## Current Research

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# Diabetes Risk, Low Fitness, and Energy Insufficiency Levels among Children from Poor Families

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**ABSTRACT**

**Background** Low-income populations have higher rates of type 2 diabetes and it is the hope of the investigators to increase support for the dissemination of evidence-based prevention programs aimed at children from poor families.

**Objective** To determine the prevalence of high blood glucose, obesity, low fitness, and energy insufficiency levels among children from poor families.

**Design** The cross-sectional study conducted in fall 2001 used fasting capillary glucose, body mass index, body fat, step test, and three 24-hour dietary recalls to assess diabetes risk factor levels.

**Subjects** Participants were 1,402 fourth-grade students aged 8 to 10 years. The racial/ethnic backgrounds were 80% Mexican American, 10% African American, 5% Asian American, and 5% non-Hispanic white.

**Statistical analysis performed** All data were analyzed for descriptive statistics and frequencies of distribution. Means were computed by sex for all diabetes risk factors and $t$ test conducted to determine differences between sexes.

**Results** Nearly 75% of participants lived in households with <\$20,400 annual income. Although 44% of students were energy insufficient, 33% were obese, and 7% had high blood glucose levels. Most of these students had marginal to unacceptable fitness levels and consumed high energy-dense and low nutrient-dense foods.

**Conclusions** Children living in poverty have high levels of diabetes risk factors and need early detection and intervention programs. Prudent advice might be to increase physical activity and intake of nutrient-dense foods rather than to restrict energy intake.

*J Am Diet Assoc. 2008;108:1846-1853.*

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*Manuscript accepted: March 23, 2008.*



*0002-8223/08/10811-0003$34.00/0*
*doi: 10.1016/j.jada.2008.08.009*

An 8-year study to determine the incidence of type 2 diabetes among adults showed that living in poor neighborhoods was a significant predictor of diabetes (1). Among Mexican Americans, the incidence of type 2 diabetes was 6%, 11%, and 14% if they lived in high-, middle-, and low-income neighborhoods, respectively. The association between diabetes risk and poverty has also been shown among children. Findings from the Third National Health and Nutrition Examination Survey (NHANES III) showed that poverty predicted body mass index (BMI) in girls and hemoglobin A1c in boys (2). Other investigators have also found a relationship between poverty and diabetes risk among youth (3-5).

A behavioral risk factor associated with poverty and diabetes is physical inactivity. Poverty is a milieu for physical inactivity. Youth growing up in poverty are more likely to be physically inactive than their more affluent peers (6-8). Data from the Medical Expenditure Panel Survey showed that the likelihood of having diabetes increased with physical inactivity regardless of BMI (9) and prospective studies have shown the protective effect of physical activity against diabetes (10,11).

Food insufficiency is an additional behavioral factor associated with poverty (12,13) and diabetes risk (14). Food insufficiency is defined as inadequate amount of food intake due to lack of money or resources (13). Because food insufficiency is associated with low energy intake (13,15,16), energy intake is one criterion against which the questionnaire-based measure is compared. In this article, energy insufficiency was defined as energy intake below daily minimum requirements for age group (17) and it was used to represent food insufficiency.

The aim of our study was to determine the prevalence of high blood glucose, obesity, low fitness, and energy insufficiency levels among children from poor families. Considering the average family size and number of children per household in our study, poor was defined by annual household income <$21,135 (18).

## METHODS

### Participants

Data for this study were drawn from the Bienestar School Health Study conducted in fall 2001 (*bienestar* means "well-being" in Spanish). The participating school district is urban, inner city, and it was the second largest school district in South Texas with 67 elementary schools and 66,000 students. The school district's student racial/ethnic composition was 84% Mexican American, 11% African American, and 5% non-Hispanic white. Students from low-income homes comprised 89% of the student population in the school district. All fourth-grade students, regardless of race and ethnicity, were invited to participate. School-level exclusion criteria included elementary schools with previous exposure to the Bienestar diabetes prevention program and schools designated as alternative learning centers. Student-level exclusion criteria included students aged 12 years and older, students previously diagnosed with types 1 or 2 diabetes, and students with extreme dietary values (<800 and >4,800 kcal/day) based on a 3-day average energy intake (17).

