Journal of Clinical Research Letters
ISSN: 0976-7061 & E-ISSN: 0976-707X, Volume 5, Issue 1, 2014, pp.-070-076.
Available online at http://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000256

ASSOCIATION OF FASTING BLOOD GLUCOSE WITH CARDIOVASCULAR RISK FACTORS: "RESULTS FROM A SEMI-URBAN POPULATION BASED STUDY ON 1502 SUBJECTS"

CHARAN REDDY K.V., NIKHILA A.P. AND GHANEKAR J.*

Department of Internal Medicine, MGM Medical College & University, Kamothe, Navi Mumbai- 410 209, MS, India.
*Corresponding Author: Email- jaishreeghanekar@gmail.com

Received: February 28, 2014; Accepted: March 10, 2014

Abstract-

Background- Cardiovascular disease (CVD) is an important cause of mortality and morbidity in India. CVD risk profile differs in different regions and ethnic groups. However, considerable research is required to comprehend the actual trends. Regionally representative and reliable prevalence data on FBG and association with CVD are scarce.

Aims and Objectives- The aim of the present study was to determine the prevalence of fasting blood glucose (FBG) and its relationship with CVD risk.

Methodology- This is a randomized study conducted in the semi-urban region of Navi Mumbai, Maharashtra, India. We enrolled 1502 participants (aged 15–95 years of age) using a convenience sampling technique. An interviewer administered questionnaire was used to obtain the bio-data and past medical history. Blood pressure, anthropometric and biochemical parameters were measured. Data obtained was analyzed using the Graph Pad Prism software version 5.0.

Results- Out of the 1502 participants that came for screening, 912 males (60.70%) and 590 (39.30%) were females. Their mean age was 50.96 ± 21.37 years. All the participants examined for major CVD risk factors (95% CI) comprising FBG (28.83%), diabetes (6.0%), hypertension (25.80%), 27.40% (95% CI) over weight (BMI ≥ 25 kg/m2) and about 22.0% were found to be obese. Females had a higher mean BMI than males. While 33.16% (95% CI) had truncal obesity (waist circumference ≥ 90 cm) and waist: hip ratio (0. 94 cm). The current smokers and alcoholic subjects were 37.10 and 39.60% respectively. Of the 42.0% subjects (631 of 1502) had 3 risk factors, 3. 3% (48 of 1502) had 5 risk factors, 0.93% (14 of 1502) had 9 risk factors and 0.13% (2 of 1502) had 10 risk factors. All 695 MS subjects (46.27%) had high FBG levels (≥ 126 mg/dL). About 31.70% individuals were physically active. In majority of individuals, the most common risk factors observed were abnormally high total cholesterol (32.69%) (491 of 1502); low HDL-c (53.06%) (797 of 1502), high TG (37.02%) (556 of 1502) and high LDL-c (17.04%) (256 of 1502) levels.

Conclusion- Association of FBG, BMI, total cholesterol and LDL-c were increased with the increase of age. Elevated FBG is quite common in our study population and it contributes to the occurrence of CVD risk. Physical activity for at least 30 minutes/day should be encouraged in order to reduce the risk of CVD.

Keywords- Obesity, BMI, CVD, FBG, Waist circumference

Citation: Charan Reddy K.V., Nikhila A.P. and Ghanekar J. (2014) Association of Fasting Blood Glucose with Cardiovascular Risk Factors: "Results from a Semi-Urban Population Based Study on 1502 Subjects". Journal of Clinical Research Letters, ISSN: 0976-7061 & E-ISSN: 0976 -707X, Volume 5, Issue 1, pp.-070-076.

Introduction

Developing countries of the world, especially India face a double burden of infectious diseases (e.g.: AIDS, tuberculosis etc.) and emerging chronic non-communicable diseases (NCDs) (e.g.: diabetes, hypertension, cardiovascular disease, renal disease and cancer etc.) [1,2]. It is well established that NCDs are the leading cause of death in the world, responsible for 63% of the 57 million deaths that occurred in 2008 [3,4]. Over the years, although efforts are being made for the prevention of NCDs, but they continue to raise especially the cardiovascular diseases (CVD) at an alarming rate [4].

Worldwide, CVD is the single largest cause of death and the second largest cause of disease burden [5,6] .Globally, over 17.5 million people die annually due to CVD and 35% of these deaths occur in low income countries including India, and this figure is predicted to increase to 25 million people by the year 2025 [7]. Lifestyle modifications such as unhealthy choices of diet, including consumption of high salt and fats, alcoholism and smoking etc., are the main causes for CVD increase. Rapid urbanization with some degree of economic development with slow but gradual increase in the proportion of older population was other causes for CVD rise [8]. Be-

sides these, metabolic syndrome (MS), which includes dyslipidemia, hypertension, diabetes mellitus (DM), body mass index (BMI), and truncal-obesity have also been considered as major CVD risk factors [9].

