Stunting is Associated with Overweight in Children of Four Nations That Are Undergoing the Nutrition Transition[1]

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ABSTRACT A higher risk of obesity in stunted children has been described in Hispanic-American, Jamaican and Andean populations, but little systematic exploration has been done concerning this area in nutrition. This paper examines the relationship between stunting and overweight status for children aged 3-6 and 7-9 y in nationally representative surveys in Russia, Brazil, and the Republic of South Africa and a large nationwide survey in China. Using identical cut-offs for body mass index, the prevalence of child overweight in these countries ranges from 10.5 to 25.6% (based on the 85th percentile); recent NHANES III results indicate that this prevalence is around 22% in the U.S. Stunting is also common in the surveyed countries affecting 9.2-30.6% of all children. Our results showed a significant association between stunting and overweight status in children of all countries. The income-adjusted risk ratios of being overweight for a stunted child ranged from 1.7 to 7.8. Clearly, there is an important association between stunting and high weight-for-height in a variety of ethnic environmental and social backgrounds. Although the underlying mechanisms remain unexplored, this association has serious public health implications particularly for lower income countries. As these countries enter the nutrition transition experiencing large changes in dietary and activity patterns, they may face, among other problems, additional difficulties in their fight against obesity. J. Nutr. 126: 3009-3016, 1996.

INDEXING KEY WORDS:

- *humans* • *child obesity* • *stunting*
- *programming*

There is limited documentation showing that subpopulations of Hispanic-American, Jamaican, and Andean children are stunted and obese or overweight (Adrienzen 1973, Forrester et al. 1996, Martorell et al. 1987, Trowbridge et al. 1987). At the same time, various hypotheses propose that nutritional insults during pregnancy or infancy may have long-term effects on a wide range of metabolic and other physiological relationships (Barker 1992 and 1994). Barker and his colleagues have shown that adults with low weight at age 1 y or low birth weights have a greater tendency to store fat abdominally (Law et al. 1992). In addition, Ravelli et al. (1976) found that males who experienced famine during the first half of gestation were more likely to become obese as young adults. We present information on the distribution of the relationship between stunting and overweight status over a range of environments and genetic backgrounds. This relationship between stunting and fat deposition was not apparent prior to the shift in incomes and the related changes in diet and activity levels in most low income countries, because stunted children had little opportunity, in terms of economic conditions, lifestyles, and resource availability, to become obese. The emergence of this nutrition transition with its rapid shifts in the composition of diet and activity patterns and subsequent shifts in body composition suggests that this relationship might lead to considerable obesity over the next several decades, affecting individuals living in environments in which current infant feeding and morbidity patterns during infancy are associated with extensive stunting (Popkin 1994). Rapid shifts in the

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structure of diets and activity patterns might lead to a major problem of obesity among these stunted children. This article attempts to direct research attention toward this topic.

It is possible that linkages between stunting and obesity are biological in origin. Barker (1992 and 1994) suggests that an infant's major adaptation to undernutrition is a reduced growth rate and related changes in fetal hormone production that yield long-term effects including changes in insulin and growth hormone. Barker has also found in a series of studies on small samples of English adults that low birth weight (particularly disproportionate growth) was related to subsequent abdominal obesity and a wide range of hormonal changes, associated with syndrome X (Barker 1992). In addition, he has shown that growth retardation is associated with later obesity and a range of hormonal changes. A rapidly emerging literature is revealing an important role related to diabetes and other biological complications for fetal and infant nutritional insults in the U.S. and elsewhere (Forrester et al. 1996, Hales et al. 1992, Valdez et al. 1994), but few have linked this with obesity. Others, including Dietz (1994) and Kumanyika (1993) link very high birth weight to subsequent obesity. These may represent two separate mechanisms, one associated with the effects of undernutrition during pregnancy and infancy, and the other with gestational diabetes and poor diet. Many others in a wide range of fields, including a recent Nobel Laureate in economics (Fogel 1994), have related shortness, a marker of deprivation early in life, to subsequent morbidity and mortality problems, even when body mass index (BMI)[3] or weight is controlled for.

