Research Article

Determinants of the glycemic status and its relationship with cardiovascular risk factors

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Abstract: Aim: Diabetes Mellitus requires adequate glycemic control along with prevention of associated morbidities, disability limitation, and rehabilitation. The present study was aimed to determine the impact of socio-demographic and lifestyle factors on the glycemic status.
Settings and Design: A cross sectional study was conducted at Ex-Servicemen Contributory Health Scheme (ECHS) Polyclinic, Sultanpur Lodhi, Kapurthala, India from Aug to Nov, 2013.
Methodology: All the retired defence personnel (N=351) were recruited to assess physical activity, body mass index, dietary habits, alcohol, family history, sleep, stress, gender, age, employment, and education as determinants of glycemic status and its co-morbidities.
Statistical analysis: The results were analyzed by Chi Square test with statistically significance of *P* value <0.05.
Results: Total prevalence of hyperglycaemia was 24.22% with higher range in females (54.12%) than males (45.88%). A rising trend was seen associated with advancing age >40years (96.47%), unemployment (77.65%), and low education levels (60.90%). Sedentary lifestyle (64.70%), stress (20.00%), alcohol (30.59%), positive family history (41.18%; $P<0.05$), and non-vegetarian diet (45.88%) had shown contribution to hyperglycaemia. A significant co-morbidities of hypertension (68.23%; $P<0.001$), obesity (61.18%; $P<0.05$) and dyslipidemia (45.88%; $P<0.001$) was found associated with hyperglycaemia. The level of awareness and medication adherence was 67.06% and 61.18% in the subjects, respectively.
Conclusion: Rising trend of hyperglycaemia and its co-morbidities prompts an urgent need for public awareness on risk factors for hyperglycaemia, and strengthening of diabetes–related health services to early detect, prevent, and treat individuals with impaired glucose metabolism.

Keywords: hyperglycaemia, dyslipidemia, obesity, hypertension

Introduction

Diabetes Mellitus (DM), particularly type 2 which accounts for 90% - 95% of all cases, has become a global health problem. It is considered equivalent to coronary heart disease in its public health impact for being responsible leading global cause of blindness, chronic kidney failure, amputations and other complications, all of which significantly lead to short life expectancy, deterioration of life quality, disability and increased health care costs [1].

The World Health Organization (WHO) has listed that diabetes will be the seventh leading cause of death in 2030 [2]. International Diabetes Federation (IDF) has further projected an increase of 50.80% from the 366 million in 2011 to 552 million people affected with diabetes by the year 2030. This equates to approximately three new cases every ten seconds or almost ten million per year [3]. In 2004, an estimated 3.4 million people died from consequences of high fasting blood sugar, where more than 80% of diabetes deaths occurred in low- and middle-income countries [2]. WHO reports that India today heads the world with over 32 million diabetic patients with an increased projection of 79.4 million by the year 2030. Diabetes affects about 10-16% of urban and 5-8% of rural population, and thus has become great economic challenge as it drains 5-25% of an average Indian family income, which translates to 2.2 billion US dollars per annum [4].

DM is usually a silent disease in its initial stages [5], only a proactive search for it will lead to a timely diagnosis. IDF estimates that about 183 million people are unaware about having diabetes [3]. This high unawareness rates relatively contribute to late diagnosis of type 2 DM probably after between 4–7 years the disease initially developed [5]. Therefore, patients at the time of the diagnosis have already developed chronic complications from the diabetes. In the United Kingdom's Prospective Diabetes Study, 25% of type 2 DM patients had retinopathy, 9% had neuropathy and 8% had nephropathy at the time of the diagnosis [6].

