

## Serum lipids and lipoprotein levels in Costa Rican 13-18 year-old teenagers

*Rafael Monge-Rojas*

Costa Rican Institute for Research and Education on Nutrition and Health (Inciensa). Costa Rica

**SUMMARY.** Adverse levels of serum lipids tend to persist over time into adolescence and young adulthood, underlying the progression of Coronary Artery Disease (CAD). Therefore, the lipid profile of Costa Rican adolescents and its relationship with dietary intake, physical activity and Body Mass Index (BMI) was evaluated in a total of 322 adolescents ages 13-18 years from urban and rural areas of San José, Costa Rica. Levels of Total Cholesterol (TC) and HDL-C (High-Density Lipoprotein Cholesterol) were significantly higher in urban adolescents than in rural youngsters. No differences were found between LDL-C (Low-Density Lipoprotein Cholesterol) and triglyceride levels among urban and rural adolescents. TC, HDL-C and LDL-C levels were higher in females than in males. The mean LDL/HDL ratio was 2.3 with no differences between gender and area. Over 20% of adolescents showed borderline TC levels (4.42-5.17 mmol/L) and 10% borderline LDL-C levels (2.86-3.35 mmol/L). The proportion of females with borderline TC and LDL-C was higher than the proportion of males. No differences were found between areas. Around 50% of adolescents showed borderline HDL-C levels (0.91-1.17 mmol/L) and over 55% presented borderline triglyceride level (1.02-1.46 mmol/L). The prevalence of borderline and high triglyceride levels ( $\geq 1.47$  mmol/L) between urban and rural adolescents was similar. However the prevalence of high triglyceride levels was higher in females (22%) than in males (14%). An independent positive relationship was found between LDL-C, triglyceride, the cardiovascular fitness score and BMI. Likewise a negative relationship was found between cardiovascular fitness, BMI, gender and HDL-C. This study suggests that primary prevention programs are required to decrease the prevalence of cardiovascular risk factors among Costa Rican adolescents.

**Key words:** Coronary artery disease, adolescents, lipids, lipoproteins, physical activity, dietary intake, Costa Rica.

**RESUMEN. Niveles séricos de lípidos y lipoproteínas en adolescentes costarricenses de 13 -18 años.** Los niveles adversos de lípidos séricos tienden a persistir a lo largo del tiempo desde la adolescencia y la juventud favoreciendo el progreso de la Enfermedad de las Arterias Coronarias (EAC). Por tal razón se evaluó el perfil lipídico y su relación con el consumo dietético, actividad física e Índice de Masa Corporal (IMC) en 322 adolescentes de 13-18 años residentes de áreas urbanas y rurales de San José, Costa Rica. Los niveles de colesterol total (CT) y HDL-C (lipoproteínas de alta densidad) fueron mayores en los adolescentes urbanos que en los rurales. No obstante, no se observaron diferencias en los niveles de LDL-C (lipoproteínas de baja densidad) y triglicéridos (TG). Los niveles promedio de CT, HDL-C y LDL-C fueron mayores en mujeres que en hombres. El valor promedio del radio LDL/HDL fue 2.3, sin evidenciarse diferencias por sexo y área. Cerca del 50% de los adolescentes mostraron un nivel limítrofe de C-HDL (0.91-1.17 mmol/L) y más del 55% presentaron niveles limítrofes de TG (1.02-1.46 mmol/L). La prevalencia de niveles limítrofes y elevados de TG entre los adolescentes urbanos y rurales fue similar. Sin embargo, la prevalencia de niveles elevados de TG fue mayor en mujeres (22%) que en hombres (14%). El análisis de regresión lineal determinó una relación positiva e independiente entre los niveles de C-LDL, TG, puntaje de resistencia cardiovascular e IMC. Así mismo se encontró una relación negativa entre el puntaje de resistencia cardiovascular, IMC, sexo y niveles de C-HDL. En conclusión, este estudio sugiere la necesidad de implementar programas de prevención primaria para disminuir la prevalencia de los factores de riesgo cardiovascular entre los adolescentes costarricenses.

