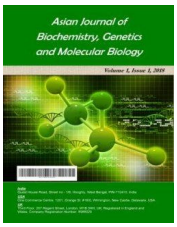

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Assessment of Cardio-metabolic Risk Factors of Pre-diabetes/Diabetes among University Students: A Cross Sectional-study at Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

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Authors' contributions

This work was carried out in collaboration between all authors. Author BOA contributed to the conception of the research idea, data collection, interpretation, paper drafting and revision. Author SD contributed to the conception of the research idea. Authors SK, JBG, SPS, BA, and KFN contributed to the paper drafting and revision. Author SPS contributed to data collection and sample analysis. Author JES contributed to patient recruitment and sample collection. All authors approved the final manuscript before publication and agree to be accountable for all aspects of the work.

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ABSTRACT

Introduction: Diabetes is one of the most common chronic diseases globally and its complications include retinopathy, nephropathy and neuropathy. Early detection of the risk factors and management of pre-diabetes can however reduce the risk of developing diabetes-related complications.

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Objective: This study was undertaken to assess cardio-metabolic risk factors for diabetes among undergraduate students at KNUST.
Method: The study was carried out at the Kwame Nkrumah University of Science and Technology at Kumasi, from January 2017 to March 2017. Questionnaires were administered to 500 participants (45% males and 55% females) to obtain demographic and anthropometric data, information on physical activity, and knowledge on diabetes. About 5 ml of venous blood was taken from participants after an overnight fast to determine fasting plasma glucose (FPG) and lipid profile.
Results: The mean age of participants were 21±2.40 years and 19.24±2.42 years for male and female respectively. Prevalence rate of pre-diabetes was 5% in this study. Mean values of systolic pressure ($p<0.001$) and blood glucose level ($p=0.042$) were significantly higher in men than the females. There was a significant association between the total cholesterol and the fasting blood sugar levels among participants ($p=0.045$). LDL-cholesterols concentrations were also significantly associated with blood sugar levels among participants ($p<0.001$). Risk factors such physical exercise ($p<0.001$) and family history ($p<0.001$) if diabetes were significantly associated with fasting blood glucose levels of participants. Obesity was no associated with serum glucose levels among participants in this study ($p=0.533$). HDL-cholesterol was inversely correlated with Fasting blood sugar even though it was no significant ($r=-0.240$, $p=0.430$).
Conclusion: The prevalence rate of pre-diabetes was 5% in this study. Education about the disease as well as appropriate modification of lifestyle can help reduce the incidence of diabetes and its associated risk factors.

Keywords: Diabetes; pre-diabetes; risk factors; lipid profile; blood glucose.

1. INTRODUCTION

Diabetes is a metabolic disorder which results in high accumulation of glucose in the blood due to the production of insufficient insulin by the pancreas or when the body cells are unable to respond to the action of insulin [1]. The epidemiology of diabetes has expressively increased world-wide and has become a concern to inhabitants and health service providers in both developed and developing nations [2].

An intermediate group of individuals whose blood glucose levels are above normal but not high enough to meet the criteria for diabetes have been identified as being pre-diabetic. In essence, pre-diabetes is “pre-type 2 diabetes,” as it is not a precursor to type 1 and thus is a milder form of type 2 diabetes [3]. Risk factors are used to determine increased susceptibility for a disease. The factors that increase one’s risk of type 2 diabetes are the same ones for pre-diabetes. The more risk factors in an individual’s profile, the higher the person’s risk of developing pre-diabetes or diabetes [4]. These include: Age, little or no exercise or an inactive and sedentary lifestyle, overweight or obesity, family history of type 2 diabetes, hypertension and elevated triglyceride[5].Currently, metformin is the only pharmacologic agent recommended for the prevention or delay of type 2 diabetes in at-risk subjects due to its effectiveness. Metformin acts primarily by enhancing the action of insulin in the liver to reduce the rate of hepatic glucose production with very little potential for inducing hypoglycemia [6].

A survey performed by WHO in 2014 showed that, 422 million people were suffering from diabetes of which 8.5% were among adults and 90% as a result of Type 2 Diabetes [7]. The prevalence of Pre-diabetes/diabetes in sub Saharan Africa has progressively increased in tremendous proportions over the past years [8].In recent years, estimation performed by the Ghana Diabetes Association on the prevalence of diabetes showed that the total number of pre-diabetes/diabetes cases in Ghana is likely to be increased at a faster pace [9]. An estimation carried out during that same decade revealed an increasing trend in the prevalence of diabetes in Africa due to urbanization and life style changes [10]. With the increasing mortality cases being recorded, identifying risk factors which predispose individuals to pre-diabetes offers the opportunity to modify their life style since some interventions can delay and even stop the progression to pre-diabetes and diabetes [11].

