Obesity Trends in Chilean Children and Adolescents: Basic Determinants

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In Chile an epidemiologic transition has been occurring at impressive speed. Chile’s biomedical indicators in the 1960s matched those of most Latin American countries—that is, high maternal and infant mortality rates and a high prevalence of infectious diseases and undernutrition. In the late 1990s the Chilean nutrition and health situation looked completely different. The present scenario is an infant mortality rate (IMR) of 10 per 1,000 live births (1), whereas the average in the region is 35.7 (2). Moreover, during this period, noncommunicable chronic diseases have increased from 54% of all deaths in 1970 to 75% in 1998 (1). The main causes of death now are cardiovascular disease, neoplasms, and trauma. Concomitantly, a rapid increase in risk factors for chronic diseases has been noted in several national surveys (3). Among these risk factors is obesity.

A virtual eradication of protein-energy malnutrition and a steady increase in obesity has occurred over the past two decades. Data from a representative sample of the adult population living in Santiago show that in 1992, 11% of men and 24% of women were classified as obese, defined by a body mass index (BMI) of 30 or more, compared with 6% and 14%, respectively, in 1988 (4). In children, there has been an important decline in the prevalence of undernutrition, concomitant with spiraling obesity rates (5). The reasons behind the reduction in childhood malnutrition are most likely related with existing social programs, including food intervention. Greater access to an improved educational system, progress in water and sanitation infrastructure, wide coverage of primary health care interventions, and declining unemployment rates are also major contributors. The improvement in the economic situation and the “modernization” of society have led to an increase in the consumption of energy-dense foods and an alarming increase in sedentary behavior (6). Despite the positive impact of food supplementation programs in preventing undernutrition, these programs may have contributed to the rise in obesity rates, especially among preschool children of low- and middle-income groups.
CRITERIA USED TO DEFINE OBESITY IN CHILE

The terms overweight and obesity are often used interchangeably, despite the fact that they are not identical. Overweight is defined as an increased weight (not necessarily excess fat) for a certain height, whereas obesity indicates an excess in fat mass (7,8). Although the long-term effect of overweight and obesity on morbidity and mortality in children has not yet been as well documented as in adults, multiple studies have shown that adiposity in childhood is correlated with the rising incidence of diabetes, hypertension, and atherosclerosis observed in this age group (9–13). These harmful consequences of overweight and obesity make it very important to have clear definitions.

In 1992, the Chilean Ministry of Health adopted the World Health Organization (WHO) international reference (NCHS 1977) (14) and the weight-for-height index as the official criteria for evaluating the nutritional status of preschool children, both for undernutrition and overnutrition. The Chilean Ministry of Education, which collects data on weight and height of children in the first and ninth grades, also adopted these criteria for children under 10 years of age, and the body mass index (BMI) compared with the WHO reference (14,15) for adolescents. We are now considering following the international recommendations to use BMI to classify overweight and obese children from the age of 2 (16–20).

No generally accepted reference standards have yet been produced. The WHO (15) and National Center for Health Statistics/Centers for Disease Control (NCHS/CDC) 2000 (21) references are based on the distribution of representative samples of the US population and use statistically based cutoff points to determine the prevalence of overweight and obesity. In contrast, the International Obesity Task Force (IOTF) reference (22) considers BMI cutoff points that are extrapolated from BMI values of 25

FIG. 1. BMI by Tanner stage (data from 6 studies).
and 30 at age 18. It is assumed that BMI values at those levels in children present an inherent health risk.

Locally, Burrows and Muzoo (23) have provided BMI cutoff points based on a representative sample of schoolchildren of all socioeconomic levels from four regions of Chile, based on anthropometric data collected on 4,531 boys and 5,326 girls between 1985 and 1988. An important contribution by these workers is the suggestion that during adolescence, the BMI should be referred to the Tanner stage of pubertal development rather than to chronologic age. They provided normative data on BMI by Tanner stage for girls aged 10 to 17 years and boys from 11 to 17 years of age. Figure 1 shows that for every one-point change in Tanner stage, there is between a one-half- and one-unit increase in BMI in the 10- to 14-year-old age group, independent of true chronologic age. Similar findings have been observed in other studies in the region (24). However, the specific effect of Tanner staging on adiposity was not evaluated. A critical point for future evaluation will be to compare BMI for age versus BMI for Tanner stage as predictors of adiposity and metabolic alterations in early adolescence.

TRENDS IN OBESITY IN CHILDREN AND ADOLESCENTS

Since 1987 the Ministry of Education has carried out a yearly census among first and ninth graders in state-supported schools. This census includes anthropometric data on children in first and ninth grades, covering approximately 75% and 56% of the country's total population, respectively.

The prevalence of obesity among 6-year-olds who entered first grade in 1987, 1990, 1993, 1996, and 2000 was determined by a cross-sectional analysis and calculated using weight-for-height (WHO 1977), BMI-NCHS/CDC 2000, and BMI-IOTF. First, we used a weight-for-height of greater than +2 SD as an indicator of obesity (13); later, we used BMI-CDC 2000 of more than the 95th centile as the cutoff. Finally, we used BMI-IOTF, determining age-specific cutoff points that project to a BMI of more than 30 at age 18. The prevalence of obesity in 14- to 16-year-old children in the ninth grade was determined for 1993 and 1996, also using BMI and comparing it to three reference datasets—the WHO values (NHANES-I) (15); the revised NCHS/CDC growth charts (21); and the figures provided by IOTF (22). In the first and second categories, children were considered obese if their BMI was beyond the 95th centile; when IOTF was used, the calculations involved cutoff points corresponding to an adult BMI of 30 or more.