**Palabras clave:** Enfermedad de las arterias coronarias, adolescentes, lípidos, lipoproteínas, actividad física, consumo dietético, Costa Rica.

### INTRODUCTION

Serum lipoproteins are an important risk factor for Coronary Artery Disease (CAD). Overweight; low cardiovascular fitness, high saturated fat intake, cigarette smoking and family genetics cause unfavorable alterations in serum lipids (1).

Elevated levels of serum low-density lipoprotein (LDL-C) and decreased levels of high-density lipoprotein (HDL-

C) are associated with atherosclerosis lesion development in many epidemiological studies (1, 2). In addition, autopsy studies have demonstrated a strong association between adverse lipoprotein levels and the initial stages of atherosclerosis in adolescents and young adults (1, 3). Elevated serum triglyceride levels play a central role in the occurrence of several CAD risk factors (4), especially those related to insulin resistance syndrome (5).

Adverse levels of serum lipids tend to persist over time into adolescence and young adulthood (6, 7), underlying the progression of CAD. Tracking data has been used to predict adult levels of Total Cholesterol, HDL-C and LDL-C from childhood and adolescence levels (8 -10). About 25-70% of adult cholesterol variability has been explained by cholesterol levels in childhood and adolescence (2, 10).

Available evidence suggests that behavior traits associated with increased CAD risk are acquired early in life and may accelerate the development of CAD (1-3). Therefore, identifying serum lipid levels in adolescents is important for the primary prevention of this disease. The results of several studies have clearly documented that avoidance of the adverse lipid profile in early youth is essential for stemming the CAD progression in later years (2,3,6,8,9,10) This reference appears particularly important in Costa Rica where CAD represents the main cause of death (11).

The aim of this study was to determine the serum cholesterol, lipoprotein and triglyceride levels in urban and rural Costa Rican adolescents and the correlation between the body mass index (BMI), cardiovascular fitness and dietary intake.

## METHODS

### Sample

Of the 350 eligible 13-18 year-old adolescents, 92% consented to participate in the survey. The total sample of 322, 52% males and 48% females, was selected from 10 public high schools in San José. High schools were classified either as urban or rural according to the socio-demographic characteristics of the zone. This classification was designed based on the socio-demographic characterization of the geographic population areas of Costa Rica as defined by the National Department of Statistics (12).

Thirty students, 50% male, were randomly selected from each education center (around 7 student per level). Both parents and adolescents gave their written consent to participate in the study. All adolescents included in the study were screened for diseases that may affect blood lipoprotein levels.

### Biochemical measurements

After 12 hours of fasting, a blood sample was taken from an antecubital vein using Vacutainer tubes containing a clot activator (Becton, Dickinson & Co). Serum was separated by centrifugation at 2000 G for 20 min at 5° C. HDL-C was separated using a phosphotungstic acid/Mg<sup>2+</sup> reagent (Randox, England) and centrifuged at 3000 rpm for 15 min. The colorimetric reaction was determined in a Gilford spectrophotometer Stasar III at 505 nm and 37°C. Total plasma cholesterol (TC), triglyceride (TG) and glucose (GL)

were determined by enzymatic methods (Wiener Lab, Rosario-Argentina) using an automatic analyzer ASCA (LSI Instruments) at 505 nm and 37°C. LDL-C was calculated with the Friedwald *et al.* equation (13). The intra-assay and inter-assay coefficients of variation for total serum cholesterol were 2.5 and 2.9 percent and for HDL cholesterol, 6 and 7 percent respectively. The coefficient of variation for triglycerides was less than 4 percent for these analyses. Serum glucose (GL) was measured by the glucose oxidase method (Beckman Glucose Analyzer II, Beckman Instruments Corp., Fullerton CA) (14). TC and LDL-C concentrations were classified according to the Expert Panel on Blood Cholesterol Levels in Children and Adolescents guidelines (1) (rounded to the nearest tenth): Acceptable TC < 4.42 mmol/L, borderline TC = 4.4 to 5.17 mmol/L; high TC 5.2 mmol/L; acceptable LDL < 1.04 mmol/L, borderline LDL-C = 2.86 to 3.35 mmol/L; high LDL-C 3.38 mmol/L. HDL-C and TG concentration were classified according to the Johns Hopkins guidelines (15) (rounded to the nearest tenth): acceptable TG < 0.85 mmol/L, borderline TG = 0.85 to 1.12 mmol/L; high TG 1.13 mmol/L; acceptable HDL > 1.17 mmol/L, borderline HDL-C = 1.04 to 1.17 mmol/L; low HDL-C = 1.04 mmol/L.