The American Diabetes Association (ADA) and the American Association of Clinical Endocrinologist has designated HbA1c level of below 6.5% as a goal of optimal blood glucose control and further recommended adequate glycemic control with fasting blood sugar from 70 to 130mg/dl [1,7]. It has been demonstrated that 1% reduction in mean HbA1c level was associated with 12–43% reduction of microvascular and macrovascular complications [6]. Glycemic control, however, is not an easy task as majority of patients fail to achieve good glycemic status in clinical

Table 1. Comparisons of the socio-demographic variables in the all study subjects*

Category	Hyperglycaemic (85)	Euglycemic (266)	*P* value
AGE (years)			
20-40	03.53 (03)	10.15 (27)	3.72
40-60	43.53 (37)	38.72 (103)	
>60	52.94 (45)	51.14 (136)	
SEX			
Male	45.88 (39)	50.75 (135)	0.60
Female	54.12 (46)	49.25 (131)	
EDUCATION			
No/Little	34.12 (29)	30.07 (80)	1.81
Primary	30.59 (26)	30.83 (82)	
Secondary	32.94 (28)	33.46 (89)	
Graduation	02.35 (02)	05.64 (15)	
SOCIO ECONOMIC STATUS			
Middle	68.23 (58)	62.03 (165)	1.07
Upper	31.76 (27)	37.97 (101)	
OCCUPATION			
Unemployed	77.65 (66)	69.17 (184)	2.26
Employed	22.35 (19)	30.83 (82)	

*parentheses represent absolute number of the sample subjects.

trials, and even routinely in clinical practice. Different studies in systematic review revealed that a good glycemic control is achieved in less than 50% of diabetic patients and further attributed this failure to both patient and healthcare provider related factors [8]. Significant knowledge and skill deficits have been found among 50–80% of diabetic patients who failed to achieve good glycemic control [9]. Factors associated with improved control are, increased sense of responsibility for self-care, increased frequency of home blood glucose monitoring, regular exercise and contact with healthcare providers, and fear of hyperglycaemia and hypoglycaemia [8].

DM virtually affects every body system due to metabolic disturbances caused by underlying suboptimal hyperglycaemic control over a period of time; and subsequently contributes to cardiovascular diseases, nephropathy, retinopathy and neuropathy which can further lead to chronic co-morbidities and mortality [1]. However, there is no cure for this disease and requires continuing medical care and education to ensure the reduced risk of disease progression. Wide glycemic variability with the episodes of both hypoglycaemia and hyperglycaemia predisposes the patients to a greater in-hospital mortality risk [10]. The needs of diabetic patients are not only limited to adequate glycemic control but also correspond with preventing complications, disability limitation, and rehabilitation. Hence, the current study was designed to determine the prevalence and various determinants affecting the glycemic status of the study subjects.

Methodology

Design overview

This cross-sectional study was undertaken on the Ex-Servicemen residing in the region of Sultanpur Lodhi, tehsil of district Kapurthala, Punjab (India). This survey was conducted at Ex-Servicemen Contributory Health Scheme (ECHS) Polyclinic which provides free at-the-point-of-access primary care and follow up services for all kind of acute and chronic diseases solely to the registered retired defence personnel under health scheme. The selection criteria for the study subjects was: the subjects who had been retired from the defence services; registered with polyclinic; their family members comprising spouse, children and parents; and had attended the polyclinic from Aug, to Nov, 2013. Institutional ethical committee approval and informed written consent of all the subjects was obtained. Chi Square test was used for statistical analysis with a significance of P value <0.05.

Survey Questionnaires

A structured in-person interview was conducted to record socio-demographic variables and cardio-metabolic risk factors. Education level was classified into four categories: no/little formal, primary, secondary and graduation. Socioeconomic status was defined into lower, middle and upper class on the basis of retired ranks of ex-servicemen including their household income and assets. The regular aerobic physical activity (e.g., brisk walking) of at least 30minutes per day for most days of the week was considered adequate [11]. The family history was defined as positive if a first-degree male relative (e.g. father, brother) and female relative have cardiovascular disease before the age of 55 or 65years respectively [11]. Sleep adequacy was evaluated on the basis of sleep duration (7 to 8 hours), difficulty in initiating and maintaining sleep. Job strain, social constraints, financial un-stability and emotional distress were included under “stress”. Men alcohol intake is limited to <2 drinks per day; and for women and lighter weight persons, it is limited to <1 drink per day (1 drink = 1/2oz or 15ml ethanol (e.g., 12oz beer, 5oz wine, 1.5oz 80-proof whiskey)) [11]. Subjects who presently use alcoholic beverages and/or exceed their limits were categorised under “Current” group; and those who had never or left their habit of heavy alcohol consumption were counted under “Ex/Never” group.

