Coronary Heart Disease and its Risk Factors in First-Generation Immigrant Asian Indians to the United States of America

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Summary

The prevalence of coronary heart disease (CHD) and its risk factors in first-generation Asian Indian immigrants to the United States of America (US) were compared with those of the native Caucasian population. A total of 1688 Asian Indian physicians and their family members (1131 men and 557 women, age ≥20 years) completed a questionnaire and in 580 subjects serum lipoproteins were determined. The age-adjusted prevalence of myocardial infarction and/or angina was approximately three times more in Asian Indian men compared to the Framingham Offspring Study (7.2% versus 2.5%; p<0.0001) but was similar in women (0.3% versus 1%; p=0.64). Asian Indians had higher prevalence of noninsulin-dependent diabetes mellitus (NIDDM; 7.6% versus 1%; p<0.0001) but markedly lower prevalence of cigarette smoking (1.3% versus 27%; p<0.0001) and obesity (4.2% versus 22%; p<0.0001). Hypertension was less prevalent in Asian Indian men (14.2% versus 19.1%, p<0.008) but similar in women (11.3% versus 11.4%). The prevalence of elevated total and low-density lipoprotein (LDL) cholesterol levels was similar in men [17% versus 23.4% (p=0.24) and 13.7% versus 22.3% (p=0.22), respectively] but lower in women [15% versus 26.1% (p=0.018) and 14.3% versus 19.6% (p=0.047) respectively]. The mean levels of high-density lipoprotein (HDL) cholesterol were less in younger (30–39 years) Asian Indian men (mean: 0.98 versus 1.18 mmol/l; p<0.001) and middle-aged (30–59 years) women (mean: 1.24 versus 1.45 mmol/l; p<0.001). The prevalence of hypertriglyceridaemia was similar in men (18.5% versus 11.3%), but higher in Asian Indian women (8.3% versus 4.1%, p=0.02). To conclude, immigrant Asian Indian men to the US have high prevalence of CHD, NIDDM, low HDL cholesterol levels and hypertriglyceridaemia. All these have "insulin resistance" as a common pathogenetic mechanism and seem to be the most important risk factors ***(Indian Heart J 1996; 48: 343–353).***

Introduction

High rates of coronary heart disease (CHD) have been noted in immigrant Asian Indians (subjects originally from India, Pakistan and Bangladesh) from Singapore[1–4], Uganda[5], South Africa[6], United Kingdom[7,8], Trinidad[9,10] and Fiji[11,12]. Major coronary risk factors, such as high levels of plasma cholesterol or low-density lipoprotein (LDL) cholesterol, hypertension and smoking fail to explain the excess risk of CHD in this ethnic group[3,4,10]. Some studies suggest that metabolic abnormalities which have insulin resistance as a common pathogenetic mechanism, such as noninsulin-dependent diabetes mellitus (NIDDM), low levels of high-density lipoprotein (HDL) cholesterol and hypertriglyceridaemia may be contributing to CHD in immigrant Asian Indians[13,14]. Whether the increased prevalence of CHD in this ethnic group is due to genetic susceptibility or lifestyle factors, is not clear.

The migration of Asian Indians to South Africa, Uganda, West Indies (including Trinidad), Fiji and the United Kingdom started during the nineteenth century. Most Asian Indians living there presently are descendants of the original immigrants and may have undergone marked changes in dietary habits and lifestyle over the years which may be partly responsible for the high rates of CHD and NIDDM reported from these countries. On the other hand, the majority of the Asian

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Indians living in the United States of America (US) are first-generation immigrants (subjects born in the Indian subcontinent who migrated to the US) and may not have undergone marked changes in lifestyle and their dietary habits may still be close to those in their native country. The aim of this study was to determine the prevalence of CHD and its risk factors in first-generation immigrant Asian Indians living in the US. The study further examined relationships of dietary practices in immigrant Asian Indians to the prevalence of CHD and its risk factors.

Material and Methods

Subjects

The participants in the study included 1688 Asian Indian physicians and their family members (≥20 years of age; 1131 men and 557 women) who were members of the American Association of Physicians from India (AAPI) and the Association of Kerala Medical Graduates (AKMG). The data were collected during three successive annual meetings of the AAPI between 1990 and 1992 and the annual meeting of the AKMG held in 1990. All participants were asked to complete a questionnaire. Responses were also obtained by mail and telephone interviews. The overall response rate was 81 percent of those attending the meetings. A total of 1269 physicians (970 men and 299 women) and 419 family members (258 men and 161 women) volunteered for the study. Those attending the AAPI meetings were asked to undergo blood screening for lipoprotein and chemistry profile after fasting overnight for more than 10 hours. The study was approved by the Institutional Review Board of the University of Texas Southwestern Medical Center at Dallas and all the subjects gave informed consent.

Data Collection

The questionnaire was designed to obtain demographic data as well as history of CHD and its risk factors according to the guidelines of the Adult Treatment Panel I Report of the National Cholesterol Education Program (NCEP)[15]. The place of birth, the number of years of residence in the US, marital status and occupation were recorded. Participants were asked if they had had definite CHD, ie. angina pectoris, myocardial infarction, positive treadmill test, abnormal coronary angiogram, coronary angioplasty, or coronary artery bypass graft surgery. The age at which CHD was diagnosed was also recorded. Inquiries were made about the diagnosis of cerebrovascular or peripheral vascular disease (stroke or claudication) and family history of premature CHD (definite heart attack or sudden death before the age of 55 years in a parent or sibling). The participants reported the number of cigarettes smoked per day in the past year, as well as the total duration of cigarette smoking. Subjects were asked about use of antihypertensive medications and reported their systolic and diastolic blood pressures. An individual was considered to have diabetes mellitus if a previous diagnosis had been made or if they were using insulin or oral hypoglycaemic agents.