Table 1 shows the obesity prevalence in 6-year-old boys and girls using the three criteria described earlier. The prevalence of obesity in boys shows an increase from 6.5% in 1987 to 17% in 2000 when determined by weight-for-height (WHO reference). These figures were slightly lower if BMI-CDC data reference was used, whereas with BMI-IOTF cutoff the values were significantly lower, 1.8% in 1987 and 7.2% in 2000. Over the 13-year period, the increase has been extremely high, at 1.5- to threefold, depending on the reference used. Obesity in girls increased from 7.8% to 18.6% with the first criterion, from 4% to 15.8% with BMI-CDC, and from
TABLE 1. Prevalence of obesity among 6-year-old Chilean boys and girls defined by three criteria (1987–2000)

<table>
<thead>
<tr>
<th></th>
<th>1987 (%)</th>
<th>1990 (%)</th>
<th>1993 (%)</th>
<th>1996 (%)</th>
<th>2000 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Index and reference to define obesity in boys</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight-for-height &gt; 2 SD WHO</td>
<td>6.5</td>
<td>8.9</td>
<td>11.4</td>
<td>13.4</td>
<td>17.0</td>
</tr>
<tr>
<td>BMI-CDC ≥ 95th centile</td>
<td>5.1</td>
<td>7.0</td>
<td>10.1</td>
<td>11.8</td>
<td>14.7</td>
</tr>
<tr>
<td>IOTF-BMI corresponding to an adult BMI ≥ 30</td>
<td>1.8</td>
<td>2.5</td>
<td>4.3</td>
<td>5.2</td>
<td>7.2</td>
</tr>
<tr>
<td><strong>Index and reference to define obesity in girls</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight-for-height &gt; 2 SD WHO</td>
<td>7.8</td>
<td>10.1</td>
<td>12.7</td>
<td>15.0</td>
<td>18.6</td>
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<td>15.8</td>
</tr>
<tr>
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<td>2.8</td>
<td>4.6</td>
<td>5.9</td>
<td>7.5</td>
</tr>
</tbody>
</table>

Abbreviations: BMI, body mass index; CDC, Centers for Disease Control; IOTF, International Obesity Taskforce.

2.1% to 7.5% with BMI-IOTF. These increments follow similar trends to those observed for boys. The analysis by sex shows that obesity is more prevalent among girls when determined by weight-for-height and BMI-IOTF.

Obesity prevalence in adolescents, determined in 1993 and 1996 from the census data on schoolchildren in the ninth grade using the stated criteria, show that these rates were low and similar for both sexes. The rate of increase over the 3-year period amounted to 33%. The prevalence in adolescents in 1996 was only one-third to one-fifth of that found in the young children. Muzzo et al. (25,26), in a cross-sectional study that included schoolchildren from all socioeconomic levels from several regions of the country, analyzed the nutritional status of boys (12 to 16 years of age) and girls (10 to 16 years of age) in 1986, 1991, 1994, and 1998. Obesity rates (determined using the BMI-CDC data) increased from 1.6% to 9.2% in boys and from 2.3% to 11.8% in girls over this 12-year period.

In summary, obesity in 6-year-olds determined from the school census data and analyzed using three definitions has shown an alarming increase over the past decades. Obesity prevalence determined by weight-for-height (NCHS 1977) was greater than that derived from the BMI-CDC reference, whereas the values obtained using the BMI-IOTF data were much lower. Our results confirm the suggestion that in epidemiologic studies of prepubertal children obesity prevalence is substantially underestimated when using BMI-IOTF (27). Presently, no reference to measure childhood obesity has been validated prospectively in terms of predicting the short- and long-term health consequences for given BMI cutoff points.

The difference in obesity prevalence in adolescents compared with prepubertal children may partly be explained by secular trends; obesity is now affecting progressively younger children, whereas historical, older cohorts may have been less affected. This difference would produce a higher prevalence among younger children. We speculate that factors leading to obesity in the population groups undergoing the nutrition transition will have a progressively greater effect on younger children than on adolescents. As income increases, sedentary lifestyles and richer diets become
more prevalent at earlier ages. Eventually, as demonstrated by the NHANES-III sample, obesity increases to a point where there are similarly high rates in both young children and adolescents (8). This age-related change may also be explained by the possibility that reference criteria derived from populations in industrialized countries have a reduced sensitivity for detecting obesity in adolescents from developing countries (28). Unfortunately, cross-sectional studies reflect the behavior of different cohorts. This issue can only be resolved by conducting longitudinal follow-up studies where body fat is measured and health effects are determined.

