Arch. Lat. Nutr., 36: 235-246, 1986.

SERUM CHOLESTEROL, TRIGLYCERIDE, AND HIGH-DENSITY-LIPOPROTEIN CONCENTRATIONS IN MEN WITH DIFFERENT DIETARY AND EXERCISE REGIMENS IN PURISCAL, COSTA RICA[1]

Laura Whitmore[2], *Alfonso Trejos*[2] *and Leonardo Mata*[3]

Instituto de Investigaciones en Salud (INISA),
Universidad de Costa Rica
San José, Costa Rica

SUMMARY

Mean serum cholesterol and triglyceride concentrations were higher for two groups of sedentary middle-aged and elderly men than for a group of physically-active, middle-aged farmers, all from rural Puriscal, Costa Rica. The mean serum cholesterol, triglyceride, and high-density lipoprotein (HDL)-risk factor levels of the three groups were all higher than the comparable US means. Dietary fat and cholesterol intake were also greater for the Puriscal men than for the comparable US counterpart. No correlations were found between dietary fat or cholesterol and the corresponding serum levels. Age was correlated with serum cholesterol and HDL-risk factor values. Weight was also correlated with these variables as well as with serum triglyceride concentrations. A high prevalance of obesity was found among the middle-aged sedentary men.

INTRODUCTION

Cholesterol is transported in the plasma by very-low-density lipoproteins (VLDL), low-density lipoproteins (LDL), and high-density lipoproteins (HDL). Of these, LDL carries most of the serum cholesterol, about 65%; HDL carries about 20%, and VLDL about 15% (1).

A feedback mechanism normally regulates the amount of cholesterol produced in the cell by monitoring the concentration already present in

---

Manuscrito modificado recibido: 24-4-86.

1 This study received support from the University of Costa Rica, the Associated Colleges of the Midwest, USA, the Ministry of Health and the National Council for Scientific Research and Technology of Costa Rica.

2 Members of the Instituto de Investigaciones en Salud (INISA), University of Costa Rica.

3 Professor and Director, Instituto de Investigaciones en Salud (INISA), University of Costa Rica, Ciudad Universitaria "Rodrigo Facio", San José, Costa Rica.

the serum. When serum cholesterol levels are high, the cell stops cholesterol production, thus regulating its concentration. An LDL receptor site on the cell's surface is responsible for controlling cholesterol biosynthesis. If this receptor site is damaged or missing, a condition known as hypercholesterolemia results. This genetic, or environmentally-induced defect results in both high concentrations of LDL in the blood, and in severe atherosclerotic disease, strengthening the case that blood cholesterol is causally involved in atherogenesis, or plaque formation in arteries (2). In contrast, HDL-cholesterol is inversely associated with atherosclerotic coronary-heart disease (CHD) (3). Therefore, it appears desirable for humans to have a low proportion of serum LDL and a high proportion of serum HDL.

Controversy still exists over the role of diet in affecting serum-cholesterol levels (4). In a 19-year study of 1,900 Western Electric employees, evidence supported the position that decreasing calorie intake derived from saturated fat, and increasing the proportion of poly-unsaturated fats as well as decreasing the amount of dietary cholesterol, will lower serum cholesterol by predictable amounts (5). Debate still exists, however, as to whether or not dietary changes can reduce the risk of cardiovascular disease (5,6).

The correlation between serum-triglyceride levels and CHD is also controversial (7). Significant correlation between triglyceride levels and CHD has been found when the cholesterol variable was not considered. Nevertheless, when only patients with normal cholesterol levels were studied, no correlation was shown between triglycerides and CHD. Thus, the question remains whether correlation between triglyceride concentrations and CHD were not just due to a correlation between triglyceride and cholesterol levels (7).

Recent evidence suggests that exercise plays an important role in influencing the levels of HDL, LDL, and triglycerides in human blood. HDL concentrations were found to increase with exercise while the levels of LDL and triglycerides tended to decrease (8-10).