The participants reported their height, weight, and waist and hip circumferences. Validation of the reported values of height and weight was done by obtaining these measurements following standardised procedures in the 1992 meeting on 70 subjects; the intraclass correlation coefficients were 0.92 and 0.95, respectively[16]. Due to limited facilities at the convention site, waist and hip circumferences and blood pressure were not measured. The relative body weights were calculated using the data of the Metropolitan Life Insurance Company for medium frame individuals[17]. Dietary practices, ie. whether the participants were vegetarians, lacto-vegetarians (consuming dairy products with vegetarian diet), lacto-ovo-vegetarians (consuming dairy products and eggs with vegetarian diet) or nonvegetarians, were recorded. For further analysis, vegetarians, lacto-vegetarians and lacto-ovo-vegetarians were all grouped as vegetarians.

Blood samples were obtained from 580 of the participants (414 men and 166 women) and of these 53 men and 15 women were on lipid-lowering medications and thus excluded from analyses. The rest of the subjects contributed to the data on total cholesterol and HDL cholesterol. Only 241 men and 91 women fasted for more than 10 hours; the data on plasma triglyceride concentrations and LDL cholesterol are restricted to these patients.

For comparison with the Framingham Offspring Study[18] data collected during 1983–1987, only subjects with myocardial infarction and/or angina were included; and as far as possible, the definitions of various similar CHD risk factors were chosen. Besides the use of insulin or oral hypoglycaemic agents, the diagnosis of diabetes mellitus in the Framingham Offspring Study included those with fasting plasma glucose ≥7.8 mmol/l (140 mg/dl) at any examination. Also, besides the use of antihypertensive medications, the diagnosis of hypertension was based on recorded blood pressures during clinic visits in the Framingham Offspring Study and reported blood pressure values (diastolic >95 mm Hg) in our study. Data on family history of CHD could not be compared because the Framingham Offspring

Study included information on parents only.

Since most of our subjects were physicians, some may question the validity of comparison of our data to that from the Framingham Offspring Study because physicians belong to a higher socioeconomic status, have more health awareness and ready access to health care; CHD may be "over-diagnosed" in them. Therefore, although limited data were available from the Physicians' Health Study[19], we compared male physicians (≥40 years of age) from our study with US physicians using similar criteria as far as possible. Our lipoprotein data were compared to that from the National Health and Nutrition Examination Survey (NHANES) III representing the general population of the US during 1988–1991.

Laboratory Methods

Blood was collected and serum separated immediately. All samples were analysed in the same laboratory (MetPath Inc., Wood Dale, IL). Plasma apolipoproteins (apo) A-I and B were determined by the rate nephelometry method using antibodies against apo A-I and B, respectively. Serum cholesterol and triglycerides were measured by enzymatic methods. High-density lipoprotein cholesterol level was measured in the supernatant after lipoproteins containing apo B were precipitated by phosphotungstic acid and magnesium chloride[21]. Cholesterol in the LDL fraction was calculated for subjects with fasting serum triglyceride levels <4.52 mmol/l (400 mg/dl) according to the Friedewald formula[22]:

LDL cholesterol (mmol/l) =
[Total cholesterol – HDL cholesterol – triglyceride]/2.2

The lipoprotein analysis by the commercial laboratory was validated by simultaneous measurement of lipids and lipoproteins in 334 samples obtained in 1991 and 1992 at the Center for Human Nutrition Laboratory, the UT Southwestern Medical Center at Dallas, Dallas, Texas, using the Lipid Research Clinics method[23]. The intraclass correlation coefficients for total cholesterol, triglycerides and HDL cholesterol were 0.92, 0.99 and 0.94, respectively.

Statistical Methods

For comparison with the Framingham Offspring Study[17] and the NHANES III Study[20], the data were stratified according to 10-year age groups and categorical variables were compared with the Mantel–Haenszel Chi-square statistic. Continuous variables such as lipoprotein measurements were compared using two-sample t-tests within each age group[24,25]. For comparison with the Physicians' Health Study[18], Pearson Chi-square statistic was used. The risk factors in Asian Indians with CHD were compared with those without CHD using the Mantel–Haenszel Chi-square test for categorical variables stratified by age and for continuous variables, analysis of covariance with age as a covariate was used. Similar statistical methods were used for comparison of data in the vegetarian and nonvegetarian Asian Indians. Multiple logistic regression was used to assess the relationships between various risk factors and the presence or absence of CHD in Asian Indian men and adjusted odds ratios were calculated. Wilk–Shapiro and Levene tests were used to examine the assumptions of normality and homogeneity of variance, respectively. All data are presented as the mean and one standard deviation (SD) unless specified otherwise. A p value less than 0.05 was considered significant. No adjustments were made for multiple testing; however, exact p values are reported, where possible. Data management and statistical analyses were done using CLINFO® (Bolt, Beranek and Newman, Cambridge, MA) and BMDP® (BMDP Statistical Software, Inc., Los Angeles, CA) software packages.

Results

Population Characteristics

The age and sex distribution of the study population are shown in Table 1. Mean (±SD) age of the participants was 46.4 (±7.5) years for men and 42.9 (±7.4) years for women. Of these, 96.1 percent were married, 2.6 percent single, 0.8 percent divorced and 0.4 percent widowed. Most of the participants were physicians (75.5%); the other occupations included other professionals (9.2%), homemakers (8.4%), office workers (2.4%), salespersons

TABLE 1

Age and Sex Distribution of the Study Group

Age (years)	Males	Females	Total
20–29	25	25	50
30–39	126	138	264
40–49	603	297	900
50–59	336	85	421
60–69	33	11	44
≥ 70	8	1	9
Total	1131	557	1688

(1.2%), technicians (0.5%), unemployed (0.2%) and others (2.6%). The participants were from all over the US with a mean (±SD) duration of residence in the US of 17.8 (±5.7) years (range 6 months to 46 years). Almost all were first-generation immigrants to the US (99.4%) born in India (96%) and Pakistan (1.0%), a few in Kenya (1.5%) and other countries (0.9%). Only 0.6 percent of the participants were born in the US. The participants belonged to Andhra Pradesh (11%), Bihar (1%), Delhi (2%), Gujarat (12%), Karnataka (8%), Kerala (28%), Maharashtra (7%), Madhya Pradesh (4%), Punjab (6%), Tamil Nadu (6%), Uttar Pradesh (4%), West Bengal (3%) and other areas (8%).