Indian Council of Medical Research (ICMR) surveillance study evaluated the differences in self-reported prevalence of behavioral, anthropometric and CVD risk factors in different states of India [10]. Though Registrar General of India report revealed that greater age-adjusted CVD mortality in southern and eastern states of India, but these studies focused on the assessment of urban-rural differences, but not regional variations [11].

Recent studies have indicated that increased CVD prevalence even in the presence of pre-hypertension and pre-diabetes (impaired fasting blood glucose and impaired blood glucose tolerance) underline the importance of fasting blood glucose (FBG) as a strong risk factor for CVD [5]. In the last three decades, FBG is rapidly rising all over the world, particularly in South Asian region and its prevalence may vary from study to study [12]. India is a vast country and has specific ethnic characteristics; lifestyle modifications and environmental conditions that require own regional assessment of link between FBG and CVD risk. To the best of our knowledge, no studies are available on prevalence as well as association between FBG and CVD risk in semi-urban regions of different states in India. The objectives of the present study are: (1) to evaluate various risk factors with regard to CVD among inhabitants in a semi-urban lower middle class population in the region of Navi Mumbai, Maharashtra India, and (2) to estimate the association of FBG with CVD risk.

Material and Methods

Ethical Approval

Individual participant written informed consent was obtained after a thorough explanation was given and understanding was established. They were also informed of the possibility of using the data obtained for academic purpose and thereafter, their free consents to participate were obtained and each given a copy of the informed consent form to sign. Confidentiality was assured to all participants and data used for this study were stripped of personally identifiable information. They were also informed about their right to withdraw their consent to be part of the study at any point, without any consequence to them. The protocol was approved by Institutional Human Ethics Committee of MGM Medical College and Hospital, Kamothe, Navi Mumbai.

Study Design and Setting

Study Area

This study was carried out within semi-urban area of Navi Mumbai during the period from 2008-2011. Geographically, Navi Mumbai is one of the world's largest well planned township on the West coast, located 23 km away from the Eastern trans harbor of Mumbai city, having the population of 11,19,477 (6,11,501 males and 5,07,976 females) as per Census Bureau of India - 2011.

Study Design

We randomly recruited 1502 participants aged between 15 and 95 years (mean: age: 50.96 ± 21.37 years), who accepted to voluntarily participate in the study. The sample size was large enough to provide reliable estimates of prevalence of FBG by sex. All participants underwent medical history and complete physical examination. Participants were advised not to smoke, drink alcohol and not to perform physical exercise at least 30 minutes before enrollment into the study. Pregnant women were excluded from the study.

Study Questionnaire

Validated structured questionnaire was used to evaluate demographic data (gender, age, smoking, alcohol and physical activity etc.). History of major CVD risk factors such as diabetes and hypertension were inquired. Physical activity was measured by asking about both work-related and leisure time physical activities as per criteria defined by Paffenberger, et al. [13]. Briefly, Samples were select that represent the population. Care was taken in matching question wording to the concepts being measured and the population studied. Appropriate statistical analysis and reporting techniques were used.

Sample Size/Sampling Technique

No specific sample size was determined because the study was primarily a screening Program, we therefore used a convenience sampling technique to select 1502 participants that came for the screening.

Anthropometry

For the baseline data, information on body weight was measured in standing position wearing light cloths and no shoes in kilograms (kg) to the nearest 0.1 kg by a modern digital bathroom scale with a calibrated clinical scale. Height was measured in meters with a wall-stadiometer to the nearest 0.1 cm. Body mass index (BMI) was calculated by dividing weight in kg by squared height in metres and overweight and obesity defined as BMI ≥ 25 kg/m^2. Obesity was defined by BMI ≥ 30 kg/m^2. Waist circumference was measured with a fiber-glass tape, midway between the lower border of ribs and iliac crest on the mid axillary line. Hip circumference was measured at the greatest protrusions of the buttocks just below the iliac crest. Truncal obesity was diagnosed when waist: hip ratio (WHR) was ≥ 0.9 cm in men and ≥ 0.80cm in women according to Bouguerra, et al. [14].Hypertension was diagnosed when blood pressure was ≥ 140 / ≤ 90 or a person was known hypertensive.

Biochemical Measurements

Venous blood samples were collected from all participants and analyzed to measure FBG levels using HEMOCUE glucose analyzer. The machine was calibrated every day with standard glucose solution to minimize the measuring error. FBG levels were classified into five groups such as Normoglycaemia was defined ≤ 74 mg/dl (group-1), 75-89 mg/dl (group-2) , 90-109 mg/dl (group-3), Impaired fasting glucose (IFG) was defined when glucose level was 110-125 mg/dl (group-4) and diabetes was diagnosed when there was a history of diabetes or fasting glucose was ≥ 126 mg/dl (group-5).