Measurements

Height was determined using a wall mounted, non-extendable measuring tape with subjects standing in an erect barefoot position, arms by side and feet together. The subjects were weighed by standing at the centre of the weighing scale in light clothing with no shoes and socks. Body mass index (BMI) was calculated as weight per square meter (kg/m^2) and classified into normal (18.00-22.99kg/m^2), overweight (23.00–24.99kg/m^2), and obesity (≥25.00kg/m^2) [12]. Blood pressure (BP) was measured using a standard mercury sphygmomanometer and suitable calibrated cuff in the right arm after subject rested for 5 minutes. Hypertension was defined as a BP ≥140/≥90mmHg or a previous diagnosis with being on anti-hypertensive therapy [11]. An antecubital sample was obtained after 8–10 hours of fasting from all pre-informed individuals. Dyslipidemia was defined by a total cholesterol levels >200mg/dl (5.2mmol/l) and tested by Erba cholesterol kit (CHOD-PAP method, end point) [13]. Hyperglycaemia was diagnosed on the basis of fasting blood glucose levels >100mg/dl (5.6mmol/l) and/or 2 hour postprandial blood glucose levels >140mg/dl (7.8mmol/l) and tested using Erba glucose kit (GOD-POD method, end point); and further included the patients already diagnosed with impaired fasting glucose (IFG), impaired glucose tolerance (IGT) or type 2 DM [1]. Subjects with normal blood glucose concentration and using no prescribed medication for IFG, IGT or DM were categorized as “Euglycemic”.

Results

Two groups were formed on the basis of glycemic status: subjects with hyperglycaemia (N=85) and euglycemia (N=266). The prevalence of hyperglycaemia was observed as 24.22% in the total sample. 03.53%, 43.53% and 52.94% of patients with hyperglycaemia were in the age group of 20-40years, 41-60years and >60years, respectively. Similarly, those with euglycemia had 10.15%, 38.72% and 51.14% for the same age groups, respectively. This shows that age contributes to a higher prevalence of hyperglycaemia in subjects >40years old (96.47%) (Table 1). Prevalence of

Table 2. Comparison of the risk factors in subjects with hyperglycaemia and euglycemia*

Category	Hyperglycaemic (85)	Euglycemic (266)	*P* value
BODY MASS INDEX			
Normal	20.00 (17)	30.07 (80)	4.61
Overweight	18.82 (16)	21.43 (57)	
Obesity	61.18 (52)	48.50 (129)	
ALCOHOL CONSUMPTION			
Yes	30.59 (26)	23.68 (63)	1.61
No	69.41 (59)	76.31(203)	
SLEEP ADEQUACY			
Adequate	71.76 (61)	72.56 (193)	0.04
In adequate	28.23 (24)	27.44 (73)	
DIETARY HABITS			
Vegetarian	54.12 (46)	62.40 (166)	1.84
Nonvegetarian	45.88 (39)	37.59 (100)	
STRESS LEVELS			
Significant	20.00 (17)	18.04 (48)	0.18
Insignificant	80.00 (68)	81.95 (218)	
FAMILY HISTORY			
Positive	41.18 (35)	29.32 (78)	4.18 **(<0.05)**
Negative	58.83 (50)	70.68 (188)	
PHYSICAL ACTIVITY			
Adequate	35.29 (35)	37.22 (99)	0.10
Inadequate	64.70 (55)	62.78 (167)	

*parentheses represent absolute number of the sample subjects.

hyperglycaemia was observed higher among females (54.12%) than males (45.88%). An inverse relation of education with glycemic status was found; where subjects with no/little, primary, secondary and graduation had 34.12%, 30.59%, 32.94% and 02.35% of hyperglycaemia; and 30.07%, 30.83%, 33.46% and 05.64% of them had euglycemia for the same education categories, respectively. A higher prevalence of hyperglycaemia in middle social class subjects (68.23%), and euglycemia in upper class subjects (37.97%) was found. Furthermore, unemployment and employment was found associated with hyperglycaemia (77.65%) and euglycemia (30.83%), respectively.