Comparison of CHD Prevalence with US Data

The prevalence of myocardial infarction and/or angina in various age groups of Asian Indians and the Framingham Offspring Study is given in Table 2 and the prevalence of CHD risk factors is compared in Tables 3 and 4. Compared to 2.5 percent prevalence of myocardial infarction and/or angina in men from the Framingham Offspring Study, the age-adjusted rate of 7.2 percent was observed in men from our study ($p<0.0001$). Women from the two studies had similar prevalence rates (0.3% versus 1.0%; $p=0.64$). Of the 88 subjects (86 men and 2 women) with CHD, 40 had coronary artery bypass graft surgery, 74 had coronary angiography of whom 28 had angioplasty, 61 had a positive treadmill test, 46 had a myocardial infarction and 43 had angina. Taking into account other diagnostic criteria for CHD besides myocardial infarction and angina, the age-adjusted prevalence of CHD in Asian Indian men was even higher (10.2%). The mean (±SD) age at the time of diagnosis of CHD in Asian Indian men was 46.3 (±6.9) (range 27–61) years.

Comparison of male physicians from our study with those from the Physicians' Health Study revealed ap-

Age Group (years)	Men		Women	
	Immigrant Asian Indians (n=1131) (%)	Framingham Offspring Study (n=896) (%)	Immigrant Asian Indians (n=557) (%)	Framingham Offspring Study (n=890) (%)
20–29	0	NA	0	NA
30–39	0	0	0	0.5
40–49	3.6	1.3	0.8	0.3
50–59	11.4	4.0	0	2.3
60–69	33.3	9.0	0	1.1
≥ 70	25.0	NA	0	NA
30–69 (age-adjusted)	7.2	2.5*	0.3	1.0†

*p<0.0001, †p=0.64, NA: not available

TABLE 2

Prevalence of Myocardial Infarction and/or Angina in Immigrant Asian Indians versus the Framingham Offspring Study

Risk Factor	Men			Women		
	Immigrant Asian Indians (n=1131) (%)	Framingham Offspring Study (n=896) (%)	p Value	Immigrant Asian Indians (n=557) (%)	Framingham Offspring Study (n=890) (%)	p Value
Hypertension	14.2	19.1	0.008	11.3	11.4	0.996†
Obesity (metropolitan relative weight >130%)	3.3	30.5	<0.0001	6.1	18.9	<0.0001
Diabetes mellitus	9.0	1.1	<0.0001	6.1	0.9	<0.0001
Smoking (≥ 10 cigarettes per day)	2.6	27.5	<0.0001	0	27.0	<0.0001
Stroke or claudication	1.1	0.9	0.79	1.2	1.1	0.57

*Analysis restricted to the age group 30–69 years. †Lack of homogeneity among various age groups was observed. p values from the Mantel–Haenszel Chi-square analysis.

TABLE 3

Age-adjusted Prevalence of Clinical Risk Factors for CHD in Immigrant Asian Indians versus the Framingham Offspring Study*

TABLE 4

Age-adjusted Prevalence of Lipid and Lipoprotein Risk Factors for CHD in Immigrant Asian Indians versus the Framingham Offspring Study*

Risk Factor	Men					Women				
	Immigrant Asian Indians		Framingham Offspring Study		p Value	Immigrant Asian Indians		Framingham Offspring Study		p Value
	(n)	(%)	(n)	(%)		(n)	(%)	(n)	(%)	
Total cholesterol level >6.2 mmol/l	361	17.0	1372	23.4	0.24	151	15.0	1282	26.1	0.018
LDL cholesterol level > 4.14 mmol/l†	221	13.7	896	22.3	0.22	87	14.3	890	19.6	0.047
HDL cholesterol level <0.91 mmol/l	361	23.8	1372	21.0	0.35‡	151	5.9	1282	5.0	0.93
Triglyceride level >2.8 mmol/l	241	18.5	1372	11.3	1.0	91	8.3	1282	4.1	0.002

* Analysis included subjects ≥20 years. 'n' refers to total number of subjects for which data were available and % refers to those with abnormal values. p values from Mantel–Haenszel Chi-square analysis.
† Analysis restricted to ages 30–69 years
‡ Lack of homogeneity among various age groups was observed.

proximately two-fold higher crude prevalence of angina in Asian Indians (2.2% versus 1.2%, respectively; p=0.033; Table 5). The increased prevalence of angina in Asian Indian physicians was even more significant considering the fact that they were on an average 5.2 years younger than the US Physicians (Table 5). Furthermore, increased prevalence of CHD in men was noted not only among physicians (8.4%, 75 out of 894) but also among nonphysicians (7.8%, 11 out of 142).

Comparison of CHD Risk Factors with US Data

Clinical Risk Factors. Asian Indian men, compared to men in the Framingham Offspring Study, had higher prevalence of diabetes mellitus (9.0% versus 1.1%; p<0.0001) but lower rates of hypertension (14.2% versus 19.1%; p=0.008), cigarette smoking (>10 per day in the last year; 2.6% versus 27.5%; p<0.0001), and obesity (3.3% versus 30.5%; p<0.0001; Table 3). The prevalence of stroke or claudication (1.1% versus 0.9%; p=0.79) was similar. Comparison of the Asian Indian male physicians and US physicians also revealed a 2.5-fold increased prevalence of NIDDM despite lower prevalence of obesity (Table 5). The Asian Indian physicians had markedly reduced rates of cigarette smoking but the prevalence of hypertension was similar (Table 5).

