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Nutrition and cataract in low-income Mexicans: experience in an Eye Camp

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RESUMEN. Nutrición y catarata en mexicanos de bajo ingreso: experiencia en un campamento de cirugía de ojos. Durante los últimos 10 años se han llevado a cabo en México Campamentos Quirúrgicos para el tratamiento de catarata en sujetos de escasos recursos. A pesar de la alta prevalencia de catarata, nunca se ha valorado el estado de nutrición ni de salud de éstas poblaciones. En este estudio comparamos los resultados obtenidos en 81 adultos (44 hombres y 37 mujeres) que recibieron tratamiento en Mayo de 1977, con los de un grupo "control" de sujetos de mayor afluencia, pareados para edad y sexo. Se valoraron los niveles de α-tocoferol y β-carotenos los cuales se analizaron con HPLC y colorimetría respectivamente. La relación tocoferol:colesterol en plasma no reveló deficiencia de ésta vitamina, y se encontraron niveles plasmáticos bajos de β-carotenos en solo 5 sujetos (2 hombres y 3 mujeres). Los IMC se encontraron elevados: 32% de hombres y 30% de las mujeres con sobrepeso y 2% y 14% obesos respectivamente. Los valores de glucosa, colesterol y triglicéridos fueron altos lo que refleja un aumento en la resistencia a la insulina y anormalidades en los lípidos. Los valores de fosfatasa alcalina se encontraron elevados lo que sugiere que muchos de estos pacientes ciegos padecen osteomalacia ya que permanecen confinados a su hogar. Aunque se ha sugerido que una ingesta adecuada de carotenos y tocoferol están asociadas a ausencia de catarata, ese no fue el caso en la población estudiada. Estudios en el país revelan, sin embargo, la deficiencia altamente prevalente de otras vitaminas tales como la niacina y la riboflavina cuyos efectos protectores en catarata han sido comprobados. En el México moderno por lo tanto, coexisten las deficiencias nutricias, la obesidad, la diabetes incipiente y las alteraciones en los lípidos. Hemos identificado la necesidad de que se inicien investigaciones que apoyen programas preventivos de nutrición a nivel poblacional que pudieran ser implementados paralelamente al tratamiento quirúrgico.
Palabras clave: Catarata, cirugía, nutrición, α-tocoferol, caroteno, pobreza.

SUMMARY. Surgical Eye-camps for cataract treatment of low-income adult Mexicans have been undertaken over the last 10 years. Despite the high prevalence of cataracts among these subjects, no assessment of their nutritional or health status has ever been made. We compare the results obtained for 81 adults (44 men and 37 women) who received treatment in May 1997 with those for a "control" group of age and sex-matched but affluent individuals in Mexico City. α-Tocopherol and β-carotene were assessed and analysed by HPLC and colorimetric procedures, respectively. The plasma tocopherol to cholesterol ratio did not reveal deficiencies of this vitamin, and only 5 patients (2 men and 3 women) had low β-carotene plasma levels. The patients had high BMI values, with 32% of men and 30% of women overweight, and 2% and 14%, respectively, obese, with higher glucose, cholesterol and triglyceride values reflecting enhanced insulin resistance and lipid abnormalities. The alkaline phosphatase values were elevated ,suggesting that many of these blind patients are osteomalacic because they now remain indoors. Although it has been suggested that an adequate intake of carotenes and tocopherol are associated with absence of cataract, this appears not to be the case in our study population. Surveys in Mexico have revealed, however, a highly prevalent deficiency of other vitamins such as niacin and riboflavin, both of which have been proved to be protective against cataract. It appears that nutritional deficiencies, obesity, incipient diabetes and lipid disorders co-exist in modern Mexico. We have identified a need for research to aid the design of preventive nutritional approaches at the population level that could be applied in parallel with ongoing surgical treatment.
Key words: Cataract, surgery, nutrition, α-tocopherol, carotene, low income.

INTRODUCTION

Cataracts are an enormous public health problem throughout the with almost half of the cases occurring in the developing countries. By the year 2025, it is estimated that 40 million people in the world will be blinded by cataract. The morbidity associated with cataract blindness is obvious, but the problem transcends suffering alone and enhances mortality: in a prospective cohort study in rural India between 1982 and 1986, people with central lens opacities had a greater (2.2) relative risk of dying than those without cataract, presumably because of the handicap and neglect of blind people in developing countries. (1, 2)

The prevalence of blindness in Latin America is 2-3.5 per thousand inhabitants which transaltes to a prevalence of 230,000 patients with cataract blindness in Mexico.