Among the 67 elementary schools, 23 schools were excluded because of previous exposure (20 schools) and being alternative schools (three schools). From the remaining 44 elementary schools, 27 schools were randomly selected to participate in this study. There were 1,993 students in the 27 schools and of these, 1,436 had assent and parent consent to participate (72% response rate). Among the remaining students, 34 more were excluded from analysis because of exclusion criteria. The racial/ethnic backgrounds of participating students were 80% Mexican American, 10% African American, 5% Asian American, and 5% non-Hispanic white.

### Design

The Bienestar School Health Study was a randomized controlled trial conducted between fall 2001 and spring 2004 to examine the effects of a school-based diabetes prevention program (19). The data presented here are cross-sectional, collected at baseline before the elementary schools were randomized to treatment groups. Recruitment was done by mail, by students taking home packages, and by parent orientations at schools. The recruitment packages included information on the study, consent/assent forms, and students receiving $5 for participating in data collection. All student data were collected at the campus of each participating school. The Institutional Review Board of the University of Texas Health Science Center at San Antonio approved the study protocol.

### Measures

**Parent Demographics.** Parent surveys were mailed home and demographic variables included age of respondents, relationship to the student, adults and children living in the household, annual income, educational attainment, and self-reported health status.

**Anthropometrics.** Percent body fat and weight was measured by bioelectric impedance analysis (BIA) (Tanita Corporation of America Inc, Skokie, IL). Percent body fat was measured because in children, body fatness has been shown to relate closely to atherogenic and diabetogenic risk factors (20) and because BMI may not represent their true body fatness (21). In addition, BIA is a quick and efficient method for group studies. Body fat measured by BIA has shown a close correlation with dual-energy x-ray absorptiometry, skinfold thickness, and underwater body density measurements in children (22). The BIA instruments consist of a laptop and a metal electrode box. The children, in indoor clothing, were asked to remove shoes and socks and step on the metal box. The instrument prints the percent body fat and weight within 30 seconds. Weight was measured a single time and recorded to the nearest 0.1 kg. Students, in indoor clothing and barefooted, also had their height measured using a stadiometer (Seca Bodymeter 206, Seca Corp, Hanover, MD). Height was measured once and recorded to the nearest 0.1 centimeter. BMI was calculated as $kg/m^2$. Obesity was defined as BMI percentile ≥95th (23).

**Blood Glucose.** Study staff members telephoned parents the day before the examination to remind them to have their children fast after midnight for the glucose test. The screening process followed Occupational Safety and Health Administration guidelines and all staff members demonstrated competency in the calibration of glucose monitoring devices and testing procedures. Fasting capillary glucose was measured by collecting a blood drop from a student's fingerstick. The blood drop was placed in a reagent strip and inserted into a Glucometer Elite XL (Bayer Corp, Mishawaka, IN). Students with a fasting capillary glucose <100 mg/dL (<5.55 mmol/L) were given a written notice explaining to parents that their child's diabetes test was normal (24). Students with fasting capillary glucose ≥100 mg/dL (≥5.55 mmol/L) were given a notice explaining to parents that their child's test screened positive for prediabetes. These parents were advised to follow up with their personal physician and if they did not have a personal physician or were uninsured, they were referred to the University of Texas Health Science Center at San Antonio pediatric endocrinology service.