The women from our study, compared to those from the Framingham Offspring Study, had higher prevalence of diabetes mellitus (6.1% versus 0.9%; p<0.0001); and markedly lower rates of cigarette smoking (0% versus 27.0%; p<0.0001), and obesity (6.1% versus 18.9%, p<0.0001; Table 3). The prevalence rates of hypertension (11.3% versus 11.4%), stroke or claudication (1.2% versus 1.1%) were similar in the two groups (Table 3).

Lipoprotein Risk Factors. Since the lipoprotein data were collected over a duration of three years, questions

TABLE 5

Prevalence of Risk Factors for CHD in Male Immigrant Asian Indian Physicians versus US Physicians from the Physicians' Health Study*

Risk Factor	Asian Indian Physicians (n=645)	US Physicians (n=22,071)	p Value
Age [mean (±SD) in years]	48.0(±5.5)	53.2 (±9.5)	<0.0001
Angina (%)	2.2	1.2	0.033
Hypertension† or drug therapy (%)	11.8	11.9	0.96
High cholesterol (≥6.46 mmol/l) or drug therapy (%)	14.4	7.9	<0.0001
Diabetes mellitus (%)	5.6	2.2	<0.0001
Obesity (body mass index ≥ 27.8 kg/m²; %)	6.7	13.6	<0.0001
Cigarette smoking (≥15 per day; %)	0.6	8.2	<0.0001

* Analysis restricted to subjects ≥40 years in both the studies. Patients with myocardial infarction, renal disease, cancer and gout were excluded from both the studies. The Physicians' Health Study also excluded patients with stroke and transient ischaemic attack, peptic ulcer, current hepatic disease; contraindications to aspirin therapy, current use of aspirin, other platelet-activating drugs and nonsteroidal anti-inflammatory agents; or current use of a vitamin A or beta-carotene supplement.
† Hypertension is defined as systolic or diastolic blood pressures ≥160 and ≥95 mm Hg, respectively.
p values from Pearson's Chi-square analysis except for age which is from the two sample t-test.

can be raised about seasonal and temporal trends. Since all the three meetings were held in early June, seasonal variation should not be a confounding factor. Further, no temporal trend was noted in total and LDL cholesterol and triglyceride values obtained in 1990, 1991 and 1992 in both the sexes (p values=0.23 to 0.99). A significant increase, was noted in HDL cholesterol values from 1990–1992 in both the sexes. Whether this is a true temporal trend or due to participation of different subjects in the three years cannot be determined because lipoprotein values were not repeated in the same subjects over the three-year period. It should be mentioned that lipoprotein data from the Framingham Offspring Study and the NHANES III study were also collected over a period of three to five years and may have been subjected to temporal variations.

Framingham Offspring Study Comparison

Figure 1 shows the mean serum levels of total and LDL cholesterol and Fig. 2 shows triglyceride and HDL cholesterol levels in different age groups of Asian Indian men and women compared with those from the Framingham Offspring Study. Overall, there was a trend towards lower levels of total and LDL cholesterol in the Asian Indian men and women aged 30–69 years (Fig. 1). In men, the prevalence of high total cholesterol levels [>6.2 mmol/l (240 mg/dl); 17.0% versus 23.4%; p=0.24] and LDL cholesterol levels [>4.14 mmol/l (160 mg/dl); 13.7% versus 22.3%; p=0.22] was similar (Table 4). Plasma triglyceride levels and the prevalence of hypertriglyceridaemia [plasma triglyceride levels >2.8 mmol/l (250 mg/dl); 18.5% versus 11.3%] were similar in the two groups of men (Fig. 2). Overall, the prevalence of low HDL cholesterol levels [<0.91 mmol/l (35 mg/dl)] was not different in the two groups (23.8% versus 21.0%; p=0.35); however, lack of homogeneity was observed. The prevalence of low HDL cholesterol levels was higher in Asian Indian men aged 20–39 years (23.8% versus 12.7%; p<0.001). In the age group 30–39 years, Asian Indian men had significantly lower levels of HDL cholesterol [mean: 0.98 mmol/l (37.9 mg/dl) versus 1.18 mmol/l (45.8 mg/dl); p<0.001; Fig. 2].

Asian Indian women, compared to women from the Framingham Offspring Study, had lower prevalence of high total (15.0% versus 26.1%; p=0.018) and high LDL (14.3% versus 19.6%; p=0.047) cholesterol levels but the prevalence of hypertriglyceridaemia (8.3% versus 4.1%; p=0.002) was higher in Asian Indian women, particularly in the age group 50–59 years (Fig. 2). Although the prevalence rates of low HDL cholesterol levels (5.9% versus 5.0%; p=0.93) were similar, the levels were significantly lower in Asian Indian women aged 30–59 years compared to those from the Framingham Offspring Study [mean: 1.23 mmol/l (48.7 mg/dl) versus 1.45 mmol/l (56.1 mg/dl); p<0.001; Fig. 2].

Physicians' Health Study Comparison

Comparison of the Asian Indian and US male physicians revealed a higher prevalence of raised serum