The age at which stunting might relate to the development of obesity is unclear. Children have four periods of critical weight gain: the third trimester of gestation, early infancy, at age 5–7 y (adipose rebound) and during adolescence (Dietz 1994). Stunting remains a major problem in most low income countries; its prevalence ranges from 11% in urban African cities to 30–48% in many African, Asian, and Latin American urban and rural areas (Von Braun et al. 1993). The most complete review of this topic estimates that 43% of preschool children in lower income countries are stunted (de Onis et al. 1993). At the same time, changes in incomes and eating practices are clearly leading to higher fat diets among many segments of these societies (Popkin 1994).

We examine the relationship between stunting and overweight status in children in four countries at various stages of economic transition. The methods and databases for information on stunting and overweight status for the large countries of China, Brazil, Russia and the Republic of South Africa are presented in the next section followed by an analysis and a discussion.

SUBJECTS AND METHODS

We used data from four large nationwide surveys. The collection of the data in China and Russia followed informed consent procedures established by both the University of North Carolina at Chapel Hill institutional review board and the institutional review boards of the Chinese Academy of Preventive Medicine and the Russian Institute of Sociology, Academy of Sciences. In both surveys, families were informed about the study and its costs and benefits and asked to cooperate. The Brazilian and South African data sets were collected by organizations in those countries and followed procedures established by the Instituto Brasileiro de Geografia e Estatistica and the University of Capetown, respectively. In all cases, a cross-section of information is examined. The objective of this study was the analysis of large representative samples of children that allowed us to examine the relative risk of overweight among stunted children. Moreover, each of these data sets contains measures of income or expenditures for the households, which provide a basis for controlling for economic status.

China. The China Health and Nutrition Survey (CHNS) is an on-going, longitudinal survey that covers eight provinces in China: Guangxi, Guizhou, Henan, Hubei, Hunan, Jiangsu, Liaoning and Shangdong. Although this survey is not nationally representative, these provinces were selected to provide significant variability in geography, economic development, and health indicators such that they may be considered to be generally representative of all provinces in the country. A multistage, random, cluster sampling procedure was used to draw the sample from each province. Data were collected from all household members. Trained teams measured weight using calibrated, portable spring scales with the individuals wearing light clothes and no shoes. We used data from the CHNS 1991 and 1993, with samples consisting of 1755 and 1637 3- to 9-y-old children, respectively. Additional detail on the research design of this survey is presented elsewhere (e.g., Popkin et al. 1995).

Russia. The Russian Longitudinal Monitoring Survey (RLMS) is a household-based survey designed to monitor systematically the effects of the Russian reforms on the economic well-being of households and individuals. The first nationally representative sample of the Russian Federation was developed specifically for this survey. We used data from the first round of phase 2 of the 1994/95 RLMS for this survey, on a sample of 1106 3- to 9-y-old children. Additional detail

[3] Abbreviations used: BMI, body mass index; CHNS, China Health and Nutrition Survey; IBGE, Instituto Brasileiro de Geografia e Estastistica; LSMS, Living Standards Measurements Survey; NCHS, National Center for Health Statistics; NHES, National Health and Examination Survey; RLMS, Russian Longitudinal Monitoring Survey; RR, relative risk; TSF, triceps skinfold.

on the research design of this survey is found elsewhere (Mroz and Popkin 1995, Popkin et al. 1996). Data collection is identical with that for our China survey except that, in China, doctors and nutritionists collected all data, whereas in Russia, this was done by trained nonmedical interview specialists.