**Physical Fitness.** Physical fitness was measured by a step test exercise protocol (25). The step test consists of connecting a heart rate monitor (Polar Vantage XL, Polar Electric Co, Port Washington, NY) transmitter to a child's lower chest and monitor to the wrist. A baseline heart rate is recorded, then the child is asked to step onto and down (both feet) a stool 30 cm high, 42 cm wide, and 38 cm deep for 5 minutes. The student is paced at 30 cycles per minute. Students whose heart rates reach 200 bpm were stopped at that moment and allowed to rest. Immediately after the child either completed exercise or stopped the exercise prematurely, heart rates were recorded at 0, 1, and 2 minutes postexercise. A physical fitness score was calculated by taking the total time of exercise in seconds×100 and dividing it by the sum of three heart rate values measured at 0, 1, and 2 minutes postexercise (3). For this study, a physical fitness score <65 was considered unacceptable, between 65 and 79 marginally acceptable and >79 acceptable (3,25).

**Dietary Assessment.** Dietary intake was measured by three 24-hour dietary recalls (2 weekdays and 1 weekend day) during a face-to-face interview. Although dietary recalls have limitations, this is still the best available means of determining nutrient intake of children within this age group (26,27). The 3 days for the 24-hour dietary recalls were collected on separate days within the same week so the child had to remember one day at a time. Sunday or a holiday were collected to represent a weekend. The reason for collecting 2 weekdays and 1 weekend day is because the source of meals for these children are different for weekdays and weekends and the goal of this measure is to quantify the nutrient intake that best represent the child's weekly diet. In this study most children participated in the National School Breakfast Program and National School Lunch Program and received two of three meals through the school cafeterias during weekdays. Other meals in the evening and all meals during weekends were provided by their family or primary caregivers.

All interviews were conducted in either English or Spanish during school hours by trained staff members. The staff training outlined two procedures for collecting dietary information. One was the interviewing technique, which consisted of a script for dialogue, prompting methods, and recording methods. The other was the measuring technique, which consisted of using food models and measuring utensils. Time of day and type of food/beverage consumed, and amount consumed measured in fluid ounces, cups, and/or portion sizes were collected for the day (24 hours) before the interview. All dietary information was entered twice for accuracy and analyzed using Nutrition Data System for Research software (version 4.04, 1998-2001, University of Minnesota Nutrition Coordinating Center, Minneapolis). These analyses provided specific macronutrient and micronutrient content of foods and values were compared to Dietary Requirement Intake guidelines (28). Children were considered energy insufficient if they consumed <1,400 kcal/day (17).

### Data Analysis

All data were analyzed for descriptive statistics, frequencies of distribution, and comparative statistics by the Statistical Package for Social Sciences software package (version 14.0, 2005, SPSS Inc, Chicago IL). Means were computed by sex for fitness levels, dietary characteristics, and health risk factors and *t* tests were conducted to determine differences between sexes. Means±standard deviation for all variables were displayed and the significant probability level for analyses was established at $P \leq 0.05$.

**Table 1.** Socioeconomic and health characteristics of parents participating in the Bienestar School Health Study

| Characteristic | Value (n=833) |
|---|---|
| **Age (mean±standard deviation)** | 36.12±7.5 |
| **Respondent (%)** | |
| Mother | 86 |
| Father | 8 |
| Other | 6 |
| **Total persons per household** | |
| Total | 4.97 |
| Adults per household | 2.10±0.9 |
| Children per household | 2.94±1.4 |
| **Annual income per household (%)[a]** | |
| ≤$5,999 | 11.5 |
| $6,000-$10,779 | 17.2 |
| $10,800-$15,599 | 24.1 |
| $15,600-$20,399 | 21.7 |
| ≥$20,400 | 25.5 |
| **Education (%)** | |
| Less than high school | 21.7 |
| High school | 46.5 |
| More than high school | 31.8 |
| **Self-reported health status (%)** | |
| Very good health | 16.0 |
| Good health | 55.5 |
| Fair health | 26.4 |
| Poor health | 2.2 |

[a]Poverty threshold in 2001 for a family of five was $21,135 (18).