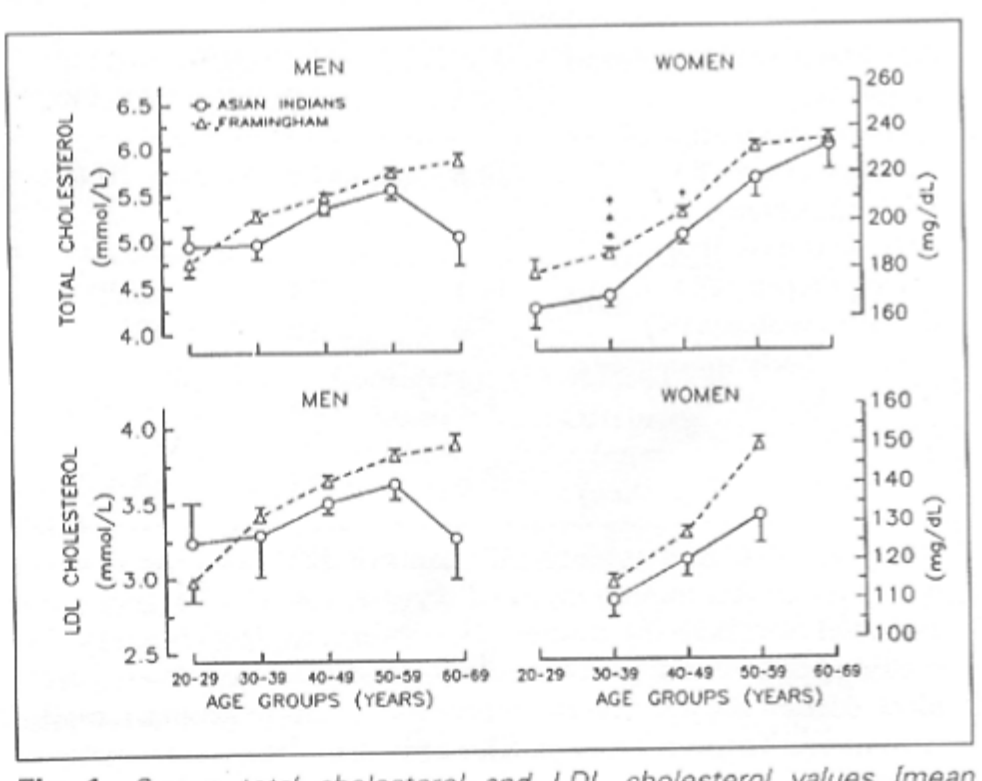

Fig. 1. *Serum total cholesterol and LDL cholesterol values [mean (SEM)] in various age groups of Asian Indian men and women and those from the Framingham Offspring Study. The circles represent values in Asian Indians and the triangles values in subjects from the Framingham Offspring Study. *p<0.05 and ***p<0.001 for the two groups.*

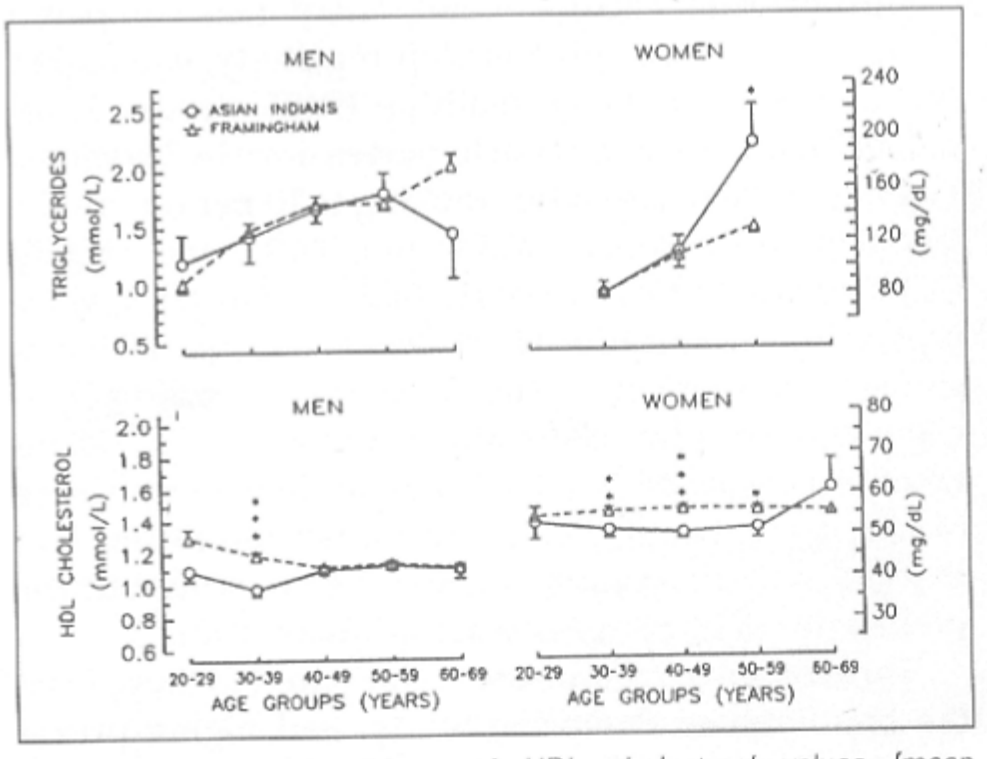

Fig. 2. *Serum triglycerides and HDL cholesterol values [mean (SEM)] in various age groups of Asian Indian men and women and those from the Framingham Offspring Study. The circles represent values in Asian Indians and the triangles represent values in subjects from the Framingham Offspring Study. *p<0.05, **p<0.01 and ***p<0.001 for the two groups.*