INFLUENCE OF CHANGES IN LINEAR GROWTH ON PREVALENCE OF OBESITY IN DEVELOPING COUNTRIES

The influence of stunting on the prevalence of obesity needs to be considered, given the effect of short stature on BMI and energy balance (29,30). We have observed a fall in stunting rates in Chile concomitant with the rise in obesity. Thus the contribution of stunting to obesity prevalence has decreased over time, suggesting that other factors are responsible for the obesity trends. The prevalence of stunting (height for age z score of less than −2, WHO standard) in 6-year-olds was 10.6% and 7.3% for boys and girls, respectively, in 1987, whereas in 1996 the values declined to 5.8% and 3.4%. During the 10-year period, the average stature of children in this age group increased by 2 cm (31).

In 1987, 6-year-old stunted boys and girls had a higher prevalence of obesity than normally grown children of the same age. In stunted boys, the obesity rate (weight-for-height z score of more than 2, WHO standard) was 10.5%, whereas in boys of normal height it was 6%. In stunted girls, the obesity rate was 12.2%, and in those of normal height, it was 7.4%. In 1996, when the prevalence of stunting had decreased and obesity had increased, stunting was less strongly associated with an increased risk of obesity. The odds ratio for obesity in stunted children in 1987 was 1.83 in boys (95% confidence interval 1.72 to 1.94) and 1.74 in girls (1.62 to 1.86), whereas in 1996, these ratios were 1.34 (1.26 to 1.43) and 1.61 (1.5 to 1.74).

In adolescents, the prevalence of height deficit has also declined considerably. In the study by Burrows et al. (25) analyzing cross-sectional samples of adolescents over a 12-year period, stunting (defined as height for age below the 10th centile of the CDC reference) decreased from 44.2% in 1986 to 20.8% in 1998 in boys and from 41.1% to 26.6% in girls. However, the relation between stunting and obesity during adolescence is confounded by the effect of pubertal development, with the obese tending to mature earlier, which affects the interpretation of BMI.

In summary, these data suggest that in countries undergoing the nutrition transition, stunting is associated with an increased risk of obesity, but as stunting decreases, short stature becomes less significant as a risk factor for obesity. In populations of normal height, obesity in children is associated with increased stature (32), most probably secondary to enhanced bone age maturation.

The relation between obesity and stature in adolescents is a particularly difficult problem, as maturational stage will have a significant effect on the BMI. Moreover,
the onset of puberty may differ between populations. Sexual maturation during this period affects weight, stature, and body composition (33). Studies published in the 1970s in Chile (34) indicated that in adolescent girls from low socioeconomic groups puberty begins 1 year earlier than in their European counterparts. In 1980, based on assessment of Tanner stage and the reported onset of menses in a representative sample of school girls, the mean age of puberty onset was found to be 12.9 years (35), whereas in 1986, using direct examination and self-reported information of the onset of menses, Burrows et al. found the mean age to be 12.6 years (36). More recent data, based on self-reports, showed the mean age to be 12.3 years (37). From these Chilean data, a trend toward earlier menarche is evident. If this trend persists, obesity estimates will be higher in younger prepubertal girls but will have less influence after the menarche. Local data on boys do not show any changes in sexual maturation relative to international standards (34). Because the correction of obesity cutoff points by pubertal stage is difficult to implement in large studies, no population reference takes this issue into account (37).

HEALTH AND NUTRITION PROGRAMS: TRANSITION FROM STUNTING AND UNDERWEIGHT TO OBESITY

Chile is often presented as a paradigm of the success of supplementary feeding programs. There has been a clear correlation between the implementation of these massive interventions and the decline in malnutrition in all age groups. Unfortunately, these programs may be also contributing to the rising prevalence in obesity (5). We have previously published examples of the impact of these assistance programs on the prevalence of obesity. Supplementary feeding programs in Latin America benefit approximately 83 million people of an estimated 414 million in the region (38). The number of malnourished individuals, however, is only 10 million—that is, around 12% of the total number receiving benefit. The explanation for this phenomenon is that nutrition programs have evolved beyond the immediate needs of the malnourished and have become part of the social provision for populations living in poverty. Despite the obvious benefits—namely, the significant reductions in underweight and wasting that have occurred in most countries—these programs have the potential to affect the trends in obesity rates. As stunting remains a problem in most of the developing world, providing food supplements may be beneficial for some individuals while being detrimental for others (39).

We will summarize in the following section the main food supplementation programs for young children and their potential effects on obesity. The Chilean supplementary feeding program, or Programa Nacional de Alimentación Complementaria (PNAC), began in the 1920s as a public milk distribution program for working mothers. It was significantly strengthened in the 1950s with the creation of the National Health Service (NHS), which provides universal health protection and health services for insured workers and the indigent population. Approximately 70% of children aged up to the age of 6 years, pregnant women, and nursing mothers are beneficiaries. The main objectives of the PNAC are to promote normal growth and
development in children from conception to 6 years of age by providing food supplements to the mother during pregnancy and lactation, and to the child from birth to 6 years of age; to protect mother's health during pregnancy and lactation; to promote breast-feeding by providing supplements to mothers during pregnancy and lactation; to prevent low birth weight related to maternal malnutrition; to prevent infant and childhood malnutrition among the beneficiaries of the NHS; and to improve coverage of primary health care activities, thus providing an incentive for beneficiaries to attend clinics regularly (40).