Transition of students from secondary schools into the university is usually characterized by a change in lifestyle and dietary patterns exposing students to various cardio-metabolic risks of pre-diabetes at a young age and later progressing to

diabetes at an older age [12]. Considering the eminent change of lifestyle among university students in Ghana [13], this study seeks to assess the prevalence of pre-diabetes/ diabetes among university students in Ghana and determine some cardio-metabolic risk factors associated the disease which are common among these students. This is important to develop risk reduction strategies at government policy level and create the necessary awareness among this high risk population. The paucity of data among this group calls for immediate interventions.

2. METHODOLOGY

2.1 Study Design and Data Collection

This study was a cross sectional study conducted between January, 2017 and March, 2017 at Kwame Nkrumah University of Science and Technology, a tertiary institution with about 40000 undergraduate students located in Kumasi, Ghana. About 514 undergraduate students were selected randomly for the study.

2.2 Study Population and Sample Size Calculation

Using a simple random sampling stratified by the 6 colleges a total of 514 students from first to fourth academic year were recruited for the study. A total of 514 students were recruited from population of 40,000 students at KNUST using as assumed distribution response rate among the respondent of 50% at 95% confidence interval (z-score of 1.96). Using the Conchran's formula, the minimum size required was 381. However, to accommodate a non-response rate of 100% and stronger statistical power and effect size, the samples were projected to 514 students.

In all a total of 500 students met the inclusion criteria and gave their consent to participate in the study. An approved research information leaflet form was provided to prospective participants to decide if they would like to be part of the study. Participants who did not consent to be part of the study were excluded. Healthy males and females 15 years who had not been diagnosed of diabetes gave their consent and were included in this study. Pregnant women and individuals with known pathological disorders were not allowed to partake in the study.

2.2.1 Ethical considerations

Approval for the study was sought from the KATH Research and Development unit and the Committee on Human Research Publication and Ethics (CHRPE), SMS, KNUST.

2.3 Questionnaire Administration and Data Collection

A detailed questionnaire was then used to collect background information of subjects through interviews. Questionnaire also captured history and knowledge on diabetes, health, and lifestyle. All consented participants were invited to the Clinical Analysis Laboratory (Can LAB) of the Department of Biochemistry and Biotechnology, KNUST the next day for physical examination (anthropometric measurements) and donation of blood sample after an overnight fast.

2.4 Anthropometric Measurements

A standard physician's scale and a wall-mounted meter rule were used to measure the weight and height, to the nearest 1.0 kg and 0.005 m respectively. The subjects were required to take off their footwear and wear light clothing. Body mass index (BMI) was expressed as the individuals body weight divided by the square of his or her height in meters (kg/m^2) (Schram et al., 2002). Waist circumference was measured with measuring tape to the nearest 0.1 cm.

2.5 Physiological Measurements

Blood pressure was measured using an automated sphygmomanometer (INTELLI SENSE^{TM} BOOTS BLOOD PRESURE MONITOR) of appropriate width at the upper arm, after the individuals have had a rested period for about 30 minutes. The diastole and systole of each participant were recorded and the mean arterial pressure was calculated; Mean arterial pressure (MAP) [Systole+2(Diastole)]/3

2.6 Sample Collection

A volume of 5 mL of venous blood was taken after a 12 hour or minimum of 8 hours overnight fast via phlebotomy. About 2 mL of the blood was transferred into a sodium fluoride tube and mixed. Serum samples in the fluoride tube was analyzed for glucose using the glucose oxidase method designed by fortress diagnostics Limited,

United Kingdom and the remaining 3 mL was transferred into serum gel separator tube.

2.7 Biochemical Tests

The unhemolysed serum in the serum gel separator tube was analyzed for total cholesterol, triglycerides and HDL-cholesterol using enzymatic methods designed by fortress diagnostics Limited, United Kingdom. The concentration LDL-cholesterol was calculated using the Friedwald formula. The biochemical assays were repeated for all samples.

2.8 Data Analysis

Data entry and analysis was done using SPSS version 20.0 and Microsoft Excel 2013. Student's t-test was used in the statistical analysis. The results obtained were considered at a significant value of $p < 0.05$. Chi-square was used to determine the relationship between two categorical variables. Anova was used to compare the means of three or more variables. Correlation was used to determine the relationship between the risk factors and the blood glucose level.