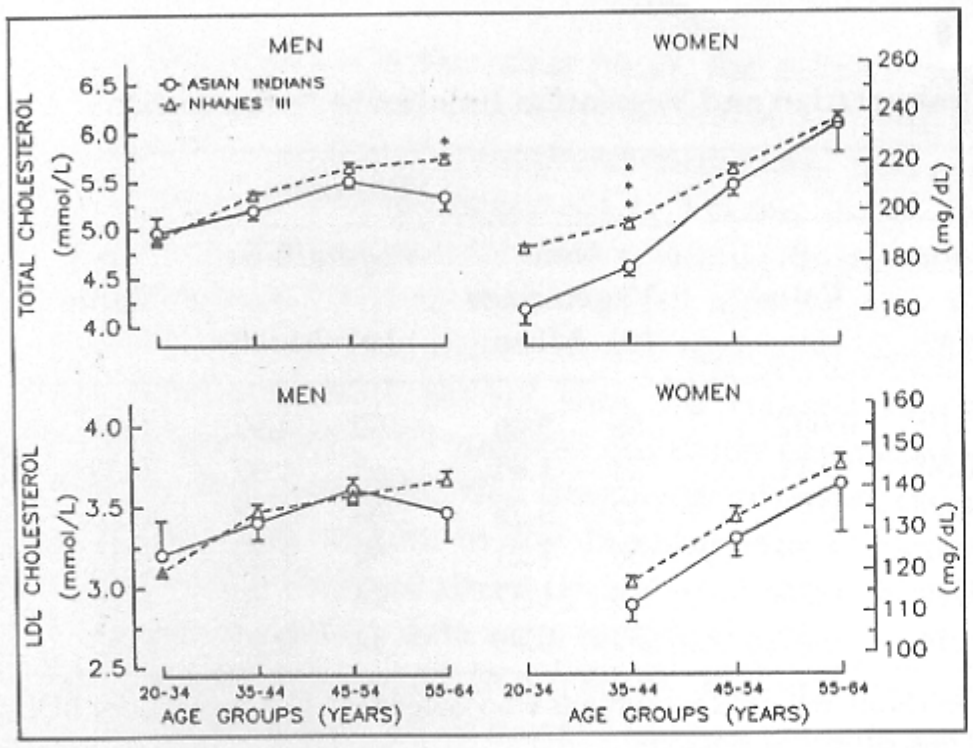

Fig. 3. *Serum total cholesterol and LDL cholesterol values [mean (SEM)] in various age groups of Asian Indian men and women and those from the NHANES III. The circles represent values in Asian Indians and the triangles values in subjects from the NHANES III Study. *p<0.05 and ***p<0.001 for the two groups.*

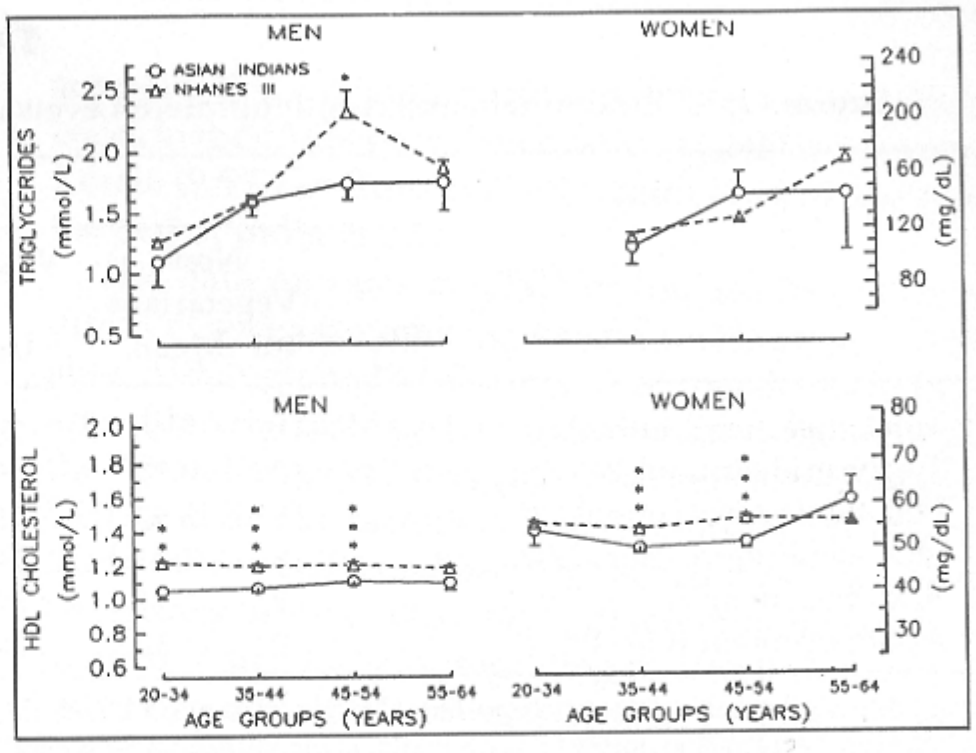

Fig. 4. *Serum triglycerides and HDL cholesterol values [mean (SEM)] in various age groups of Asian Indian men and women and those from the NHANES III. The circles represent values in Asian Indians and the triangles values in subjects from the NHANES III Study. *p<0.05, **p<0.01 and ***p<0.001 for the two groups.*

cholesterol levels [≥6.4 mmol/l (240 mg/dl)] or raised current use of lipid-lowering therapy in the Asian Indians (14.4% versus 7.9%; Table 5). This increase was mainly due to increased use of lipid-lowering therapy (8.4% out of a total of 14.4%) which probably reflects the impact of the NCEP Report published in 1988, in comparison to the Physicians' Health Study data collected in 1983–1984.

TABLE 6

Demographics and CHD Risk Factors in Immigrant Asian Indian Men With and Without CHD

	With CHD* (n=86)		Without CHD (n=951)		p Value
Age‡ (years)	53.0	(0.7)	45.9	(0.2)	0.0001
Body mass index‡ (kg/m²)	23.6	(0.3)	23.9	(0.1)	0.24
Waist/hip circumference ratio‡	0.93	(0.01)	0.92	(0.003)	0.78
Duration of residence in US‡ (years)	19.1	(0.5)	18.1	(0.2)	0.10
Hypertension (%)	37.5		11.1		0.0003
Lipid-lowering therapy (%)	35.3		6.2		<0.0001
Diabetes mellitus (%)	17.3		4.9		0.0006
Family history of premature CHD (%)	45.3		17.6		<0.0001
Cigarette smoking# (%)	41.5		24.3		0.0065
Vegetarians (%)	45.9		39.3		1.0

* Age-adjusted values reported except for age. †Age-adjusted values calculated.
‡ Mean (SEM) values reported.
# Smoking defined as current or past use of any number of cigarettes.

