	1.2	5.54	<.01
BMI, kg/m^2	16.6	0.2	19.1	0.6	17.6	0.5	8.97	<.01

[1]The first number refers to the sample size for boys and the second to girls.

Table 5.3. Estimated prevalence (%) of overweight and obesity in primary school children 6 to 13 years of age from several areas of Mexico.[1]

	n	Overweight	Obese	Total
Males				
Rural:				
Oaxaca, Zapotec	177	5	1	6
Chihuahua, Tarahumara	308	4	1	5
Urban:				
Oaxaca	173	11	4	15
Sonora	159	19	14	33
Veracruz	201	22	11	34
Mexico City	369	23	9	33
Females				
Rural:				
Oaxaca, Zapotec	184	8	1	9
Chihuahua, Tarahumara	273	8	0	8
Urban:				
Oaxaca	166	14	2	17
Sonora	144	17	7	24
Veracruz	176	23	9	32
Mexico City	386	22	6	28

[1]Based on the international criteria for overweight and obesity reported by Cole et al. (2000). The criteria were applied to individual data from Peña Reyes et al. (in preparation) Tarahumara school children in Chihuahua, from Peña Reyes et al. (2002) for children in Sonora and Veracruz, and from Siegel (1999) for children in Mexico City to derive the prevalences.

Table 5.4. Estimated prevalence (%) of wasting in primary school children 6 to 13 years of age from several areas of Mexico.[1]

	Males		Females	
	n	%	n	%
Rural:				
Oaxaca, Zapotec	177	2	184	2
Chihuahua, Tarahumara	308	<1	273	2
Urban:				
Oaxaca	173	1	166	1
Sonora	159	2	144	3
Veracruz	201	3	176	3
Mexico City	369	6	386	4

[1]Based on a BMI <5th age- and sex-specific percentiles of the new United States growth charts (Centers for Disease Control and Prevention, 2000). The criteria were applied to individual data from Peña Reyes et al. (in preparation) for Tarahumara school children in Chihuahua, from Peña Reyes et al. (2002) for children in Sonora and Veracruz, and from Siegel (1999) for children in Mexico City to derive the prevalences.

Table 5.5. Estimated prevalence (%) of growth stunting in primary school children 6-13 years of age by age group in Oaxaca and Chihuahua.[1]

	Males		Females	
	n	%	n	%
6-9 Years				
Oaxaca				
Urban	110	12.7	107	14.9
Rural, Zapotec	113	27.4	113	29.2
Chihuahua, Tarahumara	152	39.0	150	34.0
10-13 years				
Oaxaca				
Urban	63	17.5	59	16.9
Rural, Zapotec	64	31.3	71	29.6
Chihuahua, Tarahumara	158	23.0	123	33.0

[1]Stunting is defined as a z-score below –2.0 relative to age- and sex-specific reference values for height (Centers for Disease Control and Prevention, 2000). The criteria were applied to individual data from Peña Reyes et al. (in preparation) for Tarahumara school children in Chihuahua.

FIGURES

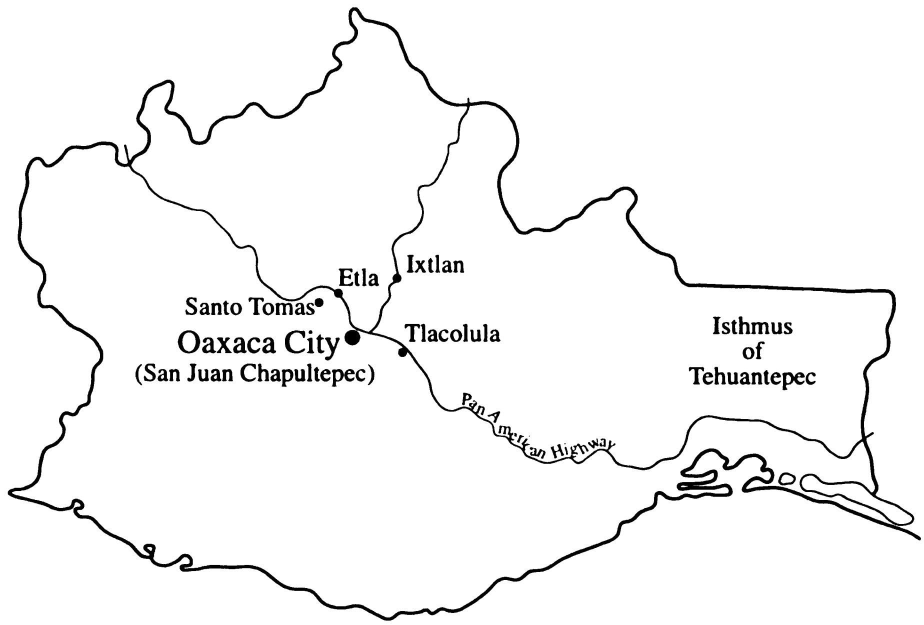


Figure 3.1. Map of the Valley of Oaxaca, indicating the location of the comunities studied Santo Tomás Malzatepec and San Juan Chapultepec.

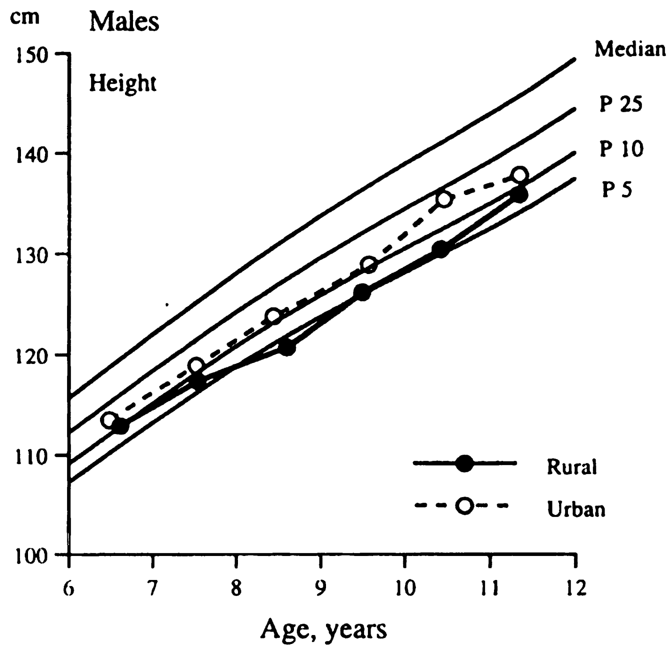


Figure 4.1. Mean height of urban and rural boys relative to selected percentiles of United States reference date (Centers for Disease Control and Promotion, 2000).

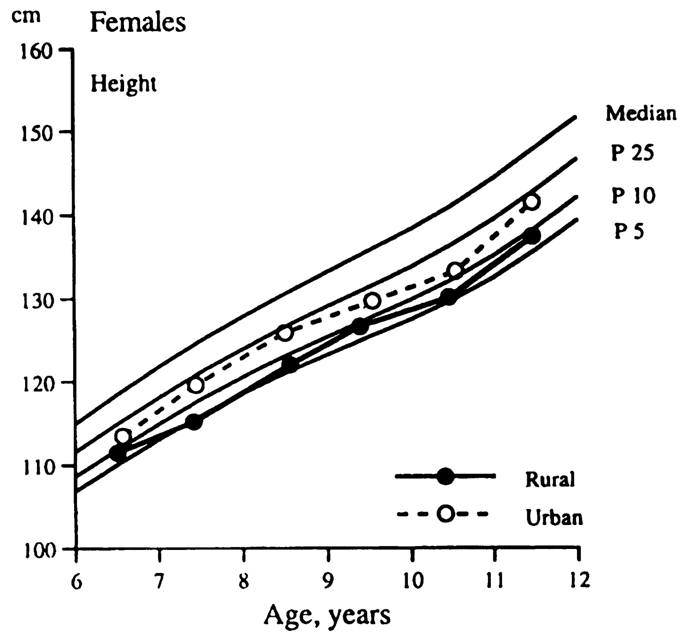


Figure 4.2. Mean height of urban and rural girls relative to selected percentiles of United States reference date (Centers for Disease Control and Promotion, 2000).

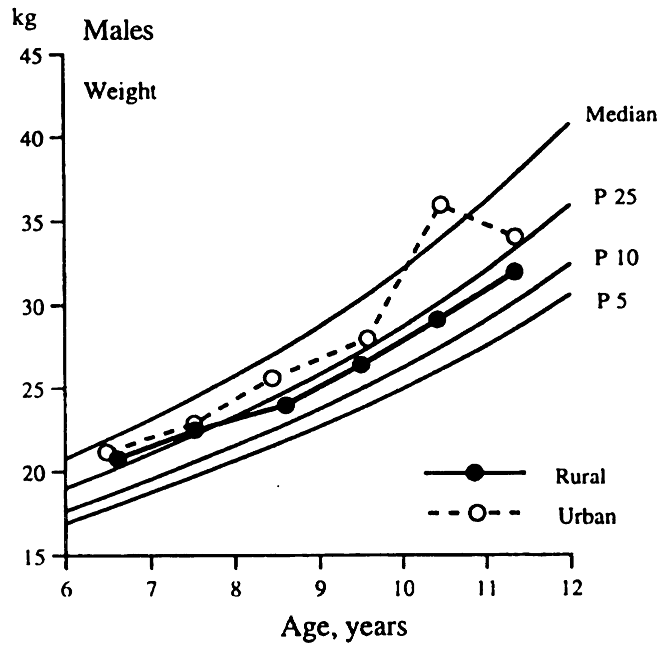


Figure 4.3. Mean weight of urban and rural boys relative to selected percentiles of United States reference date (Centers for Disease Control and Promotion, 2000).

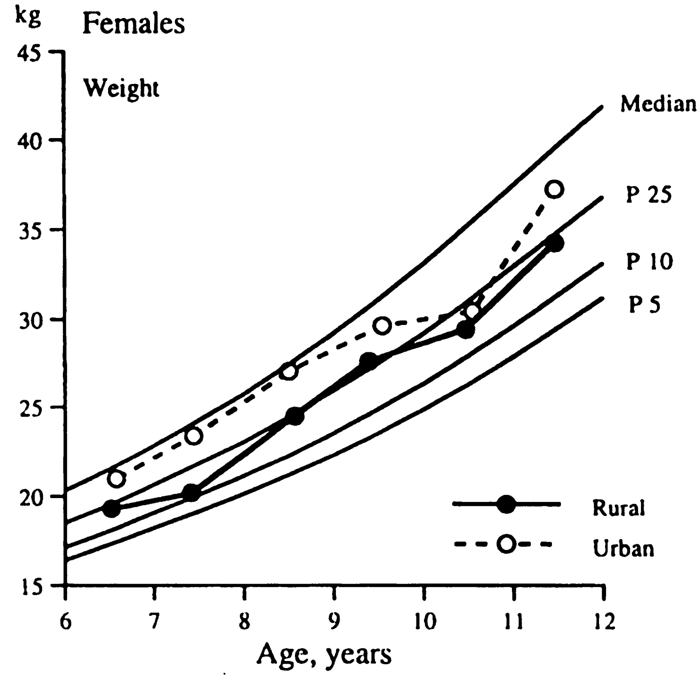


Figure 4.4. Mean weight of urban and rural girls relative to selected percentiles of United States reference date (Centers for Disease Control and Promotion, 2000).

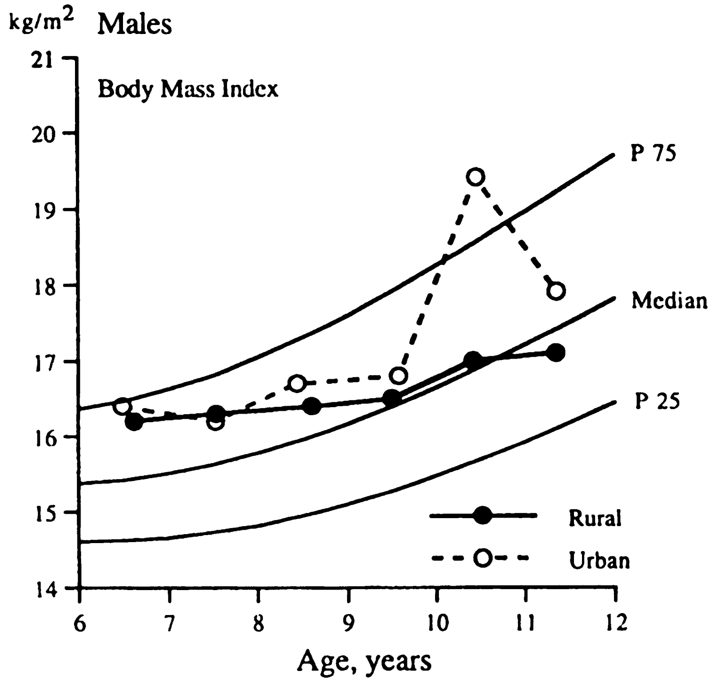


Figure 4.5. Mean body mass index of urban and rural boys relative to selected percentiles of United States reference date (Centers for Disease Control and Promotion, 2000).

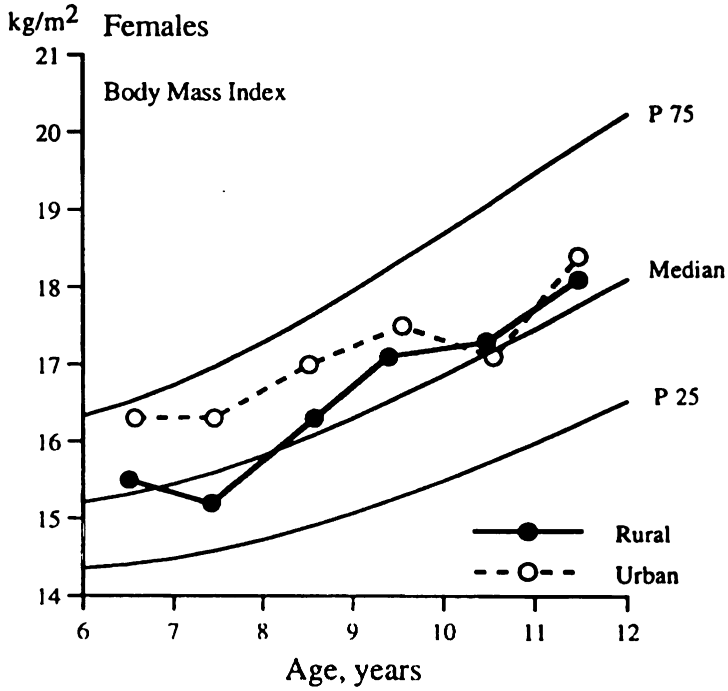


Figure 4.6. Mean body mass index of urban and rural girls relative to selected percentiles of United States reference date (Centers for Disease Control and Promotion, 2000).