Within the activities of the PNAC, the enhanced program was specifically designed for the early control of undernutrition. The energy contribution provided by this program varies from 100% of the requirement for infants of 5 months to 30% for children between 2 and 6 years. The protein contribution is considerably higher, at 180% and 58%, respectively. A controlled evaluation was conducted by Kain and Uauy (41) in a group of infants in whom weight-for-length z score category on entry to the program was compared with the corresponding z score on discharge 12 months later. The results showed that the change in the program beneficiaries in terms of length-for-age was minimal. Moreover, it was similar to that observed in a control group of nonparticipants matched for age and growth indices on entry (42). The benefit of improving mild underweight in 7.5% of the infants was offset by the number of overweight infants, which increased by 10.2%. The evidence from length-for-age z scores suggests that even stunted children gained nothing from the program compared with a control group that did not receive the benefit. The significance of being mildly underweight needs to be reassessed in the light of the emergence of a new paradigm of growth, where more is not necessarily better. What is clear from this evaluation is that if you provide additional food to stunted or normal children, they will mostly gain weight to exceed the median reference value.

A separate example is drawn from the National Nursery Schools Council Program (JUNHI). This was created in 1971 under the Ministry of Education to provide childcare as well as supplementary food for toddlers and preschool children. Coverage is close to 50% of those in need. In 1998 approximately 100,000 children under the age of 5 attended JUNHI. Of these, 95% were preschool children between 2 and 5 years of age, and the rest were infants under 2 years. The food distributed covers 58% or 75% of the children's daily energy needs, depending on whether they attend for a half-day or a full day. The energy contribution is divided by age group as follows: under 12 months, 800 kcal; 12 to 24 months, 950 kcal; 2 to 3 years, 1,000 kcal; 3 to 5 years, 1,150 kcal. If a nutritional deficit is detected, a reinforcement of 150 kcal/day is provided (43). This program seems to have contributed to the notable decrease in stunting observed in the preschool population during the past decade. The percentage of children below –1 SD weight-for-age and height-for-age has fallen significantly, and children who are mildly underweight now account for less than 5% of the total. Concomitantly, a rise in obesity has been observed in the preschool population; in the last decade this has increased from 6% in 1990 to 10.6% in 2000 (weight-for-height > 2 SD, WHO 1977). There has also been a measurable increase in obesity rates on a yearly basis from the time the children start kindergarten to the time they finish their
academic year (2). Obesity rates are progressively higher with each age cohort. Observations from a cohort of 8,086 children who attended JUNJI for three consecutive years and were measured every year showed that there was a threefold increase in the number of obese children by the end. During this same period the prevalence of overweight increased by 50% (39). On a more positive note, the program is presently adapting the food provision to the current nutritional profile of the preschool population, and on the basis of doubly labeled water measurements of energy expenditure, the energy content of the food provided has been reduced, and physical activity is being increased. The sugar and saturated fat content of the ration has been lowered, skimmed milk is being provided, and additional fresh fruits and vegetables have been added, favoring the supply of calcium, micronutrients (iron and zinc), and fiber.

TRENDS IN RISK FACTORS FOR OBESITY

Basic Determinants of the Increase in Obesity Prevalence in Chile

To evaluate possible determinants of the rapid increase in obesity in children over the past two decades, we examined indicators that could serve as a proxy for the components of the energy balance equation. As balance equals intake minus expenditure, we hypothesized that both an increase in intake and a decrease in expenditure underlie the rising prevalence of obesity in children and adolescents. We analyzed trends in indicators of components of energy balance over time, and these are depicted in Fig 2. In addition, we explored the relation between these factors and the rising prevalence of obesity in children; univariate correlation coefficients for these are presented in Table 2.

FIG. 2. Obesity percentage prevalence in 6 year olds.
### TABLE 2. Univariate correlations of basic determinants of obesity in children from cross-sectional data, Chile, 1980–2000