A cataract occurs when the lens loses its normal transparency, either focally or diffusely, and there is then an interference with the passage of light through the lens. The location, size and density of the lens opacities determine the extent of visual impairment (3); of the many different kinds of cataract, i.e. congenital, metabolic, traumatic, toxic and age-related or senile, the last is the commonest. Age-related cataract usually begins after the age of 40 years. Although the development of such cataracts may represent a process of senescence, the biochemistry and physiology remain poorly understood. The incidence of cataract is linked to poverty; there is a 2 to 10 fold difference across the socio-economic spectrum (3,4).

It is clear that there is an urgent need to identify the causes of cataract so that preventive policies may be developed in addition to the current attempts to organise and train sufficient numbers of ophthalmologic surgeons and assistants to deal with the current numbers of blind people.

The mechanisms that bring about a loss of transparency include oxidation, osmotic stress, and chemical adduct formation. Risk factors for cataract include diabetes, excessive radiation e.g. from X-rays or ultraviolet light, the impact of some nutritional problems and possibly acute episodes of dehydration and the use of some pharmaceutical substances. There are clearly interactions between risk factors (5,6). A whole series of nutrients have been found to be statistically associated with the absence of cataract in case-control and in prospective studies. Several studies have shown a significant association between high intakes of carotenoids and lowered risk of cataracts (7). More detailed U.S. prospective studies suggested that plasma tocopherol was protective but only for certain types of cataract (8). The Chinese Linxian cataract analysis with nutrient supplements amounting to 3 times the US RDA (9) and involving nearly 30,000 people in four different, double-blind, randomly selected supplementation groups found the riboflavin/niacin complex to be very protective over a 6 year period of supplementation. The other antioxidant vitamins, i.e. vitamin C, vitamin E and the carotenoids, were studied but failed to show significant reductions (10). In a careful large case-control U.S. study, those consuming multivitamin preparations or antioxidants (including riboflavin) and those taking niacin, thiamine and iron were also protected (11).

Theoretically, the antioxidants have seemed to be potentially important because oxidative stresses induce the lens protein changes that lead to opacities.

Surgical Eye-camps for cataract treatment of poor adult Mexicans have been undertaken routinely over the last 10 years. Despite the high prevalence of cataracts, no assessment of the nutritional or health status of the subjects has ever been undertaken.

Therefore, we decided to assess, in a cross-sectional study, the general nutritional status of all patients with cataracts selected for the 1997 Eye Camp, and specifically the antioxidants that are not subject to marked plasma fluctuations because of very recent intakes. The α-tocopherol and carotenoid state of the patients was therefore assessed and compared with that of a smaller, relatively affluent, group of age and sex-matched adults living in Mexico City.

MATERIALS AND METHODS

The study was undertaken in the small town of Tetecala, Morelos in May 1997, where an Inter-institutional collaborative Surgical and Nutritional Campaign on Cataract took place involving: the non-profit international organisation The PRASAD Project; PRASAD de México AC (Mexican branch); The National Program of Beyond the Walls Surgery from the Ministry of Health, Mexico; the Association for the Prevention of Blindness (APEC), the Ministry of Social Welfare from the State of Morelos, the institution for the Comprehensive Development of the Family (DIF), the National Institute of Nutrition Salvador Zubirán (INNSZ) and Fundación Clínica Médica Sur.

The subjects had the procedures of the study explained and all agreed, both verbally and in writing, to participate. Procedures included a general questionnaire, anthropometric measurements and blood samples. The study was approved by the Ministry of Health and all procedures were in accordance with the Helsinki Declaration (12).

Selection of the population, preoperative assessment and surgical procedure

The recruitment of patients was undertaken by the Ministry of Social Welfare and DIF, who located the patients and launched a TV/radio campaign to increase the number of recruits. Patients were asked to attend the 2 main regional (National Health) hospitals, where they were assessed for their socio-economic status and suitability for surgical treatment.