We categorically defined CVD risk factors such as fasting blood glucose (FBG), total cholesterol (TC), and high density lipoprotein cholesterol (HDL-c), Low-density lipoprotein cholesterol (LDL-c), triglycerides (TGs), body mass index (BMI), smoking and alcoholism. For every variable, the cut-off points were chosen as defined in the latest recommendations of the World Health Organization [15], Adult Treatment Panel III (ATP-III) of the National Cholesterol Education Program (NCEP-III) [16] the American Diabetes Association [17], and the Seventh Report of the Joint National Committee (JNC) on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure manuals [18]. [Table-1] summarizes the definitions of diagnostic criteria used for various CVD risk factors.

Table 1- Definitions of various risk factors in the study

Sr. No.	Risk Factor	Definition
1	Hypertension	Persistently elevated blood pressure (BP) ≥ 160/90 mmHg. The choice of 140/90 mmHg as a cut-off point is based on the JNC seventh report [31].
2	Diabetes mellitus	Diagnosed according to the American diabetic association [17].
3	Fasting Blood Glucose (FBG)	FBG level was considered normoglycemia when it was ≥ 75 mg/dL (group-1); hyperglycemia categorized into ≥ 76 to ≤ 89 (group-2); ≥ 90 to ≤ 109 mg/dL (group-3), a diagnosis of impaired FBG was defined when glucose levels are in between 110 -125 mg/dL (group-4) and diabetes mellitus was diagnosed when there was an history of diabetes or FBG level was ≥ 126 mg/dL (group-5).
4	Dyslipidaemia	NCEP: ATP III cut-off points were used to identify participants with desirable, borderline and high levels of lipoprotein risk factors [16]
5	Total cholesterol (TC)	NCEP ATP III cut-off points were used as ≤ 199 mg/dL, ≤ 200 to ≥ 239 mg/dL and ≥ 240 mg/dL, desirable, borderline and high levels respectively; low density lipoprotein cholesterol (LDL-c): ≤ 100 mg/dL, ≤ 130 to ≥ 159 mg/dL and ≥ 190 mg/dL respectively;
6	Serum triglyceride (TG)	Fasting serum triglycerides ≤ 149 mg/dL and ≥ 150-199 mg/dL, ≥ 200-499 mg/dL desirable, borderline and high levels respectively
7	High density lipoprotein cholesterol (HDL-c)	cut-off points used to identify participants with protective, borderline, and low levels were: ≥ 39 mg/dL, ≤ 40 mg/dL and ≤ 30 mg/dL, respectively.
9	Body mass index (BMI)	Cut-off BMI values were used to identify participants as normal = 18.5-24.90 kg/m2, overweight = 25-29.99 kg/m2; obese ≥ 30 kg/m2 [15]
10	Truncal obesity	Waist circumference ≥ 110 cm in males or ≥ 88 cm in females; truncal obesity (waist- hip ratio ≥ 0.90) [14]
11	Smoking	Considered if smoking was reported up to the day of the interview.
12	Metabolic syndrome	The presence of at least 3 of the following: FBG levels ≥ 110 mg/dl, serum triglycerides ≥ 150 mg/dl, serum HDL-c ≤ 40 mg/dL and blood pressure ≥ 130 /85 mmHg.
13	Level of physical activity	This was determined using the modified Hipny Physical Activity Questionnaire (based on the Health Insurance Plan (HIP) of New York questionnaire) [32] .

The methods for the determinations of lipids were made according to the Association for the Prevention of Atherosclerosis and its Complication (AMPAC) guidelines. TC, HDL-c and TG were determined using colorimetric assay kits, according to the manufacturer's instructions. The LDL-c was calculated using the method described by Friedewald, et al. [19] CVD risk factors were defined using WHO STEP-wise approach [15]. Dyslipidaemia was defined by the presence of TC ≥ 200 mg/dL, LDL-c ≤130 mg/dL, HDL-c ≤ 40 mg/dL and triglycerides ≤150 mg/dL. MS was defined when any three of the five diagnostic criteria (Waist circumference ≥ 95 cm in males and ≥ 88 cm in females, Hip circumference ≥ 94 cm in males and 98 cm in females, FBG ≥ 110 mg/dL, triglycerides ≥ 150 mg/dL and HDL-c ≤ 40mg/dL in men, ≤ 50 mg/dL in women) were present according to the US National Education Program criteria.

Statistical Analysis

Statistical analysis was done using Graph Pad Prism software version 5.0 (Graph Pad software, CA, USA). The prevalence of diabetes and FBG was determined by simple percentages. Group comparisons were made using t-test and x^2 test. Pearson's correlation coefficients were determined using FBG as independent variable of various CVD risk. All values are expressed as the mean ± standard deviation (SD). Values were considered to be significant if the 'p' value was less than $P<0.05$.