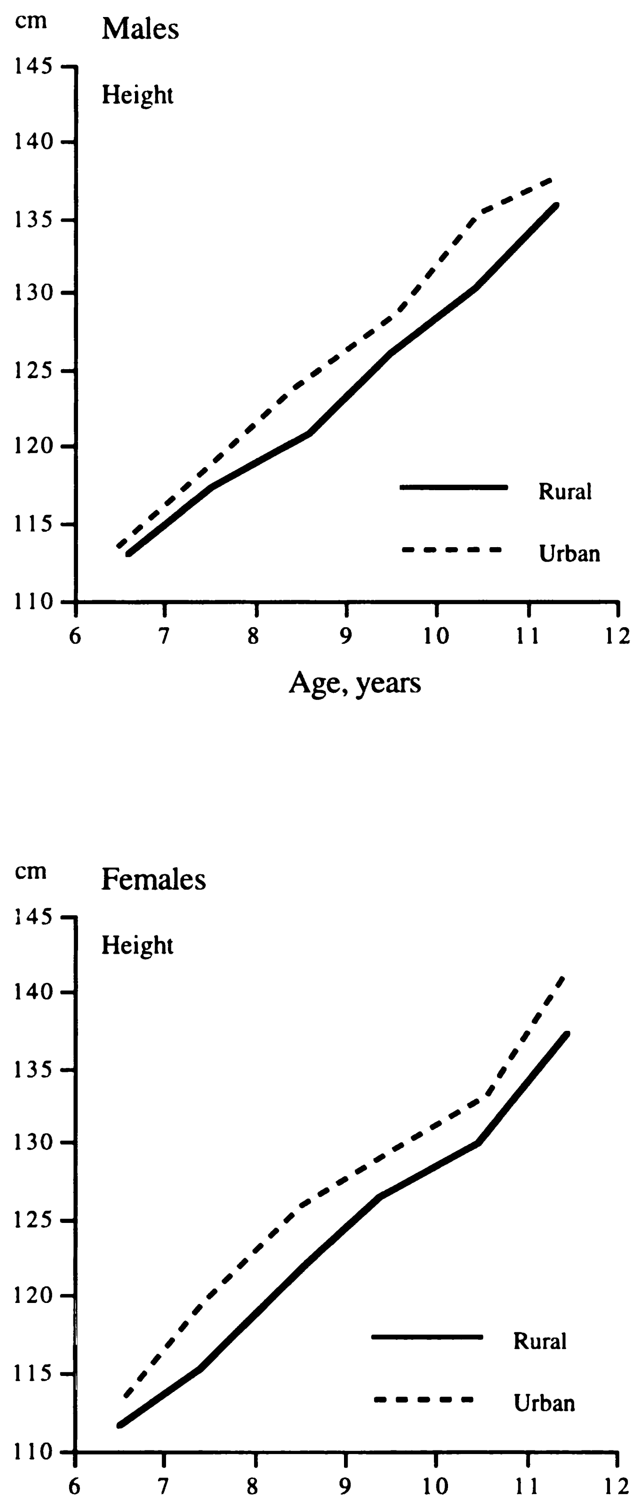


Figure 4.7. Mean height of urban and rural children.

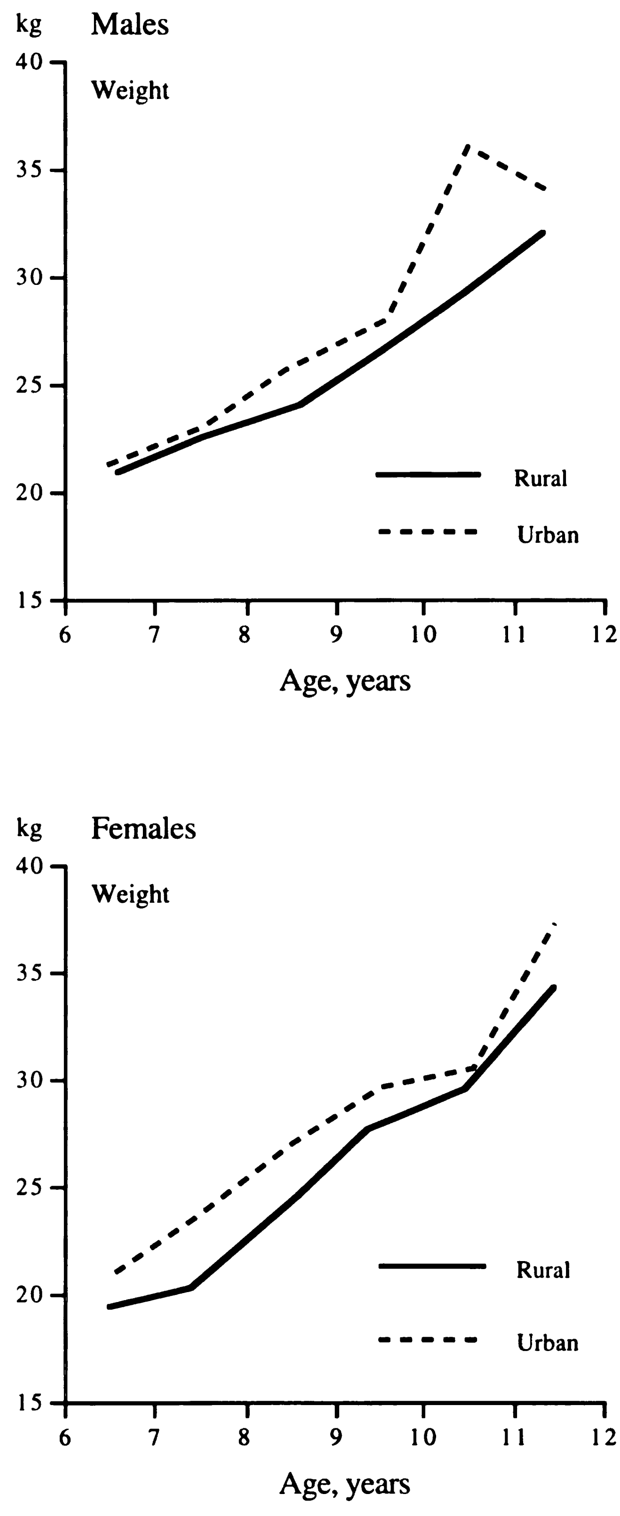
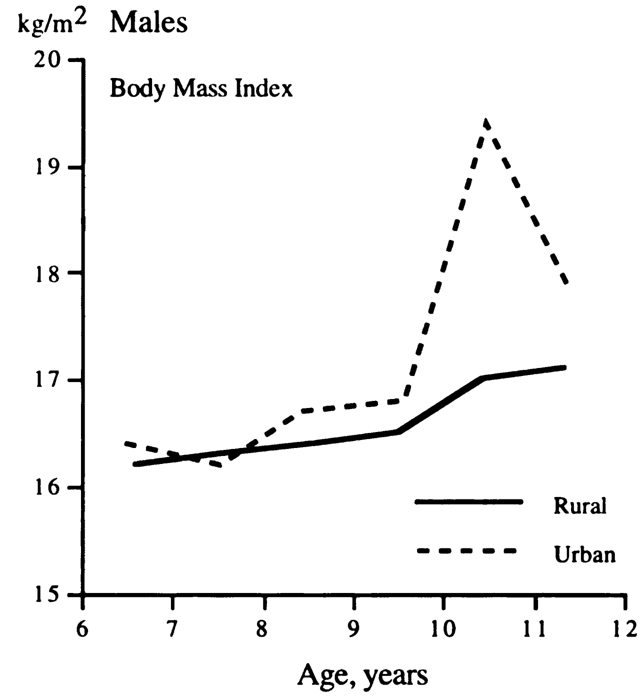


Figure 4.8. Mean weight of urban and rural children.



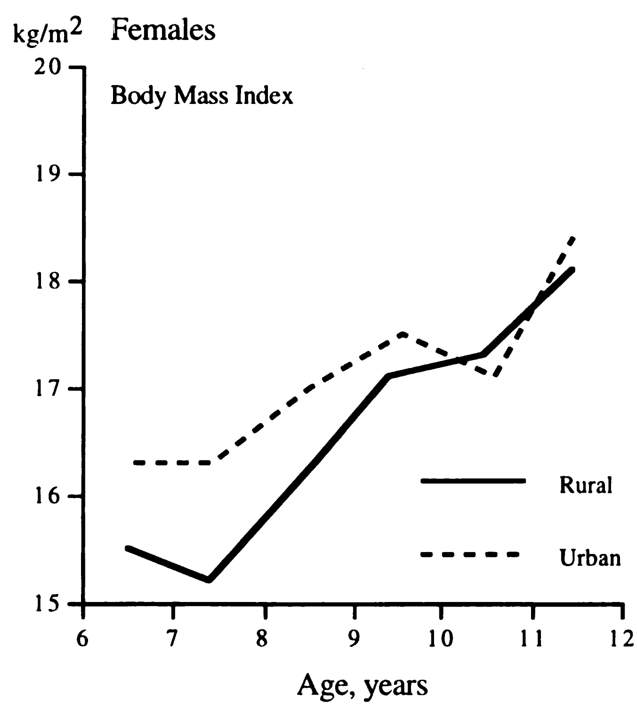


Figure 4.9. Mean body mass index of urban and rural children.

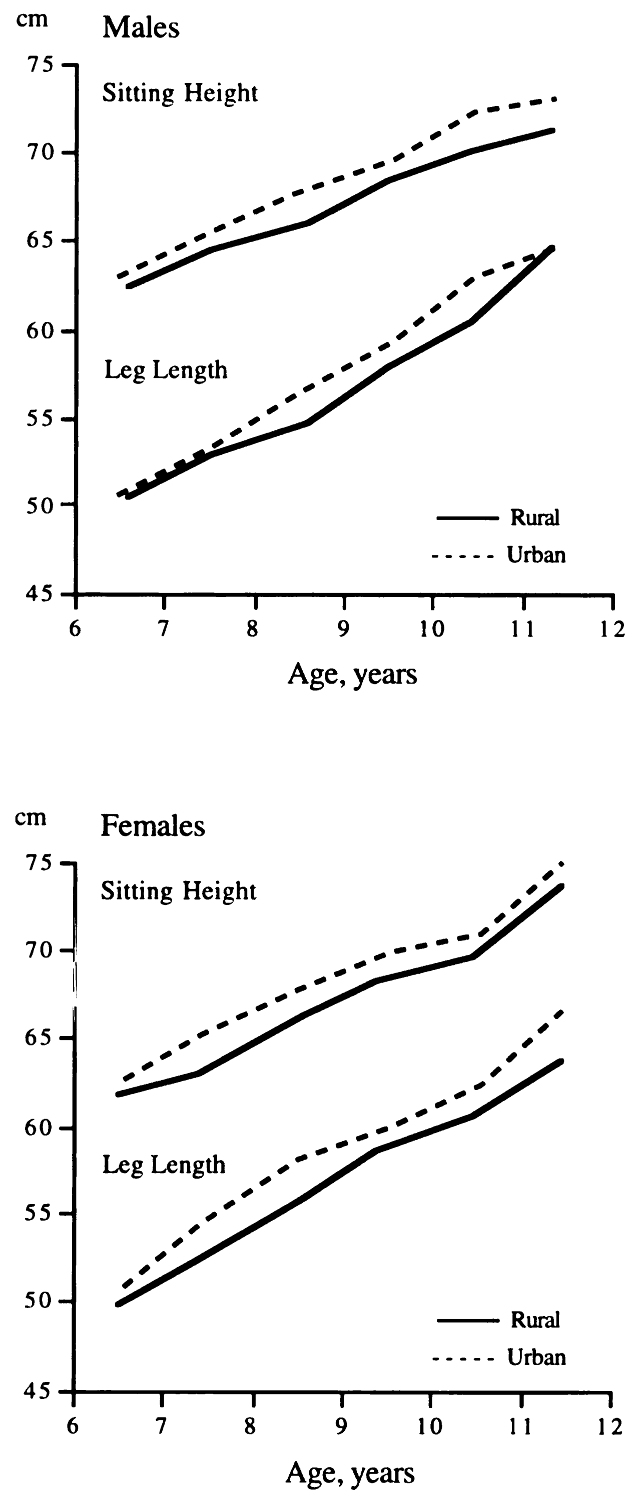
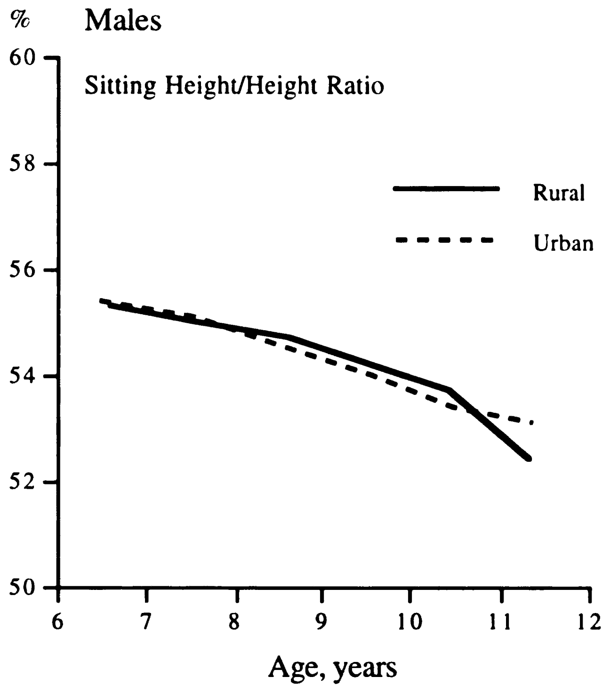


Figure 4.10. Mean sitting height and estimated leg length of urban and rural children.



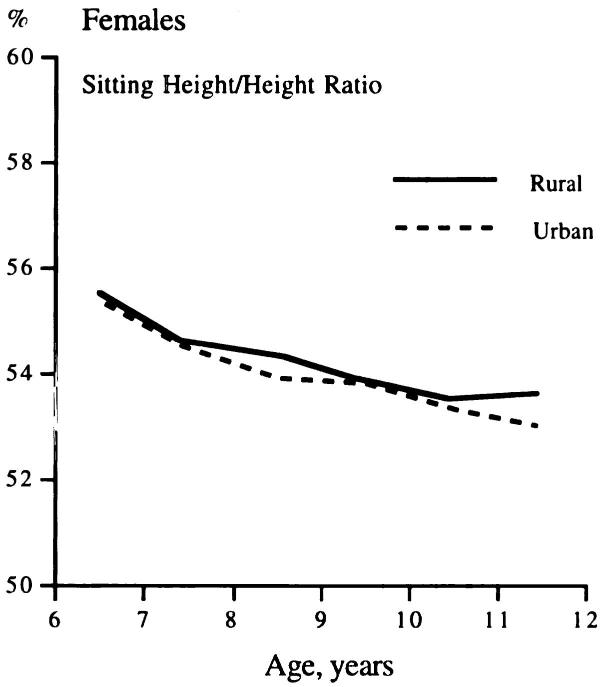
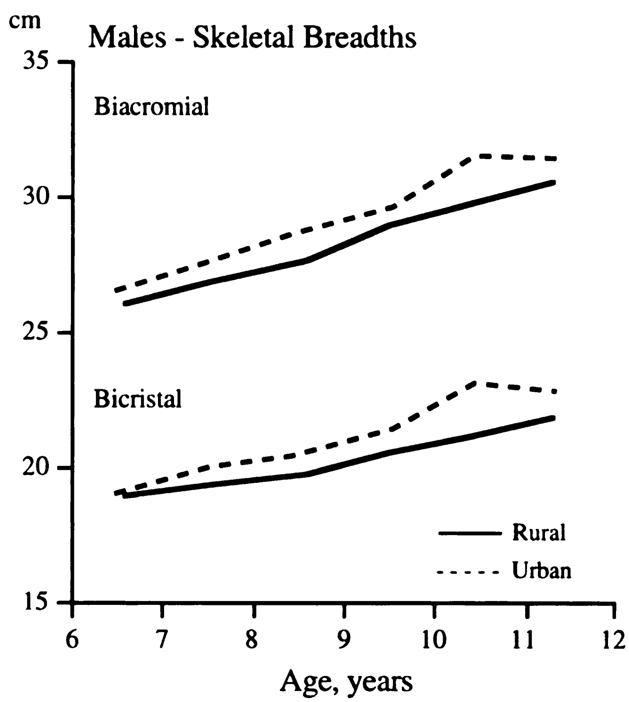


Figure 4.11. Mean sitting height/standing height ratio of urban and rural children.