A positive relation between hyperglycaemia and obesity was observed, where 20.00%, 18.82% and 61.18% of the subjects who had hyperglycaemia were in normal, overweight, and obesity ranges; and those with euglycemia had 30.07%, 21.43% and 48.50% for the same BMI groups, respectively (Table 2). Subjects under the effects of alcohol had higher prevalence of hyperglycaemia (30.59%) than their counterparts. Taking dietary habits into consideration, hyperglycaemia and euglycemia was found among subjects who prefer non-vegetarian (45.88%) and vegetarian meals (62.40%), respectively. The prevalence of inadequate (72.56%) and adequate sleep (71.76%) was approximately the same in subjects with hyperglycaemia; and the same trend was observed in euglycemic subjects. Conversely, a statistically significant subjects with positive cardiovascular family history (41.18%; $P<0.05$) had shown higher predisposition to hyperglycaemia as compared to other group. Higher prevalence of hyperglycaemia was noticed among subjects under significant stress levels (20.00%). Similarly, sedentary lifestyle was seen associated with hyperglycaemia (64.70%) than euglycemia (62.78%) in the study subjects.

Table 3 depicts a statistically significant higher prevalence of hypertension (68.23%; $P<0.001$), obesity (61.18%; $P<0.05$) and dyslipidemia (45.88%; $P<0.001$) in subjects with hyperglycaemia as compared to euglycemic subjects (hypertension: 39.47%, $P<0.001$; obesity: 48.50%, $P<0.05$; dyslipidemia: 21.05%, $P<0.001$).

Table 4 reflects 45.89%, 28.24% and 25.89% of patients have hyperglycaemia for <1year, 1-5years and >5years, respectively. The awareness and unawareness regarding the diagnosis of hyperglycaemia was seen among 67.06% and 32.95% of subjects, respectively. 61.18% and 38.83% of patients were adherent and non-adherent towards their treatment, respectively. Moreover, 42.36% of subjects take monotherapy, and 57.65% of them were under combination therapy for their hyperglycaemic status.

Discussion

Knowledge of factors influencing glycemic control and its prevalence can be used by health professionals to provide targeted interventions to patients at greatest risk of developing hyperglycaemia. The current study has observed 24.22% of the study subjects with hyperglycaemia. Evaristo-Neto et al. [14] has diagnosed 8.1% of their study subjects with IGT, 12.1% with IFG, and 2.8% with DM; and thus found the prevalence of hyperglycaemia as 23% in their study subjects which resembles to the present study. However, *National Health and Nutrition Examination Survey* reported 35.3% with either diabetes or IFG [15]. Furthermore, Assunção et al. [16] noticed the frequency of poor glycemic control among 50.5% of the study subjects. The complex interplay between genetic susceptibility; reduced physical activity; energy dense high calorie diets in addition to psychosocial stress associated with living in the new environment might be contributing to this diabetes epidemic.

A positive association (Table 1) between age and hyperglycemia with rising trend in subjects >40 years old (96.47%) was found in consistence to Ramachandran et al [17]. This shows age probably represent an accumulation of environmental influences and genetically programmed senescence in the body physiological systems. Furthermore, McDonald et al. [18] suggested that being younger than 40 years old is a protective factor against DM; and further observed that the presence of DM in individuals between 18 and 29 years old attributes to underlying risk factors (such as obesity, physical inactivity and unhealthy diets rich in fats and sugars) being present from the earliest stages of life.