Results

Demographic Characteristics

This study was designed to evaluate the incidence of CVD risk factors (FBG, hypertension, smoking, alcoholism, BMI, TC, HDL-c, LDL-c and TG) and to determine the association of FBG with CVD risk in a semi-urban lower-middle class population of Navi Mumbai, Maharashtra, India, conducted during the period from 2008-2011. Distribution of participants based on the age was presented in [Table-2].

The ages of the respondents ranged from 15-96 years. Those within the age group of 50-69 years constituted the highest number of respondents (n=659), which made up 39.90% of the whole respondents, whereas those above 70 years of age (n=181) were the least represented (12.05%). The mean age of the respondents was 50.96 ±21.37 years. Sex distribution was significantly varied with males making up 60.70% and females 39.30% of those that were surveyed in the study. The mean age of males (51.95 ± 17.22 years) and female (50.13 ± 19.75 years) participants were fairly comparable, with the males having slightly higher mean age, not statistically significant. Of the total 1502 participants, 8.5, 35.60, 44 and 12% were aged between 15-29, 30-49, 50-69 and ≥ 70 years, respectively . Most participants were low-income earners and > 90% belonged to the lower socioeconomic status (data not shown).

Table 2- Distribution of participants based on the age

Age (Years)	No. of Participants	Percentage
15-29	128	8.5
30-49	534	35.6
50-69	659	43.9
>70	181	12
Total	1502	100

One fifth of the study population was obese as per new WHO overweight definition for south Asians (≥ 25 kg/m^2).In a total of 1502 subjects, 50.60% (n=760) had normal BMI, 27.36% overweight (n=411) and 22.03% obese (n=331). The mean BMI in males was 25.01 ± 4.12 kg/m^2 (range: 16.30- 35.75 kg/m^{2}kg/m^2) and in females it was 26.03± 5.06 kg/m^2 (range: 16.76-36.76), indicating females had a higher mean BMI than males. Of the 457 subjects who had FBG levels (≥ 126 mg/dL), 72.43% (n=331) were obese. These331 obese subjects comprise 161 (48.64%) females and 170 (51.36%) males. No significant difference in the obesity was observed between males and females.

FBG levels were significantly correlated with BMI in males but not in females. Of the 1502participants, 66.84% (n=1004) had normal truncal obesity i.e. waist: hip ratio (WHR) (0.91±0.4) (range: 0.87-0.96) and 498 (33.16%) had high truncal obesity (WHR ratio (0.93±0.30) (range: 0.88-0.97). These 498 subjects comprise 260

(52.21%) males and 238 (47.80%) females. Waist circumference in males was ≥ 89 ± 11 cm (range: 80-97 cm), whereas it was 93.5 ± 9.98 cm (range, 87-99 cm) in females. Out of 498 truncal obese subjects, 331 (66.47%) had high FBG ≥ 126 mg/dL, indicating a close correlation between FBG levels and truncal obesity.

To determine the prevalence of CVD risk based on the FBG levels and age, participants (n=1502) were divided in to five groups [Table -3]. Groups 1 to 5, there were 117 (7.79%), 317 (21.11%), 445 (29.63%), 190 (12.65%) and 433 (28.83%) subjects respectively. The CVD risk found to be least in group 1 (FBG ≤ 75 mg/dl) and progressively increased with escalating FBG levels and maximum in group-5 (≥ 126 mg/dL). The mean value of FBG level was 119.97 ± 14.86 mg/dL (range: 102-138 mg/dL). The lowest observed FBG was 40 mg/dL and highest 589 mg/dL. Of the 912male and 590 female subjects, 751 (82.35%) males and 405 (68.64%) females had normal to moderate levels of FBG (≤ 109 mg/dL) respectively. Of the 433 subjects who had high FBG levels (≥ 126 mg/dL), comprise 248 (57.27%) were males and 185 (42.73%) were females, attributing a good correlation of FBG with females than males.

Table 3- Distribution of subjects based on the age and FBG levels

Condition	FBG Levels (mg/dL)	Age (Years)				Total subjects
		15-29	30-49	50-69	≥ 70	
Normoglycemia (Group-1)	≤ 75	21	33	39	24	117
Hyperglycemia-1 (Group-2)	76-89	41	113	134	29	317
Hyperglycemia-2 (Group-3)	90-109	49	175	172	49	445
Impaired fasting blood glucose (IFBG) (Group-4)	110-125	5	76	91	18	190
Diabetes (Group-5)	≥ 126	12	137	223	61	433

Anthropometric Data

In the present study, the number of current smokers was low. Of the 1502 participants, 62.78% (n=943) were non-smokers and 37.22% (n=559) were regular smokers [Table-4]. These smokers comprise 509 (91.01%) males and 50 (8.95%) females. Of these male smokers, 41.06% (n=209) had high FBG levels (≥ 126 mg/dL), indicating a close association of smoking with FBG in males. However, such an association was not seen with female participants.