### Dietary intake

Dietary intake was determined by three-day food records (16). A series of six photographs of food commonly consumed in Costa Rica was used to estimate portion size while keeping the food record. Foods and three-dimensional food models were used during the food record verification. Intake was analyzed by the Food Processor software for Windows, version 6.0 (Esha Research).

### Physical activity

Cardiovascular fitness was measured using a Harvard step test modified by Bush *et al.* (17). Each adolescent stepped up and down on a 33 cm. high bench 30 times per minute for 4 minutes. At the end of the test, pulse was measured at 30 second intervals for three minutes and summed at one, two and three minutes to derive the sum of pulses. The sum of pulses determined the score assigned to each adolescent. : ≥ 397 = 5; 342 - 396 = 4; 300 - 341 = 3; 266 - 299 = 2; and ≤ 299 = 1. Scores were interpreted as follows: 1 = excellent cardiovascular fitness, 2 = above average, 3 = average, 4 = below average, 5 = needs improvement. Adolescents who scored above 3 were considered sedentary.

### Anthropometry

Weight was measured without shoes and with heavy outer clothing removed. Height was measured with the student shoeless and facing away from the scale. Standing height was measured to the nearest 0.1 cm and weight was measured to 0.1 kg. Independent duplicate measurements were obtained

for height and weight, and the average of two readings, required to be within  $\pm 0.50$  cm or 0.5 kg respectively, was used in data analyses.

Adolescents with a Body Mass Index (BMI)  $\geq$  85th percentile but  $<$  95th percentile were considered at risk for overweight as suggested by the World Health Organization Expert Committee (18). In the absence of other data specifying optimum cut-off values for BMI in adolescence; the BMI for age data for US children was used, as recommended by the WHO Expert Committee (18).

Biochemical, dietary, physical activity and anthropometry data were collected during three consecutive months under similar environmental conditions.

### Statistical analysis

Data were examined with SPSS for Windows using analysis of variance as appropriate for continuous variables and a Chi-square test for categorical data. Multiple regression analysis was used to develop models with the different lipids as dependent variables. After examining univariate relationships between variables, multivariate stepwise models were initially used to identify which correlated variables provided the best model with a particular dependent variable. Collinearity was minimized by this approach, and correlation coefficients between independent variables included in the regression models did not exceed 0.3. A level of  $p < 0.05$  was considered significant.

## RESULTS

Table 1 shows the characteristics of the study population. The sample consisted of 170 urban and 152 rural adolescents; 52% from urban areas and 48% from rural areas. All adolescents were from the same ethnic background (mestizo). Mean age was  $15 \pm 1.6$  year-old.

Mean energy intake was  $2151 \pm 679$  calories, with urban adolescents consuming more calories than rural youngsters ( $p=0.0048$ ) (Table 1). Energy intake from saturated fats was 2% lower in rural than in urban adolescents ( $p=0.000$ ), for whom it was 12%. More than 35% of the adolescents studied had a saturated fat intake greater than 10% Total Energy (TE). Indeed, saturated fat intake was significantly high ( $> 10\%$  Total Energy) among urban adolescents and females ( $p < 0.001$ ) (data not shown).

Reported mean daily energy from total carbohydrate was 4% higher in rural adolescents ( $p=0.003$ ), for whom the reported approaches 55%. Mean intake of energy from sucrose was 19%, with no differences between urban and rural youngsters. Around 95% of urban and rural adolescents reported a sucrose intake higher than 10% of total energy. Mean intake of energy from polyunsaturated fat was similar

among urban and rural adolescents (6%). Only 30% of adolescents reported appropriate intake of polyunsaturated fatty acids (7-8% of the total energy intake).