A total of 81 low-income adults were studied, 44 men and 37 women aged between 26 and 104 years. Eighty of the subjects were natives of the State of Morelos, the other patient was from the State of Hidalgo. The men were involved in activities such as agriculture, bricklaying, driving, mechanics and house painting, while the women were housewives, employed as a laundress or in helping in the fields. All the subjects were considered to be very poor and unable to contribute to the costs of their surgical treatment.

Patients with infectious processes, chronic renal insufficiency, hepathopaties and uncontrolled diabetes were excluded, as were those who, in addition to cataract, had other ocular disease. None of the patients was taking vitamin supplementation.

Pre-operative assessment for each selected patient and surgical risk tests (clinical history, vital signs and general conditions, electrocardiogram and laboratory analysis were undertaken. Visual acuity pre-operative tests verified that all patients had poor visual acuity associated, in most cases, with an age-related cataract. In all patients, asepsis was undertaken (cleansing of the area in both eyes); 75 patients with a very dense cataract had an extracapsular cataract extraction (ECCEPC) and the other 6 patients in whom the cataract was not very dense had phacoemulsification (PHA20J).

Age and sex-matched healthy control

Thirty-four healthy volunteers, 19 men aged between 27 and 67 years, and 15 women aged 33-79 years, from a more affluent environment in Mexico City were recruited from Médica Sur, where they attended for routine check up. They had no cataract or visual impairment. The healthy subjects were matched for age and sex with a subgroup of cataracteous patients in order to determine whether differences were found in the variables measured.

Nutrition research study

Standardized anthropometric measurements were taken, by a single observer, to be used singly or in combination with derived indices of nutritional status. The following anthropometric measurements were taken to calculate indices for the assessment of nutritional status: Body weight (Wt), without shoes and with minimum clothing, was recorded for all subjects. Digital scales were used to measure Wt to the nearest 0.1 kg. (Soenhle),(CMS Weighing equipment LTD, 18 Camden High Street London NW1 OJH, UK) (13); Height (Ht) was measured, with subjects wearing minimal clothing and without shoes or accesories that could affect the measurement using a Harpenden portable stadiometer, (CMS Weighing equipment LTD, 118 Camden High Street London NW1 OJH, UK), with a 0.001 m scale.

Mid upper arm (MUAC) and waist circumference were measured, for all subjects, with a flexible steel tape (CMS Weighing Equipment LTD, 18 Camden High Street London NW1 OJH, UK). Waist circumference was measured at the level of the natural waist, which is the narrowest part of the torso. In obese subjects, due to the difficulty in identifying the position of the natural waist, the measurement was made midway between the last rib and the iliac crest. Hip circumference was taken at the maximum level of the buttocks (14).

Triceps, subscapular and suprailiac skinfold thicknesses were measured in subjects aged ≥17 years with Holtain skinfold calipers (CMS Weighing equipment LTD, 18 Camden High Street London NW1 OJH, UK) (15).The measurements were taken in triplicate and the average of these was recorded.

Several indices were calculated to classify malnutrition and overnutrition. Body mass index (BMI) was calculated as: $Wt(kg)/Ht^2(m^2)$. BMI was used to assess overweight via the classification proposed by WHO (16).

Body fat content was calculated by the method of Durnin & Womersley (15).

Another derived index in subjects ≥12 years of age was the waist/hip circumference ratio (WHCR), which is considered a simple method for describing the distribution of both subcutaneous and intra-abdominal adipose tissue (17).

An estimation of height was made from knee height in subjects aged 50 or more. The equations developed by Chumlea et al. (18) were used to calculate height in cm.

Blood sampling and analysis

Patients were asked to fast at least 12 hours before blood samples were taken. Vacuum blood tubes containing EDTA anticoagulant were used to collect the blood samples for haematological tests. A separate blood sample was taken into specially treated tubes for the determination of vitamin E and β-carotene. These blood samples were immediately centrifuged in a Beckman G5-15R centrifuge (Beckman Instruments INC) at 3000 rpm for 10 minutes. Serum was then carefully separated with Pasteur pipettes and placed into 2 ml Eppendorf tubes. The samples were covered with aluminium foil to protect them from light. They were then placed in solid CO_2, covered, and sent to the laboratory at the National Institute of Medical Sciences and Nutrition in Mexico City, where they were stored frozen at -70°C.