Republic of South Africa. We used data from the Living Standards Measurement Survey (LSMS) as adapted by a group of social science researchers in South Africa. Collected in 1994, this was the first attempt to develop a representative sample for the Republic of South Africa. Census enumeration districts were used as the first stage when possible, and in the former homelands, villages or village groups were used with a probability proportionate to their size. The second stage was a random sample of noninstitutionalized households, which incorporated migrant labor hostels. The final sample consisted of 8848 households and involved 43,974 individuals. The 12.7% of the sample aged 0–6 y was surveyed for weight and height. For each child, the exact date of birth was obtained. Techniques standardized by the World Bank set of LSMS were followed for collecting weight and height data.

Brazil. Data in this study came from a random national nutrition survey undertaken by the Brazilian agency in charge of national statistics (Instituto Brasileiro de Geografia e Estatistica, IBGE), from June to September 1989. Details of the methodologies used in the survey have been described previously (Monteiro et al. 1992). Multistage stratified clustering sampling was used. The survey consisted of 14,455 households with data collected from all household members. We focused on children aged 1–9 y (11,109 in 1989). Trained teams measured weight using calibrated, portable spring scales with the individuals wearing light clothes and no shoes.

Measures. Height-for-age and weight-for-height expressed in Z-scores of the National Center for Health Statistics (NCHS)/WHO standard were used to assess stunting and overweight for children under age 10 y, respectively (WHO 1986). Children with height-for-age below two Z-scores were classified as stunted and those with weight-for-height above two Z-scores as overweight. Weight adjusted for height represents a measure of overweight and only indirectly measures obesity (Flegal 1993). Despite the limitations associated with using weight-for-height as an indirect measurement of child obesity, this indicator is the conventional measure used in most population studies of children (Gorstein et al. 1994).

BMI represents an alternative measure of overweight. Unfortunately there is no consistent set of BMI standards for preschool children. Later, we present BMI results for children aged 6 y and older. When these BMI measurements of overweight are used, our results do not change. Because this analysis focuses on children aged 3–9 y, we required a consistent standard for all ages and were forced to use the weight-for-height index.

While there are limitations and advantages related to the use of the weight-for-height index, there is still a need for a more direct measure of body fat. Ideally, a measure of total body fat is required that can be used for children in all four countries (cf. Bandini and Dietz 1987, Roche et al. 1981). As a simplified measure of body fat, triceps skinfold has been the site most frequently selected for a single measurement (Bandini and Dietz 1987, Dietz and Robinson 1993). For three of the countries in this study, weight and height were the only available measurements. In China in 1991, skinfold measurements were collected from a subsample of children. To determine how our measurement of overweight related to a more accurate measure of excess fat, we examined the mean and median triceps skinfold (TSF) for Chinese children with weight-for-heights above and below the 85th percentile. They were 7.5 and 7.0 mm, respectively, for non-overweight and 8.2 and 7.5 mm, respectively, for overweight children (t test; $P < 0.002$). For the same Chinese sample, we estimated the risk ratio of overweight for those with a TSF higher than the 85th percentile against a measure of weight-for-height based on overweight at the 85th percentile. The risk ratio for this relationship of overweight based on TSF with that for weight-for-height was 3.63 (CI:2.18–6.05). This subset of Chinese children experienced a lower prevalence of overweight, using triceps skinfolds above the 85th percentile, based on the age-specific cutoffs from NHANES I and II (Frisancho 1990). These results are not unusual, and a concern exists that the comparison of triceps skinfolds of Asian children to a U.S. reference population is not relevant. For example, Asian adults and adolescents have more subcutaneous adipose tissue on the trunk than on their limbs relative to other ethnic groups (Malina et al. 1995, Wang et al. 1994). These results suggest that we must be cautious in interpreting high weight-for-height measures in the Chinese children as indicative of overweight status.

Household income per capita was used to control for access to resources. All four surveys collected either detailed cash and in-kind measures of income, a complete set of expenditures, or both. The income per capita measure used in the analysis for China, Russia and Brazil is based on the combination of income from all sources divided by total household membership. In South Africa there was no measure of income. That survey used an alternate measure often used by economists, which was total family expenditures for food and all other goods and services purchased.