TABLE 1  
Characteristics of the study population

Variable	Urban adolescents <sup>a</sup>	Rural adolescents <sup>a</sup>	p value*
n	170	152	—
Age (years)	$15.4 \pm 1.6$	$15.2 \pm 1.7$	NS
Energy intake (Kcal)	$2268 \pm 681$	$2035 \pm 731$	0.0048
% Energy from saturated fat	$12 \pm 3$	$10 \pm 3$	0.0000
% Energy from polyunsaturated fat	$6 \pm 3$	$6 \pm 3$	NS
% Energy from total carbohydrate	$56 \pm 7$	$59 \pm 8$	0.0008
% Energy from sucrose	$20 \pm 7$	$18 \pm 5$	NS
BMI (Kg/m <sup>2</sup> )	$21.1 \pm 3$	$21.2 \pm 3$	NS
Cardiovascular fitness score	$3.6 \pm 1.1$	$3.2 \pm 1.2$	0.0040

<sup>a</sup> Means  $\pm$  standard deviation, \* Tested with analysis of variance,  $p > 0.05$  = not significant "NS".

Mean BMI was similar among urban and rural adolescents. The prevalence of overweight was higher in urban (13%) than rural adolescents (9%), but these differences were not significant.

The mean fitness scores for urban and rural youngsters were 3.6 and 3.2%, respectively ( $p=0.004$ ). The low score found in rural adolescents suggests that they have a higher level of cardiovascular fitness than urban; however, the mean fitness score for both groups was below average (score equal 3). 63% of urban and 44% of rural adolescents ( $p=0.000$ ) were considered sedentary.

The prevalence of sedentariness (cardiovascular fitness score below 3) among females (76.5%) was significantly higher ( $p=0.001$ ) than among males (31.5%). Likewise, sedentariness among urban males (43%) was significantly greater ( $p=0.012$ ) than among rural males (20%). There were no significant differences in females (data not shown).

### Serum lipids and glucose levels

The mean values for serum cholesterol, lipoproteins, triglyceride and glucose levels from the adolescent population studied are presented in Table 2. Total cholesterol (TC) was significantly higher ( $p=0.000$ ) in females than males (4.23 mmol/L and 3.82 mmol/L respectively). Likewise, HDL-C and LDL-C levels were significantly higher in females than in males (1.14 mmol/L and 0.07 mmol/L respectively,  $p=0.000$ ).

TABLE 2  
Serum lipids and glucose levels in urban and rural Costa Rican adolescents (n=322)

Parameter	Gender		p*	Males		p*	Females		p*	Total		p*
	Males (n=166)	Females (n=156)		Urban (n=87)	Rural (n=79)		Urban (n=83)	Rural (n=73)		Urban (n=170)	Rural (n=152)	
Total cholesterol (mmol/L)	3.82± 0.6	4.24± 0.6	0.0000	3.93± 0.5	3.72± 0.6	0.0188	4.26± 0.6	4.18± 0.6	NS	4.08± 0.6	3.95± 0.6	0.0420
HDL cholesterol (mmol/L)	0.07± 0.2	1.14± 0.2	0.0011	1.14± 0.2	1.01± 0.2	0.0000	1.14± 0.2	1.07± 0.1	0.0000	1.17± 0.2	1.04± 0.2	0.0000
LDL cholesterol (mmol/L)	2.18± 0.5	2.47± 0.6	0.0000	2.21± 0.5	2.13± 0.5	NS	2.44± 0.8	2.49± 0.6	NS	2.31± 0.5	2.31± 0.5	NS
LDL-C/HDL-C ratio	2.4 ± 0.3	2.3 ± 0.2	NS	2.5 ± 0.2	2.3 ± 0.3	NS	2.2 ± 0.3	2.4 ± 0.2	NS	2.4 ± 0.3	2.3 ± 0.4	NS
Triglyceride (mmol/L)	1.16± 0.3	1.31± 0.3	NS	1.17± 0.3	1.19± 0.3	NS	1.24± 0.3	1.34± 0.3	NS	1.22± 0.3	1.26± 0.4	NS
Glucose (mg/dl)	74±9	73 ±8	NS	74±7	74±11	NS	72 ±7	75±8	NS	73±7	74±10	NS