Laboratory analysis

The biochemical tests performed were: glucose, total protein, albumin, bilirubin, cholesterol, triglycerides, sodium, potassium, chloride, magnesium, calcium, phosphorus, iron, creatinine, urea nitrogen, alkaline phosphatase. These were analysed on a Synchron CX5 instrument (Beckman Instrument Inc.). For the quality control of all the analyses except bilirubin, liquid control serum levels 1, 2 and 3 were run with the instrument (Beckman Synchron controls, Clinical System, 1995). For the analysis of total and direct bilirrubins, Ultimate-D- Billirubin Kontrollserum levels 1,2, and 3 were used (Beckman Instrument GmbH). Haemoglobin was analysed in a Coulter Equipment instrument.

The concentrations of vitamin E and β-carotenes were measured as follows: the α-tocopherol fraction was extracted and analyzed by reverse-phase HPLC as described by Hatam & Kayden (19): For serum α-tocopherol analysis, 0.35 ml of sample was mixed with 2 ml of absolute ethanol (containing

1% pyrogallol), 0.1 ml of concentrated HCl and 6 ml of *n*-hexane. Tubes were vortex mixed for 2 minutes and the hexane phase was removed and the sample was dried under nitrogen gas. The dried extract was solubilized in 0.6 ml of methanol and this solution was filtered using nylon filters (4 mm, 0.2 µm; Waters Corp. Milford, MA, USA). The reversed phase HPLC analysis of α-tocopherol was performed with a Waters model 510 pump, model 486 UV/VIS detector and model 746 data module. A 3.9mm x 150 mm Novopak C_{18} column (Waters Corp. Milford, MA, USA) was used. The eluant (pure methanol) was pumped at a rate of 1ml/minute. The tocopherols were detected by measuring absorbance at 292 nm and the data were integrated and processed by a data module. The α-tocopherol content was calculated from a standard curve, which was constructed using USPC standard (r=0.9994). Results were expressed as the average of duplicate extractions and injections. Pyragallol and (+)-α-tocopherol were obtained from Sigma Chemical Co. (St. Louis, MO, USA). The USP standard of *dl* α-tocopherol was purchased from USPC, Inc. (Rockville, MD, USA). Methanol, ethanol and *n*-hexane HPLC grade were obtained from Mallinckrodt Baker, Inc. (Paris, KY, USA). Reference samples were analysed with each batch, with standard additions being used to assure the quality of analysis. A known amount of α-tocopherol was added to tubes containing reagents and plasma samples ,and recoveries were calculated. The recovery of α-tocopherol in all samples ranged between 94 and 100%.

The β-carotene contents were determined in duplicate by colorimetry (20,21). Carotene was extracted with petroleum ether (2ml)(Merck: anhydrous, 99% ACS), to separate it from interfering substances in the serum (1ml). Because of its hydrophobic properties, carotene binds to serum proteins. Ethyl alcohol (2ml) (Merck: 9% ACS) was added to break this complex and to free the carotene. After vortex mixing, the tubes were centrifuged at 4000 rpm for 10 minutes. Finally, the absorbance of the supernatant at 405 nm was measured, using a petroleum ether blank. A stock solution consisting of 100 mg of β-carotene (Merck: 95% ACS), plus 13 ml of chloroform (Merck: 99.8% ACS) in 100 ml of petroleum ether was diluted 100 times to make up the standard curve (r=0.9996, m=0.003, b=0.011). A reference sample was analysed with each batch (CV= 2.5%, n=5).

Statistical analysis

The statistical analysis included the summary values of the mean and standard deviation. All analyses were divided by sex and compared with the control group of affluent, age and sex-matched individuals. Student's *t*-test was used for the comparison of continuous variables with a similar to normal distribution; otherwise, the Mann-Whitney non-parametric test was used. The Statistical Package for Social Sciences, SPSS-PC v.5.0 (22) was used for all the analyses.

RESULTS

Table 1 shows the general anthropometric data and Table 2 the general biochemistry. Each Table includes the subgroup of 34 affluent age and sex-matched healthy volunteers from Mexico City. Over 70% of subjects were elderly (>60 years) and no statistically significant difference was found between the elderly and the other adults for any of the variables studied. It is evident, however, that there are a number of differences between the men and women, and between the cataract patients and the healthy controls. Noteworthy is the high BMI of the cataract patients, especially the women, 30% (n=11) of whom were overweight and 14% (n=5) obese compared with 32% (n=14) overweight and 2% (n=1) obese male patients. These observations were confirmed by the skinfold measurements, which showed that these patients had markedly excessive body fat, especially the women, so the shorter height of the patients (Table 1) was not distorting the significance of the high BMI values, and by recalculating the height from knee height (not shown). Only 4, (2 men and 2 women), patients had BMI<18.5. The excess adiposity was confirmed with women subjects having significantly (p<0.00001) higher biceps and triceps skinfold than men, but men in the affluent control group had ignificantly (p<0.001) higher triceps skinfold thickness than the low-income subjects.

