Inverse Association between Insulin Resistance and Frequency of Milk Consumption in Low-Income Argentinean School Children

Valeria Hirschler, MD, Karin Oestreicher, MD, Matin Beccaria, MD, Mariana Hidalgo, MS, and Gustavo Maccallini, MS

Objective To determine the association between milk consumption, lifestyle, components of the metabolic syndrome, and insulin resistance in school children.

Study design Students (n = 365 [175M]) age 10 ± 2.3 years from 2 poor suburbs of Buenos Aires were examined for body mass index, waist circumference, blood pressure, and Tanner stage in April 2007. Fasting concentrations of lipids, insulin, and glucose were determined. Mothers completed questionnaires about their children's lifestyle.

Results Approximately 14.0% of the children were obese, and 12.1% were overweight by use of norms from the Centers for Disease Control and Prevention. Half were at Tanner I. Mean values of waist circumference, systolic blood pressure, insulin resistance, and insulin were higher as subjects consumed more glasses of milk. Multiple regression analysis with insulin resistance as the dependent variable showed that there was a significant and positive association with triglyceridemia (β = 0.007) and waist circumference (β = 0.024), and a negative association with milk consumption (β = −0.135) adjusted for blocks walked daily, TV viewing, soft drink consumption, parental educational level, sex, age, high-density lipoprotein (HDL) cholesterol, and systolic blood pressure (R^2 = 0.27).

Conclusions Increased milk consumption was associated with greater insulin sensitivity, suggesting that it might reduce the risk of type 2 diabetes. *(J Pediatr 2009;154:101-5)*

Increasing prevalence of overweight and obesity among both adults and children has been observed in many countries throughout the world.[1,2] Childhood obesity plays a central role in the metabolic syndrome, which also includes hyperinsulinemia/insulin resistance, hypertension, and hyperlipidemia.[3] Dietary pattern analysis, which may provide more insight than examination of single nutrients or foods, has been used to investigate diet-disease relations.[4,5]

Although several dietary factors have been associated with the metabolic syndrome,[6] few studies have examined the association between dietary patterns and insulin resistance. The epidemiologic evidence has suggested a lower prevalence of the metabolic syndrome associated with dietary patterns rich in fruits, vegetables, whole grains, dairy products, and unsaturated fats.[7,8]

Previous studies have shown some benefits from dairy consumption with respect to obesity and metabolic syndrome; however, epidemiologic data on the association between milk intake and insulin resistance in children are sparse. The aim of this study was to determine the association between milk consumption, other food intake, extent of TV viewing, physical activity, components of the metabolic syndrome, and insulin resistance (HOMA-IR) in school children.

METHODS

Data were collected cross-sectionally from children in 2 elementary schools from the low-income suburbs of Buenos Aires in April 2007. The sampling design of the survey was a 2-stage probability sample. The first stage was the selection of the schools, and the second stage consisted of an invitation to all the students to undergo testing. The overall response rate was 95%. There was not a significant difference in the mean age (P = .78), body mass index (BMI; P = .58), sex (P = .66), and socioeconomic class among all the school children and those who underwent testing.

Although Argentina is a Spanish-speaking country, the population differs greatly from what is usually referred to as Hispanic in the United States. About 85% of the

BMI	Body mass index	WC	Waist circumference
HOMA-IR	Homeostasis model assessment of insulin resistance		

From the Nutrition and Diabetes Department (V.H.) and the Pediatrics Department (M.B.), Hospital Durand, the Division of Chemistry, Hidalgo Laboratories (M.H., G.B.), Hospital Durand, and the Public Health Department (K.O.), University of Buenos Aires, Argentina.

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Reprint requests: Valeria Hirschler, Hospital Durand, Maipu 812 5 M, 1006 Capital Federal; Argentina. E-mail: vhirschler@intramed.net.

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population is of European descent (largely Spanish and Italian), with the remainder of mixed European and American Indian (12%) or American Indian (3%) descent.[9]

Sociodemographic characteristics included age and level of education. Mothers were asked to define their level of formal education as having 1 of the following: no formal education, completed elementary school, completed high school, or having a university degree.

Exclusion criteria included the following: missing BMI information; not in the fasting state for at least 8 hours; known diabetes or other chronic disease; and the use of medication that would affect blood pressure or glucose or lipid metabolism. All subjects were examined by the same physician. The study was approved by the Human Rights Committee of Durand Hospital in Buenos Aires. Each subject and parent gave written informed consent after an explanation of the study and before its initiation.

Mothers were asked about their children's lifestyle behaviors. Questionnaires were completed by the same pediatrician because mothers had a fairly low education level and they might have not understood the questions.