TC: Total Cholesterol, HDL-C: HDL Cholesterol. To convert mmol/L cholesterol to mg/dl multiply mmol/L by 38.7. To convert mmol/L triglyceride to mg/dl, multiply mmol/L by 88.6. \* Tested with analysis of variance, p> 0.05= not significant " NS".

The mean value for TC was 3.93 mmol/L in urban males. This value was 0.21 mmol/L higher (p= 0.0188) than the mean value for TC evidenced in rural males (3.72 mmol/L). No differences were found between TC levels in females. The mean value for HDL-C was 0.62 mmol/L. The mean value for HDL-C was significantly higher in urban adolescents than in rural youngsters (1.17 mmol/L and 1.04 mmol/L respectively, p= 0.0000). LDL/HDL ratio averaged 2.3 with no differences between gender and area.

Serum triglyceride levels averaged 1.19 mmol/L for males with no differences between urban and rural youngsters. Females behaved similarly, but their mean value was slightly higher (1.31 mmol/L; NS).

Glucose levels averaged 73 mg/dl with no differences between urban and rural youngsters.

Table 3 provides the classification of serum lipids for urban and rural adolescents based on the National Cholesterol Education Program and Johns Hopkins guidelines. The proportion (25%) of females with borderline TC levels (4.42-5.17 mmol/L) was significantly higher (p=0.002) than the proportion of males (13%). The fraction of adolescents with serum TC at borderline or high levels (≥ 5.2 mmol/L) was similar between urban and rural areas.

The proportion of females (12%) with borderline levels of serum LDL-C (2.86- 3.35 mmol/L) was significantly greater (p=0.025) than the proportion of males (7%). In addition, the proportion of adolescents with borderline LDL-C levels was lower, but not significant, in rural area than in urban area.

TABLE 3  
Classification of serum lipids for urban and rural Costa Rican adolescents based on the National Cholesterol Education Program guidelines (n=322)

Parameter	Gender		p*	Males		p*	Females		p*	Total		p*
	Males (n=166)	Females (n=156)		Urban (n=87)	Rural (n=79)		Urban (n=83)	Rural (n=73)		Urban (n=170)	Rural (n=152)	
<b>Total cholesterol mmol/L</b>												
<4.42	84.9	70.2	0.027	79.3	81.3	NS	66.3	72.6	NS	75.3	79.7	NS
4.42-5.17	13.3	26.0	0.025	13.5	12.7	NS	28.9	20.5	NS	21.2	16.4	NS
≥5.2	1.8	3.8	0.027	7.2	6.0	NS	4.8	6.9	NS	3.5	3.9	NS
<b>HDL cholesterol mmol/L</b>												
<0.91	20.5	7.8	0.002	13.7	27.9	0.038	6.0	9.6	NS	10.0	19.0	NS
0.91-1.17	48.8	55.8	NS	40.3	58.2	0.031	41.0	72.6	0.000	40.6	65.2	0.000
>1.17	30.7	36.4	NS	46.0	13.9	0.000	53.0	17.8	0.000	49.4	15.8	0.000
<b>LDL cholesterol mmol/L</b>												
<2.86	91.0	81.4	0.028	90.8	91.1	NS	79.5	83.6	NS	84.3	87.4	NS
2.86-3.35	7.2	12.2	0.025	6.9	7.6	NS	14.5	9.6	NS	10.1	8.6	NS
≥3.38	1.8	6.4	0.077	2.3	1.3	NS	6.0	6.8	NS	5.6	4.0	NS
<b>Triglyceride mmol/L</b>												
<1.02	29.5	12.2	0.000	27.6	31.6	NS	12.0	12.3	NS	20.0	22.4	NS
1.02-1.46	56.0	65.4	NS	59.8	51.9	NS	67.5	60.3	NS	63.5	55.9	NS
≥1.47	14.5	22.4	NS	12.6	16.5	NS	20.5	27.4	0.002	16.5	21.7	NS

TC: Total Cholesterol, HDL-C: HDL Cholesterol. To convert mmol/L cholesterol to mg/dl multiply mmol/L by 38.7. To convert mmol/L triglyceride to mg/dl, multiply mmol/L by 88.6.