## RESULTS

### Demographics

Parent demographic surveys were mailed to the home of the 1,436 consented students. Of these, 948 were returned filled out and 833 had complete information. Most of the respondents were mothers and their average age was 36 years (Table 1). Compared to US average (29), respondents had a higher number of people living per household (2.6 and 4.9, respectively). Nearly 75% of respondents came from households with <$20,400 annual income; 68% had a high school or less education; and only 16% self-reported being in very good health.

### Health Risk Factors

Mean percent body fat was greater than that recommended for children of this age group (30) and mean BMI was near 4 units above the 50th percentile (31) (Table 2). The prevalence of being obese was higher for students (33%) in our study than that reported by the NHANES III for non-Hispanic white (12%) and Mexican American (27%) children (32,33). Nearly 7% of students had fasting capillary glucose at or above 100 mg/dL (5.55 mmol/L). Mean BMI was significantly greater and obesity prevalence was significantly higher among boys than girls ($P<0.001$; not shown). All other health risk factor values were not significant between boys and girls.

**Table 2.** Diabetes risk factor levels of children participating in the Bienestar School Health Study

| Health risk | Recommended for boys | Boys (n=699) | Recommended for girls | Girls (n=703) | Total (n=1,402) |
|---|---|---|---|---|---|
| **Body composition** | | | | | |
| Percent body fat (mean±standard deviation) | <14[a] | 26.83±11.89 | <20[a] | 26.99±10.63 | 26.90±11.27 |
| Body mass index (mean±standard deviation) | 16.2[b] | 20.92±5.05 | 16.4[b] | 20.12±4.79 | 20.52±4.94 |
| Obesity prevalence (≥95th percentile) (%) | 5.2[c] | 38.5 | 5.2[c] | 28.2% | 33.3 |
| **Blood glucose level** | <100 mg/dL[d] | | <100 mg/dL[d] | | |
| | | *n* (%) | | ←——— *n* (%) ———→ | |
| ≥100 mg/dL | | 45 (6.4) | | 50 (7.1) | 95 (6.8) |
| 100-125 mg/dL | | 43 (6.1) | | 48 (6.8) | 91 (6.5) |
| ≥126 mg/dL | | 2 (0.3) | | 2 (0.3) | 4 (0.3) |

[a]Based on American Academy of Pediatrics guidelines (30).
[b]Based on 50th percentile on Centers for Disease Control and Prevention growth chart (31).
[c]Based on National Health and Nutrition Examination Survey Cycle II (1963-1970) (33).
[d]Based on American Diabetes Association guidelines (24). To convert mg/dL glucose to mmol/L, multiply mg/dL by 0.0555. To convert mmol/L glucose to mg/dL, multiply mmol/L by 18.0. Glucose of 100 mg/dL=5.55 mmol/L.

**Table 3.** Fitness levels of children participating in the Bienestar School Health Study

| Fitness level | Boys (n=699) | Girls (n=703) | Total (n=1,402) |
|---|---|---|---|
| Age (mean±standard deviation) | 9.38±0.57 | 9.37±0.56 | 9.38±0.56 |
| **Physical fitness score[a] (%)** | | | |
| Unacceptable[b] | 30.6 | 46.5 | 38.6 |
| Marginally acceptable[c] | 53.5 | 47.2 | 50.4 |
| Acceptable[d] | 15.9 | 6.3 | 11.1 |

[a]Based on Keen and colleagues (3) and Treviño and colleagues (25).
[b]Unacceptable scores were those 0-64.
[c]Marginally acceptable scores were those 65-59.
[d]Acceptable scores were those 80-100.

### Fitness Levels

Fitness levels of children participating in the Bienestar School Health Study are presented in Table 3. The average age for boys and girls was similar (9 years). There were more than three times as many students with unacceptable physical fitness scores as with acceptable scores (38.6% and 11.1%, respectively). The majority of children scored in the marginally acceptable range with boys and girls having near similar percentages (53.5% and 47.2%, respectively). Acceptable physical fitness score was the least common category and girls had significantly lower percentages compared with boys ($P<0.001$; not shown).