Statistics. The risk ratio was used to measure the association between being stunted and being overweight, that is, the probability of being overweight in the stunted subsample of each population divided by the probability of being overweight in the nonstunted sample. Confidence intervals at the 0.95 level are calculated. We present crude and income-adjusted risk ratios calculated according the Mantel-Haenszel procedure

TABLE 1

Prevalence of 6- to 8-y-old children with body mass index (BMI) higher than the U.S. reference—NHES 85th and 95th percentiles in five countries[1]

				South Africa (1994)		
NHES percentiles	NHANES III (1988–91)	China (1993)	Russia (1994–95)	Total	Only black and colored	Brazil (1989)
			%			
NHES 95th[3]						
Males	11.7	8.0	11.8	7.4	8.2	4.6
Females	13.7	9.2	8.1	4.1	4.5	3.3
NHES 85th[3]						
Males	21.3	14.1	25.6	25.0	23.0	12.8
Females	24.2	12.2	17.8	20.3	20.9	10.5

[1] Source: National Health and Examination Survey (NHES) BMI standards at the 95th and 85th percentiles; personal communications, Richard P. Troiano, National Center for Health Statistics, April, 1996.

[2] Source of NHANES III data: Troiano et al. 1995.

[3] Note: 6–8 y is equivalent to 72–108 mo.

(Hennekens and Buring 1987). Income control is essential in this case because income itself can be associated with stunting and overweight (usually in different directions).

Sample. Children aged 36–119.9 mo (3–9 y) are considered except for the South African sample for which children aged 36–91 mo were included. The sample was separated into 36–83.99 mo (3–6 y) and 84–119.9 mo (7–9 y). Children aged 0–35 mo were not considered because it is during this age that most stunting occurs (Waterlow 1988). By 36 mo, most stunting has taken place and children are proceeding on a normal height trajectory until adolescence; thus we can explore the association between stunted status and overweight status.

RESULTS

Children in the United States are thought to have very high levels of obesity (Troiano et al 1995). To put child overweight status in our sample countries in perspective, we looked at the high BMI status of our sample populations in reference to the United States. Comparisons of combined prevalence estimates for overweight children aged 6–8 y in five national surveys are presented in **Table 1** to contrast levels of child overweight status in the United States with those in our sample countries. The values in Table 1, adjusted for age, estimate the percentage of persons in each category with BMI at or above the sex- and age-specific overweight criteria defined by the National Health and Examination Survey (NHES) percentiles. Russian boys showed comparable overweight prevalences with that of the U.S. at the 95th percentile of BMI from NHES, with prevalences of 11.8 and 11.7%, respectively. Lower levels of overweight are experienced by boys in China and South Africa, and by girls in China, Russia, and South Africa than in the U.S. population. When the 85th percentile is used, the prevalence of overweight more than doubles in three of the study populations and became more comparable to the U.S. prevalences. However, in China the majority of overweight children are concentrated at the 95th percentile.

In **Table 2,** we present the prevalence rates for being stunted and overweight. The proportion of children who are stunted ranges from 15% in Brazil to close to 30.6% among black and colored South African children. In Russia, stunting is a relatively new phenomenon. As shown elsewhere, only in the last half decade, with the decline in social services and the provision of free or very inexpensive weaning food, has stunting emerged as a new nutrition problem (Mroz and Popkin 1995, Popkin et al. 1996).

A high weight-for-height is emerging as a growing nutrition concern among children not only in these sample countries but elsewhere in the low income world (Monteiro et al. 1995, Popkin 1994). The proportion of children who are overweight in each country varies from 3.6% in Brazil to 10.4% in China in 1993.