To assess physical activity, a 4-level index that ranked participants according to the number of blocks walked daily was used (<5, 5-10, 10-20, ≥ 20 blocks daily). A 5-level index that ranked participants according to daily consumption of vegetables or fresh fruits, glasses of milk, sweetened beverages, and number of hours of TV viewing was used (1, 2, 3, 4, ≥ 5 daily). Standard serving sizes and food models were provided as a reference for estimation of dietary intake.

The physical examination included determination of the stage of puberty according to the criteria of Tanner.[10] Pubic hair was staged from I, representing immaturity, to V, for full maturity.[11]

Height and weight were measured with subjects wearing light clothing and without shoes. Height was recorded to the nearest 0.1 cm with a wall-mounted stadiometer. Weight was measured to the nearest 0.1 kg on a medical balance scale. BMI was calculated as weight in kilograms divided by height in meters squared. Normal-weight children were defined as having a BMI $\leq$85th percentile. Overweight and obesity were defined as a BMI in the 85th to 94th and $\geq$95th percentiles, respectively, for age and sex according to the Centers for Disease Control standards for U.S. children. The BMI z-score (BMI-z) was also determined.[12]

Waist circumference (WC) measurement was taken at the level of the umbilicus and recorded to 0.1 cm. A nonelastic flexible tape measure was used with the subject standing without clothing covering the waist area. Because WC varies according to age and sex, we standardized values for age and sex by converting them to z scores. Central obesity was defined for children as WC $>$90th percentile on the basis of 5000 normal Argentinean children (unpublished data).

Three separate blood pressure measurements were recorded by a trained technician using a random-zero sphygmomanometer after the participant was seated at rest for 5 minutes. The average of the last 2 measurements was used. Because normal pediatric blood pressure varies significantly, we used the National Heart, Lung and Blood Institute's recommended cut point for age, sex, and height.[13]

Baseline blood samples were obtained from subjects while they were fasting, for measurement of levels of glucose, and lipids. Plasma glucose was measured by the glucose oxidase technique, and serum lipids were measured with a Hitachi Modular P analyzer (Hitachi High Technologies Corp., Tokyo, Japan).

BMI was converted to age- and sex-standardized percentiles based on the Centers for Disease Control and Prevention 2000 growth charts, which are not race specific.[12] The χ^2 test was used to compare proportions. When more than 20% of the cells had expected frequencies <5, Fisher's exact test was used. The fit to normal distribution of continuous variables was assessed with the Shapiro-Wilks test. When comparing 2 groups with normally distributed data, a Student t test was performed. When comparing more than 3 groups and with data that were normally distributed, 1-way analysis of variance was used (Student-Newman-Keuls post hoc test). When the homogeneity of the variances could not be proved, we used the nonparametric Kruskal Wallis instead of analysis of variance, with Dunn post hoc test. To measure the strength of association between 2 variables, a Spearman rank correlation coefficient was used. The primary focus of the analysis was to determine the association between milk consumption, lifestyle, and HOMA-IR in children.

Multiple linear regression analysis was done to examine the relationship between HOMA-IR as a dependent variable and milk consumption, lifestyle, and components of children's metabolic syndrome as independent variables. P values $<.05$ were considered statistically significant. Data are presented as mean $\pm$ SD. Analyses were done with the SPSS version 10.0 statistical software package (SPSS, Chicago, Illinois).

RESULTS

Students (n = 365; 175 males) age 10.1 $\pm$ 2.3 years from 2 elementary schools in lower-income Buenos Aires suburbs, were examined in April 2007. Physical and metabolic profiles are presented in Table I. Fifty one (14%) of the children were obese, 44 (12.1%) were overweight, and 269 (74%) were normal weight with norms from the Centers for Disease Control and Prevention.[12] The mean BMI-z of these 3 groups was as follows: obese, 2.03 $\pm$ 0.40; overweight, 1.29 $\pm$ 0.16; and normal, 0.19 $\pm$ 0.85. There was no significant difference in age (P = .24) and sex (P = .68) among these groups. Forty-nine percent, 25.4%, 19.5%, 5.6%, and 0.3% were Tanner stage I, II, III, and IV, respectively. None was Tanner stage V. The prevalence of Tanner stage I was significantly lower in girls (39.2%) than in boys (60.8 %) ($P <$ .001), as expected with earlier pubertal maturation in girls.

Participants were of low socioeconomic status, reflected in educational backgrounds of the parents, with 93.1% of the mothers and 92.7% of the fathers having only an elementary school education or less. Approximately 16% of the families did not have a refrigerator, and 9% had a dirt floor.