The prevalence of abdominal obesity in women with cataract, based on waist measurements and WHO cut-off points, based on those proposed by Han et al (17), was high, with 27% of women having elevated values (>80 cm). The prevalence of values in excess of the suggested sex-specific WHO limits (>94 cm) in men with cataract was only half that of women. Of the overweight women, 19% had values above the upper cut-off point of 88 cm, compared with only 2% of overweight men who exceeded their upper cut-off point of 102 cm. However, there was no significant difference in BMI between cases and controls for either men or women.

The biochemical values (Table 2) of the cataract patients were surprising. Both men and women had somewhat higher values than the healthy controls for many indices. All samples were taken in an equivalent manner, i.e. after 12 hours fast, and analyzed by the same laboratory, which routinely used quality control checks. However, the blood samples of the cataract patients were taken at a follow-up, post-operative visit that often involved the cataract patients in a long journey, so they may have been considerably dehydrated by the time the samples were taken.

Glucose levels were high (>126mg/dl) in 39% (n=17) of men and 27% (n=10) of women with cataract. Almost 50% of men and women had high (>161 mg/dl) trygliceride levels, and 74% and 64% of men and women, respectively, had total cholesterol levels in excess of 200 mg/dl.

TABLE 1
Anthropometric measurements (mean ± SD) and derived indices in 81 cataract patients and in healthy affluent controls

Variable	Cataract group			Subgroup comparisons					
				Men			Women		
	Men (n=44)	Women (n=37)	p	Cataract/ poor (n=19)	Healthy/ affluent (n=19)	p	Cataract/ poor (n=15)	Healthy/ affluent (n=15)	p
				Mean ±SD					
Age (yrs)	65.4±14.6	67.2±14.4	0.58	53.5±11.8	52.8±11.7	0.72	55.7±13.9	56.1±13.3	0.9
Weight (kg)	61.3±11.6	54.7±11.6	<0.01	65.1±9.8	80.3±12.7	0.0009	58.7±11.2	62.7±10.9	0.2
Height (m)	1.60±0.07	1.46±0.06	<0.00001	1.62±0.05	1.69±0.05	0.0001	1.49±0.06	1.55±0.06	0.013
BMI	23.8±3.4	25.5±5.0	0.07	24.7±3.3	27.8±3.6	0.33	26.3±4.6	26.1±4.4	1.0
Waist circum. (cm)	78.9±11.6	75.1±12.7	0.16	79.7±8.3	91.9±11.6	0.0006	76.0±14.6	79.4±11.0	0.4
Hip circum. (cm)	80.4±8.1	85.3±12.5	<0.03	80.9±5.8	91.2±9.4	0.0002	87.5±15.3	92.4±8.8	0.1
W/H ratio *	0.98±0.08	0.88±0.07	<0.00001	0.98±0.07	1.01±0.05	0.137	0.86±0.08	0.85±0.07	0.7
Skinfolds:									
Biceps (mm)	5.1±1.8	9.1±5.5	<0.00001	5.4±1.5	8.5±3.5	0.003	10.8±5.3	10.2±5.0	0.7
Triceps (mm)	9.3±2.8	17.3±6.8	<0.00001	9.9±2.5	15.0±5.7	0.001	19.4±6.9	20.4±7.9	0.9
Subscapular(mm)	15.0±6.4	18.1±9.0	.07	16.4±6.4	18.5±6.8	0.49	19.8±9.3±	20.1±9.1	0.96
Suprailiac (mm)	16.1±8.3	18.1±10.3	0.33	17.7±8.9	19.6±7.4	0.5	21.6±11.3	22.0±8.9	0.71
MUAC [†] (cm)	26.9±3.6	27.3±4.8	0.68	28.9±3.3	30.9±2.5	0.04	28.7±4.9	30.1±3.5	0.4
Body Fat (%)	23.2±6.2	34.8±6.5	<0.0001	24.1±5.2	27.4±6.0	0.107	33.8±6.4	35.9±7.2	0.443
MUAMC [d] (cm)	24.0±3.0	21.9±3.3	<0.001	25.9±3.0	26.2±2.2	0.287	22.7±3.5	23.7±1.3	0.044
MUAMA [e] (cm^2)	46.6±12.1	38.9±12.6	<0.001	54.0±13.2	55.2±9.5	0.287	41.7±14.1	44.7±5.0	0.044
MUAFA [f] (cm^2)	12.1±4.6	22.2±12.0	<0.0001	13.8±4.5	21.6±8.6	0.002	25.8±15.0	28.2±13.1	0.787