The effects of previous stunting on present overweight status can be assessed by examining the risk ratios in Table 2. For children in Brazil, there was apparently no association between stunting and a high weight-for-height because the risk ratio was 1.0. In the other countries, stunted children have a higher chance of being overweight: the risk ratios ranged from 2.6 in South African children (either black and colored or the total population of whites, Asians, blacks, and colored children) to 7.7 among Russians. There was no clear effect of age group on the magnitude of the association between stunting and overweight status.

Table 3 presents the effect of income control on the

TABLE 2

The relationship between stunted and overweight status

Country, year	Age, y (n)	Prevalence of stunted children	Prevalence of overweight children	Prevalence of overweight in stunted children	Prevalence of overweight in nonstunted children	Relative risk of overweight being stunted	Confidence interval (for RR)[1]
				%			
Russia							
1994/5	3–6 (607)	12.2	12.2	48.6	7.1	6.8	(4.7, 9.9)[2]
	7–9 (499)	5.6	6.2	35.7	4.5	8.0	(4.3, 14.8)[2]
	3–9 (1106)	9.2	9.5	45.1	5.9	7.7	(5.6, 10.5)
China							
1991	3–6 (1068)	32.4	8.2	17.0	4.0	4.2	(2.9, 6.3)
	7–9 (687)	26.6	9.5	20.8	5.4	3.9	(2.5, 6.0)
	3–9 (1755)	30.1	8.7	18.3	4.6	4.0	(3.0, 5.4)
1993	3–6 (949)	26.7	11.1	22.5	6.9	3.3	(2.3, 4.6)
	7–9 (688)	24.6	9.6	22.5	5.4	4.2	(2.7, 6.4)
	3–9 (1637)	25.9	10.4	22.4	6.3	3.6	(2.8, 4.7)
South Africa							
Total	3–6 (2467)	28.5	7.3	13.1	5.0	2.6	(2.0, 3.4)
Black and colored	3–6 (2229)	30.6	7.5	13.0	5.1	2.5	(1.9, 3.4)
Brazil	3–6 (6237)	16.6	4.0	3.5	4.0	0.9	(0.6, 1.2)
	7–9 (4872)	13.0	3.1	3.4	3.1	1.1	(0.7, 1.3)
	3–9 (11109)	15.0	3.6	3.5	3.6	1.0	(0.7, 1.3)

1 RR = relative risk.

2 The relative risks for the two age groups are not equal.

association between stunted and overweight status. It should be noted that income may act as a negative confounder for that association because wealth is usually associated, in different directions, with stunting and a high weight-for-height. Controlling for income in this case means essentially to make equal the two subgroups of stunted and non-stunted children regarding access to food and also to resources that affect activity levels of children, the central factors affecting child obesity. Data in Table 3 indicate that income control was particularly important in Brazil revealing that in this country there is also a significant association between stunting and overweight status [relative risk (RR) =1.7; 1.2–2.3]. Elsewhere, we have shown a strong positive relationship between income and a high weight-for-height in Brazil and also a significant inverse relationship between undernutrition and income (Monteiro et al. 1995). However, in none of the other countries did income function as a significant confounder or effect modifier (data not shown).

A measurement problem emerges: Is this relationship of stunting with high weight-for-height merely a statistical artifact resulting from the fact that height is on "both sides" of the stunting/overweight relationship? Analyzing the scatter plots and Pearson correlations (not shown) for a linear relationship between weight-for-height and height-for-age for children aged 3–10 y, revealed only a slight inverse relationship between weight-for-height and height-for-age for all countries, with a stronger negative relationship seen in the Russian survey. Plots and correlations implied a linear relationship; however, the inverse relationship was not

TABLE 3

The relationship between stunting and overweight status: the effects of income adjustment for children aged 3–9 y