Table 4- Distribution of study participants (Males and Females) based on the traditional CVD risk factors

Risk Factors	Participants (n=1502)		Total
	Males (n=912)	Females (n=590)	
BMI (kg/ m^2) 25 - 29.90	237 (25.99%)	174 (29.49%)	411
Obese (BMI: ≥ 30	170 (18.67%)	161 (27.29 %)	331
Truncal obesity	260 (28.53 %)	238 (40.39%)	498
Hypertension	239 (26.24%)	147 (24.98 %)	386
Smoking	509 (55.84%)	50 (8.95%)	559
Physical activity (Heavy)	250 (27.41%)	40 (6.78%)	290
Alcohol	523 (57.35%)	71 (12.05%)	594
FBG (≥ 126 md/dL) / Diabetes	248 (27.19 %)	185 (31.38%)	433
Total cholesterol (≥ 200 mg/dL)	96 (10.53%)	395 (66.95%)	491
High LDL-c (≥ 130 mg/dL)	118 (12.94%)	138 (23.50%)	256
Low HDL-c (≤ 40 mg/dL)	432 (47.37%)	365 (65.84%)	797
Triglycerides (TG) (≥ 150 mg/dL)	344 (37.72%)	212 (35.93%)	556

The proportion of participants consuming alcohol was 39.55% (594 of 1502). These alcoholic subjects comprise 88.05% (523 of 594) males and 12.0% (71 of 594) females. Of the 594 alcoholic males, 57.07% (n=339) had high FBG levels (≥ 126 mg/dL), indicating significant association (P < 0.001) between alcohol intake and elevated FBG levels in males. However, this association was not observed in female participants.

Physical activity data revealed that nearly half (49.0%) of the participants (736 of 1502) had given the history of moderately active, 31.70% (477 of 1502) reported physically inactive and 19.30% (n=290) perform heavy physical activity like farming on a regular basis. These 290 physically active subjects comprise 250 (86.21%) males and 40 (13.79%) females. Of the 477 physically inactive subjects, 44.86% (n=214) were males and 55.14% (n=263) were females, indicating higher prevalence of sedentary life style in females than males. Of these 477 physically inactive subjects, 51.15% (244 of 477) had high FBG levels (≥ 126 mg/dL), indicating that similar to other risk factors, sedentary lifestyle is also closely associated with elevated FBG levels.

For the possible effect of gender on CVD, data on the prevalence of traditional CVD risk factors are presented in [Table-4]. There was an increasing trend in mean hypertension BMI, WHR, smoking, alcohol consumption, physical inactivity, overweight (BMI ≥ 25) and obesity (BMI ≥ 30) and various lipid profile. Of the 1502 participants, 25.70% (n=386) were hypertensive. These 386 hypertensive subjects comprise 61.91% males (n=239) and 38.08% females (n=147). About 74.09% (n=286) of these hypertensive subjects had higher levels of FBG (≥ 126 mg/dL), which comprise, 31.08% (n=203) males and 21.50% (n=83) females, suggesting significant (P<0.001) correlation between hypertension and elevated FBG levels.

Clinical Measurements

The highest levels of triglycerides were 967 mg/dL and minimum was 19 mg/dL, and mean levels were 146.19 ± 42.24 mg/dL [Table-5]. Of the 912 males and 590female participants, 61.40% (n=568) and 64.10% (n=378) had normal levels of triglycerides (≤ 150 mg/dL) respectively, whereas 37.72% males (344 of 912) and 38.12% females (212 of 590) had high levels of TG (≥ 150 mg/dL. Of the 556 subjects who had high TG levels (48.01%), 241 (43.35%) (148 males and 93 females) had FBG ≥126 mg/dL, indicating a close association between triglycerides and FBG levels.

Table 5- Biochemical and anthropometric parameters of the study population (n = 1502).

Parameters	Mean ± SD	Lowest (mg/dL)	Highest (mg/dL)
Total Cholesterol (mg/dL)	187 ± 23.72	10	478
LDL-c (mg/dL)	121 ± 32.26	30	47
HDL-c (mg/dL)	43.79 ± 3.99	9	60
Triglycerides (mg/dL)	146 ± 42.24	19	967
TC/ HDL-c ratio	4.28 ± 0.93	-	-
BMI (kg/m^2)	25.01 ± 4.12	16.76	36.76
Waist Circumference (cm)	92.20 ± 8.76	-	-
Hip Circumference (cm)	94.69 ± 7.33	-	-
Waist / Hip ratio	0.97 ± 0.17	-	-
FBG (mg/dL)	119.97±14.86	40	589

The lowest measured TC was10 mg/dL and highest was 478 mg/dL. It was observed that 28.70% participants (431 of 1502) had normal levels, and 32.69% (491 of 1502) had high TC levels (≥ 200 mg/dL). These 491 subjects who had high TC comprise 395 (80.45%) females and 96 (19.55%) males. Of the total 491 subjects (32.69%) who had hypercholesterolemia, 37.10% (325 of 491) had elevated levels of FBG (≥ 126 mg/dL) (P<0.001). These 325 subjects who had elevated levels of FBG comprise 177 (20.20%) males and 148 (16.89%) females, indicating a close association of TC with CVD risk.