Around 20% of males showed low HDL-C (< 0.91 mmol/L) levels. This prevalence was significantly higher ( $p=0.002$ ) than that observed in females (8%). The prevalence of adolescents with borderline HDL-C levels (0.91-1.17 mmol/L) was significantly higher in rural than in urban areas (65% and 40 % respectively,  $p= 0.000$ ).

The prevalence of borderline triglyceride levels (1.02-1.46 mmol/L) was 60%, with no differences between gender and area. However, the proportion of rural females with high triglyceride levels ( $\geq 1.47$  mmol/L) (27%) was significantly ( $p=0.002$ ) higher than the proportion of urban females (20%). Over 45% of adolescents studied presented both levels of triglyceride higher than 1.02 mmol/L and levels of HDL-C lower than 1.17 mmol/L.

### Multiple regression analysis

Linear regression models with TC, HDL-C, LDL-C and TG as dependent variables are presented in Table 4. These regression models explained about 15% of the variance in Costa Rican adolescents' lipid profiles.

TABLE 4  
Regression models with Total Cholesterol, HDL-C, LDL-C and Triglyceride as dependent variables

Independent variables	Estimated coefficient	95% CI
<b>Total cholesterol</b>		
Age	-0.003	-0.045, 0.039
Gender	-0.217	-0.377, -0.057
BMI	0.022	-0.001, 0.046
Area	0.085	0.001, 0.004
Cardiovascular fitness score	0.002	6.33E-04, 0.003
constant	2.753	
$R^2 = 0.1640$		
<b>HDL- cholesterol</b>		
Age	0.005	-0.007, 0.172
Gender	-0.062	-0.108, 0.015
BMI	-0.015	-0.022, -0.009
Area	0.103	0.062, 0.144
Cardiovascular fitness score	$-3.88 \times 10^{-4}$	$-1.08 \times 10^{-5}$ , $-7.87 \times 10^{-4}$
constant	1.181	
$R^2 = 0.2120$		
<b>LDL- cholesterol</b>		
Age	0.002	-0.038, 0.042
Gender	-0.089	-0.240, 0.061
BMI	0.029	0.007, 0.052
Area	-0.016	-0.150, 0.117
Cardiovascular fitness score	0.003	0.001, 0.003
constant	0.727	
$R^2 = 0.1439$		
<b>Triglyceride</b>		
Age	-0.020	-0.044, 0.005
Gender	-0.003	-0.096, 0.089
BMI	0.019	0.006, 0.033
Area	-0.048	-0.130, 0.034
Cardiovascular fitness score	0.001	$4.31 \times 10^{-4}$ , 0.002
constant	0.729	
$R^2 = 0.0855$		

BMI: Body Mass Index.

Using TC as the dependent variable after adjustment for age, a significant independent positive relationship with cardiovascular fitness score (95% CI 0.001, 0.004) and a negative relationship with gender was found. Mean TC was 0.217 mmol/L (95% CI -0.377, -0.057) lower than females. A similar model with HDL-C as the dependent variable showed a significant independent negative relationship with gender (95% CI -0.108, -0.015), BMI (95% CI -0.022, -0.009) and cardiovascular fitness score (95% CI  $1.08 \times 10^{-5}$ ,  $7.87 \times 10^{-4}$ ). Mean HDL-C was 0.062 mmol/L lower than in females. Likewise this regression model showed a positive relationship with area (95% CI 0.0062, 0.144). Mean HDL-C was 0.103 mmol/L higher in urban adolescents than in rural youngsters.