Country, year	Unadjusted risk ratio	Confidence interval	Adjusted risk ratio	Confidence interval
Russia, 1994/5	7.7	(5.6, 10.5)	7.8	(5.7, 10.7)
China				
1991	4.0	(3.0, 5.2)	4.2	(3.1, 5.7)
1993	3.6	(2.7, 4.6)	3.5	(2.7, 4.6)
South Africa				
Total	2.6	(2.0, 3.4)	2.6	(2.0, 3.5)
Black and colored	2.5	(1.9, 3.4)	2.6	(1.9, 3.4)
Brazil	1.0	(0.7, 1.3)	1.7	(1.2, 2.3)

consistent within height-for-age categories. The Pearson correlation coefficients of weight-for-height with each height-for-age category revealed that weight-for-height did not vary inversely across all height-for-age categories, with short but not stunted children having slightly positive correlations. Percentages of overweight children classified in five height-for-age categories revealed a distinct U- or inverted J-shaped relationship between weight-for-height and height-for-age categories in all countries; that is, the majority of overweight children clustered in the lower height-for-age Z-score categories. These results also support a biological relationship similar to the U-shaped relationship McCance et al. (1994) observed in which low and high birth weight infants were at increased risk for diabetes. These results show that the height bias does not explain all of the overweight status of our study populations, i.e., tall children do not necessarily weigh more than short children.

DISCUSSION

As noted earlier, we have no way to validate our use of weight-for-height in these four populations against a more valid measure of body fatness. We did find that the estimate of overweight levels is lower in China when skinfolds are used. This indicates that it is quite possible that in China and our other countries, overweight levels might be overestimated with either weight-for-height or BMI, and the impact of the association noted here should be treated cautiously. In fact, Trowbridge et al. (1987) examined this topic more systematically among Peruvian children and did not find that a high weight-for-height associated with stunting was indicative of obesity.

It is important to note that we are not testing the exact Barker hypothesis (Barker 1992 and 1994). The Barker hypothesis and other biological hypotheses tend to focus on fetal effects. Independent of intrauterine growth retardation, many children in developing countries, and poor children in the U.S. and other developed nations, become stunted during infancy as the result of inappropriate weaning practices, repeated infections, and poor diet—all in the context of poverty (Adair and Guilkey 1996, Wiecha and Casey 1994). This study presents evidence of an equally important relationship but one that we must be cautious in overinterpreting without additional animal and epidemiological research.

This analysis has not controlled for the wide range of factors that affect stunting and may also affect the development of overweight. Many of these are biological or behavioral factors that are not even measured (often termed unobserved heterogeneity). Much more thorough, careful epidemiological research is required to confirm these findings.

Possible mechanisms. A number of highly speculative explanations for the relationship found between stunting and overweight in children stem from the work of Barker and others (Barker 1992 and 1994, Law et al. 1992), and none seem to be mutually exclusive. Barker and others propose that hormonal changes and their physiologic responses, such as abdominal obesity, stem from fetal or infant undernutrition facilitating long-term changes based on metabolic adaptations (Barker 1992, Law et al. 1992). The relationship of Barker's findings to stunting is not straightforward. However, the extensive explorations of Fogel (1994) on the ways in which height, independent of weight and BMI, relates to morbidity and mortality patterns and trends, give more relevance to a biological hypothesis. For example, stunting during the developmental stages has far reaching effects into adulthood by increasing the risk of chronic diseases. Parallel evidence by Ravelli et al. (1976) suggests that metabolic tissues such as the hypothalamus are reprogrammed as a result of early malnutrition during gestation. An inappropriate setting of the hypothalamus, altering appetite control, could possibly lead to obesity. Clearly, a great deal more work is required to explore this topic.

Alternate reasons for the stunting/obesity relationship focus on slowed growth and a changed hormonal response in combination with a poor dietary intake. Stunted (chronically malnourished) children have less lean body mass, resulting in decreased basal metabolic rate and physical activity. When energy intake is adequate, we see a difference in linear growth potential vs. deposition of adipose tissue (Barac-Nieto 1984, Trowbridge 1983). This may occur for a number of reasons: *1*) the diet is limited in essential nutrients required for linear growth but not for an increase in adipose tissue; and *2*) early nutritional programming may result in a number of hormonal effects such that linear growth is limited, but potential for weight gain is not. In the past, stunting and access to food were highly associated, but that linkage may not be as apparent now in countries undergoing the nutrition transition.