3. RESULTS

3.1 Socio-demographic Data

This study assessed a population of 500 individuals, of which 225(45%) were males and 275(55%) females. The mean ages were 21±2.40 and 19.24±2.42 for male and female respectively ranging from 17 to 32 years. Of the total number, 320 (64%) were first year students, 25(5%) were second year students, 55(11%) were third year students and 100(20%) were fourth year students. Majority of the study participants were in the age group (21-24) years.

3.2 Anthropometric, Physiological and Biochemical Characteristics of Participants by Gender

In Table 1, mean values of systolic pressure ($p<0.001$) and blood glucose level ($p=0.042$) were significantly higher in men than the females as anthropometric, physiological and biochemical characteristics categorized by gender was obtained from study participants.

3.3 Prevalence of Pre-diabetes/Diabetes among Participants

Majority of the study participants (95%) had normal fasting blood sugar (FBS) and 25(5%) were pre-diabetics of which 15 (60%) were males and 10(40%) were females.

3.4 Lipid Profile among participants

Blood samples of participants were used to determine their lipid profile such as total cholesterol, HDL, LDL and triglyceride levels. There was a significant association between the total cholesterol and the fasting blood sugar levels among participants ($p=0.045$). LDL-cholesterols concentrations were also significantly associated with blood sugar levels among participants ($p<0.001$).The results are shown in Table 2.

3.5 Stratification of Anthropometric and Physiological Characteristics by Blood Glucose Level of Participants

The anthropometric and physiological characteristics of pre-diabetes were obtained from participants. About 40% of the pre-diabetic participants were overweight (BMI), 20% had both pre-hypertensive systolic and pre-hypertensive diastolic blood pressure and 100%

Table 1. Anthropometric, physiological and biochemical characteristics of participants by gender

Variable	Male	Female	P-value
Body Mass Index(kg/m^2)	22.98±3.45	23.13±3.47	0.630
Waist circumference(cm)	75.56±7.11	74.90±7.18	0.305
Diastole(mmHg)	71.78±8.14	71.08.21±8.21	0.289
Systole(mmHg)	124.78±12.32	116.38±12.44	**<0.001**
Blood Glucose Level (mmol/L)	4.9±0.55	4.8±0.54	**0.042**
Total Cholesterol(mmol/L)	4.92±1.02	4.98±1.02	0.513
HDL-Cholesterol(mmol/L)	1.66±0.21	1.68±0.21	0.290
LDL-Cholesterol(mmol/L)	2.72±0.94	2.89±0.27	0.240
Triglyceride(mmol/L)	0.86±0.27	0.89±0.92	0.637

Mean values are significantly different at p-value <0.05

Table 2. Lipid profile of participants

Variable	Normal FBS(n=475)	Pre-diabetic(n=25)	Total(n=500)	p-value
Total cholesterol				**0.045**
Normal	365(76.8%)	15(60.0%)	380(76.0%)	
Borderline	95(20.0%)	10(40.0%)	105(21.0%)	
High	15(3.2%)	0(0%)	15(3.0%)	
HDL				0.669
Low	5(1.1%)	0(0%)	5(1.0%)	
Normal	345(72.6%)	20(80.0%)	365(73.0%)	
Borderline	125(26.3%)	5(20.0%)	130(26.0%)	
LDL				**<0.001**
Normal	280(58.9%)	5(20.0%)	285(57.0%)	
Borderline	190(40.0%)	20(80.0%)	210(42.0%)	
High	5(1.1%)	0(0%)	5(1.0%)	
Triglyceride				1.000
Normal	470(98.9%)	25(100%)	495(99.0%)	
Borderline	5(1.1%)	0(0%)	5(1.0%)	
High	0(0%)	0(0%)	0(0%)	

Mean values are significantly different at p-value <0.05, HDL-chol=high density lipoprotein cholesterol, LDL-chol=low density lipoprotein cholesterol

had normal waist circumference. There was no significant association between anthropometric and physiological characteristics and the blood glucose levels of participants. The results are illustrated in Table 3.

3.6 Correlation Analysis of Risk Factors against Blood Glucose

Correlation analysis of certain risk factors against blood glucose was measured to determine if the risk factor contributes to blood glucose levels. A p-value less than 0.05 implied a correlation between the risk factor and blood glucose. Risk factors such as lipid profile parameters, WC, blood pressure and BMI showed no significance correlation among study participants. The results are clearly illustrated in Table 4.