### Nutrient Intake

The recommended average energy intake for a 9-year-old child is 1,900 kcal (range 1,400 to 2,500 kcal) (17) and students in our study consumed an average of 1,588 kcal (Table 4). Approximately 44% of students consumed energy less than the minimum recommended level. On average, students consumed 138 kcal more during school days than during the weekend (not shown). The students' intake percentage derived from saturated fat was higher and grams of dietary fiber were lower than recommended standards (28). The daily sucrose intake was almost equivalent to that of an added sugar beverage can (12 oz). Except for sodium, zinc, and iron, mineral intake was below recommended standards. Vitamin intake, on the other hand, was within or above recommended standards. Compared with girls, boys consumed significantly more energy, cholesterol, fiber, and all micronutrients except vitamin C (value range $P<0.001$ to 0.02; not shown).

## DISCUSSION

A school-based health screening was conducted and students from poor South Texas families were found to have high levels of blood glucose, obesity, and energy insufficiency, and low levels of fitness. These findings indicate that children living in poverty need health screenings for early detection and programs for early intervention to mitigate diabetes risk factors.

This is not the first study to show the existence of diabetes risk, obesity, low fitness levels, or energy insufficiency with poverty, but it is the first to show all among a population of minority children from poor families. Data from the NHANES III showed that among youth aged 5 to 24 years, hemoglobin A1c was statistically higher among those living in poverty than among those who were not (4). The relationship between hemoglobin A1c and poverty remained significant among youth aged 20 to 24 years even when multiple linear regression models were fitted.

Obesity and physical inactivity are other diabetes risk factors reported to be more common among children from poor families. A recent study showed that over the last four NHANES, the prevalence of obesity increased at a faster rate among youth aged 15 to 17 years from poor families compared with youth from nonpoor families (34). Additional analysis showed that physical inactivity and added-sugar beverage consumption might have contributed to the unfavorable health outcome among youth from poor families.