<table>
<thead>
<tr>
<th></th>
<th>Obesity, boys (r)</th>
<th>Obesity, girls (r)</th>
<th>Total obesity (r)</th>
<th>Total obesity ($R^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GNP US $ per person per year</td>
<td>0.98</td>
<td>0.99</td>
<td>0.98</td>
<td>0.97</td>
</tr>
<tr>
<td>Indigence, % prevalence</td>
<td>-0.97</td>
<td>-0.97</td>
<td>-0.97</td>
<td>0.942</td>
</tr>
<tr>
<td>Poverty, % prevalence</td>
<td>-0.9912</td>
<td>-0.9948</td>
<td>-0.9929</td>
<td>0.98593</td>
</tr>
<tr>
<td>Indigence + poverty, % prevalence</td>
<td>-0.9887</td>
<td>-0.9888</td>
<td>-0.9894</td>
<td>0.97892</td>
</tr>
<tr>
<td>Energy kcal/person/day</td>
<td>0.835</td>
<td>0.85</td>
<td>0.841</td>
<td>0.708</td>
</tr>
<tr>
<td>Protein g/person/day</td>
<td>0.83</td>
<td>0.84</td>
<td>0.84</td>
<td>0.7</td>
</tr>
<tr>
<td>Fat g/person/day</td>
<td>0.968</td>
<td>0.973</td>
<td>0.971</td>
<td>0.942</td>
</tr>
<tr>
<td>Energy, kcal/poor person/day</td>
<td>0.984</td>
<td>0.991</td>
<td>0.987</td>
<td>0.974</td>
</tr>
<tr>
<td>Protein, g/poor person/day</td>
<td>0.984</td>
<td>0.991</td>
<td>0.987</td>
<td>0.975</td>
</tr>
<tr>
<td>Fat, g/poor person/day</td>
<td>0.984</td>
<td>0.99</td>
<td>0.986</td>
<td>0.973</td>
</tr>
<tr>
<td>Social expenditure, USS/person/year</td>
<td>0.89939</td>
<td>0.91101</td>
<td>0.90294</td>
<td>0.8153</td>
</tr>
<tr>
<td>Social expenditure, USS/poor person/year</td>
<td>0.95656</td>
<td>0.96449</td>
<td>0.95926</td>
<td>0.92018</td>
</tr>
<tr>
<td>PNAC, kg/person/year</td>
<td>-0.93</td>
<td>-0.93</td>
<td>-0.93</td>
<td>0.861</td>
</tr>
<tr>
<td>PNAC, kg/poor person/year</td>
<td>0.7681</td>
<td>0.7682</td>
<td>0.7681</td>
<td>0.5901</td>
</tr>
<tr>
<td>Cars per 100 persons</td>
<td>0.97109</td>
<td>0.96647</td>
<td>0.97056</td>
<td>0.94198</td>
</tr>
<tr>
<td>Cars per 100 poor persons</td>
<td>0.99109</td>
<td>0.99394</td>
<td>0.99273</td>
<td>0.98551</td>
</tr>
<tr>
<td>Infant mortality, %/oo</td>
<td>-0.877</td>
<td>-0.8679</td>
<td>-0.8734</td>
<td>0.7628</td>
</tr>
<tr>
<td>Low birthweight, %</td>
<td>-0.8536</td>
<td>-0.8545</td>
<td>-0.8545</td>
<td>0.7302</td>
</tr>
<tr>
<td>Late infant mortality, %/oo</td>
<td>-0.9024</td>
<td>-0.89321</td>
<td>-0.89885</td>
<td>0.80793</td>
</tr>
<tr>
<td>Death from diarrhea disease per 10^5 persons per year</td>
<td>-0.83</td>
<td>-0.816</td>
<td>-0.824</td>
<td>0.68</td>
</tr>
<tr>
<td>Obesity in boys</td>
<td>1</td>
<td>0.999</td>
<td>0.9998</td>
<td>0.9996</td>
</tr>
<tr>
<td>Obesity in girls</td>
<td>0.999</td>
<td>1</td>
<td>0.9996</td>
<td>0.9993</td>
</tr>
<tr>
<td>Total obesity</td>
<td>0.9998</td>
<td>0.9996</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Note: Correlation coefficient $r$ was calculated using simple linear regression model. Abbreviations: GNP, gross national product; PNAC, Programa Nacional de Alimentación Complementaria.

Socioeconomic changes may be related to both increased intake and decreased activity, because as income increases, consumption of animal foods and high-fat foods increases, at the same time that physical activity decreases as people use motorized vehicles and other labor-saving devices. We have analyzed the GNP trends in Chile (in 1986 adjusted US$). After 1988 the economy grew at an average of nearly 7% a year for a full decade, income more than doubled, and poverty (defined as percentage of income spent on the basic family food basket) fell considerably. Through the 1980s poverty declined from 50% to around 40%, and during the 1990s it declined still further, to 20%.

As there were no systematic assessments of food intake during this period, we decided to use estimates of food availability, as defined from food balance data collected using FAO standardized methodology. This enabled computation of energy and macronutrient (protein, carbohydrate and fat) availability per capita. Because we were particularly interested in assessing the changes that affected the lower income groups, we also determined the availability per poor person in the country. The assumption that the energy and macronutrients available per poor person serve as an
indicator of food availability is an obvious oversimplification. The expression of energy and macronutrient availability per poor person will strengthen the correlation with obesity prevalence; a higher $r^2$ can be noted in Table 2. As income has more than doubled and poverty has dropped by half during the past two decades, we considered that this oversimplification was necessary for a full assessment of the potential impact of increased food intake. For example, mean daily energy intake per person increased by only 200 kcal over the two decades, but when expressed per poor person, it more than tripled. The changes in dietary fats are particularly pronounced, per capita availability remained stable at around 60 g a day during the 1980s but rose sharply to close to 90 g a day during the 1990s.

This information was validated in part by data from apparent food consumption surveys based on food expenditure according to income group, which have been conducted every 10 years in Chile from 1969 (44). Chilean national food availability data for the last 20 years are consistent with an important increase in the consumption of meat (poultry, +140%; beef, +54%; pork, +200%) and dairy products (+61%), and a stable or decreased intake of cereals and legumes (−10%) (45). A recent analysis of the latest national household food expenditure survey has shown that for the lowest quintile of the income distribution, the highest-ranked items are bread, meat, and soft drinks (46). The mean fat intake as a percentage of total energy is 28%. This is low relative to most industrialized countries yet the prevalence of obesity is rising sharply (1). A food consumption survey carried out in Santiago in 1995 (46) showed that 70% of adults consumed less than two fruits and 59% less than two portions of vegetables a day. This dietary pattern is clearly inadequate to contribute to the prevention of obesity.