NHANES III Comparison

The comparison of our data with the NHANES III data yielded results similar to those obtained on comparison with the Framingham Offspring Study (Figs. 3 and 4). The levels of total and LDL cholesterol were similar in the two groups of men and women except that 55–64-year-old Asian Indian men had significantly lower total cholesterol levels [mean: 5.31 mmol/l (205.5 mg/dl) versus 5.72 mmol/l (221.3 mg/dl); p=0.03; Fig. 3] as did the 35–44-year-old women [mean: 4.58 mmol/l (177.3 mg/dl) versus 5.03 mmol/l (194.7 mg/dl); p<0.0001; Fig. 3] compared to the NHANES III subjects. Levels of plasma triglycerides were similar in the two groups except that lower levels were noted in the 45–54-year-old Asian Indian men [mean: 1.74 mmol/l

TABLE 7

Risk Factors Associated with CHD in Asian Indian Men by Multiple Logistic Regression Analysis

Risk Factors	Odds Ratio	95% Confidence Interval	p Value
Age*	1.11	1.06–1.16	<0.001
Lipid-lowering therapy	13.1	7.2–23.6	<0.001
Hypertension	2.7	1.4–5.2	0.003
Diabetes mellitus	2.9	1.3–6.5	0.01
Family history of CHD	2.5	1.4–4.7	0.004
Cigarette smoking	1.8	1.0–3.2	0.054

* Odds ratio corresponds to one- year increment in age. The model included a total of 950 men including 73 patients with CHD.

TABLE 8

Serum Lipid, Lipoprotein and Apolipoprotein Levels in Nonvegetarian and Vegetarian Immigrant Asian Indians

	Men					Women				
	Non-Vegetarians		Vegetarians		p Value	Non-Vegetarians		Vegetarians		p Value
	(n)	Mean	(n)	Mean		(n)	Mean	(n)	Mean	
Total cholesterol (mmol/l)	183	5.50	179	5.19	0.002	56	5.06	92	4.97	0.55
Triglyceride (mmol/l)*	121	1.77	119	1.50	0.11	24	1.62	65	1.37	0.32
LDL-cholesterol (mmol/l)*	115	3.63	116	3.39	0.03	22	3.28	64	3.08	0.26
HDL-cholesterol (mmol/l)	183	1.11	179	1.07	0.09	56	1.21	92	1.29	0.16
Apolipoprotein A-I (g/l)†	91	1.17	84	1.18	0.78	33	1.37	44	1.30	0.26
Apolipoprotein B (g/l)†	91	1.10	84	1.02	0.02	32	0.98	44	0.94	0.55

Age-adjusted mean values are reported. *Triglyceride and LDL cholesterol levels are reported for subjects who fasted for >10 hours and for LDL cholesterol estimation, subjects with triglyceride values >4.52 mmol/l (400 mg/dl) were excluded.
To convert cholesterol and triglyceride values from mmol/l to mg/dl, multiply by 38.674 and 88.574, respectively.
p values from analysis of covariance with age as covariate.

(154.3 mg/dl) versus 2.31 mmol/l (204.7 mg/dl); p=0.01; Fig. 4]. Levels of HDL cholesterol were significantly lower in Asian Indian women aged 35–54 years and in men aged 20–54 years (Fig. 4).

Comparison of Asian Indians With and Without CHD

The demographics and the age-adjusted prevalence of CHD risk factors in Asian Indian men with CHD in comparison to those without CHD are given in Table 6. Those with CHD were on an average 7.1 years older; however, age-adjusted duration of residence in the US was not different in the two groups. Those with CHD had higher age-adjusted prevalence rates of hypertension, use of lipid-lowering therapy, NIDDM, family history of premature CHD and cigarette smoking (Table 6). There were no differences in the two groups with respect to dietary habits, body mass index, and waist-to-hip circumference ratio. Because more than 50 percent of the Asian Indian men with CHD were on lipid-lowering drugs, plasma lipoprotein values were not available for enough untreated subjects with CHD for meaningful comparisons.

Results from the multiple regression analysis are presented in Table 7. Increasing age, use of lipid-lowering drugs, hypertension, diabetes mellitus and family history of CHD were identified as predictors of the probability of having CHD in Asian Indian men whereas cigarette smoking achieved only borderline significance.

Relationship of Dietary Practices to CHD and its Risk Factors

Forty-three percent of the participants were vegetarian, whereas 57 percent were nonvegetarian. Plasma total cholesterol, LDL cholesterol and apo B values were significantly lower in the vegetarian Asian Indian men compared with those in the nonvegetarians, but no differences were observed in women (Table 8). There were no differences in plasma triglyceride, HDL cholesterol and apo A-I values between the vegetarians and nonvegetarians of either sex (Table 8). The two groups had similar rates of CHD, hypertension, obesity and family history of premature CHD (data not shown). The vegetarians had lower prevalence of cigarette smoking (12.9% versus 21.4%; p<0.0001), but a higher prevalence of NIDDM (7.6% versus 5.1%; p=0.04).

Discussion

The present study assessed the prevalence of CHD and its risk factors in first-generation immigrant Asian Indians living in the US, and noted strikingly high prevalence rates of CHD in men but not in women. The total number and particularly that of postmenopausal women were very few, and any estimates of CHD prevalence in women would be unreliable. Only 97 of the 557 women were more than 50 years old. Given the young age and small number of women, our study had low power to detect even a two-fold difference in CHD event rates among women. It is also possible that despite increased prevalence of NIDDM, hypertriglyceridaemia and low HDL cholesterol levels in women from our study, premenopausal status, virtual absence of smoking and reduced prevalence of high LDL cholesterol levels could be protecting them against CHD.