**Table 4.** Dietary intake of children participating in the Bienestar School Health Study[a]

| Nutrient | Dietary Reference Intake[b] | Boys (n=703) | Girls (n=699) | Total (n=1,402) |
|---|---|---|---|---|
| **Macronutrients** | | | | |
| Total energy (kcal) | 1,400-2,200 | 1,674.90±615.85 | 1,501.09±598.17 | 1,587.75±613.03 |
| Calorie insufficiency (%) | <1,400 | 36.1 | 51.2 | 43.7 |
| Protein (% g) | 10 | 15.52 (63.99±22.80) | 15.36 (57.06±23.52) | 15.44 (60.52±23.42) |
| Carbohydrates (% g) | 55 | 50.65 (208.88±81.39) | 51.41 (189.11±75.36) | 51.03 (198.97±79.02) |
| Fat (% g) | 35 | 34.76 (66.56±28.39) | 34.22 (59.06±28.25) | 34.49 (62.80±28.56) |
| Saturated fat (% g) | 10 | 12.72 (24.39±10.93) | 12.47 (21.49±10.74) | 12.59 (22.94±10.93) |
| Monounsaturated fatty acids | n-6 (5-10); n-3 (0.6-1.2) | 24.37±11.12 | 22.89±11.04 | 24.37±11.13 |
| Polyunsaturated fatty acids | | 10.14±5.72 | 9.62±5.61 | 10.14±15.72 |
| Cholesterol (mg) | 300 | 236.96±148.65 | 226.77±150.08 | 236.96±148.65 |
| Fiber (g/day) | 30 | 10.52±5.19 | 10.18±5.41 | 10.52±5.19 |
| Soluble fiber (g/day) | NA[c] | 3.49±1.66 | 3.37±1.71 | 3.49±1.66 |
| Insoluble fiber (g/day) | NA | 6.87±3.59 | 6.66±3.79 | 6.87±3.59 |
| Pectins (g) | NA | 0.95±0.59 | 0.94±0.58 | 0.94±0.59 |
| Starch (g) | NA | 86.67±35.76 | 77.78±34.92 | 82.21±35.60 |
| Sucrose (g) | NA | 38.48±23.03 | 36.53±21.34 | 38.47±23.03 |
| **Minerals** | | | | |
| Sodium (mg) | 1,500 | 2,866.36±1,591.70 | 2,696.04±1,820.35 | 2,866.36±1,591.70 |
| Potassium (mg) | 4,500 | 1,814.14±679.14 | 1,736.49±676.21 | 1,814.14±679.14 |
| Calcium (mg) | 1,300 | 735.19±322.17 | 685.69±299.87 | 735.19±322.17 |
| Magnesium (mg) | 240 | 177.82±69.53 | 169.48±69.59 | 177.82±69.53 |
| Phosphorous (mg) | 1,250 | 991.51±374.67 | 932.27±367.02 | 991.51±374.67 |
| Zinc (mg) | 8 | 9.08±3.83 | 8.63±4.09 | 9.07±3.82 |
| Iron (mg) | 8 | 11.47±4.79 | 10.96±5.07 | 11.47±4.78 |
| Folate ($\mu$g dietary folate equivalents) | 300 | 277.88±116.92 | 266.67±119.63 | 277.88±116.92 |
| **Vitamins** | | | | |
| Vitamin A (IU) | 2,000 | 2,933.08±2,133.89 | 2,685.46±1,778.82 | 2,933.08±2,133.89 |
| Vitamin D ($\mu$g) | 5 | 4.72±2.271 | 4.49±2.24 | 4.72±2.21 |
| Vitamin C (mg) | 45 | 70.94±43.98 | 70.94±44.27 | 70.94±43.98 |
| Thiamin (mg) | 0.9 | 1.377±0.53 | 1.24±0.54 | 1.31±0.54 |
| Riboflavin (mg) | 0.9 | 1.74±0.63 | 1.56±0.62 | 1.65±0.63 |
| Niacin (mg) | 12 | 16.92±6.64 | 15.12±6.62 | 16.02±6.69 |
| Vitamin B-6 (mg) | 1 | 1.35±0.53 | 1.23±0.53 | 1.29±0.53 |
| Vitamin B-12 ($\mu$g) | 1.8 | 3.96±2.45 | 3.47±1.87 | 3.72±2.19 |

[a]Average of 3-day, 24-hour dietary recalls.
[b]Institute of Medicine (28).
[c]NA=not available.

The relationship between low physical activity and socioeconomic status was studied in the 1996 National Longitudinal Study of Adolescent Health (7). This large school-based study assessed 17,766 seventh- to 12th-grade students. Activity and inactivity were collected as outcome variables and ethnicity, socioeconomic status, and neighborhood crime were used as exposure and control variables. All variables were collected by questionnaire. Adolescents from households with high maternal education or family income were more likely than their less affluent counterparts to engage in moderate to vigorous physical activity and less likely to fall in the highest category of inactivity. Living in neighborhoods with high crime rates and attending schools with decreased physical education time was given as a determinant for low physical activity and high inactivity levels among adolescents from poor families. The association between low physical activity and poverty has also been reported among Mexican-American (35) and Mexican children (6).

An additional diabetes risk indicator found to coexist among children from poor families is food insufficiency. Although it is often assumed that children with reduced energy intake would have reduced body fat and be less likely to be overweight, that was not the case among this study's participants. Forty-four percent of children consumed below minimum energy requirements and many were still overweight. A particular finding was the low intake of most dietary minerals. This is important because minerals play active roles in cell metabolism and transport. Similar to the our findings, recent studies have found comparable associations between food insufficiency and prevalence of overweight among children (36,37), women (38-40), and men (41).