Table 3. Comparison of the cardiovascular co-morbidities in subjects with hyperglycaemia and euglycemia*

Category	Hyperglycaemic (85)		Euglycemic (266)		*P* value
	Normal	Diseased	Normal	Diseased	
Hypertension	31.76 (27)	68.23 (58)	60.53 (161)	39.47 (105)	14.94 **(<0.001)**
Obesity	38.83 (33)	61.18 (52)	51.51 (137)	48.50 (129)	04.16 **(<0.05)**
Dyslipidemia	54.12 (46)	45.88 (39)	78.95 (210)	21.05 (56)	20.14 **(<0.001)**

*parentheses represent absolute number of the sample subjects.

A higher prevalence of hyperglycemia was observed among females (54.12%) than males (45.88%) in the current study. Similarly, Evaristo-Neto et al. [14] found women with almost twice the prevalence of IGT than men. Contrarily, Binh et al. [19] has observed a higher prevalence in men than women. On the other hand, Ramachandran et al. [17] reported no gender differences in the prevalence of hyperglycaemia. Women transition from pre-menopause to post-menopause state with substantial metabolic changes and estrogen deficiency might have led them to an increased predisposition to impaired glucose haemostasis.

An inverse relation of hyperglycaemia with education, employment status, and socioeconomic status was observed in the present study. Similarly, Assunção et al. [16] found that majority of the subjects reported with hyperglycaemia were over 50years old; had a family income of fewer than three minimum wages; and upto eight years of schooling. High education levels plays a protective role through greater knowledge and awareness levels about the impact of lifestyle factors on health and more accurate health risk perception. However, more educational opportunities enable to find sedentary jobs, higher incomes, physical inactivity, rich diet, and high mental stress predisposing them to hyperglycaemia. Similarly, McDonald et al. [18] found higher prevalence rate among subjects with post-graduation degrees and earning more than 600 USD and higher monthly.

A higher prevalence of hyperglycaemia (Table 2) in subjects under alcohol consumption (30.59%) was found similar to Binh et al [19]. Contrarily, Shai et al. [20] noticed an initiation of moderate daily alcohol consumption reduces fasting plasma glucose but not postprandial glucose among previous alcohol abstainers with type 2 DM, and furthermore found higher HbA1c may benefit more from the favourable glycemic effect of alcohol. The present study observed that sleep has no association with glycemic status. Conversely, Gislason et al. [21] reported diabetes was associated with near frequent complaints of difficulty in initiating and maintaining sleep, and excessive daytime sleepiness.

The current study found higher glycemic status (45.88%) among subjects who prefer non-vegetarian than vegetarian meals. Similarly, Tonstad et al. [22] observed that vegans, lacto-ovovegetarians, pesco-vegetarians, and semi-vegetarians had a lower risk of type 2 DM than non-vegetarians after adjustment for age, sex, ethnicity, education, income, physical activity, television watching, sleep habits, alcohol use, and BMI. Vegetarian diet being rich in vegetables and fruits; typically includes a low

Table 4. Clinical characteristics of hyperglycaemic subjects (N=85)

Category	Percentage (%)	Number of subjects
DURATION (years)		
<1	45.89	39
1-5	28.24	24
>5	25.89	22
LEVEL OF AWARENESS		
Aware	67.06	57
Unaware	32.95	28
MEDICATION ADHERENCE		
Yes	61.18	52
No	38.83	33
DRUG UTILIZATION PATTERN		
Monotherapy	42.36	36
Combination therapy	57.65	49

glycemic index foods such as beans, legumes, and nuts which reduces oxidative stress, chronic inflammation and impaired glucose metabolism.