* Waist-Hip ratio; [†] Mid-upper arm circumference (cm); [a]BMI, Body Mass Index; [b]MUAC, mid-upper-arm circumference; [c]W/H ratio, waist to hip ratio; [d]MUAMC, mid-upper-arm muscle circumference; [e]MUAMA, mid-upper-arm muscle area; [f]MUAFA, mid-upper-arm fat area.

TABLE 2
Biochemical analysis of low income subjects with cataract and in healthy affluent controls

Variable	Cataract group			Subgroup comparisons					
				Men			Women		
	Men (n=44)	Women (n=37)	p	Cataract/ poor (n=19)	Healthy/ affluent (n=19)	p	Cataract/ poor (n=15)	Healthy/ affluent (n=15)	p
				Mean ±SD					
Glucose (mg/dl)	127.8±79.3	116.7±40.2	0.71	145.6±107.7	110.1±56.0	0.03	117.8±42.0	109.1±57.2	0.16
Proteins, Total (mg/dl)	8.8±1.04	8.7±1.0	0.83	8.9±1.1	6.7±0.5	<0.0001	9.0±1.1	7.2±0.7	<0.0001
Bilirubin,Total (mg/dl)	0.93±0.25	0.77±0.2	0.006	0.92±0.21	0.86±0.23	0.3	0.73±0.20	0.87±0.33	0.32
Bilirubin, Direct (mg/dl)	0.14±0.08	0.09±0.05	0.002	0.16±0.09	0.13±0.06	0.58	0.10±0.05	0.10±0.08	0.68
Bilirrubin, Indirect (mg/dl)	0.80±0.22	0.68±0.17	0.02	0.79±0.20	0.73±0.20	0.4	0.62±0.16	0.77±0.28	0.08
Alkaline Phosphatase (IU/L)	-	-	-	110.5±33.4	65.5±19.6	<0.0001	140.9±102	70.1±15.9	<0.0001
Cholesterol, Total (mg/dl)	227.6±49.9	233.2±49.5	0.63	224.2±50.0	207.8±61.0	0.11	225.9±50.2	218.9±34.8	0.6
Triglycerides (mg/dl)	181.6±157.4	178.7±102.2	0.93	229.8±204.8	176.8±116	0.11	178±125.0	137.4±76.5	0.41
Na (mEq/l)	150.8±8.4	149.3±9.2	0.47	149.5±8.3	136.2±4.5	<0.0001	150.0±9.2	140.3±7.0	0.004
K (mEq/l)	4.6±0.7	4.4±0.6	0.35	4.4±0.5	3.9±0.3	0.001	4.4±0.7	4.0±0.4	0.14
Cl (mEq/l)	115.8±5.9	114.9±7.5	0.55	115.0±5.8	106.2±4.4	<0.0001	115.5±7.6	108.5±6.5	0.005
Mg (mg/dl)	2.6±0.3	2.6±0.3	0.76	-	-	-	-	-	-
Ca (mg/dl)	11.3±0.7	10.9±1.3	0.06	11.4±0.8	10.0±0.8	<0.0001	10.6±1.9	10.4±0.9	0.04
P (mg/dl)	3.9±0.7	4.6±1.3	0.005	3.9±0.7	3.6±0.4	0.10	4.9±1.9	4.0±0.6	0.10
Fe (µg/dl)	72.6±33.1	71.1±30.5	0.84	-	-	-	-	-	-
Creatinine (g/dl)	1.03±0.48	0.78±0.20	0.006	0.99±0.28	0.96±0.23	0.95	0.71±0.11	0.92±0.12	0.0002
Urea Nitrogen (mg/dl)	16.3±7.9	16.1±7.6	0.95	15.6±7.2	15.2±4.0	0.8	14.2±4.0	15.6±3.5	0.23
Albumin (mg/dl)	4.0±0.5	3.9±0.4	0.42	4.0±0.6	4.1±0.4	0.5	3.9±0.4	4.4±0.4	0.0075