Studies on this issue have been mainly conducted in industrialized countries where diet, exercise, and stress have been correlated with CHD and cancer. Limited investigation has been done to determine if the same associations exist in less developed nations. Cross-cultural comparisons between stress, diet, and exercise, could lead to a better understanding of the effect of these variables on human health. The objective of the following study was to examine the concentrations of total serum cholesterol, HDL-cholesterol, and triglycerides as functions of diet, exercise, age, and weight, of three distinct groups of rural men living in Puriscal, Costa Rica.

MATERIAL AND METHODS

Puriscal, a large county in south central highland and lowland Costa Rica, has eight districts at elevations ranging from 765 to 1,325 meters in an extremely rugged terrain. The county seat, Santiago, is located 43 km west of San José, the capital of Costa Rica. The population is of Spanish and American Indian descent. The society is in transition and had some health problems of developing nations such as malnutrition and

diarrhea, although they are clearly declining, as well as problems characteristic of industrialized nations, such as cancer, CHD and obesity (11).

For the study herein discussed, 45 men aged 40 to 55 years were selected. Twenty-one were farmers, and 24 held office jobs or worked as salesmen; 15 additional men, 59 to 95 years, lived in a home for the elderly in Santiago. The groups were chosen because their occupations demanded different levels of exercise. The most active were the farmers and the least active the elderly. It was anticipated that the diet of the farmers would be lower in fat and cholesterol, because of a lower level of meat consumption. A demonstration of differences in total-serum cholesterol, triglycerides and HDL-risk factor levels between the groups was attempted.

Field Procedure

The headquarters of the Instituto de Investigaciones en Salud (INISA) in Santiago Puriscal, was used as a base of operations. Suitable participants were found, in part, in the files of the Ministry of Health; and, in part, by asking men visiting central Santiago to participate.

The aims of the study were explained, and written consent was obtained from all men. Whole blood samples were collected from subjects who had fasted 12-14 hours; 5 ml of blood were distributed into two silicone-coated test tubes (100x16 mm) containing 0.1 ml of 10%/o ethylene-diamine-tetracetic acid (EDTA). Within a two-hour period, the samples were centrifuged for 10 minutes at 4,000xg, using a Sorvall RC-5B centrifuge. The serum was refrigerated at 4°C for up to five days and then transported under refrigeration to the San Juan de Dios Hospital for laboratory analysis. The procedure for total cholesterol determination was as outlined by Ferro and Ham (12). The HDL-cholesterol fraction was measured using the Pierce-HDL/Cholesterol Rapid Stat Kit (13). Serum triglyceride concentrations were determined using the Tri-25 Triglyceride Method outlined by Dade Diagnostics, Inc. (14).

Total dietary fat, saturated fat, oleic fatty acids, linoleic fatty acids, and cholesterol were estimated for each participant from a dietary questionnaire. The form included specific questions for foods rich in fats and cholesterol, and for fried foods. Data were calculated using the food composition tables recommended for the area (15,16), and conversion tables (for units of measurements) developed by INISA (unpublished).

Weight and height were determined for each man, but due to physical handicaps and changes in residency, this information was not obtained from three of the elderly men. Ideal weight deviations were calculated using weight-for-height measurements (17).

The two-sample t-test for equal variances was used to test for statistically significant differences among mean serum cholesterol, triglyceride, HDL-risk factor values, and ideal weight deviations for the three groups (18). Correlation coefficients were calculated between dietary, serum, age, and weights variables (18).

RESULTS

The mean total-serum cholesterol, triglyceride and HDL-risk factor

levels are found in Table 1 along with US means for groups of similar age (19). Significant differences in cholesterol levels were found between the agriculture and sedentary groups ($t = 2.73$, 43 d.f., $p < 0.01$) and the agricultural and elderly groups ($t = 2.67$, 34 d.f., $p < 0.02$). No significant difference was found between the mean cholesterol values of the sedentary and elderly groups (Figure 1). The only significant difference in mean serum-triglyceride levels for the three groups occurred between the agricultural and the sedentary middle-aged groups ($t = 2.55$, 43 d.f., $p < 0.05$), (Table 1 and Figure 2). The mean HDL-risk factor values differed slightly, but not significantly, among the three groups (Table 1 and Figure 3).