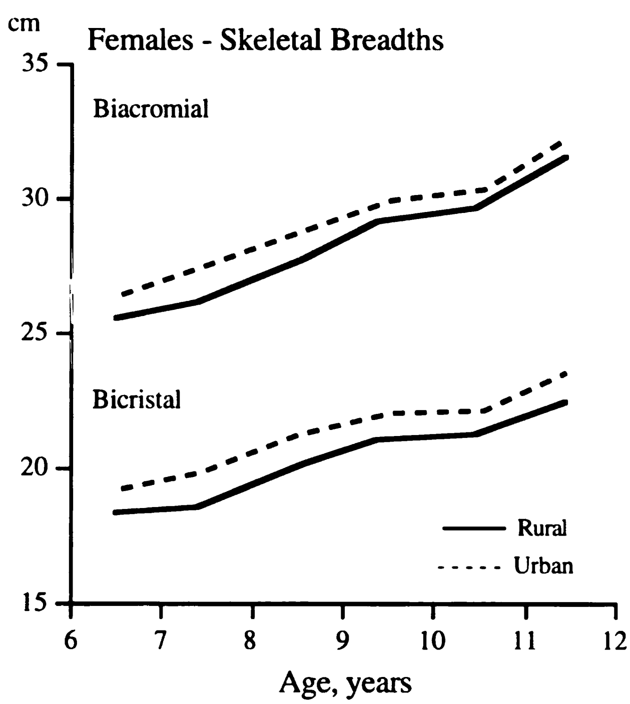


Figure 4.12. Mean biacromial and bicristal breadths of urban and rural children.

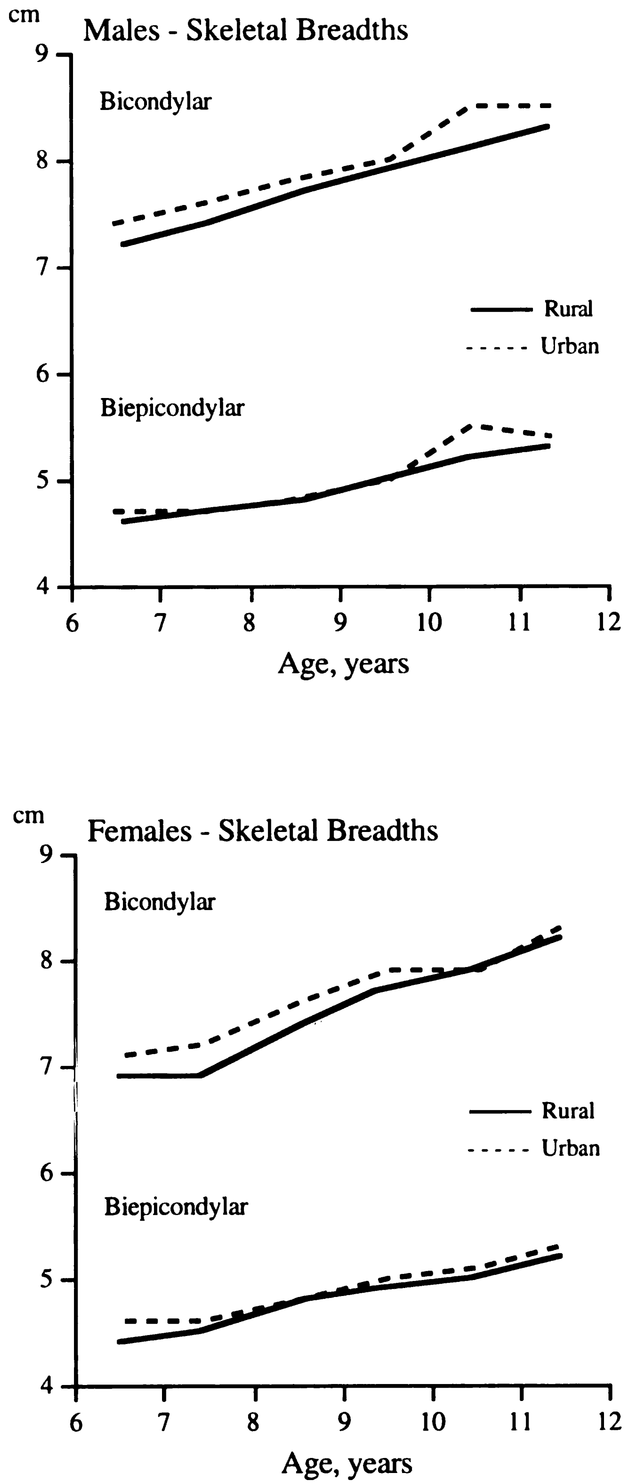


Figure 4.13. Mean bicondylar and biepicondylar breadths of urban and rural children.

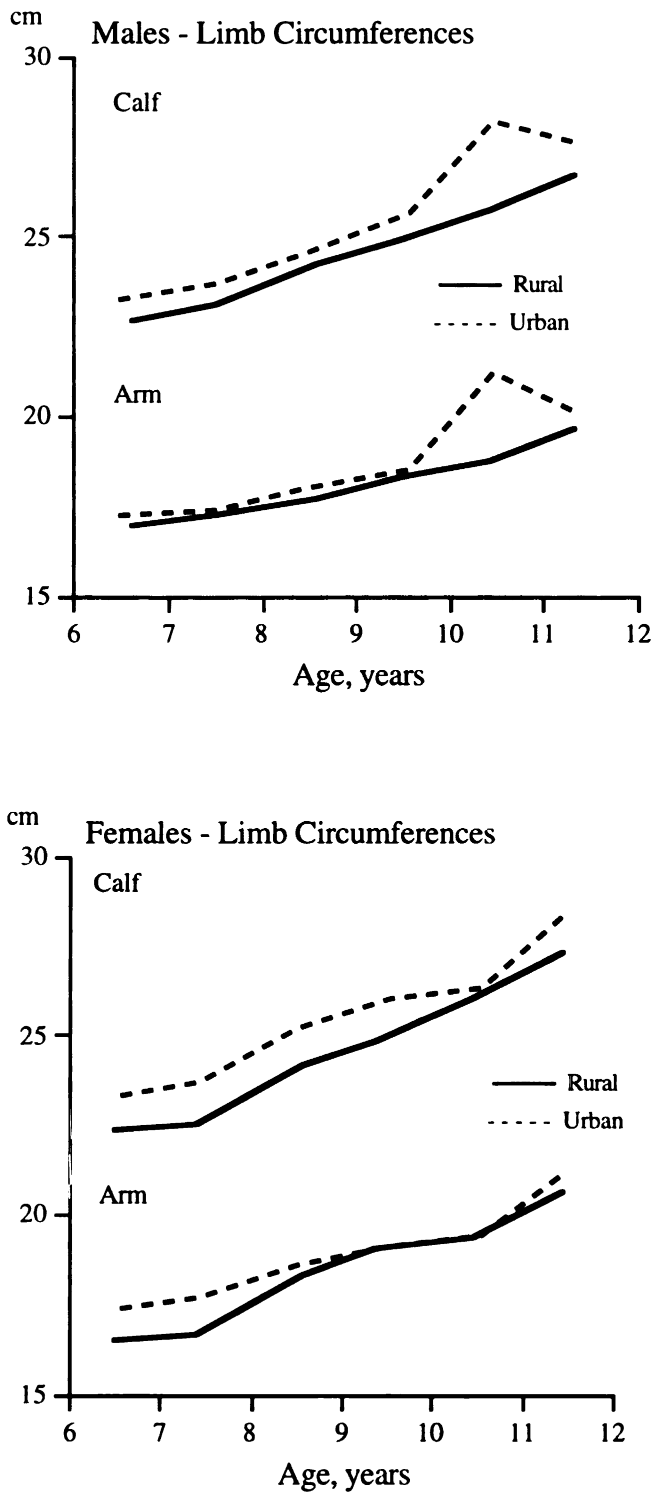
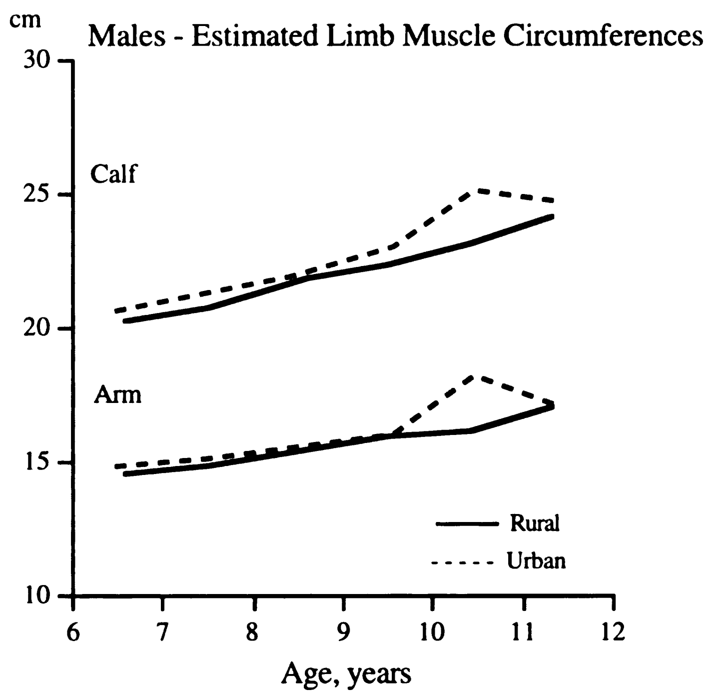


Figure 4.14. Mean arm and calf circumferences of urban and rural children.



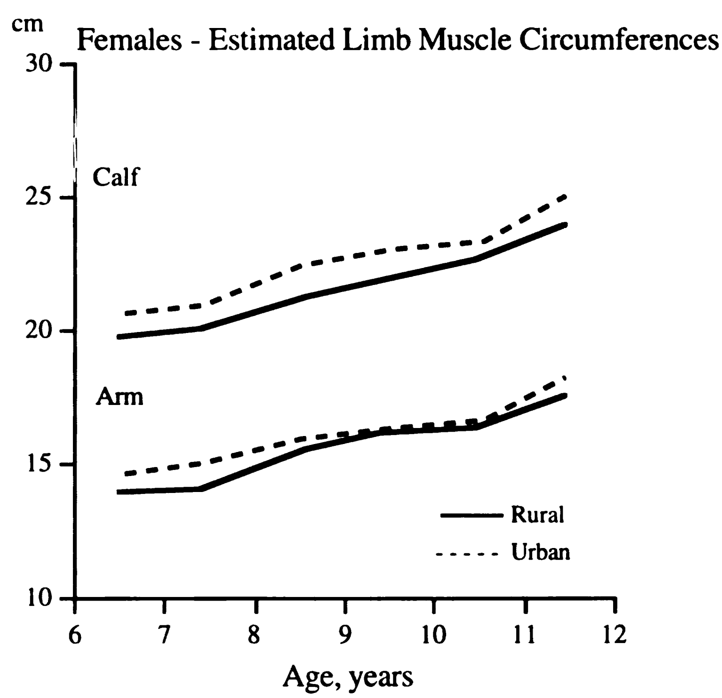


Figure 4.15. Mean estimated arm and calf muscle circumferences of urban and rural children.

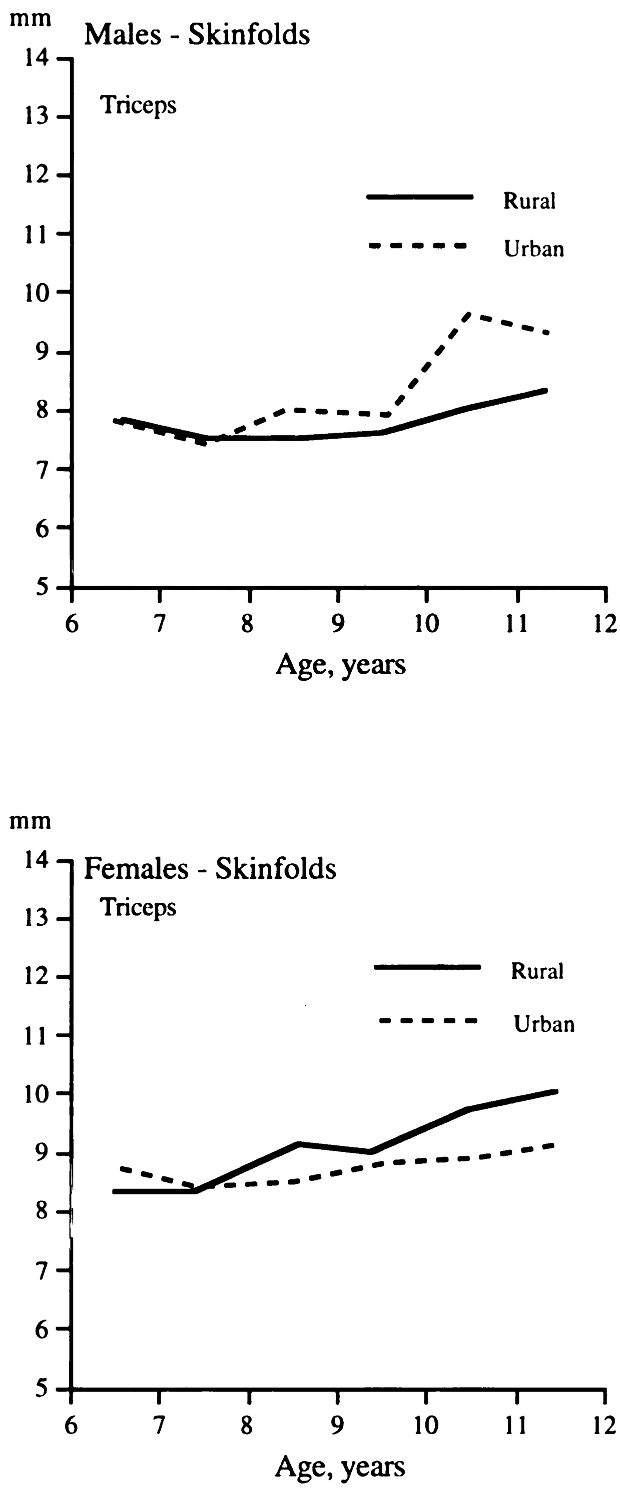
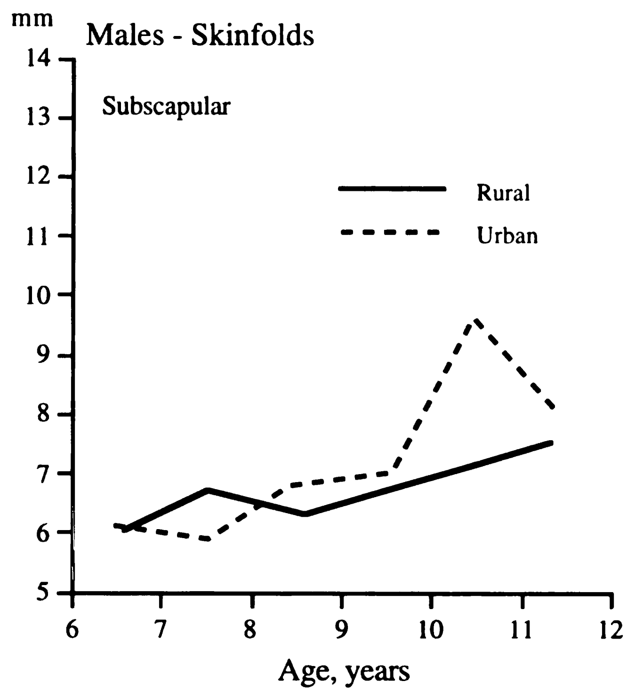


Figure 4.16 Mean triceps skinfold thicknesses of urban and rural children.



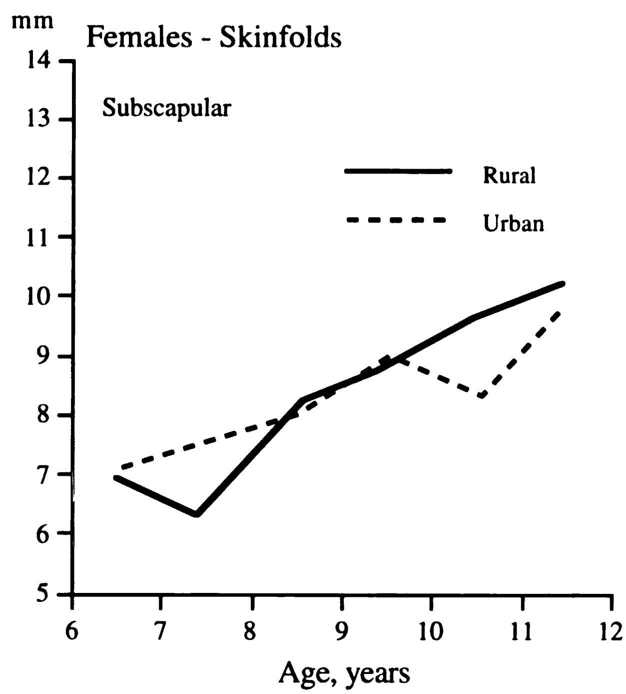


Figure 4.17. Mean subscapular skinfold thicknesses of urban and rural children.