Little systematic clinical research has been done on the stunting period and its subsequent relationship to obesity. Others have linked multiple other causes of infant obesity such as bottle feeding, and infant obesity itself, with subsequent obesity, but they have overlooked another cause, the stunted child (see Popkin et al. 1986). Serdula and others (1993) have shown relationships between child obesity for a variety of ages and subsequent obesity.

The results of our research and previous literature are generalizable to a wide range of populations and environments. Research among U.S. Hispanics (Valdez et al. 1994), Jamaican children (Forrester et al. 1996), and others found some of the same biological relationships as did Barker (1992). Research on stunting and overweight seems most common among Hispanic populations. Mexican-American children are more likely to be short and overweight (Malina et al. 1986, Martorell et al. 1987, Zavaleta and Malina 1980). Other ethnic groups in the U.S., particularly the Hmong, a Laotian immigrant group, are experiencing increasing obesity while also manifesting high levels of stunting. By age 4 y, close to 25% of a sample of Hmong children living in Minnesota was stunted and by that same age over 22% were overweight (Himes et al. 1992).

Why have researchers not found this pattern of stunting and obesity at earlier periods of history when high rates of stunting also existed? The most logical reason is that the underlying social and economic circumstances that caused the high level of stunting did not provide the basis for obesity to emerge as a public health concern. Why with the very large distribution of low birth weight status in lower income countries, and the very high incidence of stunting, do we not have more obesity? It might be as simple as stating that there has been a lack of research on this issue: researchers interested in stunting were focused on problems of infectious diseases and undernutrition and not worried about obesity. Or it is possible that the biological and behavioral adaptations associated with stunting were important and that the underlying food, disease, and socioeconomic conditions that caused stunting continued to affect the lives of these children. In other words, poor socioeconomic conditions did not allow for the expression of obesity in the population. The nutrition transition with the rapid shift in the composition of diet and activity patterns provides the conditions for the complications of stunting to emerge. Further research is required to unravel this speculation.

More importantly, the vast set of economic and demographic changes occurring in many lower income and middle income countries over the past few decades creates an entirely new set of circumstances for the future. There is minimal opportunity for leisure activity in many areas, and large changes in transportation and work are beginning to require much less energy expenditure. Elsewhere, we demonstrated these activity pattern changes for Chinese adults (Popkin 1994). There are few data to show if these same trends will occur for children. Concurrent changes in the structure of diet are rapid. A higher fat and lower carbohydrate diet is replacing the traditional one in many countries. The result is a significant change in body composition among all age groups as was demonstrated in Thailand (Ladda et al. 1993).

More research is being undertaken on all aspects of child stunting, but there are still few serious initiatives to develop the range of public health programs to reduce infant nutrition insults (e.g., improvement of infant weaning foods). It is important to point out that if the programming hypothesis (Barker 1992 and 1994) is proved to be correct, a major weapon against chronic diseases is this improvement of maternal and infant nutrition. The rapid increase in stunting in Russia following the economic reforms and dismantling of parts of a maternal and child health nutrition program provides an example of the importance of public health programs or lack thereof in addressing this concern (Mroz and Popkin 1995). We hope the future will lead to more aggressive work on this most complex problem. What we do know is that there are conditions under which stunting might be reversed among older children and adolescents, but there is little evidence in lower income countries to show that we are reversing it (Adair and Guilkey 1996, Martorell et al. 1994). Moreover, if stunting were to be reversed, we do not know that the metabolic changes Barker and others hypothesize to be related with growth retardation will be reversed. That is, we cannot answer the question yet whether children who face stunting will grow up with a special biological vulnerability and thus if the only option is to reduce insults during pregnancy and infancy.

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