TABLE 1

MEAN (± SD) OF SERUM CHOLESTEROL, TRIGLYCERIDE, AND HDL-RISK-FACTOR, PURISCAL RURAL MEN, COMPARED WITH AMERICAN MEN OF SIMILAR AGE

Group	Number of Subjects	Total Serum Cholesterol	Serum Triglycerides	HDL-Risk Factor
Puriscal, 40-55 years old				
agriculture	21	218 ± 44	158 ± 76	6.19 ± 1.9
sedentary	24	258 ± 53	220 ± 86	6.72 ± 1.4
United States, 40-54 years old*		210 ± 23	149 ± 44	4.72 ± 1.8
Puriscal, 59-95 years old				
sedentary	15	265 ± 63	186 ± 41	7.04 ± 1.8
United States, 70 + years old*		210 ± 21	133 ± 35	4.16 ± 1.8

*Source: Tamir, Rifkind and Levy (19).

The mean group intake of total dietary fat, saturated fat, oleic and linoleic fatty acids, and cholesterol are detailed in Table 2, along with the corresponding US norms for men in similar age groups (20). The mean total fat consumption among the three groups was similar, but the elderly group consumed less saturated fat and more oleic fatty acids than the other groups, while the middle-aged sedentary group's cholesterol intake was lower than that of the other two groups.

No significant correlations were found between dietary fat or cholesterol consumption and serum cholesterol, triglyceride or HDL-risk factors. The elderly group was excluded from the dietary correlations to remove the age variable. The correlation coefficient between total dietary fat and serum cholesterol levels was 0.002. The randomness is illustrated in the scatter diagram of Figure 4.

Deviations from ideal weight are given in Figure 5. Significant differences were observed between means for the agricultural and sedentary groups ($t = 4.63$, 43 d.f., $p < 0.001$), as well as for the elderly and sedentary groups, ($t = 4.55$, 37 d.f., $p < 0.001$). Weight was positively correlated with total-serum cholesterol concentrations ($r = 0.30$, 43 d.f., $p < 0.05$), triglyceride concentrations ($r = 0.29$, 43 d.f., $p < 0.05$) and HDL-risk factor values ($r = 0.34$, 43 d.f., $p < 0.05$).