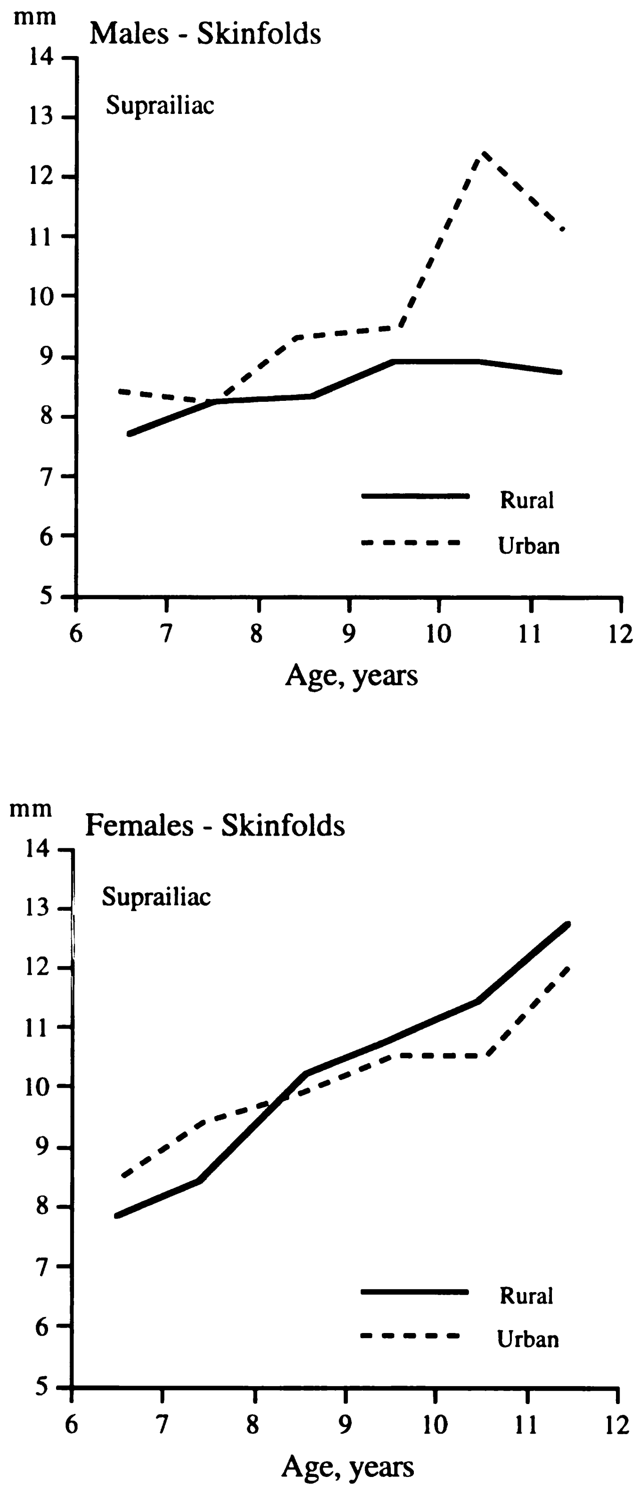


Figure 4.18. Mean suprailiac skinfold thicknesses of urban and rural children.

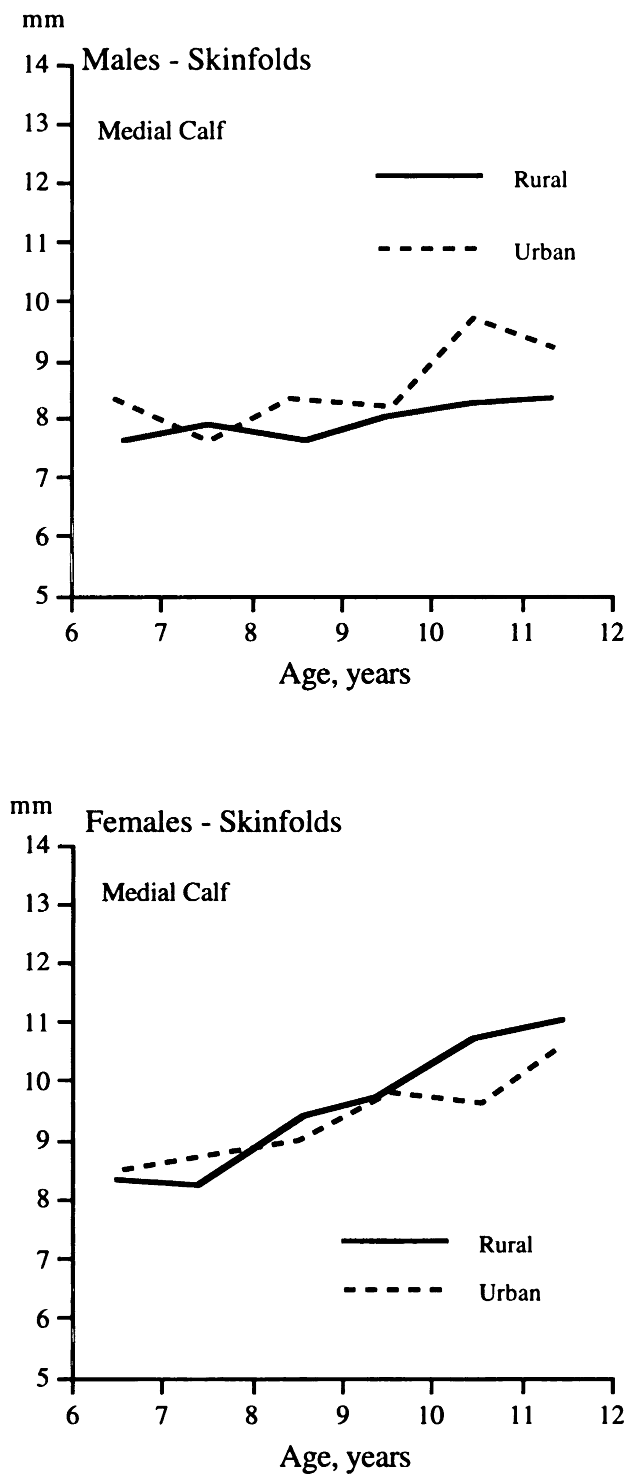


Figure 4.19. Mean medial calf skinfold thicknesses of urban and rural children.

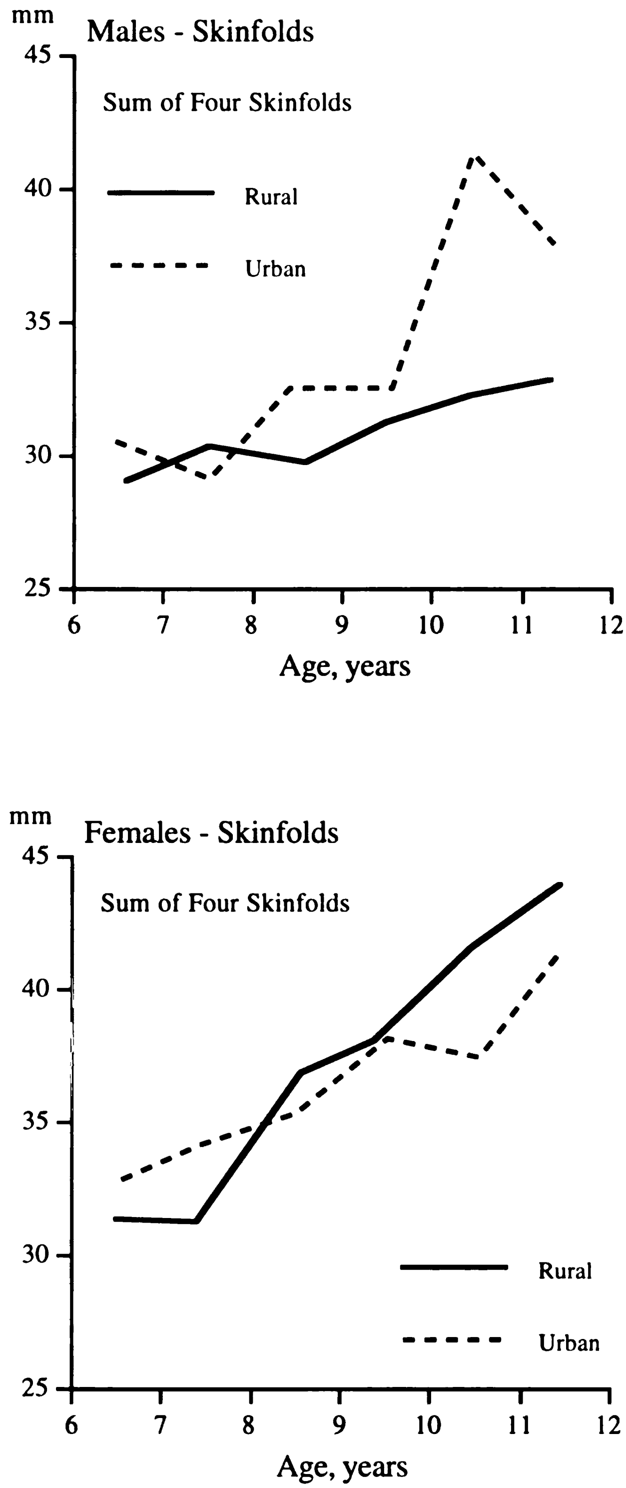


Figure 4.20. Mean sum of skinfold thicknesses of urban and rural children.

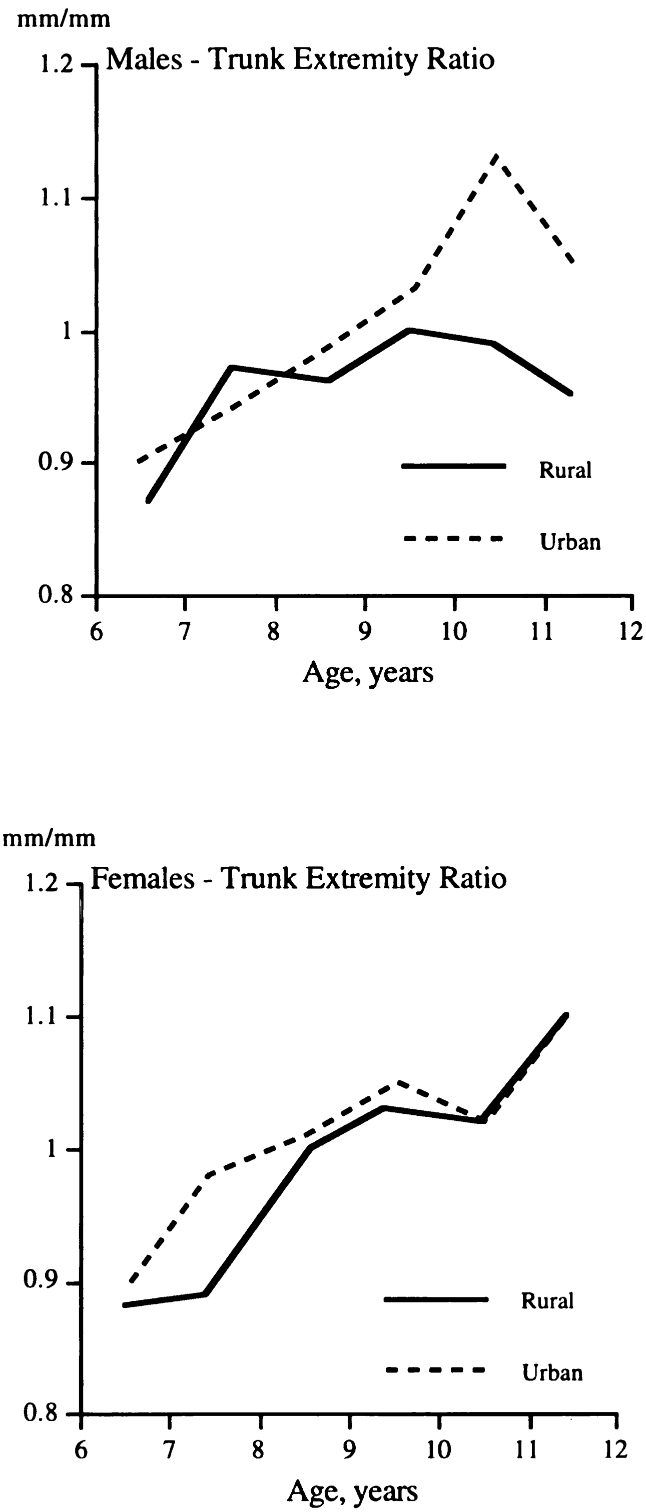


Figure 4.21. Mean trunk/extremity skinfold ratios of urban and rural children.

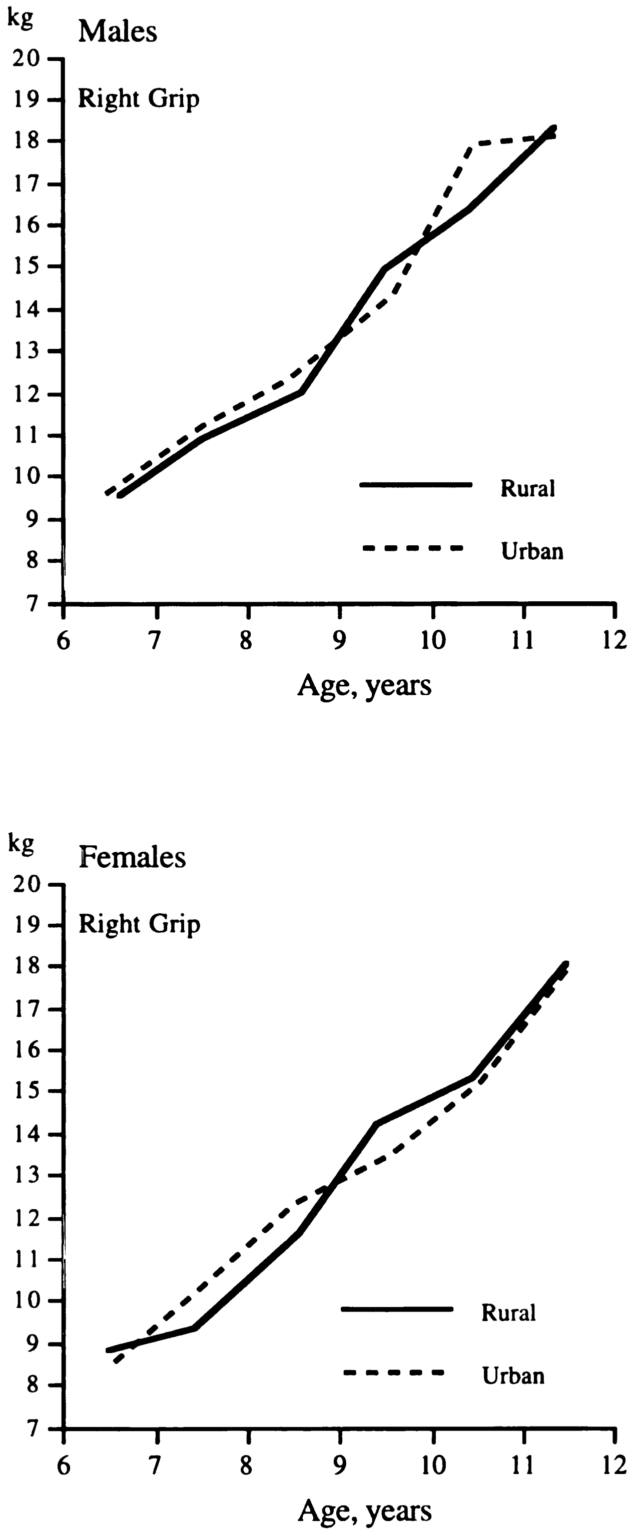
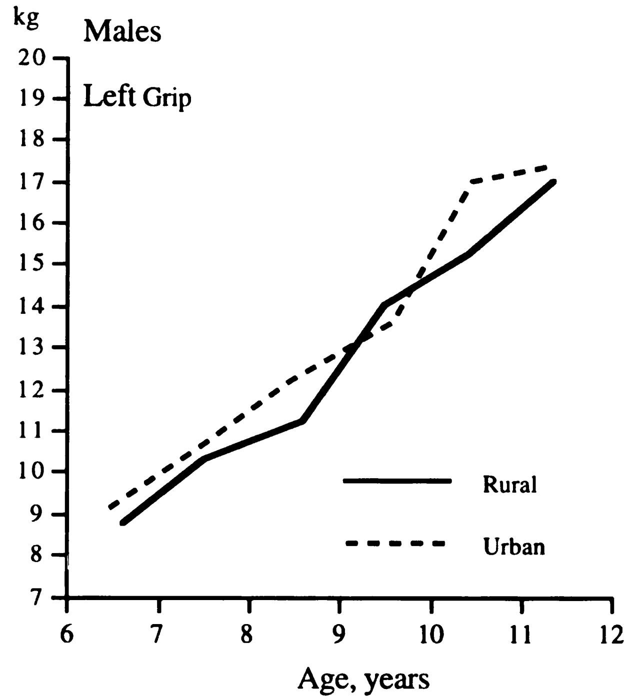


Figure 4.22. Mean right grip strength of urban and rural children.