3.7 Association of Risk Factors and Fasting Blood Sugar Levels among Participants

Life style characteristics that can make an individual susceptible to diabetes were obtained from participants. Majority of the participants

Table 3. Anthropometric and physiological characteristics by blood glucose level among participants

Variable	Normal FBS(n=475)	Pre-diabetic(n=25)	Total(n=500)	p-value
BMI				0.553
Underweight	48(10.1%)	1(20.0%)	49(9.8%)	
Normal	330(69.5%)	2(40.0%)	332(66.4%)	
Overweight	95(20%)	2(40.0%)	97(19.4%)	
Obese	2(0.4%)	0(0.0%)	2(4.4%)	
Systolic BP				0.165
Normal	291(61.3%)	20(80%)	311(66.2%)	
Pre-hypertensive	180(37.9%)	5(20%)	185(36.2%)	
Hypertensive	4(0.8%)	0(0%)	4(0.8%)	
Diastolic BP				0.323
Normal	423(87.4%)	20(80%)	443(88.6%)	
Pre-hypertensive	50(10.5%)	5(20%)	55(11.0%)	
Hypertensive	2(0.4%)	0(0%)	2(0.4%)	
WC				0.232
Normal	425(89.5%)	25(100%)	450(90.0%)	
Borderline	48(10.1%)	0(0%)	48(9.6%)	
High	2(0.4%)	0(0%)	2(0.4%)	

Mean values are significantly different at p-value <0.05, BP=Blood Pressure, WC=Waist Circumference

have knowledge about diabetes and there was a positive significant (p<0.001) association with fasting blood glucose. Risk factors such physical exercise (p<0.001) and family history (p<0.001) if diabetes were significantly associated with fasting blood glucose levels of participants. The results are presented in Table 5.

3.8 Association between Physical Activity and Risk Factors among Participants

Fasting Blood Sugar, BMI, Waist Circumference, Lipid profile, diastolic and systolic pressure values were compared across physical activity levels and there were no significant differences between the various parameters across the physical activities categories. The results are presented in Table 6.

Table 4. Correlation analysis of risk factors against blood glucose level among participants

Variable	Correlation co-efficient	P-value
LDL-cholesterol	+0.424	0.367
HDL-cholesterol	-0.240	0.430
Triglyceride	+0.134	0.500
Total cholesterol	+0.686	0.770
Body Mass Index	+0.201	0.340
Waist circumference	+0.451	0.770
Blood Pressure	+0.421	0.181

Table 5. Association between risk factors and fasting blood glucose among participant

Risk factors	Blood glucose level		Total(n=500)	P-value
	Normal FBS(n=475)	Pre-diabetes(n=25)		
Physical exercise				**<0.001**
Never	10(2.1%)	5(0%)	15(3.0%)	
Once while	30(6.3%)	20(100%)	50(10.0%)	
Once Daily	305(64.2%)	0(0%)	305(61.0%)	
Weekly	130(27.4%)	0(0%)	130(26.0%)	
Smoking				1.000
Yes	2(0.4%)	0(0.0%)	2(0.4%)	
No	475(100.0%)	23(100%)	498(99.6%)	
Drinking of alcohol				0.093
Yes	45(9.5%)	5(20.0%)	50(10.0%)	
No	430(90.5%)	20(80.0%)	450(90.0%)	
Knowledge about diabetes				**<0.001**
Yes	400(84.2%)	5(20.0%)	405(81.0%)	
No	75(15.8%)	20(80.0%)	95(19.0%)	
Family history				**<0.001**
Yes	150(31.6%)	20(80.0%)	170(34.0%)	
No	325(68.4%)	5(20%)	330(66.0%)	

p<0.05 =statistically significant

Table 6. Association between Physical Activity and risk factors among participants

Variable	Physical activity				P-value
	Never	Once awhile	Daily	Weekly	
	mean±SD	mean±SD	mean±SD	mean±SD	
FBS	4.67±0.59	4.82±0.57	4.55 ±0.32	4.85± 0.63	0.310
Diastole	73.5±12.28	70.46±8.49	71.19±7.4	70.73±5.78	0.851
Systole	127.3±13.85	120.3±12.57	117.4±13.1	119.8±9.56	0.952
MAP	91.44±9.66	87.60±8.80	86.58±9.00	87.09±5.68	0.610
BMI	21.80±3.55	22.86±3.47	22.45±3.38	22.06±3.45	0.411
Waist Circumference	71.3±6.60	75.67±7.13	72.94±6.46	73.53±7.11	0.324
Total cholesterol	4.517±0.73	4.789±0.10	5.206±1.24	4.627±0.96	0.339
TAG	0717±0.17	0.848±0.30	0.938±0.25	0.933±0.17	0.242
HDL-chol	1.733±0.20	1.656±0.22	1.644±0.21	1.627±0.16	0.760
LDL-chol	2.458±0.72	2.748±0.89	3.136±1.14	2.576±0.92	0.287