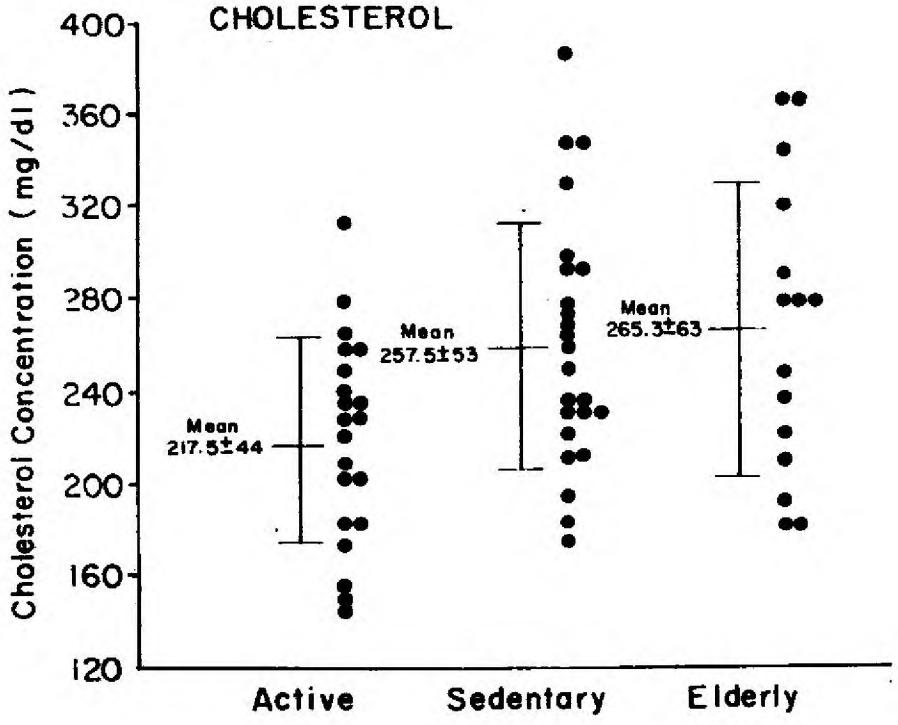

FIGURE 1

Scatter diagram of plasma cholesterol values and means (± one standard deviation) for each group of individuals. See text

Age was significantly correlated with both total-serum cholesterol ($r = 0.32$, 58 d.f., $p < 0.05$) and HDL-risk factor values ($r = 0.29$, 58 d.f., $p < 0.05$). However, no correlation was found between age and serum triglyceride concentrations.

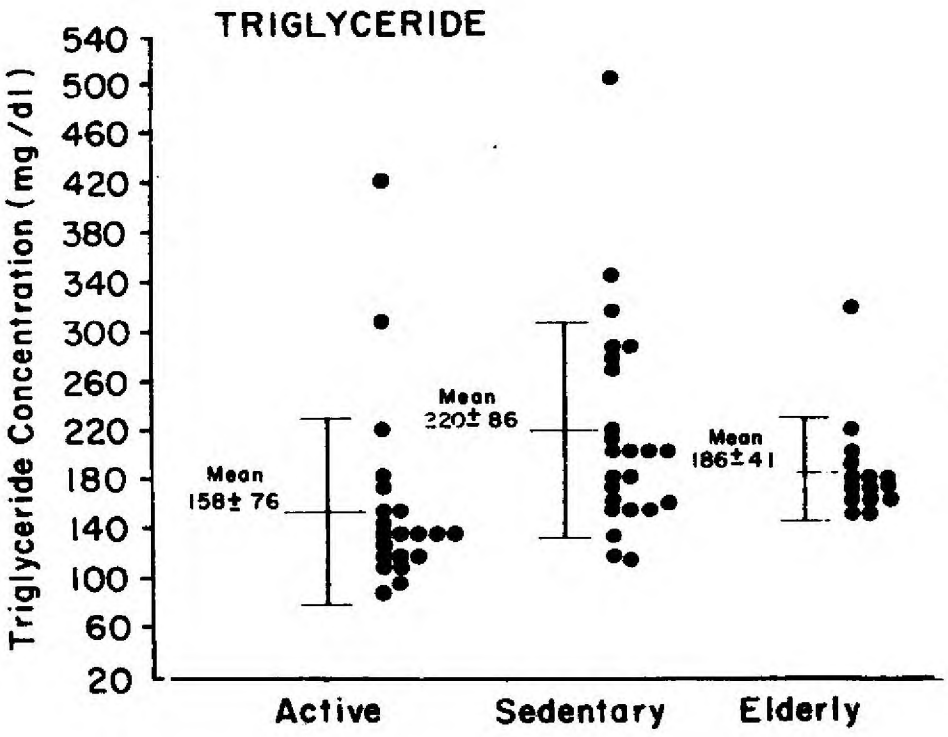

FIGURE 2

Scatter diagram of plasma triglyceride values and means (± one standard deviation) for each group of individuals. See text

DISCUSSION

Serum cholesterol distributions were similar for both the sedentary middle-aged group and the elderly group, although their ages were markedly different. Significant differences in means were found only between the active agricultural group and the two less active groups. From the standpoint of serum cholesterol composition, the middle-aged sedentary group seemed to have "prematurely aged", while the levels of the physically active men of the same age, remained lower.