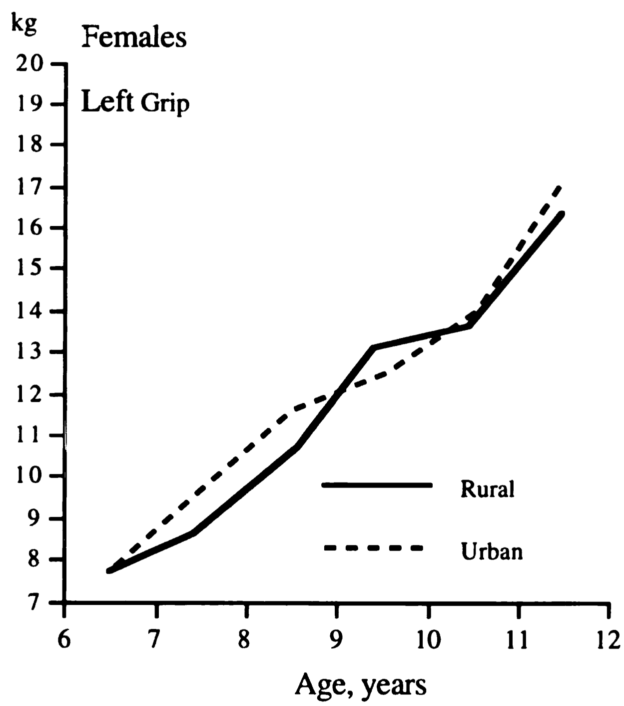


Figure 4.23. Mean left grip strength of urban and rural children.

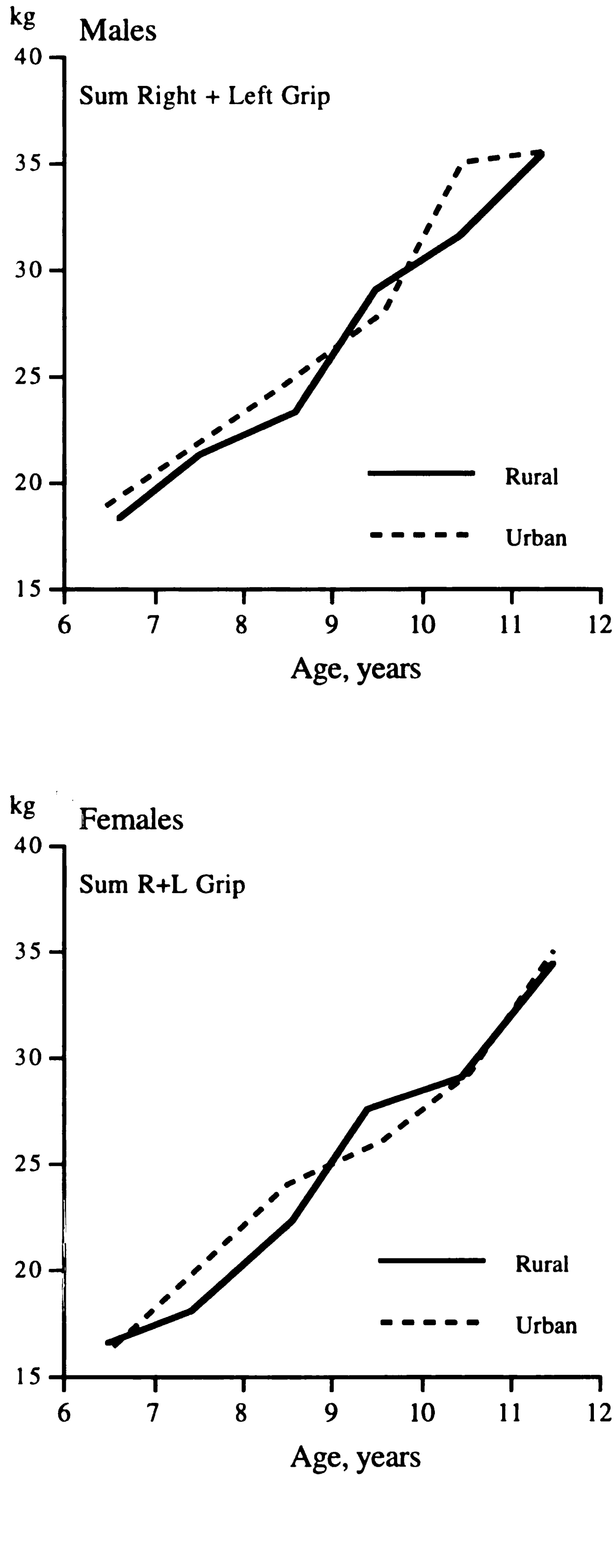
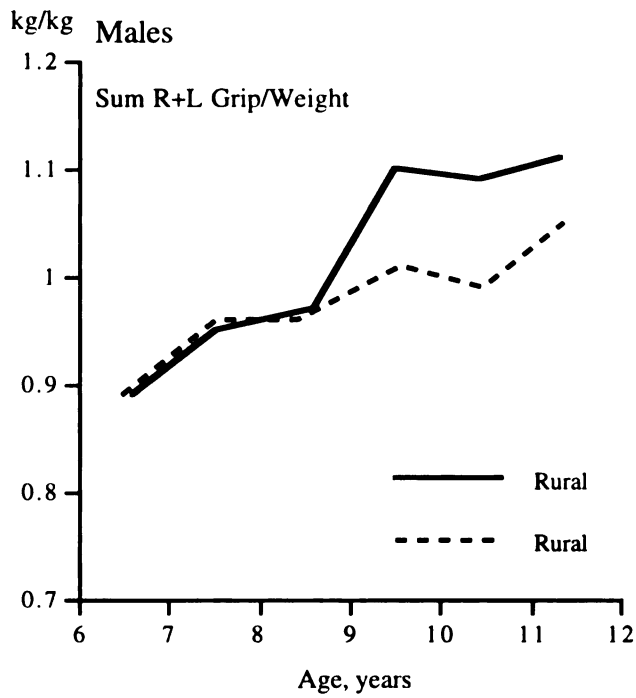


Figure 4.24. Mean sum of right and left grip of urban and rural children.



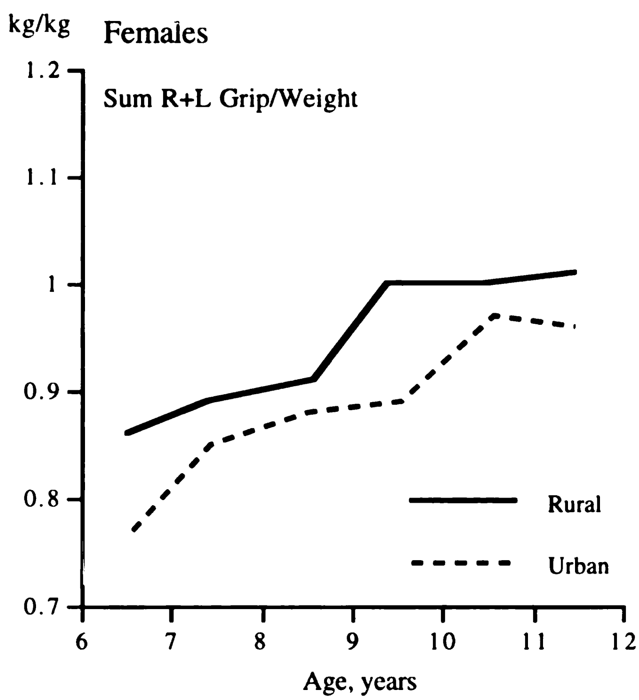


Figure 4.25. Mean grip strength (sum of right and left) per unit body weight in urban and rural children.

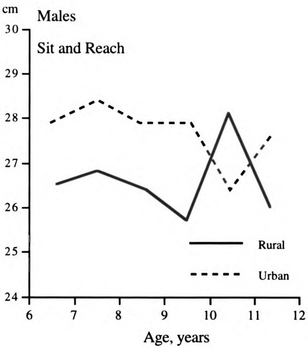
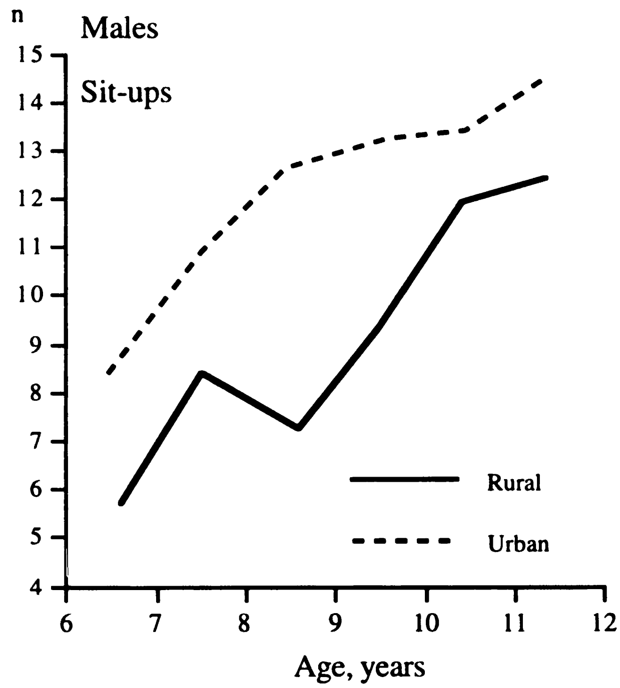


Figure 4.26. Mean sit-and-reach of urban and rural children.



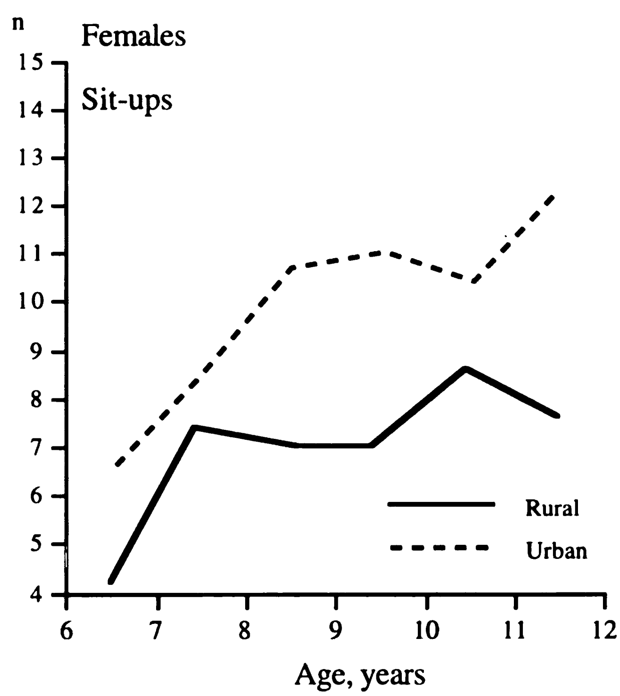


Figure 4.27. Mean timed sit-ups in urban and rural children.

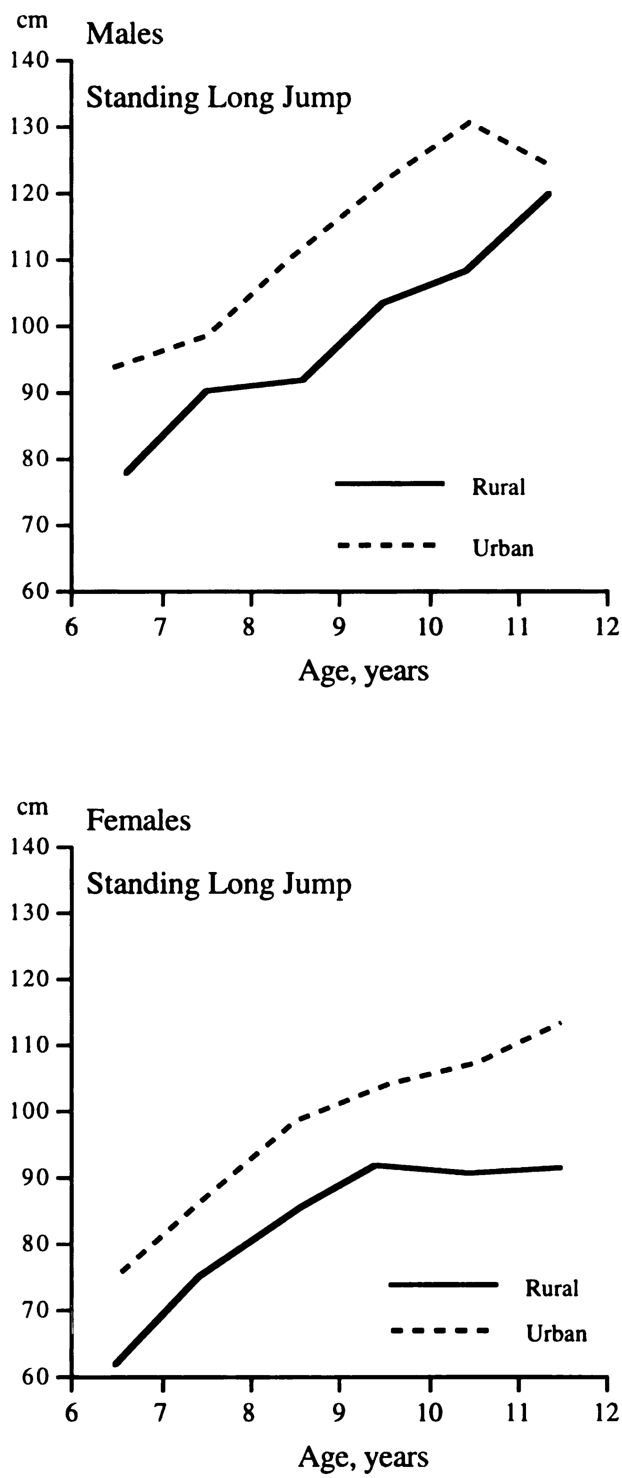


Figure 4.28. Mean standing long jump performance of urban and rural children.