With LDL-C as the dependent variable, after adjustment for age, levels were positively related to BMI (95% CI 0.073, 0.052), cardiovascular fitness score (95% CI 0.001, 0.003). Likewise these variables were positively related to triglyceride when this lipid was used as the dependent variable in the regression model.

A variable for the evaluation of the interaction between gender, area, and lipid levels was created and incorporated in the different regression models, even though no statistical significance was found.

No dietary variable showed to be an important predictor for serum lipid levels.

## DISCUSSION

LDL-C levels have been linked to early arterial lesion in the aorta and the coronary arteries (1-7), and the measurements in young people are powerful predictors of CAD in middle-age people (6). From this viewpoint, the low prevalence of high LDL-C levels observed in Costa Rican adolescents may suggest a slow progression of atherosclerosis and therefore a low risk of CAD. However, as compared to the United States, the plasma lipid profile among Costa Ricans was more atherogenic. The LDL/HDL ratios show that Costa Rican adolescents have higher ratios in both males and females (2.4 and 2.3) as compared to their United States counterparts (1.9 and 1.9) (19). The LDL/HDL ratio is the variable that most clearly would predict the increased CAD risk for Costa Rican adolescents' (20). Therefore, these data suggest that Costa Rican adolescents may be at an increased risk of CAD as compared to adolescents in the United States.

Additionally, the high proportion of adolescents with borderline-high levels of triglyceride and borderline-low HDL-C levels (around 47%) is worrisome. Data from the Prospective Cardiovascular Münster (PROCAM) study and the Helsinki Heart Study suggest that the combination of high triglyceride and low HDL-C levels constitutes a powerful risk factor for non-fatal myocardial infarction or CAD death, that would escape attention if LDL-C levels alone were

determined (21-23).

This situation is worrisome since it may indicate a trend toward further future increases in the prevalence of CAD in Costa Rica. The Bogalusa Heart Study suggests that over 70% of children with adverse lipid profiles tend to remain so as young adults (9).

These results could reflect the Costa Rican adolescents' dietary habits. Populations that habitually consume low-fat and high-carbohydrate diets usually have low HDL-C and high triglyceride levels (24). The adolescents' diet presents a total fat and total carbohydrate intake that ranges between recommended levels (30% kcal from total fat and 55-60% Kcal from total carbohydrates). Nevertheless, sucrose intake was as high as that reported by the Bogalusa Heart study; around 20% of the total energy (twice the established recommendation,  $\leq 10\%$  kcal) (25). Elevated sucrose intakes increase the hepatic production of triglyceride and generates a reduction in the half-life of the HDL-C particles (26,27).

A high prevalence of low HDL-cholesterol ( $< 1.0$  mmol/L) was found in the rural areas. This may also be a consequence of the lower saturated fat intake observed in these areas (around 10 g/day less than urban areas). Several new and sometimes controversial concepts have arisen that challenge the assumptions underlying the Keys-Hegsted regression equations. Although saturated fats as a class raise LDL, they also appear to have primary responsibility among dietary fatty acids for raising HDL-C (28,29), possibly by translational and posttranslational mechanism (30).

The no association between dietary intake and serum lipids levels found among adolescents, may be a consequence of the methodological difficulty in measuring nutrient intake. However, it has been postulated that above a certain "ceiling" level of dietary components, variability in serum lipids reflects individual metabolic variations rather than differing dietary intake (31).

Low HDL-C is also usually associated with a lack of physical activity (32). In this report a significantly independent relationship between these variables was found. This is worrisome, as 31% of adolescents with borderline HDL-C levels were sedentary. Multiple evidence suggests that exercise may favorably affect the levels of triglyceride, HDL-C, apolipoprotein A, apolipoprotein B and the size and density of HDL particles (4,5,32)

The trend toward low HDL-C and high triglyceride levels in urban and rural adolescents could be also owe to the mestizo genetics of Costa Ricans (23). A similar pattern has been observed in the Pima Indians, the Tarahumara Indians and in Mexican Americans (33-35). This may also explain why the Costa Rican adolescents' present lower HDL-C levels (Figures 1 and 2), compared with other similar adolescents from the US, Venezuela and Spain whose sucrose intake is similar to the described one (10,36,37). On the contrary,

triglyceride levels tend to be significantly higher in Costa Rican youngsters.