The mean serum cholesterol value found in the United States for 11 population groups of white males aged 40-54 (19), was lower than that found in both Puriscal middle-aged group means. While the mean serum-cholesterol level of the agricultural group was close to the US mean,

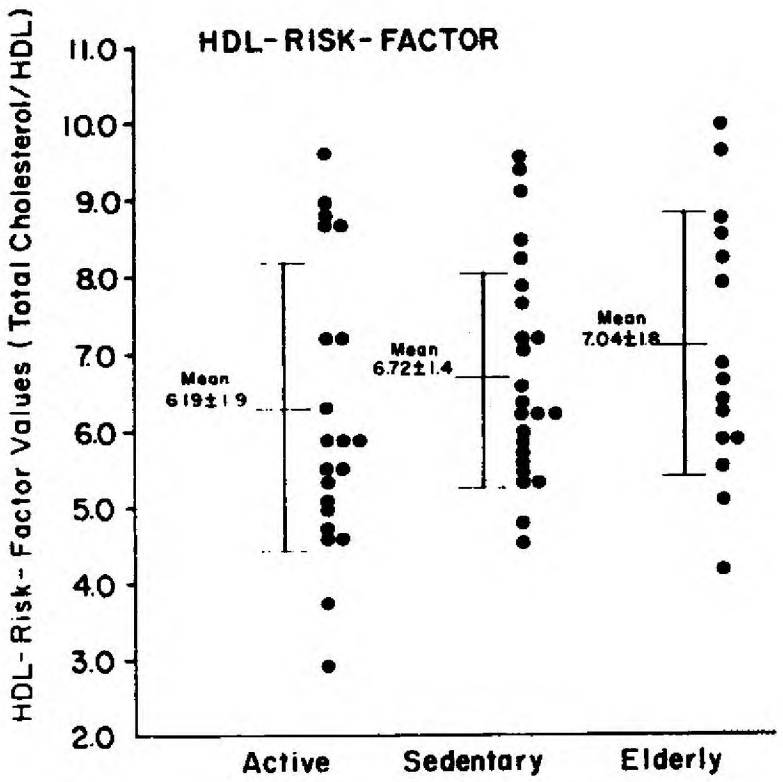

FIGURE 3

Scatter diagram of HDL-risk factor ratios, and means (± one standard deviation) for each group of individuals. See text

that of the sedentary group was slightly higher than the upper-10th percentile value (257.3 mg/dl) of the same sample (19). Likewise, the mean serum-cholesterol value for the elderly group was slightly higher than the 90th percentile value (253 mg/dl) for US men over 70 years studied by Tamir Rifkind and Levy (19).

Although the only significant difference in mean triglyceride levels was found between the active and sedentary middle-aged groups, it should be noted that the average serum-triglyceride level was higher for the middle-aged sedentary group than for both the active group of the same age and the physically-inactive elderly group. The means for all three groups exceeded the respective US means, even though they were all under the 90th percentile value of the same US sample (19).

TABLE 2

MEAN (± SD) DAILY FAT AND CHOLESTEROL CONSUMPTION, PURISCAL RURAL MEN, COMPARED WITH AMERICAN MEN OF SIMILAR AGE

Group	Total Fat (g)	Saturated Fat (g)	Oleic Fatty Acids (g)	Linoleic Fatty Acids (g)	Cholesterol (mg)
Puriscal, 40-55 years old					
agriculture	108 ± 89	40 ± 47	41 ± 30	8 ± 5.9	731 ± 486
sedentary	107 ± 50	41 ± 18	40 ± 20	8 ± 5.4	617 ± 346
USA, 45-64 years old*	93*	34*	36*	9*	465*
Puriscal, 59-95 years old					
elderly	103 ± 4	35 ± 3	49 ± 1	4 ± 0.1	736 ± 14
USA, 65-74 years old*	74**	27*	29*	7*	411*

*Abraham and Carrol (20).
**Standard deviations were not available for the US values.