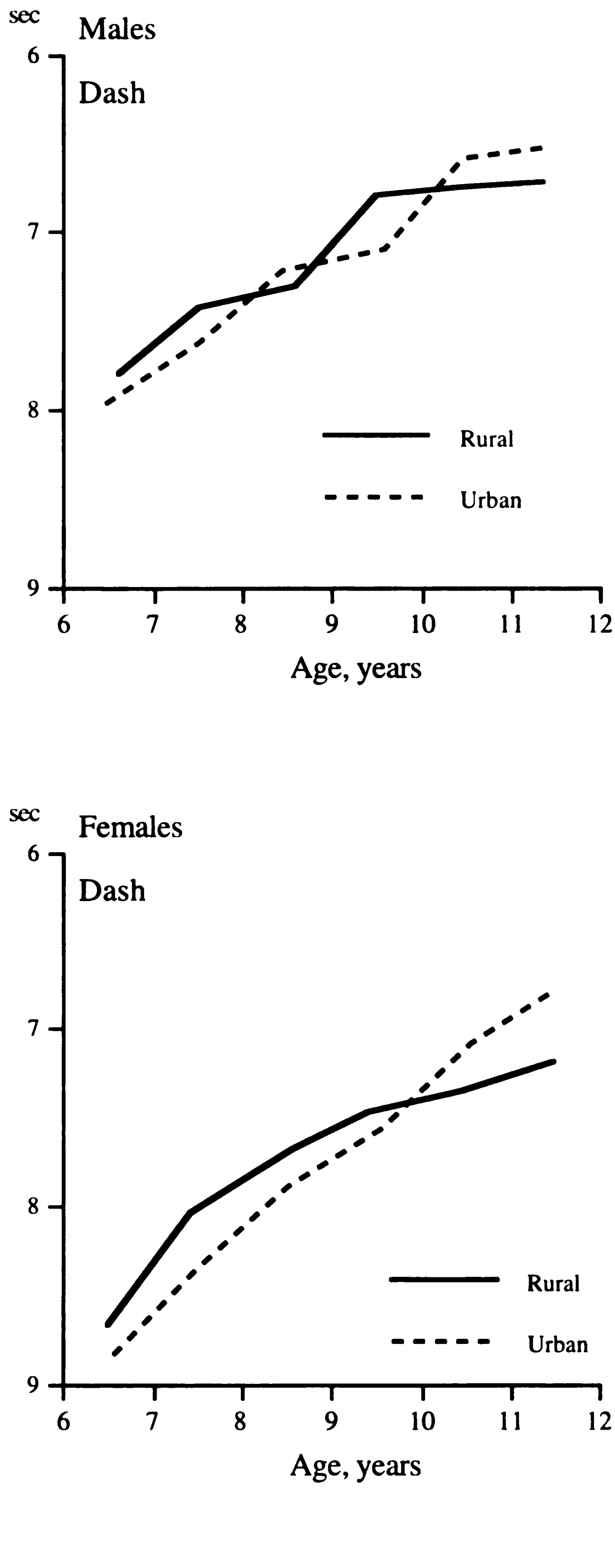


Figure 4.29. Mean 35-yard dash performance of urban and rural children.

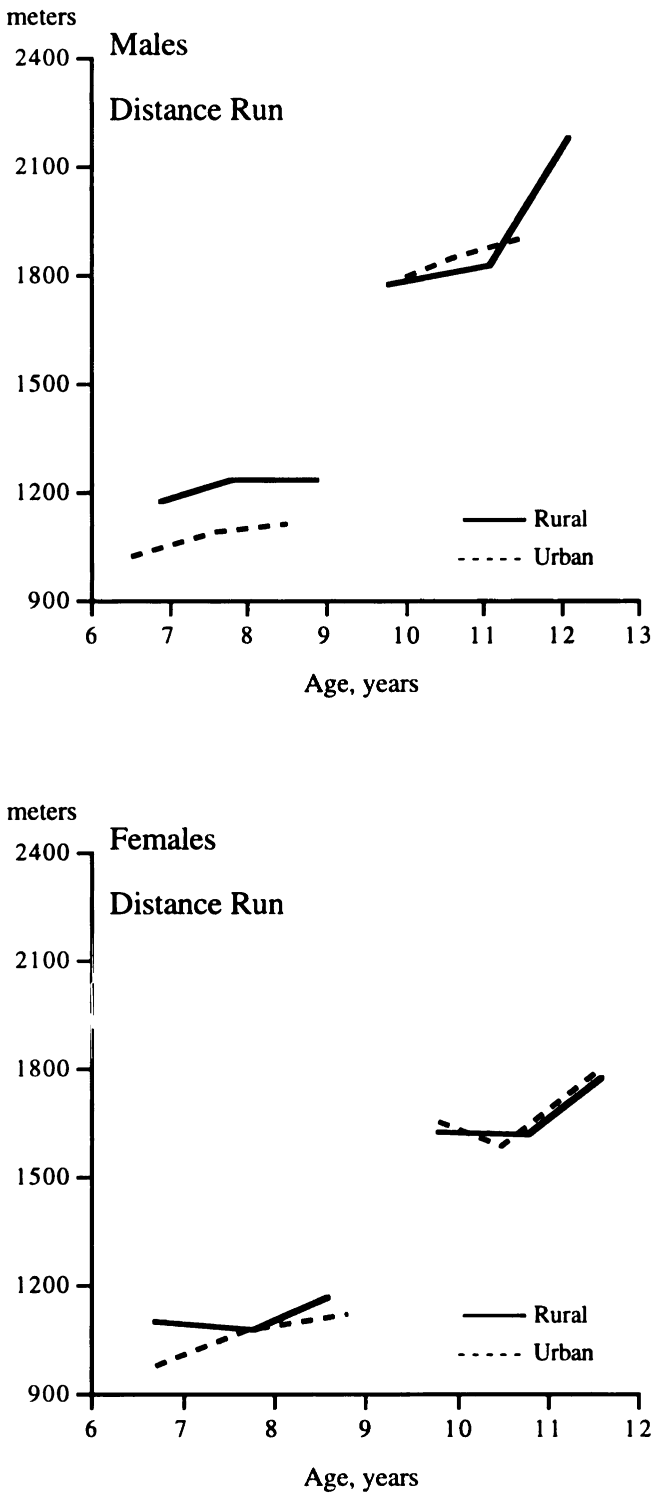


Figure 4.30. Mean distance run in 8 minutes (grades 1-3) and in 12 minutes (grades 4-6) by urban and rural children.

APPENDICES

APPENDIX I

UNIVERSITY COMMITTEE FOR RESEARCH INVOLVING HUMAN SUBJECTS AT MICHIGAN STATE UNIVERSITY

APPROVAL FORMS

MICHIGAN STATE
UNIVERSITY

April 14, 1998

TO: Robert M. Malina
213 IM Sports Circle

RE: IRB#: 98-118
TITLE: SECULAR CHANGE IN SIZE, STRENGTH AND MOTOR FITNESS IN THE VALLEY OF OAXACA, MEXICO
REVISION REQUESTED: N/A
CATEGORY: FULL REVIEW
APPROVAL DATE: 04/06/98

The University Committee on Research Involving Human Subjects' (UCRIHS) review of this project is complete. I am pleased to advise that the rights and welfare of the human subjects appear to be adequately protected and methods to obtain informed consent are appropriate. Therefore, the UCRIHS approved this project and any revisions listed above.
ONE REVIEWER SUGGESTS REVISING THE CONSENT FORM LANGUAGE REGARDING REMOVAL OF CLOTHING TO "ONLY SHOES AND OUTER CLOTHES LIKE JACKETS & BULKY SWEATERS WILL NEED TO BE REMOVED IN SOME CASES."

RENEWAL: UCRIHS approval is valid for one calendar year, beginning with the approval date shown above. Investigators planning to continue a project beyond one year must use the green renewal form (enclosed with the original approval letter or when a project is renewed) to seek updated certification. There is a maximum of four such expedited renewals possible. Investigators wishing to continue a project beyond that time need to submit it again for complete review.

REVISIONS: UCRIHS must review any changes in procedures involving human subjects, prior to initiation of the change. If this is done at the time of renewal, please use the green renewal form. To revise an approved protocol at any other time during the year, send your written request to the UCRIHS Chair, requesting revised approval and referencing the project's IRB # and title. Include in your request a description of the change and any revised instruments, consent forms or advertisements that are applicable.

PROBLEMS/ CHANGES: Should either of the following arise during the course of the work, investigators must notify UCRIHS promptly: (1) problems (unexpected side effects, complaints, etc.) involving human subjects or (2) changes in the research environment or new information indicating greater risk to the human subjects than existed when the protocol was previously reviewed and approved.

If we can be of any future help, please do not hesitate to contact us at (517)355-2180 or FAX (517)432-1171.

Sincerely,

David E. Wright, Ph.D.
UCRIHS Chair

DEW:bed

OFFICE OF
RESEARCH AND GRADUATE STUDIES

University Committee on Research Involving Human Subjects (UCRIHS)

Michigan State University
246 Administration Building
East Lansing, Michigan
48824-1046

517/355-2180
FAX: 517/432-1171

MICHIGAN STATE
UNIVERSITY

March 1, 1999

TO: Dr. Robert Malina
213 IM Sports Circle
Dept of Kinesiology
MSU

RE: **IRB # 98118** CATEGORY: FULL REVIEW

RENEWAL APPROVAL DATE: March 1, 1999

TITLE: SECULAR CHANGE IN SIZE AND PHYSICAL FITNESS IN THE VALLEY OF OAXACA, MEXICO

The University Committee on Research Involving Human Subjects' (UCRIHS) review of this project is complete and I am pleased to advise that the rights and welfare of the human subjects appear to be adequately protected and methods to obtain informed consent are appropriate. Therefore, the **UCRIHS APPROVED THIS PROJECT'S RENEWAL.**

This letter also acknowledges and approves the title change.

OFFICE OF
RESEARCH AND GRADUATE STUDIES

niversity Committee on Research Involving Human Subjects (UCRIHS)

Michigan State University
'46 Administration Building
East Lansing, Michigan
48824-1046

517/355-2180
FAX: 517/353-2976

RENEWALS: UCRIHS approval is valid for one calendar year, beginning with the approval date shown above. Projects continuing beyond one year must be renewed with the green renewal form. A maximum of four such expedited renewals possible. Investigators wishing to continue a project beyond that time need to submit it again for a complete review.
REVISIONS: UCRIHS must review any changes in procedures involving human subjects, prior to initiation of the change. If this is done at the time of renewal, please use the green renewal form. To revise an approved protocol at any other time during the year, send your written request to the UCRIHS Chair, requesting revised approval and referencing the project's IRB# and title. Include in your request a description of the change and any revised instruments, consent forms or advertisements that are applicable.
PROBLEMS/CHANGES: Should either of the following arise during the course of the work, notify UCRIHS promptly: 1) problems (unexpected side effects, complaints, etc.) involving human subjects or 2) changes in the research environment or new information indicating greater risk to the human subjects than existed when the protocol was previously reviewed and approved.

If we can be of further assistance, please contact us at 517 355-2180 or via email: UCRIHS@pilot.msu.edu. Please note that all UCRIHS forms are located on the web: http://www.msu.edu/unit/vprgs/UCRIHS/

Sincerely,

Daniel Bronstein,S.J. D.
Vice UCRIHS Chair

DAB: bd

MICHIGAN STATE
UNIVERSITY

March 14, 2000

TO: Robert MALINA
213 IM Sports Circle

RE: **IRB # 98-118** CATEGORY: FULL REVIEW

RENEWAL APPROVAL DATE: March 13, 2000

TITLE: SECULAR CHANGE IN SIZE, STRENGTH AND MOTOR FITNESS IN THE VALLEY OF OAXACA, MEXICO

The University Committee on Research Involving Human Subjects' (UCRIHS) review of this project is complete and I am pleased to advise that the rights and welfare of the human subjects appear to be adequately protected and methods to obtain informed consent are appropriate. Therefore, the **UCRIHS APPROVED THIS PROJECT'S RENEWAL.**

This letter also approves the revised consent form and the addition of a

RENEWALS: UCRIHS approval is valid for one calendar year, beginning with the approval date shown above. Projects continuing beyond one year must be renewed with the green renewal form. A maximum of four such expedited renewal are possible. Investigators wishing to continue a project beyond that time need to submit it again for complete review.
REVISIONS: UCRIHS must review any changes in procedures involving human subjects, prior to initiation of the change. If this is done at the time of renewal, please use the green renewal form. To revise an approved protocol at any other time during the year, send your written request to the UCRIHS Chair, requesting revised approval and referencing the project's IRB# and title. Include in your request a description of the change and any revised instruments, consent forms or advertisements that are applicable.
PROBLEMS/CHANGES: Should either of the following arise during the course of the work, notify UCRIHS promptly: 1) problems (unexpected side effects, complaints, etc.) involving human subjects or 2) changes in the research environment or new information indicating greater risk to the human subjects than existed when the protocol was previously reviewed and approved.

OFFICE OF
RESEARCH AND GRADUATE STUDIES

University Committee on Research Involving Human Subjects

Michigan State University
246 Administration Building
East Lansing, Michigan
48824-1046

517/355-2180
FAX: 517/353-2976
Web: www.msu.edu/user/ucrihs
E-Mail: ucrihs@msu.edu

If we can be of further assistance, please contact us at 517 355-2180 or via email: UCRIHS@pilot.msu.edu.

Sincerely,

David E. Wright
Chair, UCRIHS

DEW: bd

cc: Maria Eugenia Pena Reyes
213 IM Sports Circle

MICHIGAN STATE UNIVERSITY

May 8, 2001

TO: Robert MALINA
128 IM Sports Circle

RE: **IRB # 98-118** CATEGORY: FULL REVIEW
RENEWAL APPROVAL DATE: May 8, 2001

TITLE: SECULAR CHANGE IN SIZE, STRENGTH AND MOTOR FITNESS IN THE VALLEY OF OAXACA, MEXICO

The University Committee on Research Involving Human Subjects' (UCRIHS) review of this project is complete and I am pleased to advise that the rights and welfare of the human subjects appear to be adequately protected and methods to obtain informed consent are appropriate. Therefore, the **UCRIHS APPROVED THIS PROJECT'S RENEWAL.**

This letter also approves the recategorization to Expedited 2-H (Continuing analysis), archival research

RENEWALS: UCRIHS approval is valid for one calendar year, beginning with the approval date shown above. Projects continuing beyond one year must be renewed with the green renewal form. A maximum of four such expedited renewal are possible. Investigators wishing to continue a project beyond that time need to submit it again for complete review.

REVISIONS: UCRIHS must review any changes in procedures involving human subjects, prior to initiation of the change. If this is done at the time of renewal, please use the green renewal form. To revise an approved protocol at any other time during the year, send your written request to the UCRIHS Chair, requesting revised approval and referencing the project's IRB# and title. Include in your request a description of the change and any revised instruments, consent forms or advertisements that are applicable.

PROBLEMS/CHANGES: Should either of the following arise during the course of the work, notify UCRIHS promptly: 1) problems (unexpected side effects, complaints, etc.) involving human subjects or 2) changes in the research environment or new information indicating greater risk to the human subjects than existed when the protocol was previously reviewed and approved.

OFFICE OF
RESEARCH AND GRADUATE STUDIES

Assistant Vice President for Research

Michigan State University
246 Administration Building
East Lansing, Michigan
48824-1046

517/355-2180
FAX: 517/353-2976

If we can be of further assistance, please contact us at 517 355-2180 or via email: UCRIHS@pilot.msu.edu.