The most common concurrent components among all the studied CVD risk parameters, HDL-c was found to be significantly low. Of the 912 male participants, 432 (47.40%) had normal to moderate levels of HDL-c (~40 mg/dL) and 480 (52.60%) had higher levels (≥ 40 mg/dL) with a mean value of 43.79 ±3.99 mg/dL. Of the 590 female subjects, 365 (61.87%) had low to moderate levels of HDL-c (≤50 mg/dL), whereas 225 (38.14%) had higher levels of HDL-c (≥ 50 mg/dL), indicating a close association of HDL-c with FBG in males as compared to females.

There is also an increasing trend in mean LDL-c levels with increasing FBG. In a total of 912 male participants, 794 (87.06%) had normal to moderate levels of LDL-c (≤130 mg/dL) and 118(13.0%) had significantly higher levels of LDL-c (≥ 130 mg/dL). Of the 590 female participants, 452 (76.61%) had low to moderate levels of LDL-c (≤ 130 mg/dL), whereas138 (23.38%) had significantly higher levels of LDL-c (≥ 130 mg/dL).

With respect to MS, this study revealed a prevalence rate of 35.55%. Of the 1502 participants, 22.20% males (334 of 1502) and 19.80% females (297 of 1502) had MS, indicating high prevalence of MS in male participants than the females, though the difference was statistically not significant. Of the 1502 participants, 631 MS subjects (42.0%) had3 risk factors, 48 (3. 3%) had 5 risk factors, 14 (0.93%) had 9 risk factors and 2 (0.13%) had all the 10 analyzed risk factors (smoking, alcoholism, sedentary lifestyle, hypertension, obesity, FBG, BMI, TC, LDL-c and TG). All 695 MS subjects (46.27%) had high FBG levels (≥ 126 mg/dL).

Discussion

The study sample reflects the CVD risk factors of the semi urban lower middle class population of Navi Mumbai region in the state of Maharashtra, India. During the last 4-5 decades, Navi Mumbai area has experienced rapid change in economic and cultural front that significantly modified the nutritional and epidemiological trends. Due to the adoption of a western lifestyle, Indians are highly susceptible to CVD risk even they are modest obese [6].

The result of our findings showed that the prevalence rate of smokers was 40%. This is higher than the national prevalence rate in India reported in the WHO country profile reports for NCDs in 2011, where a prevalence rate of tobacco consumption of all forms at 65% and 33%, respectively, among men and women was reported. This is significantly higher than the prevalence observed in our study, although we are not sure about this issue that how much we can trust individuals self-report. This observation could also be explained as due to the religious nature and poverty in our study population. Moreover, 75.83% of our smokers had higher FBG levels (≥ 126 mg/dL), attributing a significant (P<0.001) correlation between smoking and FBG levels.

The high prevalence of MS in males (22.44%) than the females (19.80%) observed in our study is in agreement with previous reports [1]. In contrast, Gupta, et al. [12] showed higher prevalence of MS in women (31.60%) than in men (22.90%). This may be explained as due to age difference of our population and the cut-off values considered to define MS. Furthermore, in our study, we observed higher prevalence of sedentary lifestyle in females (36.27%) than males (31.70%). These results are in agreement with the report Prabhakaran, et al. [5], but contradicting the results of Gupta, et al. [12], which showed high prevalence of physical inactivity in males than females. The discrepancies may be explained as due to differences in targeted population, gender, age and the cut-off values used to define various CVD risk factors in our study.

The result of our findings showed that the prevalence rate of generalized FBG was 28.83%. However, a much higher prevalence (51.04%) was reported by Noeman, et al. [20]. The Australian Diabetes Obesity and Lifestyle study reported the prevalence of impaired FBG to be 16.4%, which is lesser than the prevalence found in our study. Furthermore, we also observed that 53% hypertensive subjects had FBG ≥ 126 mg/dL, attributing significant association of hypertension with elevated FBG. About 44% of our participants were in the age group of 50-69 years, therefore could be classified as elderly people, hence the possibility of a greater burden of hypertension. Over the time, the cut-off value for hypertension has also been lowered from 160/95 mmHg to 140/90 mmHg, which is bound to identify more people as having hypertension. Age-related increase in the prevalence of hypertension was also observed [21]. Studies also showed that relationship between anthropometric measurements (BMI and WC) and CVD risk varies globally [4,8]. Our study showed that impaired FBG was more strongly related to CVD than other risk factors. These discrepancies in the degree of association between FBG and CVD may be attributable to socio-demographic differences between the study populations.