The trend shown in other studies that HDL-cholesterol concentrations tend to increase with physical activity (8-10), was corroborated here (Figure 3). The most active agricultural group had the highest proportion of HDL to total cholesterol concentration (the lowest HDL-risk factor), while the least active elderly group, had the lowest, but these results were not statistically significant. It should be noted that the mean HDL-risk factor values in Puriscal were all considerably higher than their US counterparts.

Age correlated with an increase in total serum cholesterol as had been previously found (1). Weight may have been a confounding variable in evaluating the effects of exercise on serum composition. Mean deviations between serum cholesterol levels for the agricultural and sedentary groups could have been due to differences in physical activity and/or ideal weight. Likewise, variables of exercise and/or age could have been responsible for the differences in cholesterol concentrations between the agricultural and elderly groups. Serum triglyceride levels, however, seemed to be more sensitive to weight than to exercise or age, because similar levels were found between the physically active agricultural group, and the relatively inactive elderly group. If there is also a serum triglyceride-age correlation, as has been previously found (14), its detection may have been hampered by the large weight differences among the groups.

The mean serum cholesterol and triglyceride composition of the agricultural group was closer to the US values than were the two seden-

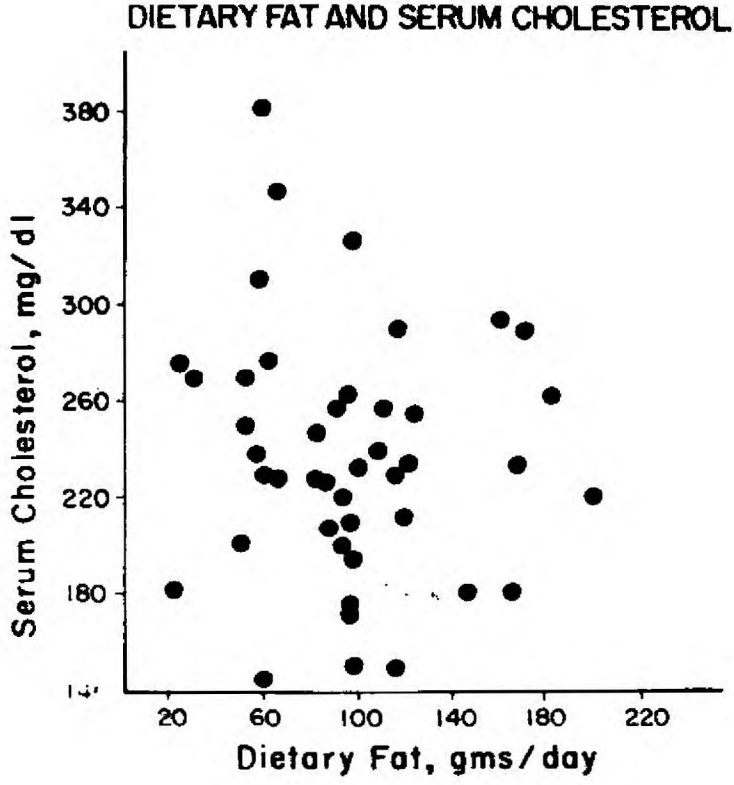

FIGURE 4

Correlation of total-daily-dietary fat consumption and serum cholesterol concentrations. One value of daily dietary fat which was greater than 450 grams was not included in the diagram. A high degree of randomness was observed

tary groups (Table 1). HDL-risk factor falues were substantially higher than the respective US means for all three groups. The sedentary middle-aged group had a high prevalence of obesity, while the agricultural and elderly groups tended to be under the ideal-weight-for-height values cited by Robinson (17). Dietary fat and cholesterol intake were also higher in Puriscal than in the US for males of comparable age. While no correlations were found between dietary and serum values, it should be noted that dietary fat and cholesterol consumption, as well as serum lipid levels, were higher in Puriscal than in the US. Whether variables such as diet, exercise, or race are involved, a trend of higher serum cholesterol, triglyceride, and HDL-risk factor values was observed in Puriscal, Costa Rica than in the US where so much concern has been placed on these variables. Further study needs to be done to determine if trends found