Sincerely,

Ashir Kumar, M.D.
Interim Chair, UCRIHS

AK: bd

cc: Maria Eugenia Pena Reyes
128 IM Sports Circle

APPENDIX II

DATA COLLECTION FORMS

Anthropometry

Name ______________________ Age______ Sex______ Number__________

Birth date and place________________ School grade__________

Address____

Menarche: Yes__________ Age____________ Menarche: No__________

1. Weight ______________kg
2. Height______________
3. Sitting height______________
4. Biacromial breadth__________
5. Bicristal breadth__________
6. Bicondylar breadth__________
7. Biepicondylar breadth__________
8. Arm circ, relaxed__________
9. Arm circ, flexed__________
10. Calf circumference______________
11. Triceps skinfold______________
12. Subscapular skinfold______________
13. Suprailiac skinfold______________
14. Medial calf skinfold______________
15. Head length______________
16. Head breadth______________
17. Bizygomatic breadth______________
18. Bigonial breadth______________

Type of clothing______________________________

Date of measurement______________________________

Technician:________________ Recorder:________________

Observations:____

Physical Fitness

Name ______________________________ Age______ Sex_____ Number__________

Birth date and place_________________ School grade_____________

Grip strength, Right ______ ______ ______

Grip strength, Left ______ ______ ______

35-yard dash ______ ______

Standing long jump ______ ______ ______

Sit and reach ______ ______ ______

Sit-ups ______

8 minute run walk (grades 1 through 3) __________

12 minute run walk (grades 4 through 6) _________

Place:_____________________________ Date:______________________

Technician:______________________ Recorder:__________________

Observations:____

Demographic information

Name ____________________________ Age_______ Sex______ Number__________

Birth date and place__________________________ School grade_________

Address____

How long have you been living in the community?______________________________

Parent information: Father Mother

	Father	Mother
Occupation	_____________	_______________
Age	_____________	_______________
Education	_____________	_______________
Place of birth	_____________	_______________

Family members:

Number of members__________________________

Adults_____________ Brothers________________ Sisters__________________

Number of rooms in your house____

Household appliances:

Radio	Yes_________	No_________
TV-black & white	Yes_________	No_________
TV-color	Yes_________	No_________
Telephone	Yes_________	No_________
Refrigerator	Yes_________	No_________

Others?____

Date__________________________ Signature of Parent__________________________

Technican________________ Observations______________________________________

Activity Questionnaire (Grades 4 through 6)

Name________________________________ Age________ Sex________ Number_____

Date___________________ Grade__________________

Interviewer____________________________

1. At what time do you wake up? ____________________
2. Do you have breakfast before going to school ? Yes ________ No _______
3. At what time do you leave for school? ____________
4. What activities do you do at home before school? ______________________________

____

5. Do you have to do house chores before leaving for school? Yes _____ No______
6. What do you do? ____
7. At what time do you get at school? ______________________
8. At what time do you finish classes? ______________________
9. What are your activities when you are in the classroom?________________________

____

10. Do you have a physical education class? Yes ________ No ________
11. How many days a week you have a PE class? ___________________
12. How much time of physical education per day? _________________
13. At what time you get the school break? _______________________
14. How do you spend the break time (sitting, standing, chating, eating, running, playing)?

____

____

15. At what time do you return home after school?_______________________________
16. At what time you have lunch? ____
17. What do you do after school and before lunch? ______________________________

____

18. What do you do after lunch? ____________________________________
19. Do you do household chores Yes ________ No ________

20. What are your chores? ____

____

21. Do you do homework? Yes __________ No ________

22. How long it takes to do your homework? ________________________________

23. Do you have TV? Yes _______ No ________

24. How many hours you watch TV each day? ________________

25. Do you have a night meal (dinner)?Yes _______ No ________

26. What do you do in your spare time[after you are done with chores, homework] before going to bed? ____

____

27. At what time do you go to bed?___________________________________

28. Do you do sports? Yes __________ No _________

29. What sports? (football basketball, other) ___________________________________

____

30. When and how long do you do sports (other places after school)?

____

31. What do you do when you are with your:

Father ____

Mother ____

Grandparents ____

Aunts/uncles ____

Brothers ____

Sisters ____

Boy friends ____

Girls friends ____

32. What do you do on Saturdays? ____

____

33. What do you do on Sundays? ____

(weekend activities: household chores, working activities with parents, brothers, sisters games, go out of town).

34. What do you like to do or to play the most? ______________________________

____

35. What are the games played by children your age? ___________________________

____

36. What are the games played by children older than you? ______________________

____

37. What are the games played by children younger than you?_____________________

____

APPENDIX III

TABLES OF DESCRIPTIVE STATISTICS

Table III.1. Descriptive statistics (means and standard deviations) for weight, height and the body mass index (BMI) by age group in rural and urban children.

MALES:

Age	Weight, kg				Height, cm				BMI, kg/m^2			
	Rural		Urban		Rural		Urban		Rural		Urban	
Group	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
6	20.8	3.9	21.2	3.2	112.9	6.6	113.5	3.2	16.2	1.7	16.4	2.1
7	22.5	4.2	22.9	3.1	117.3	5.2	118.9	4.9	16.3	2.0	16.2	1.6
8	24.0	3.2	25.6	3.4	120.7	5.2	123.8	4.3	16.4	1.2	16.7	1.6
9	26.4	4.0	28.0	4.9	126.2	5.6	128.9	5.0	16.5	1.6	16.8	2.0
10	29.1	4.8	35.9	9.2	130.4	5.1	135.3	6.3	17.0	1.8	19.4	3.4
11	31.9	6.3	34.0	5.5	135.8	6.5	137.7	6.7	17.1	2.0	17.9	1.7
12	33.6	6.2	38.3	6.5*	142.0	6.3	144.9	10.2	16.5	2.2	18.8	2.7*
13	36.7	5.5	35.0	-	142.4	6.5	142.0	-	18.0	1.4	17.4	-

FEMALES:

Age	Weight, kg				Height, cm				BMI, kg/m^2			
	Rural		Urban		Rural		Urban		Rural		Urban	
Group	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
6	19.3	2.1	21.0	2.3	111.5	4.7	113.5	4.1	15.5	1.1	16.3	1.5
7	20.2	2.4	23.4	4.0	115.2	4.7	119.6	6.6	15.2	1.1	16.3	1.8
8	24.5	4.8	27.0	4.3	122.0	6.4	125.9	6.4	16.3	2.0	17.0	1.8
9	27.6	5.2	29.6	5.6	126.6	5.0	129.7	5.9	17.1	2.5	17.5	2.3
10	29.4	5.6	30.4	5.4	130.1	6.9	133.2	7.5	17.3	2.3	17.1	2.3
11	34.2	6.2	37.2	8.8	137.3	6.1	141.4	7.1	18.1	2.1	18.4	3.1
12	42.1	8.8	41.9	7.5*	145.3	5.9	146.3	5.4	19.8	2.7	19.8	2.5*
13	38.4	5.4	45.2	-	144.5	6.8	153.8	-	18.3	1.5	19.1	-

*One male and one female in the respective age groups were obese; their weight and BMI are not included in the descriptive statistics.

Table III.2. Descriptive statistics (means and standard deviations) for sitting height, estimated leg length and the sitting height/height ratio (SH/H Ratio) by age group in rural and urban children.

MALES:

	Sitting Height, cm				Leg Length, cm				SH/H Ratio, %			
Age	Rural		Urban		Rural		Urban		Rural		Urban	
Group	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
6	62.4	3.6	62.9	2.4	50.5	3.4	50.6	1.9	55.3	1.1	55.4	1.2
7	64.5	2.9	65.5	2.5	52.8	2.8	53.4	3.2	55.0	1.0	55.1	1.4
8	66.0	3.0	67.6	2.1	54.7	3.1	56.2	2.9	54.7	1.4	54.6	1.2
9	68.3	3.1	69.6	2.7	57.8	3.3	59.3	3.4	54.2	1.2	54.0	1.5
10	70.0	2.3	72.3	3.4	60.4	3.2	63.0	3.5	53.7	1.0	53.4	1.0
11	71.2	2.8	73.0	3.1	64.6	4.6	64.6	4.3	52.4	1.6	53.1	1.2
12	75.0	3.0	76.7	4.7	67.0	3.9	68.3	5.8	52.8	1.2	52.9	1.0
13	75.3	3.7	74.2	-	67.1	3.6	67.8	-	52.9	1.1	52.2	-

FEMALES:

	Sitting Height, cm				Leg Length, cm				SH/H Ratio, %			
Age	Rural		Urban		Rural		Urban		Rural		Urban	
Group	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
6	61.8	2.6	62.8	2.6	49.7	2.8	50.8	2.1	55.5	1.3	55.3	1.0
7	62.9	2.6	65.2	3.5	52.3	3.8	54.4	3.8	54.6	2.1	54.5	1.4
8	66.3	2.9	67.8	3.6	55.8	3.8	58.0	3.6	54.3	1.2	53.9	1.3
9	68.2	2.1	69.8	3.4	58.4	3.4	59.9	3.3	53.9	1.2	53.8	1.2
10	69.5	3.3	70.9	4.3	60.6	4.0	62.3	4.2	53.5	1.0	53.3	1.5
11	73.6	3.0	74.9	4.5	63.7	3.7	66.5	3.7	53.6	1.0	53.0	1.4
12	75.6	6.7	77.5	2.3	69.8	1.9	68.8	4.4	51.9	2.7	53.0	1.6
13	77.5	3.9	82.1	-	67.0	3.4	71.7	-	53.7	0.9	53.4	-

Table III.3. Descriptive statistics (means and standard deviations) for skeletal breadths by age group in rural and urban children: MALES.

	Biacromial, cm				Bicristal, cm			
Age	Rural		Urban		Rural		Urban	
Group	Mean	SD	Mean	SD	Mean	SD	Mean	SD
6	26.0	2.1	26.5	1.1	18.9	1.2	19.0	1.0
7	26.8	1.8	27.6	1.2	19.3	1.4	20.0	1.1
8	27.6	1.6	28.6	1.3	19.7	1.1	20.4	0.8
9	28.9	1.3	29.6	1.6	20.5	1.3	21.4	1.2
10	29.7	1.4	31.5	1.9	21.1	1.3	23.1	2.0
11	30.5	2.0	31.4	1.8	21.8	1.4	22.8	1.5
12	32.3	1.6	33.7	3.3	22.2	1.6	24.9	3.8
13	32.5	1.3	32.8	-	22.5	1.0	22.9	-

	Bicondylar, cm				Biepicondylar, cm			
Age	Rural		Urban		Rural		Urban	
Group	Mean	SD	Mean	SD	Mean	SD	Mean	SD
6	7.2	0.5	7.4	0.5	4.6	0.3	4.7	0.4
7	7.4	0.5	7.6	0.3	4.7	0.4	4.7	0.3
8	7.7	0.4	7.8	0.4	4.8	0.3	4.8	0.3
9	7.9	0.5	8.0	0.4	5.0	0.4	5.0	0.3
10	8.1	0.4	8.5	0.6	5.2	0.4	5.5	0.5
11	8.3	0.5	8.5	0.4	5.3	0.4	5.4	0.4
12	8.6	0.5	9.0	0.9	5.4	0.4	5.8	0.7
13	8.7	0.5	8.8	-	5.7	0.3	5.6	-

Table III.4. Descriptive statistics (means and standard deviations) for skeletal breadths by age group in rural and urban children: FEMALES.

	Biacromial, cm				Bicristal, cm			
Age	Rural		Urban		Rural		Urban	
Group	Mean	SD	Mean	SD	Mean	SD	Mean	SD
6	25.5	0.9	26.4	1.0	18.3	1.1	19.2	0.9
7	26.1	1.2	27.4	1.5	18.5	0.9	19.8	1.3
8	27.7	1.8	28.7	1.6	20.1	1.4	21.2	1.5
9	29.1	1.6	29.9	1.4	21.0	1.4	22.0	1.5
10	29.6	1.8	30.3	2.2	21.2	1.4	22.1	1.5
11	31.5	1.4	32.2	2.9	22.4	1.4	23.5	1.6
12	33.5	1.4	34.3	2.7	24.9	1.4	25.5	2.3
13	32.7	2.1	34.0	-	23.5	1.8	26.3	-

	Bicondylar, cm				Biepicondylar, cm			
Age	Rural		Urban		Rural		Urban	
Group	Mean	SD	Mean	SD	Mean	SD	Mean	SD
6	6.9	0.4	7.1	0.3	4.4	0.2	4.6	0.2
7	6.9	0.3	7.2	0.4	4.5	0.2	4.6	0.3
8	7.4	0.5	7.6	0.4	4.8	0.3	4.8	0.3
9	7.7	0.5	7.9	0.5	4.9	0.3	5.0	0.4
10	7.9	0.5	7.9	0.5	5.0	0.4	5.1	0.4
11	8.2	0.4	8.3	0.5	5.2	0.3	5.3	0.4
12	8.4	0.4	8.6	0.6	5.7	0.1	5.6	0.5
13	8.4	0.5	8.3	-	5.6	0.3	5.5	-

Table III.5. Descriptive statistics (means and standard deviations) for limb circumferences by age group in rural and urban children: MALES.

	Arm Circumference, cm				Calf Circumference, cm			
Age	Rural		Urban		Rural		Urban	
Group	Mean	SD	Mean	SD	Mean	SD	Mean	SD
6	16.9	1.4	17.2	1.8	22.6	1.6	23.2	1.7
7	17.2	1.8	17.4	1.4	23.1	1.9	23.7	1.3
8	17.7	1.3	18.0	1.7	24.2	1.5	24.5	1.6
9	18.3	1.8	18.5	1.8	24.9	1.8	25.6	1.7
10	18.7	1.5	21.2	2.9	25.7	1.9	28.2	2.8
11	19.6	2.2	20.1	1.7	26.7	2.3	27.6	2.0
12	19.7	2.3	22.4	4.8	27.2	2.1	29.8	5.0
13	20.4	1.6	20.1	-	28.3	1.7	28.1	-

	Estimated Arm Muscle Circumference, cm				Estimated Calf Muscle Circumference, cm			
Age	Rural		Urban		Rural		Urban	
Group	Mean	SD	Mean	SD	Mean	SD	Mean	SD
6	14.5	1.1	14.8	1.5	20.2	1.2	20.6	1.5
7	14.8	1.3	15.1	1.3	20.7	1.5	21.3	1.2
8	15.4	1.0	15.5	1.4	21.8	1.1	21.9	1.3
9	15.9	1.3	16.0	1.7	22.3	1.6	23.0	1.6
10	16.1	1.5	18.2	2.4	23.1	1.7	25.1	2.2
11	17.0	1.7	17.1	1.7	24.1	1.9	24.7	1.9
12	17.7	1.7	19.5	3.9	25.0	1.9	26.4	4.1
13	18.2	1.2	18.5	-	25.6	1.3	25.4	-

Table III.6. Descriptive statistics (means and standard deviations) for limb circumferences by age group in rural and urban children: FEMALES.

	Arm Circumference, cm				Calf Circumference, cm			
Age	Rural		Urban		Rural		Urban	
Group	Mean	SD	Mean	SD	Mean	SD	Mean	SD
6	16.5	1.1	17.4	1.1	22.3	1.3	23.3	1.2
7	16.6	1.1	17.7	1.5	22.5	1.2	23.7	1.9
8	18.3	2.0	18.6	1.8	24.1	2.1	25.2	1.8
9	19.0	2.1	19.1	2.0	24.8	3.4	26.0	2.1
10	19.3	2.2	19.4	1.7	26.0	2.4	26.3	2.1
11	20.6	1.7	21.1	2.4	27.3	2.2	28.3	2.4
12	21.9	1.6	23.2	3.0	29.9	1.4	30.2	2.9
13	20.9	1.8	21.9	-	28.1	1.4	30.5	-

	Estimated Arm Muscle Circumference, cm				Estimated Calf Muscle Circumference, cm			
Age	Rural		Urban		Rural		Urban	
Group	Mean	SD	Mean	SD	Mean	SD	Mean	SD
6	13.9	0.8	14.6	1.0	19.7	1.1	20.6	1.0
7	14.0	1.0	15.0	1.4	20.0	1.0	20.9	1.6
8	15.5	1.6	15.9	1.6	21.2	1.7	22.4	1.6
9	16.1	1.6	16.3	1.9	21.8	2.9	23.0	1.7
10	16.3	1.9	16.6	1.6	22.6	2.0	23.3	1.7
11	17.5	1.6	18.2	2.0	23.9	1.9	25.0	2.0
12	18.4	1.8	19.6	2.5	26.2	1.3	26.3	2.3
13	17.7	1.8	18.9	-	24.9	1.6	27.2	-

Table III.7. Descriptive statistics (means, standard deviations and medians) for skinfold thicknesses by age group in rural and urban children: MALES.