In the affluent control group, high glucose levels were less prevalent, 16% (n=3) and 13% (n=2) for men and women, respectively, whereas the prevalence (47% and 27%) of high triglyceride values was lower than in the cataract patients for men but specially for women, however, no statistically significant differences were observed between groups. There was no statistically significant difference in plasma cholesterol between either men or women with cataract or between cases and controls.

Most unexpected were the elevated alkaline phosphatase values, which clearly did not signify obstructive liver disease, since the bilirubin fractions were within a normal range. This suggests that many of these patients were osteomalacic, despite living in a semi-tropical environment.

Anaemia (Hb <14 g/dl) was found in 25% (n=11) of the low-income men. Mean haemoglobin values (not shown in table) in these cataract patients were 14.8 (± 2.2) g/dl and 13.8 (± 1.0) g/dl for men and women, respectively.

Table 3 lists the means (± SD) of the plasma levels of α-tocopherol (absolute values) and those for β-carotene. The α-tocopherol values were standardized with lipids, using the ratio of tocopherol (μmol) to cholesterol (mmol) as described by Thurnham (23). The ratios for the cataract patients ranged from 3.2 to 7.5 in men and from 2.1 to 5.9 in women. Only 1 woman in the cataract group and 1 woman in the control group were found with a ratio < 2.5, which is the threshold established to assess deficiency (23).

In the cataract group, 96% of men (*n*=42) and 89% of women (*n*=33) had normal β-carotene values ranging from 0.57 to 3.08 μg/ml and from 0.79 to 3.85 μg/ml for men and women, respectively.

There was no evidence that the values for the cataract patients were lower than those for the healthy controls; indeed, values for 5 affluent women and 8 affluent men were below the normal reference. However, there were no marked differences in β-carotene values ($p < 0.065$ men; $p < 0.33$ women) or α-tocopherol values ($p < 0.06$ men; $p < 0.05$ women) between the cases and controls, although the difference ($p < 0.05$) between affluent women and women with cataract just reaches significance There was no suggestion therefore of α-tocopherol or β-carotene deficiency specifically among the cataract group. For comparison, Table 3 includes values obtained in other populations.

TABLE 3
The α-tocopherol and β-carotene (Mean ± SD) in plasma in different populations

Ref No.	Study	n	Age range (y)	Country	α-tocopherol* μg/ml	β-carotene (Mean±sd) μg/ml	β-carotene (range)
	Men						
	Present study						
	- (cataract/low income)	44	65.4 ± 14.6	Morelos, Mexico	10.8 ± 3.8	1.69 ± 0.56 §	0.57- 3.08§
	- (healthy/affluent)	19	52.8 ± 11.7	Mexico City	9.0 ± 2.5	1.17 ± 0.65 §	0.32- 2.38§
37	Galván-Guerra *et* al. (1990)	70	18-48	Mexico City	-	-	0.50- 3.0§
38	Ross *et* al. (1995)	50	50-59	Scotland, UK	11.4 ± 0.4	0.29 ± 0.02 **	
39	Stryker *et* al. (1988)	137	18-79	USA	8.7	0.13**	
	Women						
	Present study						
	- (cataract/low income)	37	67.2 ± 14.4	Morelos, Mexico	11.8 ± 3.4	1.59 ± 0.58 §	0.79- 3.85§
	- (healthy/affluent)	15	56.1 ± 13.3	Mexico City	8.9 ± 2.7	1.26 ± 0.52 §	0.56- 1.94§
37	Galván Guerra *et* al. (1990)	70	18-48	Mexico City	-	-	1.12- 4.0§
39	Stryker *et* al. (1988)	193	18-79	USA	8.9	0.22**	
	Men & Women						
40	Ziouzenkova *et* al. (1996)	59	-	Austria	10.1 ± 3.1	-	
40	Ziouzenkova *et* al. (1996)	43	-	Swiss	11.5 ± 2.04	-	
41	Moran *et* al. (1993)	82	19-70	USA	5.0 - 23.3	-	
42	Babiy *et* al. (1990)	15	20-59	Australia	5.9 - 23.2	-	
43	Lehmann *et* al. (1982)	10	20-59	USA	5 - 12.5	-	
44	Fabianek *et* al. (1968)	4	-	USA	8 - 15	-	