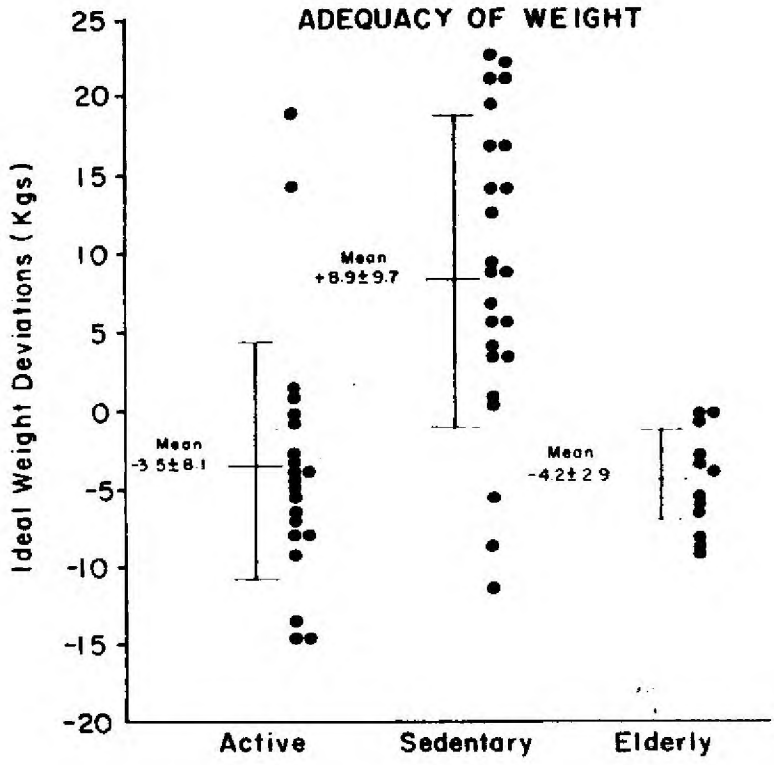

FIGURE 5

Ideal weight-to-height deviations and means (± one standard deviation) for each group of individuals. Sedentary persons had a marked tendency to be overweight

in Puriscal are representative of Costa Rica, and also if elevated levels of serum cholesterol, triglycerides, and HDL-risk factor values are associated with an increased incidence of atherosclerosis.

ACKNOWLEDGEMENTS

We thank the following people for their time and contribution to this study: the villagers of Puriscal; Dr. José Miguel Esquivel and Dr. Julio Mora, Lic. Francisco Sánchez, for their help in the evaluation; and the staffs of INISA, the Ministry of Health, the Hospital San Juan de Dios, and the Associated Colleges of the Midwest.

RESUMEN

COLESTEROL SERICO, TRIGLICERIDOS Y CONCENTRACIONES DE LIPOPROTEINAS DE ALTA DENSIDAD EN HOMBRES CON DIFERENTES REGIMENES DIETETICOS Y DE EJERCICIO, PURISCAL, COSTA RICA

Las concentraciones medias de colesterol sérico y triglicéridos fueron más altas en dos grupos de sujetos integrados por hombres sedentarios de mediana edad, y de ancianos, respectivamente, que en un grupo de agricultores físicamente activos, de mediana edad, todos ellos del área rural de Puriscal, Costa Rica. Todos los niveles medios de colesterol sérico, triglicéridos y lipoproteínas de alta densidad —factor de riesgo HDL— de los tres grupos fueron más elevados que los valores medios comparables de los EUA. La ingesta dietética de grasa y colesterol también fue mayor en los hombres de Puriscal que en sus contrapartes comparables de los Estados Unidos. No se encontraron correlaciones entre la grasa de la dieta o colesterol, y los niveles séricos correspondientes. La edad fue correlacionada con los valores medios de colesterol sérico y del factor de riesgo HDL. El peso también se correlacionó con estas variables, así como con las concentraciones séricas de triglicéridos. Se constató una alta prevalencia de obesidad entre los hombres sedentarios, de mediana edad.