	Triceps Skinfold, mm						Subscapular Skinfold, mm					
Age	Rural			Urban			Rural			Urban		
Group	Mean	SD	MD	Mean	SD	MD	Mean	SD	MD	Mean	SD	MD
6	7.8	1.8	7.0	7.8	1.6	7.0	6.0	2.2	6.0	6.1	2.3	6.0
7	7.5	2.0	7.0	7.4	1.3	8.0	6.7	2.3	6.0	5.9	1.7	6.0
8	7.5	1.9	7.0	8.0	1.7	8.0	6.3	2.0	6.0	6.8	2.4	6.0
9	7.6	2.2	8.0	7.9	1.6	8.0	6.7	2.3	6.0	7.0	2.1	7.0
10	8.0	2.4	7.0	9.6	2.1	9.0	7.1	2.8	6.0	9.6	3.7	8.0
11	8.3	2.1	8.0	9.3	2.6	9.0	7.5	2.7	6.0	8.1	2.1	8.0
12	6.2	2.6	5.0	9.3	3.4	8.0	7.3	3.0	7.0	10.6	6.9	9.0
13	7.1	1.6	7.0	5.0	-	-	7.9	2.8	7.0	6.5	-	-

	Suprailiac Skinfold, mm						Medial Calf Skinfold, mm					
Age	Rural			Urban			Rural			Urban		
Group	Mean	SD	MD	Mean	SD	MD	Mean	SD	MD	Mean	SD	MD
6	7.7	2.8	7.0	8.4	2.5	8.0	7.6	2.2	7.0	8.3	1.5	8.0
7	8.2	3.1	7.0	8.2	2.1	8.0	7.9	2.5	8.0	7.6	1.8	8.0
8	8.3	2.8	8.0	9.3	3.1	9.0	7.6	1.9	7.0	8.3	1.9	8.0
9	8.9	3.3	8.0	9.5	2.3	9.0	8.0	1.9	8.0	8.2	1.6	8.0
10	8.9	3.2	8.0	12.4	3.9	12.0	8.2	2.3	8.0	9.7	2.7	9.0
11	8.7	4.0	8.0	11.1	3.0	11.0	8.3	1.9	8.0	9.2	1.9	8.0
12	8.3	3.8	7.0	13.2	6.6	12.0	7.1	2.0	8.0	10.7	4.4	10.0
13	8.6	2.8	8.0	6.5	-	-	8.4	2.7	8.0	8.5	-	-

Table III.8. Descriptive statistics (means, standard deviations and medians) for skinfold thicknesses by age group in rural and urban children: FEMALES.

	Triceps Skinfold, mm						Subscapular Skinfold, mm					
Age	Rural			Urban			Rural			Urban		
Group	Mean	SD	MD	Mean	SD	MD	Mean	SD	MD	Mean	SD	MD
6	8.3	2.1	8.0	8.7	1.5	8.0	6.9	2.4	7.0	7.1	2.1	7.0
7	8.3	1.9	8.0	8.4	1.5	8.0	6.3	1.7	6.0	7.5	2.6	7.0
8	9.1	2.3	8.0	8.5	1.4	8.0	8.2	3.4	8.0	8.0	2.2	8.0
9	9.0	2.3	8.0	8.8	1.8	8.0	8.7	3.6	8.0	9.0	2.8	8.0
10	9.7	2.4	9.0	8.9	1.5	9.0	9.6	4.1	8.0	8.3	2.4	9.0
11	10.0	2.2	10.0	9.1	1.7	9.0	10.2	2.6	10.0	9.8	2.8	10.0
12	11.0	1.4	12.0	11.3	2.8	12.0	12.5	3.9	14.0	12.1	4.3	12.0
13	10.3	2.1	11.0	9.5	-	-	10.6	1.7	11.0	11.5	-	-

	Suprailiac Skinfold, mm						Medial Calf Skinfold, mm					
Age	Rural			Urban			Rural			Urban		
Group	Mean	SD	MD	Mean	SD	MD	Mean	SD	MD	Mean	SD	MD
6	7.8	2.6	7.0	8.5	1.8	8.0	8.3	1.9	8.0	8.5	1.4	8.0
7	8.4	3.0	8.0	9.4	2.7	9.0	8.2	1.6	8.0	8.7	1.5	8.0
8	10.2	2.8	10.0	9.9	2.7	10.0	9.4	2.5	9.0	9.0	2.3	9.0
9	10.7	3.9	11.0	10.5	3.2	9.0	9.7	3.3	8.0	9.8	2.3	9.0
10	11.4	4.0	10.0	10.5	2.5	10.0	10.7	3.1	11.0	9.6	2.0	9.0
11	12.7	2.7	13.0	12.0	2.8	11.0	11.0	2.3	11.0	10.6	2.1	11.0
12	13.0	1.4	14.0	14.3	3.8	13.0	11.7	1.3	12.0	12.4	3.9	12.0
13	12.8	1.5	13.0	15.0	-	-	10.0	1.0	10.0	10.5	-	-

Table III.9. Descriptive statistics (means, standard deviations and medians) for the sum of four skinfold thicknesses (triceps, subscapular, suprailiac, medial calf) and the trunk-extremity ratio (TER, subscapular + suprailiac/triceps + medial calf) by age group in rural and urban children.

MALES

	Sum of Skinfolds, mm						TER					
Age	Rural			Urban			Rural			Urban		
Group	Mean	SD	MD	Mean	SD	MD	Mean	SD	MD	Mean	SD	MD
6	29.0	8.3	27.0	30.5	6.6	28.5	0.87	0.15	0.87	0.90	0.23	0.90
7	30.3	8.8	27.0	29.1	5.7	29.0	0.97	0.20	0.92	0.94	0.15	1.00
8	29.7	7.8	28.5	32.5	8.0	31.0	0.96	0.16	0.92	0.98	0.22	1.00
9	31.2	8.5	29.0	32.5	6.1	32.0	1.00	0.22	1.00	1.03	0.21	1.06
10	32.2	9.2	29.5	41.3	11.4	38.0	0.99	0.25	0.93	1.13	0.22	1.11
11	32.8	9.7	30.0	37.9	7.0	37.0	0.95	0.24	1.00	1.05	0.21	1.06
12	29.0	9.9	25.0	43.8	20.5	37.5	1.16	0.26	1.10	1.17	0.25	1.10
13	31.9	8.6	30.5	26.5	-	-	1.07	0.20	1.08	0.97	-	-

FEMALES

	Sum of Skinfolds, mm						TER					
Age	Rural			Urban			Rural			Urban		
Group	Mean	SD	MD	Mean	SD	MD	Mean	SD	MD	Mean	SD	MD
6	31.3	7.8	30.0	32.8	5.6	32.0	0.88	0.17	0.83	0.90	0.16	0.87
7	31.2	6.4	30.0	34.1	6.8	34.0	0.89	0.20	0.89	0.98	0.23	0.95
8	36.8	9.9	34.5	35.3	7.7	34.0	1.00	0.19	1.00	1.01	0.16	1.06
9	38.0	12.3	32.5	38.1	8.7	35.0	1.03	0.21	1.02	1.05	0.20	1.04
10	41.5	11.7	38.0	37.4	6.6	36.0	1.02	0.21	1.00	1.02	0.23	0.95
11	43.9	8.1	43.0	41.4	8.1	42.0	1.10	0.19	1.11	1.10	0.18	1.07
12	48.3	5.9	50.0	50.1	13.9	49.0	1.12	0.21	1.17	1.12	0.16	1.16
13	43.8	5.3	43.5	46.5	-	-	1.14	0.08	1.13	1.30	-	-

Table III.10. Descriptive statistics (means and standard deviations) for muscular strength by age group in rural and urban children: MALES

	Right Grip, kg				Left Grip, kg			
Age	Rural		Urban		Rural		Urban	
Group	Mean	SD	Mean	SD	Mean	SD	Mean	SD
6	9.5	1.8	9.6	1.9	8.7	1.9	9.1	1.9
7	10.9	1.7	11.2	2.3	10.3	2.2	10.7	2.3
8	12.0	2.6	12.3	2.8	11.2	2.7	12.2	2.5
9	14.9	2.6	14.3	2.7	14.0	2.9	13.6	2.4
10	16.3	3.0	17.9	4.1	15.2	2.9	17.0	4.4
11	18.3	3.6	18.1	3.4	17.0	4.0	17.4	3.9
12	21.4	2.8	22.0	7.0	19.3	2.9	20.3	5.9
13	22.6	3.4	20.5	-	20.6	3.5	22.0	-

	Sum Right + Left Grip, kg				Sum Grip/Weight, kg/kg			
Age	Rural		Urban		Rural		Urban	
Group	Mean	SD	Mean	SD	Mean	SD	Mean	SD
6	18.2	3.6	18.8	3.6	0.89	0.14	0.89	0.17
7	21.2	3.7	21.8	4.4	0.95	0.13	0.96	0.19
8	23.2	5.1	24.5	5.1	0.97	0.17	0.96	0.18
9	28.9	5.2	27.9	4.9	1.10	0.17	1.01	0.15
10	31.5	5.7	34.9	8.1	1.09	0.16	0.99	0.15
11	35.3	7.5	35.5	7.2	1.11	0.12	1.05	0.15
12	40.8	5.2	42.3	12.8	1.24	0.17	0.99	0.15
13	43.2	6.7	42.5	-	1.18	0.10	1.21	-

Sum Grip/Weight is the sum of right and left grip strength divided by body weight.

Table III.11. Descriptive statistics (means and standard deviations) for muscular strength by age group in rural and urban children: FEMALES

	Right Grip, kg				Left Grip, kg			
Age	Rural		Urban		Rural		Urban	
Group	Mean	SD	Mean	SD	Mean	SD	Mean	SD
6	8.8	1.4	8.5	1.5	7.7	1.4	7.8	1.6
7	9.3	2.2	10.2	2.0	8.6	1.9	9.6	2.1
8	11.6	2.3	12.3	2.6	10.7	2.5	11.6	2.9
9	14.2	2.7	13.5	2.5	13.1	2.5	12.5	1.9
10	15.3	2.9	15.2	3.3	13.6	2.9	14.0	3.2
11	18.0	2.7	17.9	4.3	16.3	3.3	17.1	3.5
12	21.0	3.6	19.9	4.3	20.3	2.6	19.9	3.4
13	21.6	3.4	26.0	-	19.8	3.6	23.5	-

	Sum Right + Left Grip, kg				Sum Grip/Weight, kg/kg			
Age	Rural		Urban		Rural		Urban	
Group	Mean	SD	Mean	SD	Mean	SD	Mean	SD
6	16.5	2.5	16.3	2.7	0.86	0.12	0.77	0.11
7	17.9	4.0	19.8	3.9	0.89	0.17	0.85	0.14
8	22.2	4.5	23.9	5.3	0.91	0.14	0.88	0.13
9	27.4	5.1	26.0	4.2	1.00	0.16	0.89	0.15
10	28.9	5.6	29.2	6.3	1.00	0.16	0.97	0.17
11	34.3	5.8	35.0	7.6	1.01	0.11	0.96	0.17
12	41.3	5.3	39.7	7.4	0.99	0.07	0.90	0.22
13	41.4	6.8	49.5	-	1.08	0.14	1.12	-

Sum Grip/Weight is the sum of right and left grip strength divided by body weight.

Table III.12. Descriptive statistics (means and standard deviations, medians for sit-ups) for indicators of physical fitness by age group in rural and urban children: MALES

Age	Sit and Reach, cm				Sit-Ups, n/30 sec					
	Rural		Urban		Rural			Urban		
Group	Mean	SD	Mean	SD	Mean	SD	MD	Mean	SD	MD
6	26.5	4.5	27.9	3.8	5.7	4.3	7.0	8.4	4.8	9.0
7	26.8	3.6	28.4	4.0	8.4	3.4	9.0	10.9	4.0	12.0
8	26.4	4.1	27.9	3.8	7.2	4.4	8.0	12.6	5.0	13.0
9	25.7	4.9	27.9	4.5	9.3	3.9	10.0	13.2	4.8	14.0
10	28.1	5.3	26.4	5.2	11.9	4.3	12.0	13.4	4.7	14.0
11	26.0	4.5	27.6	4.8	12.4	3.9	13.0	14.5	3.1	14.0
12	25.1	5.8	26.8	6.6	11.2	1.5	11.0	14.4	5.7	15.0
13	27.0	4.1	30.8	-	13.4	2.2	13.0	17.0	-	

Age	Standing Long Jump, cm				35 Yard (32.3 m) Dash, sec			
	Rural		Urban		Rural		Urban	
Group	Mean	SD	Mean	SD	Mean	SD	Mean	SD
6	77.3	14.2	93.4	19.2	7.81	0.55	7.97	0.54
7	89.8	17.7	98.3	18.6	7.43	0.41	7.62	0.55
8	91.5	20.9	110.0	15.8	7.31	0.67	7.22	0.47
9	103.0	19.4	122.1	16.7	6.80	0.49	7.10	0.58
10	107.9	21.6	130.3	14.6	6.75	0.45	6.59	0.54
11	119.5	10.6	123.9	18.9	6.72	0.31	6.53	0.56
12	109.0	32.5	135.9	23.0	6.45	0.38	6.25	0.48
13	116.1	20.1	159.1	-	6.43	0.26	5.79	-

Table III.13. Descriptive statistics (means and standard deviations, medians for sit-ups) for indicators of physical fitness by age group in rural and urban children: FEMALES

	Sit and Reach, cm				Sit-Ups, n/30 sec					
Age	Rural		Urban		Rural			Urban		
Group	Mean	SD	Mean	SD	Mean	SD	MD	Mean	SD	MD
6	27.3	4.0	26.7	3.8	4.2	3.9	3.0	6.6	4.8	6.0
7	26.8	3.2	29.2	4.6	7.4	4.2	8.0	8.4	4.9	8.0
8	27.0	3.9	27.6	3.5	7.0	3.7	8.0	10.7	4.7	12.0
9	27.7	5.1	27.5	5.7	7.0	4.3	9.0	11.0	4.4	12.0
10	25.3	4.1	29.2	5.0	8.6	4.8	9.0	10.4	4.4	11.0
11	27.7	4.3	27.8	5.5	7.6	5.0	9.0	12.3	3.4	12.0
12	27.3	3.2	30.5	6.1	4.0	0.8	4.0	10.1	5.3	11.0
13	25.8	4.0	28.0	-	12.6	4.0	14.0	11.5	-	-

	Standing Long Jump, cm				35 Yard (32.3 m) Dash, sec			
Age	Rural		Urban		Rural		Urban	
Group	Mean	SD	Mean	SD	Mean	SD	Mean	SD
6	61.6	16.4	75.5	14.6	8.68	0.57	8.84	0.70
7	74.5	17.6	86.1	25.1	8.04	0.81	8.37	0.83
8	85.0	18.8	98.1	15.8	7.69	0.73	7.89	0.51
9	91.3	23.0	104.0	14.0	7.47	0.60	7.56	0.61
10	90.2	15.1	107.1	18.6	7.36	0.38	7.08	0.63
11	90.9	16.0	113.2	11.7	7.19	0.59	6.78	0.51
12	88.8	12.6	114.3	12.2	7.22	0.47	7.01	0.67
13	86.5	9.2	94.1	-	7.09	0.85	7.57	-

Table III.14. Descriptive statistics (means, standard deviations, medians) for the distance run (meters) by age group in rural and urban children.

MALES

		Rural			Urban	
Grade	Mean	SD	Median	Mean	SD	Median
1*	1172	142	1170	1028	117	1020
2	1228	157	1230	1064	133	1086
3	1209	140	1230	1147	164	1109
4**	1767	213	1765	1742	272	1792
5	1840	222	1820	1805	219	1840
6	2104	226	2170	1908	303	1898

FEMALES

		Rural			Urban	
Grade	Mean	SD	Median	Mean	SD	Median
1*	1095	130	1090	985	88	974
2	1070	152	1070	1045	123	1071
3	1200	194	1159	1098	143	1116
4**	1618	234	1614	1668	231	1650
5	1556	205	1612	1573	227	1581
6	1742	193	1770	1810	204	1797

*For grades 1-3, it is the distance run in 8 minutes.

**For gtrades 4-6, it is the distance run in 12 minutes.

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