Social expenditure, usually targeted to vulnerable low-income groups, is aimed at improving access to food, health, and education. In a country where malnutrition has traditionally been considered the main problem, social expenditure includes direct transfer of food products targeted at pregnant and lactating women, children under 6 years of age, and school-aged children living under conditions of poverty. In terms of US$ per person per year, expenditure on education and health remained more or less constant from 1980 until 1991, when, after the return to democratic rule, it grew steadily, almost doubling over the decade. As the reduction in poverty accelerated during the 1990s and social expenditure increased, expenditure per poor person tripled, assuming that all was spent on the poor. Food distribution programs—taking PNAC for women and children under 6 years as an example—declined by 50% if expressed as the amount given per person per year in the population as a whole, but increased by 20% per beneficiary in the poor population. Data from preschool and school feeding programs were also available but were not included in the analysis, as there have been multiple changes in the selection criteria of the beneficiaries and in the amounts of food provided; nevertheless these programs are reflected in the overall social expenditure.

On the energy output side, we found no systematic survey data on activity patterns of children and adolescents over recent decades, but specific studies support the view that sedentary behavior is very prevalent. This has been assessed by direct
OBESITY TRENDS IN CHILEAN CHILDREN AND ADOLESCENTS

Observations of children and television viewing. Sedentarism is related to the urbanization process. By 1970, three-quarters of the population lived in urban areas; in 1997 this figure increased to 87%. The number of cars in the country was 363,150 in 1970, increasing to 2,024,510 in 1998. Phone lines increased from 1,818,000 in 1995 to 2,753,000 in 1998, and TV appliances from 12,170 in 1970 to more than 2 million in 1997 (47). In 1988 a survey conducted in Santiago (48) indicated that 55% of men and 77.4% of women were sedentary (performing less than two periods of 15 minutes of exercise a week); these figures had increased to 57.8% in men and 80.1% in women in 1992. In Valparaiso (the second largest city) in 1997, more than 90% of women were inactive in their leisure time, and this figure was even higher (97%) in the lower socioeconomic group (49). Currently, low-income preschool children watch 3 hours of TV daily, increasing to 4 hours during weekends (50). Older schoolchildren also spend a considerable amount of time in sedentary activities. A recent survey conducted in a representative sample of schools of Santiago showed that 90% of school-aged children watched an average of 2 hours of television during weekdays, and 20% watched more than 3 hours daily (51).

Data on the increase in electricity consumption per person over the period are confounded by the inherent increases related to industrial production and economic growth, so we chose the number of cars per 100 persons as a proxy for physical inactivity. This was also expressed after adjustment for the number living in poverty. Both indices remained fairly stable over the 1980s but increased sharply during the 1990s. The slope was steeper when the variable was adjusted by the number of poor people, as the latter decreased over the decade. Because the increase in the number of cars is also closely linked to improved income, the rise in cars per 100 persons will reflect both of the components of the energy balance equation—increased energy intake and decreased activity.

We also considered improvements in health and nutrition in women and children, as these could be construed as indices of improved nutrient utilization, less energy being wasted in responding to infections and diarrheal disease, thus favoring a positive energy balance. Changes were marked over the 1980s, with a fall in infant mortality from 32 per 1,000 live-born infants in 1980 to 16 per 1,000 in 1990; a further fall to 10 per 1,000 occurred over the 1990s. The prevalence of low birth weight fell from 9% to 7% in the 1980s, and further to around 5% over the 1990s. Late infant mortality, which is dominated by deaths from respiratory infections and malnutrition, fell from 15.1 per 1,000 to 8 per 1,000 in the 1980s, and further to around 4 per 1,000 over the 1990s. The marked decline in deaths from diarrheal disease per 10^5 inhabitants, from around 8 in 1980 to close to 1.5 in 1993, has remained stable since, and reflects a significant improvement in environmental sanitation, access to clean water, and appropriate waste disposal. This coincided with an increase in sanitary food control, prohibiting the use of wastewater in the irrigation of vegetables, and intensive educational efforts relating to the consumption of raw vegetables imposed after a cholera scare related to the epidemic that affected Peru and other neighboring countries.

This information was analyzed more specifically for its relation to the rising prevalence of obesity in children entering school. The criteria used to define obesity by
Uauy et al. in 1980 (35) (120% of median weight-for-height by sex) were used consistently across the census datasets obtained from 6-year-old children. As these cross-sectional datasets included 1987, 1990, 1993, 1996, and 2000, the prevalence of obesity for the in-between years was derived by interpolation from the two nearest datasets. Simple correlation analyses were conducted and revealed extremely high correlation coefficients. Table 2 summarizes this information, providing correlation coefficients for each sex and for total obesity. It is tempting to speculate on potential causal relations based on the high r values, but as most variables are tightly interrelated, we cannot establish causal relations from simple correlation indices. A stepwise multivariate logistic regression analysis was also performed in an attempt to isolate the main determinants. Obesity in the whole population was best explained by including increase in the number of cars per 100 persons, the decrease in deaths from diarrheal disease, and the increase in fat availability per poor person per day. The $r^2$ value for this analysis was 0.994. To explore possible hierarchies for the main determinants, we forced the exclusion of specified main determinants to examine which variables made an additional contribution to explaining the obesity trends over the decade.