BIBLIOGRAPHY

1. Thompson, P. & W.M. Bortz. Significance of high-density lipoprotein cholesterol. **J. Am. Geriat. Soc., 26**: 440-442, 1978
2. Marx, J.L. Atherosclerosis: The cholesterol connection. **Science, 194**: 711-714, 1976.
3. Stein, E.A. Development and evaluation of a method for quantitation of plasma high-density-lipoprotein cholesterol. **Clin. Chem., 24**: 1112-1115, 1978.
4. Grundy, S. Can changes in the American diet reduce the likelihood of developing coronary heart disease? **Wash. Pub. Hlth., 2**: 13-17 1981.
5. Shekelle, A.M. Shryock, P.O. Oglesby, M. Lepper, J. Stamler, S. Liu & W.J. Raynor. Diet, serum cholesterol, and death from coronary heart disease. **N. Eng. J. Med., 304**: 65-69, 1981.
6. Dietary cholesterol restriction value challenged in NRC Report. **Hosp. Pract., 15**:26-27, 31, 1980.
7. Cohn, P.F., S.I. Gavvay & W.B. Weglicki. Serum lipid in angiographically defined coronary artery disease. **Ann. Int. Med., 84**: 241-245, 1976.
8. Willet, W., C.H. Hennekens, A.J. Siegel, M.M. Adner & W.P. Castelli. Alcohol consumption and high-density-lipoprotein cholesterol in marathon runners. **Med. Intel., 303**: 1159-1161, 1980.
9. Lopez-S, A., R. Vial, L. Balart & G. Arroyave. Effect of exercise and physical fitness on serum lipids and lipoproteins. **Atherosclerosis, 20**: 745-752, 1979.
10. Vodak, P.A., P.D. Wood, W.L. Haskell & P.T. Williams. HDL-cholesterol and other plasma lipid and lipoprotein concentrations in middle-aged male and female tennis players. **Metabolism, 29**: 745-752, 1980.
11. Mata, L.J. Nutrition and health in societies in transition. In: **Nutrition in Transition**. Monroe, Wisconsin, The American Medical Association, 1978.
12. Ferro, P.V. & A.B. Ham. Rapid determination of total and free cholesterol in serum. **Am. J. Clin. Path., 33**: 71-75, 1960.
13. HDL/Rapid Stat Kit. Pierce Chemical Company. 1978.
14. Tri-25 Triglyceride Method. Dade Diagnostics Inc., 1976.

15. U.S. Department of Agriculture. **Nutritive Value of Foods.** Washington, D.C., U.S. Government Printing Office, 1977. (Home and Garden Bulletin No. 72).
16. Flores, M., M.T. Menchú & M.Y. Lara. **Valor Nutritivo de los Alimentos para Centro América y Panamá.** Guatemala, Instituto de Nutrición de Centro América y Panamá, mayo de 1971, 18 p.
17. Robinson, C. **Normal and Therapeutic Nutrition.** New York, N.Y., McMillan Co., 1960.
18. Armitage, P. **Statistical Methods in Medical Research.** Oxford, Blackwell Scientific Publications, 1971.
19. Tamir, I., B.M. Rifkind & R.I. Levy. Measurement of lipids and evaluation of lipid disorders. In: **Chemical Pathology and Clinical Chemistry.** 16th ed. Philadelphia, W.B. Saunders Co., 1979.
20. Abraham, S. & M.D. Carrol. Fats, cholesterol, and sodium intake in the diets of persons 1-74 years, United States. **Vital Health and Statistics of the National Center for Health Statistics** Number 54, 1981.

"1987: trigésimo aniversario de la creación de los Estudios Generales en Costa Rica"

Impreso en la Oficina de Publicaciones de la Universidad de Costa Rica