A significant stress predisposition of the present study subjects to a higher glycemic status has also been reported by Marcovecchio and Chiarelli [23]. Hormonal changes that occur during acute and chronic stress situations might have affected glucose homeostasis in both healthy and hyperglycaemic individuals. The effect of stress on glycemic control in diabetics may be related to a direct effect of stress hormones on blood glucose levels; and an indirect effect of stress on patient's behaviour related to diabetes treatment and monitoring, and meal and exercise plans [23]. The current study found a statistically significant association between positive cardiovascular family history and hyperglycaemia (41.18%; $P<0.05$). Similarly, Scheuner et al. noticed individuals having at least one first-degree relative with diabetes were significantly associated with early-onset coronary heart disease [24].

Sedentary lifestyle has been found to be associated with a higher glycemic status (64.70%) in the current study. Similarly, Hamilton et al. [25] found that prolonged sitting time and fewer skeletal muscle contractions may results in reduced lipoprotein lipase activity and TGs clearance, reduced oral glucose clearance load, and less glucose-stimulated insulin secretion which predisposes to high glucose and lipid levels. On the other hand, Johannsen et al. [26] observed that a decrease in HbA1C after 9 months of exercise was associated with shorter duration of diabetes, lowering of serum FFA concentrations, increasing serum adiponectin concentrations, and skeletal muscle protein expression.

A statistically significant (Table 3) co-morbidities of hypertension (68.23%; $P<0.001$), obesity (61.18%; $P<0.05$), and dyslipidemia (45.88%; $P<0.001$) were observed associated with hyperglycaemia. Similarly, Wabe et al. [27] found hypertension (61.2%) and obesity (10.8%) as the most frequent co-morbidities among the hyperglycaemic patients. Furthermore, Rahim et al. [28] reported that age, BMI, waist circumference (WC) and waist to hip ratio (WHR) were higher in glucose–intolerant subjects than in normal glucose tolerant group. Binh et al. [19] further revealed that BP, family history of diabetes, obesity related measures (WC, WHR, body fat percentage, and abdominal obesity), and alcohol consumption were the independent risk factors for hyperglycaemia (IFG, IGT, and diabetes). With regard to the relationship between the elevated BP and diabetes, both disorders commonly occur together and tend to share many predisposing factors including obesity, physical inactivity, and high fat diets which further affect patients who are already at risk for the other [19]. Similarly, Harris [29] found that high or borderline high total cholesterol is common in diabetes and is present in 70% of adults with diagnosed diabetes and 77% with undiagnosed diabetes.

The clinical characteristics of hyperglycaemia in the current study further observed 67.06% of awareness level, 61.18% of medication adherence, the use of mono-therapy by 42.36%, and combination therapy by 57.65% of the study subjects for their hyperglycaemic control (Table 4). Furthermore, Mohan et al. [4] found 75.5% of Chennai's population was aware of their diabetic condition. However, various factors including patient factors (adherence, attitude, beliefs, knowledge about diabetes, culture and language capabilities, health literacy, financial resources, co-morbidities and social support) and clinician related factors (attitude, beliefs and knowledge about diabetes, effective communication) predicts achievement of adequate glycemic control and the likelihood of diabetic complication [30].

Limitations

A cross-sectional design couldn't able to establish the causality between glycemic control and different factors affecting it, which shows requirement of longitudinal study to assess the relationship over time. The sample size was small and recruited from a single institute rather than being a community-based sample, thus making it difficult to generalize the findings. The use of fasting blood glucose test instead of oral glucose tolerance test (OGTT) may underestimate the prevalence of diabetes. Hence, it is essential to conduct a national survey on diabetes to evaluate the burden of the disease in different geographic regions.

Conclusion

Hyperglycaemia and its comorbidities of hypertension, dyslipidemia and obesity projects the multi-faceted nature of the problem which requires an urgent need for greater public awareness on risk factors for hyperglycaemia status and strengthening of diabetes related health services to early detect, prevent, and treat individuals with diabetes. To prevent diabetes related morbidity and mortality; the role of clinicians in promoting self-care, and further following a dedicated self-care behaviour by patients in multiple domains of food choices, physical activity, proper medications intake and regular blood glucose monitoring has to be emphasized.

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Conflict of interests

The authors declare no conflict of interest.

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