CATEGORIES OF DETERMINANTS FOR OBESITY INCLUDED IN THE ANALYSIS, DEFINITIONS, AND UNITS USED

The following are categories of determinants for obesity:

- **Socioeconomic changes:** Per capita income: gross national product from 1980 to 1999 adjusted to a constant (1986 US$). Data obtained from the Central Bank of Chile.

- **Prevalence of poverty, indigence, and total poverty:** Data for poverty and indigence obtained from the CASEN surveys (socioeconomic characterization of the Chilean population) carried out every 2 years by the Chilean Ministry of Planning since 1987. Data for 1980 were estimated by a regression model that incorporated death from diarrheal disease, low birth weight, and social expenditure (inverse). Data from 1981 to 1986 were obtained from a linear estimate from the 1980 and 1987 figures by the least squares method. This same methodology was applied for the intermediate points from 1987 to 2000.

  Poverty is defined by an income of less than twice the amount necessary to buy a predetermined basic food basket. Indigents are those for whom total income is less than the amount required to buy a food basket; total poverty is the sum of poverty plus indigence.

- **Trends in food availability:** Per capita energy and macronutrient (energy, protein, carbohydrate, fat) availability were obtained from the FAO food balance sheets posted on the Internet. The same indices were computed per poor person in the country, assuming that all food was available for the poor.

- **Social expenditures:** The adjusted 1986 US$ spent on health, education, and housing per person, and the same index per poor person, assuming that all expenditures are concentrated in the poor. Data are provided by the Ministry of Planning.
• Food distribution programs: The amount of food supplements provided by PNAC, per person in the country, and the same index per poor person, assuming that all food was provided to the poor. Data from 1980 until 1999 are provided by the Ministry of Health.

• Increase in sedentarism: The number of cars per 100 persons, and the same index per poor person, assuming that all cars are available to the poor. Data are available from 1985 until 1999 and are provided by the Ministry of Transport. Data for 1980 to 1984 were estimated by extrapolating from the 1985 to 1990 trend.

• Improvement in health and nutrition of women and children: Infant mortality, prevalence of low birth weight, late infant mortality. Data from 1980 until 1998 for the three indices were provided by the Ministry of Health.

• Improvement in sanitation and decrease in gastrointestinal infections: Deaths from diarrhea per $10^5$ inhabitants. The data for 1980 to 1998 were provided by the Ministry of Health.

CONCLUSIONS

Chile is undergoing a rapid nutritional transition with a progressive increase in the prevalence of obesity in children. The factors responsible for these trends are changes in lifestyle and diet, which are similar to those observed in industrialized societies except for the faster rate of change. We consider that nutrition interventions programs, especially in stunted populations, may aggravate the obesity epidemic. Weight-for-age definition of undernutrition in children without assessment of length will overestimate the dimension of malnutrition and neglect the identification of stunted overweight children. As malnutrition rates fall, the need to prevent overweight and obesity should be considered of equal importance to the eradication of undernutrition.

Based on the observed effect of socioeconomic, dietary, and other environmental factors on the prevalence of obesity between 1980 and 2000, the high correlation coefficients observed, and the multivariate regression analysis, income-related factors explain most of the variance in obesity. However, a decrease in infection and a rise in apparent fat consumption were also significant. The number of cars per 100 persons, especially if adjusted by the decrease in poverty, had the highest relation to the development of obesity in both univariate and multivariate analysis. The contribution of rising income; increased expenditure on social programs, including food supplementation; increase in apparent fat consumption; and rise in indices of sedentary lifestyles in explaining the rise in obesity indicate that the prevalence will continue to rise unless measures are taken to increase physical activity and reduce the consumption of energy-dense foods.

REFERENCES

DISCUSSION

Dr. Koletzko: You showed data where you applied different reference standards for defining obesity in your population, so I want to return to the point I made after Dr. Cole’s presentation. In applying the IOTF standard you had about a 6% prevalence of children above the upper threshold, and using the traditional standard about 18%—that is, a threefold difference. While we cannot be sure of the consequences of this discrepancy, we ought to question whether it is right to refer to both these outcomes as the “obese population.” If we do, we risk confusing the public, not to mention governments and funding agencies. Are we not running a risk that the obesity epidemic may be underestimated?

Dr. Uauy: I agree with your general point, but I think we need to be very careful in our interpretation of Dr. Cole’s paper. He does not talk about “standards.” He was very careful every time he mentioned the IOTF to use the term reference. I hope that everybody here has heard this more than once. It’s the IOTF reference, not the IOTF standard. We still do not have a risk-based standard, only a population-based standard. You can choose the WHO weight-for-height standard or the latest CDC, and they nearly match. However, the latest CDC standard has obviously recognized the increase in obesity in the US data and has not included current values
for children over 6 years of age. Thus I’m not sure whether we can still call the CDC a population-based standard because it’s a mixture of a recent survey and an older survey. Eventually, when we have data on BMI versus hyperlipidemia, BMI versus hypertension risk, BMI versus insulin resistance, and so on, then maybe I’ll be convinced to use an IOTF risk-based standard. But for now I would use the population-based standard and use the IOTF reference for comparative purposes only.