Our study is not population-based, and therefore, may be subject to bias due to volunteerism, ie. individuals with CHD may be more likely to volunteer to be

part of a study. On the other hand, the subjects with symptoms of CHD may not have been able to attend the conventions and this "nonrepresentativeness" may artificially lower the prevalence of CHD in our study. The likelihood of nonresponder bias explaining the increased prevalence of CHD in men is small also because the overall response rate was relatively high at 81 percent. Another potential caveat may be related to the ascertainment of CHD status in our study compared to others. For example, the diagnosis of myocardial infarction and angina in the Framingham Offspring Study was established after a review session in which all available laboratory data were reviewed and two out of three experts concurred. In our study, although records were not reviewed, since most of the participants were physicians and their relatives, the chances of a spurious diagnosis were minimal. Further, in 74 out of 88 subjects, the diagnosis was reportedly made after coronary angiography which is the "gold standard" diagnostic method. Nevertheless, an overall two- to three-fold higher prevalence rate of CHD among immigrant Asian Indian men compared to the US physicians or the Framingham cohort, cannot all be explained by sample bias. Our study revealed a similar increase in prevalence of CHD in both physicians and nonphysicians. Our results, therefore, have implications for all first-generation Asian Indian immigrant men.

A relevant question is whether Asian Indians are already predisposed to high risk of CHD or if they acquire it only after migration and adopting a more affluent Western lifestyle. In general, the prevalence rates of CHD are reported to be low from rural India[26–29], whereas urban populations have higher rates[30–35]. The data were recently reviewed by Bhatia[36]. Only a short-term (3-year) prospective study from Delhi[33] provides data on annual incidence of myocardial infarction in men and women (3.6 and 2.2 per 1000) which was lower than that reported from Framingham (11.3 and 5.4 per 1000)[37]. In our study, the prevalence of CHD in immigrant Asian Indian men surpassed the rates observed in the indigenous population of the US, suggesting that migration further increases the risk of CHD.

Whether Asian Indians born in a particular geographic area in the Indian subcontinent are at higher risk of CHD than others, is controversial[8,38]. Despite the genetic heterogeneity and diverse lifestyles of people from the Indian subcontinent, consistently high rates of CHD are observed in immigrant Asian Indian populations. For example, the majority of Indians migrating to Singapore were from South India (Tamil Nadu and Kerala) whereas those migrating to Trinidad and England were mostly from North India. Our study also supports this contention and did not reveal any differences in the crude prevalence rates of CHD in men from Kerala (9.5%) or Gujarat (7.4%), compared to that from the rest of India (8.2%).

The data on rates of CHD in Indians belonging to different socioeconomic strata and castes are not available. Although on the decline, most marriages in India are within the caste system, and therefore, theoretically the "founder genes" may influence prevalence rates of CHD and its risk factors in different castes. We did not study the caste of the subjects. Most of our subjects being physicians belonged to a high socioeconomic status. In general, Asian Indians migrating to Western countries belong to affluent families and a large proportion of migration is kin- or clan-structured, and therefore both the higher socioeconomic status and genetic predisposition may contribute to higher rates of CHD in migrant Asian Indians. However, it should be mentioned that despite the low socioeconomic status of most of the original migrants to the UK and South Africa in the nineteenth century, high rates of CHD were noted.

Our data suggest that NIDDM is the most important CHD risk factor in immigrant Asian Indians; low HDL cholesterol levels and elevated plasma triglyceride levels may also contribute. Interestingly, the prevalence rates of diabetes mellitus from urban Indian populations, and recently from a rural area in South-Central India are reported to be comparable to that observed in immigrant Asian Indians[39–42]. Prevalence of diabetes mellitus in recent studies, however, have only ranged from 1 to 4 percent[29,32,33]. Asian Indians, therefore, may already be predisposed to NIDDM, and lifestyle changes with migration further increase this tendency. Our study supports this contention, since obesity (defined as body mass index >25 kg/m^2) was more prevalent in men from our study compared to men from Delhi (29.8% versus 21.3%, $p<0.0001$) but less prevalent among immigrant women (22.7% versus 33.4% $p<0.02$)[43]. It seems that even modest changes in adiposity predispose Asian Indian immigrants to higher risk of CHD and NIDDM. McKeigue et al[13] recently proposed an increased metabolic susceptibility in Asian Indians to increases in waist-to-hip circumference ratio which can result in hyperinsulinaemia, insulin resistance and NIDDM. Plasma insulin levels were not measured in our study and therefore we cannot comment on the relationship of obesity or body fat distribution to hyperinsulinaemia or insulin resistance.

Comparison of Asian Indian men with CHD and those without CHD revealed that conventional risk factors such as age, hypertension, family history of CHD and to a lesser extent, cigarette smoking, do matter;

however, they are operative against a background of increased susceptibility due to NIDDM and possibly insulin resistance. The lack of differences in eating habits (eg. vegetarian versus nonvegetarian), obesity, waist-to-hip circumference ratio and an increased use of lipid-lowering drugs may be in part due to changes in lifestyle and drug therapy after the diagnosis of CHD and could be somewhat biased. Vegetarian lifestyle did not seem to protect Asian Indians from high risk of CHD, which is in contrast to several observations of low risk of CHD in vegetarians[44–46]. An increased prevalence of CHD in the vegetarian Asian Indian men, despite lower LDL cholesterol and apo B levels and less smoking, may probably be because of increased prevalence of NIDDM, and similar rates of obesity, hypertension and familial predisposition compared to nonvegetarians.

Based on the high prevalence of NIDDM, low HDL cholesterol levels and possibly hypertriglyceridaemia in immigrant Asian Indians, it can be postulated that insulin resistance plays a key role in causing CHD in this ethnic group. Although high prevalence of insulin resistance has also been noted in other populations such as the Mexican Americans and Pima Indians of Arizona[47–49], they do not have high rates of CHD[50,51]. In fact, Pima Indians have much lower rates of CHD as compared to Caucasians but they also have strikingly low LDL cholesterol levels which may be protecting them from CHD[52]. The immigrant Asian Indians may therefore be a unique ethnic group in whom insulin resistance, possibly interacting with other coronary risk factors, may be responsible for high rates of CHD. It is critical to determine the causes of CHD in this population, because with rapid urbanisation of the population in India, rates of CHD may increase dramatically, even reaching epidemic proportions. This may be an urgent public health issue for India.

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