* (Reference values: deficient <6.5 μg/ml; marginal deficient 6.5-8.6 μg/ml; normal 8.6-10.8 μg/ml; optimum >10.8μg/ml (40);
** HPLC assay; § colorimetric assay (§ Reference values: men 0.89-2.82 μg/ml; women 1.02-3.63 μg/ml). (45)

DISCUSSION

The results obtained for almost blind adult Mexican patients with cataract, who come from a low-income section of the population, highlight the nutritional dilemma of modern Mexico, where nutritional deficiency and obesity, incipient diabetes, hypertension and lipid disorders can co-exist (24-27). From a cataract etiological point of view, it is recognized that marked multiple nutritional deficiencies continue to be major public health problems in Mexico (28). Retinol equivalent intakes from a variety of carotenoid sources in the community from which these patients came have been documented as relatively low, (301 μg/d) at about half of the 500-600 μg/d WHO reference value (29). In both northern and southern Mexico, however, dietary intakes of calcium (839 mg/d), iron (17.7 mg/d), thiamine (1.5 mg/d) and vitamin C (33 mg/d) are all in excess of the WHO reference intakes (30-32). Although some studies in Mexico have shown marginal deficiencies of vitamin E, vitamin B_{12} and appreciable deficiencies of folic acid, those studies were not extensive (28). Our values for β-carotene and α-tocopherol (Table 4), although reflecting, in part, their predominant transport within the elevated lipid fractions of plasma, do not suggest that these patients were deficient in these antioxidants.

Other nutritional deficiencies that continue to be major public health problems in Mexico (28) are riboflavin and niacin deficiencies (not investigated in this study),which is associated particularly with the very poor diet of rural communities. Mexico City populations have a much more varied diet, with a higher antioxidant density, and only riboflavin intakes (0.98 mg/d) are considered to be relatively low.

Riboflavin and niacin are the two nutrients identified as protective of cataract in the Linxian study (10) The estimated average riboflavin intake amounts to only 0.9 and 0.7 mg/d in northern and southern Mexico, respectively (33,34), compared with the WHO reference values of 1.3-1.8 mg/d. Similarly, niacin intakes are only 9.0 mg/d, compared with reference values of 14.5-19.8 mg/d (30).

We might therefore conclude that the age-related cataract of the patients in this study may well have come from a prolonged exposure to ultraviolet light during a life-time of predominantly outdoors work in a community living at 1500 metres altitude and consuming a diet that is recognized to be particularly deficient in niacin (30) because of the poor meat intake and the unusual predilection to niacin deficiency in maize-consuming communities (35, 36). Yet by the time they have developed cataract (and are recognized to have greater difficulty in moving about), these patients become very inactive and confined to their home whilst still subsisting on their predominant tortilla/bean diet which limits calcium as well as zinc absorption. The lime-treated maize is particularly conducive to a high phosphorus intake and this, associated with their confinement to home, and absence of either vitamin D_3 intake or skin-derived vitamin D_2. probably account for their biochemical evidence of osteomalacia.

It is noteworthy that the total protein to albumin ratio is much higher in the cataract group than in the age and sex-matched controls, consistent with a much higher infection-related globulin fraction. The glucose, cholesterol and triglyceride values were also much higher, reflecting enhanced insulin resistance and the lipid abnormalities of inactive, almost blind patients eating a high-fat diet, consistent with their elevated BMI values.

We conclude that this preliminary study highlights the need for more extensive assessment of the nutritional status of the poor in Mexico because the association of high rates of age-related cataract in low-income communities living at altitude in this semi-tropical environment with a diet poor in riboflavin and niacin, in particular, suggests that new nutritional strategies need to be developed if the excess rate of cataract formation is to be counteracted. To undertake riboflavin and niacin assays requires particular care in samples obtained in hot rural areas but the relationship of these two vitamins to cataract in Mexico deserves particular attention. Current evidence suggests that these rural poor need to make their diet more nutrient-dense. In addition, these data suggest the need to consider routine oral vitamin D supplements in the Mexican elderly if they are confined to their homes.

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