It has been reported that, BMI appears to be associated with diabetes and CVD risk and reduction of weight led to lower BMI [22]. In our study, the truncal obesity (waist-hip ratio) was observed in 22% of participants, with no difference between males and females. These results were closed to what was reported earlier by Narsingrao et al. [23]. In contrast, Gulati, et al. [24] demonstrated lower prevalence of obesity (14.50%) in their study. This discrepancy might be explained as a result of high caloric expenditure and physical strength arising from their farming activities. The prevalence of diabetes is significantly lower among people who engage in vigorous physical activities. Defay, et al. [25] reported that, physically active subjects had substantially reduced the risk of diabetes and the risk remained significantly reduced after adjustment for age, BMI, WHR and CVD.

A long-standing association between elevated levels of triglycerides and LDL-c, low HDL-c with CVD risk has been well established [26,27]. In our study, 35% of the subjects had elevated triglyceride levels, a fact that might be associated with HDL-c as their inverse relationship. Apart from high LDL-c, we also observed most common CVD risk factor was elevated cholesterol levels. Our results are in consonance with the results reported [28], which suggests positive association between impaired FBG and CVD risk factors.

Gerstein, et al. [29] demonstrated ≤ 88 mg/dL FBG was associated with lowest myocardial infarction (MI). In contrast, a prospective study from Japan, reported that impaired FBG is not a risk factor for CVD [30]. Other studies however, reported relatively higher prevalence rates in some regions both within and outside India (4,6). Our results indicated that CVD risk is the least in those with FBG ≤ 75 mg/dL and there is a step wise escalation in CVD risk factors with an increase in FBG levels. Possible explanation for FBG-CVD relationship includes direct toxic effect of glucose on cellular function [12]. Indirect effects owing to insufficient insulin secretion to maintain normoglycemia and a long history of insulin resistance and hyper-insulinemia prior to glucose elevation. This association could also be due to dysglycemia being a marker of other known and unknown risk factors for CVD.

Conclusions

This study has been able to demonstrate the close association between FBG and CVD risk. Many CVD risk factors increased linearly with impaired FBG and are an under-diagnosed condition. FBG levels ≤ 75 mg/dL were associated with the lowest CVD risk. Like LDL-c, FBG appears to be one of the major CVD risk factors, pointing towards the timely need for health screening, create awareness and design intervention strategies to contain the burden of CVD risk.

Limitations

Though the present study showed that FBG ≥ 126 mg/dL is linked with multiple CVD risk factors, the lower middle class semi-urban population is different from the general population in terms of its socioeconomic profiles. The prevalence of physical activity and some CVD risk factors may be underestimated when it is elicited by participant self-report. Taking into account all the limitations of the study and the previous literature on prevalence of FBG, it is safe to conclude that FBG has significant association with CVD in our study population. In support of our current findings, large scale prospective studies are needed for obtaining FBG prevalence data and confirmation of its association with CVD risk.

Abbreviations

AIDS: Acquired immunodeficiency syndrome.

NCDs: Non-Communicable Diseases.

CVD: Cardiovascular disease.

FBG: Fasting blood glucose.

BMI: Body Mass Index.

LDL-c: Low density lipid cholesterol.

HDL-c: High density lipid cholesterol.

TG: Triglycerides.

TC: Total cholesterol.

MS: Metabolic syndrome.

WHR: waist: hip ratio.

ATP-III: Adult Treatment Panel III.

Acknowledgements

We acknowledge the contribution of many people involved in facilitating the work reported here. We are also thankful to all participants of the study for their co-operation, because of whom this study was possible.

Conflicts of Interest: The authors declare no conflict of interest.

References

[1] Reddy K.S. (2002) *Public Health Nutrition,* 5, 231-237.

[2] Boutayeb A. (2006) *Trans. R. Soc. Trop. Med. Hyg.,* 100, 191-199.

[3] WHO (2011) *Global Status Report of NCD*, Geneva.

[4] Meaney A., Ceballos-Reyes G., Salmean G.G., Méndez V.S., Huerta A.V., Alcocer L., Chavarría E.Z., Castelán E.M., Corichi I.O ., Sánchez R.G., Marroquín Y.M., Sánchez I.R. and Meaney E. (2013) *Arch. Cardiol. Mexico*, 83, 249-256.

[5] Prabhakaran D., Shah P., Chaturvedi V., Ramakrishnan L., Manhapra A. and Reddy K.S. (2005) *The Natl. Medical. J. India*,18, 59-65.