FIGURE 1

Comparative serum lipids percentiles for adolescents males

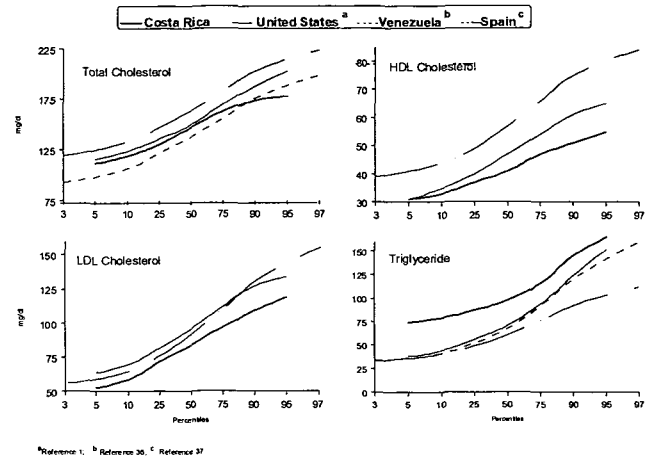
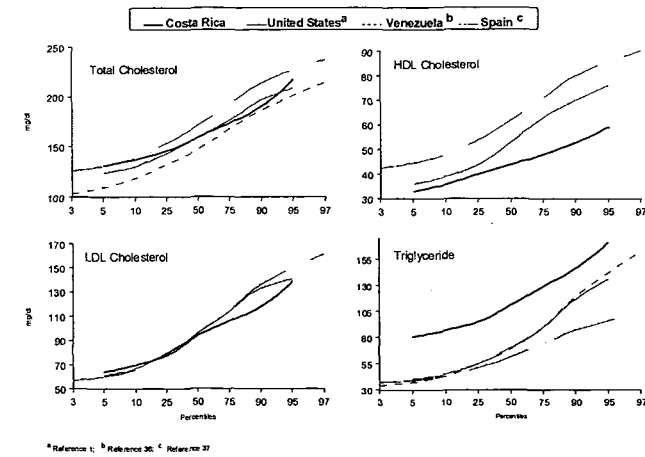


FIGURE 2

Comparative serum lipids percentiles for adolescents females



Considering the lipid profile presented by Costa Rican adolescents, it could be predicted that these youngsters might be at high CAD risk if they increase the prevalence of other risk factors such as high LDL-C, overweight, high saturated fat and sucrose intake and sedentariness. Clustering indicates that each elevated risk factor tends to support the elevation of others (38). This is particularly important, since it has been observed that when LDL-C levels increase, the CAD risk raises 2.5 times approximately in individuals with high triglyceride levels (39). Likewise obesity, especially central

type in presence of high triglyceride levels represents an important predictor for diabetes mellitus development (40).

In this regard, the high prevalence of sedentariness (53%), high saturated fat intake (37%), high sucrose intake (95%) and overweight (22%) found in this study is worrying. This is very important since, according to the regression model, for each Kg/m<sup>2</sup> of increase on the BMI, the LDL-C levels will raise 0.029 mmol/L and the HDL-C will decrease 0.015 mmol/L. Likewise, for each pulse of increase on the cardiac frequency (high cardiovascular fitness score), the HDL-C will diminish 3.88 x 10<sup>-4</sup> mmol/L and the LDL-C levels will raise 0.003 mmol/L.

These results suggest the urgent need of developing primary intervention programs, oriented to modify Costa Rican adolescents' eating and physical activity pattern. A school-based health promotion program of exercise and health lecture-discussion could be beneficial, as several researchers have suggested (41,42). This is vital, because in Costa Rica the prevalence of obesity increases after childhood (43), therefore the risk for CAD could be increased.

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