There are several possibilities to explain the food insufficiency and obesity paradox. Individuals not having enough food at certain time periods may engage in binge eating (42) or compromise the nutritional quality of their diets when food becomes available resulting in being overweight (40).

Binge eating may promote fat accumulation due to the dramatic rise in postprandial lipid (43), glucose (42), and insulin (44) levels. Following periods of fasting, the liver is primed to synthesize lipids and increase fat storage capacity (45,46). This may be especially crucial when the period of binging precedes bedtime (42,47). The second explanation is compromised food quality. A study found that women in food insufficient households had a significantly worse diet quality than women in food sufficient households (40). Food insufficient women had significantly lower Healthy Eating Index scores for the consumption of vegetables, fruits, and milk as well as overall food variety. With a rise in the literature showing the relationship between food insufficiency and overweight, further investigation within this area is warranted. Understanding this relationship could help reshape obesity control programs aimed at this special population.

Our results should be interpreted with caution because of measurement limitations. Prediabetes and diabetes are diagnosed by clinical laboratory analyzers and not by self-monitoring blood glucose systems. Because blood was collected in the schools, on a large number of students, over short periods, and with limited incentives, self-monitoring blood glucose instead of laboratory-based analysis was used. Despite not being a diagnostic tool, self-monitoring of blood glucose does collect a biological marker and is recommended by the American Diabetes Association for blood glucose monitoring (24).

A second limitation was the use of children's self assessment of dietary intake. Inaccurate reporting has been shown among populations from different age, sex, ethnicity, culture, education, social class, and nationality regardless if food records, dietary recalls, food frequency questionnaires, food weighed, and cafeteria menus were used (48-56). That study participants worldwide knowingly or subconsciously systematically misreport their dietary intake and that energy intake is consistently and significantly in opposite direction to BMI and body fat appears all too coincidental. Even in studies where children and parents were interviewed separately showed that both children and parents coincided with overweight children underreporting and lean children overreporting (52). From a societal perspective it is understood why overweight children might underreport, but it is not clear why lean children might have overreported. It is more likely that lean children are more active and activity, along with growth, increases energy intake (57).

Could obesity in children be more closely related to low physical activity and low micronutrient intake than to excessive energy intake? Children in our study had low fitness levels and low calcium, magnesium, potassium, phosphorus, and folate dietary intake. The literature showing the relationship between inactivity and obesity is extensive (58,59) but the literature showing the relationship between micronutrient insufficiency and obesity is less examined. Animal, human being, and population-based studies have recently shown that for any given level of energy expenditure and energy intake, a low-calcium diet increased adipose tissue and a high calcium diet had the opposite effect (60-62). A 5.8-year longitudinal study assessed children's food consumption and related these to body fat development (63). During the study period, percent body fat was shown to be significantly and negatively related to servings of dietary calcium. Similarly, magnesium insufficiency has been shown to be related to insulin resistance and the metabolic syndrome among children and young adults (64,65). Because these findings are recent and not all studies have shown conclusive results (66), more research is needed to better define the role of micronutrients in obesity development.

## CONCLUSIONS

Our results elucidate the high levels of diabetes risk among children from poor South Texas families. Because Texas ranks seventh nationally in the percentage of children living in poverty, a disproportionate increase in diabetes morbidity and health care costs is expected (29). A report from the Texas Comptroller of Public Accounts showed that state health expenditures increased from $107 to $114 billion between 2004 and 2005 (67). Obesity-related illnesses alone cost Texas businesses $3.3 billion in 2005 and are expected to increase to $15.8 billion annually by 2025. Legislation that promotes physical activity and healthful eating in schools has been enacted but none is funded and accountability measures are lacking. Unless we invest in early age interventions and quantify the results, diabetes morbidity and health care cost will remain uncontrolled.

This research was supported by the National Institute of Diabetes and Digestive and Kidney Disease grant no. DK 59213.

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