*Dr. Dullo*o*: When malnourished children are treated it has been known for many decades that fat rather than lean tissue is preferentially recovered. What you are seeing now is surely just an exacerbation of this phenomenon, with our high-fat foods and low levels of activity. Basically, catch-up growth is now catch-up fat. What kind of dietary regimen should we be recommending? It’s a very difficult situation.

*Dr. Uamy*: It’s even worse than you say because we know that rapid catch-up growth is not necessarily a good thing if you consider insulin resistance and long-term cardiovascular risk. I think we should redefine what is optimal in terms of recovery from the malnourished state. Gaining fat may be all right if the child is returning to a situation of continued energy deficit. That’s what we did in the 1980s when our philosophy was that 1 kg of fat mass would buy 7,500 kcal of deficit later on. But now, as countries are getting better off, there is no point in building up an excess of fat, and we are just setting the children up for an adverse outcome in the future. Another point is that to achieve fat gain, all you need is energy and a little protein. To achieve linear growth, you also need all the micronutrients, so optimizing the micronutrient intake becomes a crucial factor in stunted populations. We need to worry about fetal growth as well, because the cycle starts with malnutrition and stunting in utero; this sets the scene for later obesity. There are populations now that are stunted and overweight, and the increase in obesity is often clearly related to that. Thus improving the quality of the diet is more than just throwing in calories. Another factor is exercise. Providing exercise is probably important even in early life. Many children in preschool day care centers are given long rest periods when they are told to sit quiet and not move about. We probably should be doing exactly the opposite—this is the time for children to be active. We need to change the generally held view that putting on weight is the most important thing.

*Dr. Bar-Or*: I’d like to play the devil’s advocate for a moment. We are dealing here with populations that for centuries have been undernourished but that now show an improvement in their nutritional status. I wonder if we are not too liberal in our use of the term obesity. The BMI and other indicators are mathematical constructs or ratios. You alluded to this yourself—does a disproportionate increase in body fat versus linear growth really make a person obese? Mathematically, yes, but physiologically? I would argue that rather than educating people to reduce their body fat, one should aim to increase their linear growth, at which point they will no longer be obese. I would even go one step further: Is there no danger that, if we jump too early to the conclusion that there is obesity in countries like rural Chile, we will cause the pendulum to swing back in the opposite direction, so that people will again be eating insufficient amounts?

*Dr. Uamy*: I agree with your overall statement, but when you look at the actual data you find that in most urban centers in developing countries the main causes of death have shifted, as I showed you. It is no longer infectious disease; it is now chronic disease. On a worldwide basis, the burden of disease shifted in 1997 such that there were more deaths from preventable diet-related, chronic, noncommunicable diseases than from malnutrition. I agree with you that the first goal should be to improve height. But you don’t need to build obese infants and children to improve their height; you need micronutrients, a better quality of diet overall, and physical activity. And while you are doing that, you will also be preventing obesity. The problem
is to get things moving. Governments in particular are too slow to react. In Chile, we have been aware of the problem for a decade, but the government is still giving only three fruits a month in the school feeding program, rather than spending more on fruit and less on calories. We only started to measure linear growth in 1991; before that, height was not part of routine surveillance, because weight for age was the criterion— anybody under the 50th centile was considered at risk for malnutrition. The result is that we may have overdone it. One needs to put both things into the equation. The first is to improve linear growth, I agree. However, controlling excess weight-for-height is not a contradictory objective; it is complementary. If you do not act to prevent obesity early on, you will end up with the situation that is now occurring in all urban centers in Latin America, where the main cause of death is cardiovascular disease.

Dr. Dullo: In Europe and the United States, where children and adults become obese without having gone through a period of malnutrition—that is, “normal” obesity—there is an increase not just in fat but also in lean tissue, linear growth, and organ mass. Do you have any data from, say, Chile or Brazil in which organ mass has been assessed in children who are stunted and obese?

Dr. Uauy: I think the best data come from Asia, specifically from Hong Kong, Singapore, and India, where short people develop abdominal obesity predominantly (1). There the metabolic complications of obesity are seen at a lower BMI, so it may not be body fat alone that is the problem but the metabolic response. That’s why I would like to define obesity on the basis of risk, not on the amount of adipose tissue per se. This is easier said than done, but I do not think we can talk about a reference standard until we have achieved that.

Dr. Caballero: As you have several decades of good data, have you looked at any effect of early nutritional conditions—for example, birth weight or early growth—on later obesity?

Dr. Uauy: Unfortunately, in Chile the excitement of getting things done has been more than the excitement of getting the evaluations performed. We are now in the process of trying to follow up about 500 of the infants treated in the malnutrition recovery ward to try to answer some of these questions. Unfortunately, while there is money for interventions, there is often none for evaluation.

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