[6] Gupta R., Guptha S., Sharma K.K., Gupta A. and Deedwania P. (2012) *World J. Cardiol.*, 4, 112-120.

[7] Dalal P., Bhattacharjee Vairale J. and Bhat P. (2008) *J. Assoc. Physicians India*, 56, 675-679.

[8] Reddy K.S., Prabhakaran D., Chaturvedi V., Jeemon P., Thankappan K.R., Ramakrishnan L., Mohan B.V., Pandav C.S., Ahmed F.U., Joshi P.P., Meera R., Amin R.B., Ahuja R.C., Das M.S. and Jaison T.M. (2006) *Bull. World Health Organ*., 84, 461 -469.

[9] Unwin N. (2001) *Health Policy Plan*, 16, 351-352.

[10] Registrar General of India (2009) *Report on Cases of Death in India 2001-2003*, New Delhi: Ministry of home affairs.

[11] National Institute of Medical Statistics & Indian Council of Medical Research (2009) *Integrated Disease Surveillance Project (IDSP), non-communicable disease risk factors survey, India*.

[12] Gupta R., Sarna M., Thanvi J., Sharma V. and Gupta V.P. (2007) *J. Assoc. Physicians India*, 55, 705-709.

[13] Paffenberger R.S., Hyde R.T., Wing A.L., Lee I.M., Jung D.L. and Kampert J.B. (1993) *N. Engl. J. Med*., 328, 538-545.

[14] Bouguerra R., Salem B.L. Alberti H., Rayana B.C., Khadhi E.A., Alti E.J., Gaigi S., Slana B.C., Zouari B. and Hetal S. (2006) *Diabetes Metab.*, 32, 215-221.

[15] WHO (2005) *The WHO STEPwise Approach to Chronic Disease Risk Factor Surveillance*, Geneva.

[16] Thomas G.N., Ho S.Y., Janus E.D., Lam K.S., Hedley A.J. and Lam T.H. (2005) *Diabetes Res., Clin. Pract.*, 67, 251-257.

[17] American Diabetes Association (2012) *Diabetes Care*, 35, S64-71.

[18] Cuddy M.L. (2005) *J . Pract. Nurs.*, 55, 17-21.

[19] Friedewald W.T., Levy R.I. and Fredrickson D.S. (1972) *Clin. Chem.*,18, 499-502.

[20] Noeman A., Ahmad N. & Azhar M. (2010) *Annals of King Edward Medical University*, 13(2), 162-163.

[21] Adedoyin R.A., Mbada C.E., Balogun M.O., Martins T., Adebayo R.A., Akintomide A. and Akinwusi P.O. (2008) *Eur. J .Cardiovasc. Prev. Rehab*., 15, 683-687.

[22] Singh R.B., Rastogi V., Rastogi S.S., Niaz M.A. and Beegom R. (1996) *J. Ame. Coll. Nutr*., 15, 592-598.

[23] Narsingrao B.S., Deosthale Y.G. and Pant K.C. (1989) *Nutrient Composition of Indian Foods, National Institute of Nutrition*, Hyderabad, 1, 8-10.

[24] Defay R., Delcourt C., Ranvier M., Lacroux A. and Papoz L. (2001) *Int. J. Obes. Relat. Metab. Disord*. 25, 512-518.

[25] Gulati S., Sekhon A.S., Goel N.K. and Sharma M.K. (2004) *Ind. J .Prev. Soc. Med.*, 35, 163-167.

[26] Sarwar N., Danesh J., Eiriksdottir G., Sigurdsson G., Wareham N., Bingham S., Boekholdt S.M., Khaw K.T. and Gudnason V. (2007) *Circulation*, 115, 450-458.

[27] Mahmood S.S., Levy D., Vasan R.S. and Wang T.J. (2013) *Lancet*, 27, 61752-61753.

[28] Mohan V., Deepa R., Rani S.S. and Premalatha G. (2001) *J .Am .Coll. Cardiol*. 38, 682-687.

[29] Gerstein H.C., Islam S., Anand S., Almahmeed W., Damasceno

A., Dans A., Lang C.C., Luna M.A., McQueen M., Rangarajan S., Rosengren A., Wang X. and Yusuf S. (2010) *Diabetologia*, 53, 2509-2517.

[30] Qiao Q., Jousilahti P., Eriksson J. and Tuomilehto J. (2003) *Diabetes Care*, 26, 2910-2914.

[31] Chobanian A.V., Bakris G.L., Black H.R., Cushman W.C., Green L.A., Izzo J.L., Jones D.W., Materson B.J., Oparil S., Wright J.T. and Roccella E.J. (2003) *J. Am. Med. Assoc.*, 72, 256-289.

[32] Elley C.R., Kerse N.M., Swinburn B., Arroll B. and Robinson E. (2003) *New Zealand Family Physician*, 30(3), 171-180.