Mean values are significantly different at p-value <0.05. TAG=triacylglyceride, FBS=Fasting blood sugar, MAP= mean arterial pressure, BMI=Body mass index, HDL-chol=high density lipoprotein cholesterol, LDL-chol=low density lipoprotein cholesterol, SD= standard deviation

4. DISCUSSION

Diabetes was known to be highly associated with aging but recently the disease is becoming common among young children and young adults [14]. In this work, majority of the study participants were between the ages of 17-24 years with a mean age of 19.56±1.60. This is inconsistent with other literatures, in which most of the participants used in the study were within age ranges which differed from this study [15]. One reason for this observation is the fact that, all of the participants used in this current study were students and most were within the youthful age.

Most of the study participants (95%) for this research had normal fasting blood sugar while 5% of them were pre-diabetics. A study by Amoah et al. (2002) in Accra, recorded a higher prevalence rate of diabetes been 6% among the study participants. The use of aged study participants in their study may accounts for their findings [9].Another reason for the low prevalence rate recorded in this study can be due to the fact that most of the participants have knowledge on diabetes, its causes and management [16] ($p<0.001$) in Table 5.

Mean value of systolic blood pressure was significantly higher in males than females in this study ($p<0.001$) from Table 1. A research done by Lee et al. (2008) a showed that females are likely to be hypertensive compared to males which opposes the results from this study [17]. There are controversies as to whether hypertension is usually caused by insulin resistance and/or hyperinsulinemia remains an unresolved issue [18]. It was also observed in this study that males have a significant higher mean value of fasting blood glucose level than the females ($p=0.042$). This result is consistent with a work done by Ghadge et al. in India. In their work, Males had significantly higher serum glucose levels as compare to that of the females [19]. Lipid profile test which is done to determine the risk of an individual being diabetic and hypertensive [20] was also determined in table 2. Total cholesterol recorded a significantly association with the serum glucose level of the study participants ($p=0.045$). This results is in accordance with observations from a study by Strandberget al. as they deduced that cholesterol absorption and its synthesis is strongly associated with insulin resistance [21]. Low density lipoprotein which is considered as a bad cholesterol was also related to the blood glucose level among the study participants. It is parallel to a work done by Veiraiah (2005) in wales which concluded that hyperlipidemia such as high LDL-cholesterol levels are associated with hyper-glycaemia [22].

Obesity is associated with resistance to the up-take of glucose facilitated by insulin and hyperinsulinemia, however, weight loss increases insulin sensitivity [23]. There was no significant association BMI and the serum glucose levels among the participants in his study ($p=0.553$). Most participants had normal BMI for the pre-diabetics category in Table 3.

Regular physical activity is essential for maintaining physical and cardiovascular fitness, maintaining healthy weight, and sustaining weight loss once achieved [24]. Regular physical activity reduces cardiovascular risk factors (high blood pressure, hyperlipidemia, and hyperglycemia) and lowers the risk of developing other chronic diseases, including type 2 diabetes, osteoporosis, obesity, depression, and cancer of the breast and colon [25]. Physical exercise patterns obtained from the study participants were associated with the serum glucose levels in this study ($p<0.001$).

Participants who are inactive (no exercise) recorded the lowest LDL-Cholesterol levels (2.458±0.72 mmol/L), followed by those who exercise weekly (2.576±0.92 mmol/L), once awhile (2.748±0.89 mmol/L) and daily (2.458±0.72 mmol/L) in Table 5 even though it was no statistically significant ($p=0.287$).

Alcohol consumption ($p=0.093$) and cigarette smoking ($p=1.000$) are not statistically risk factors for pre-diabetics in this investigation. Other studies have shown that low alcohol consumption is not a risk factor for obesity and diabetes [15]. Alcohol can be highly addictive. Apart from being addictive, high intake of alcohol can be associated with serious adverse health and social consequences [26].

4. CONCLUSION

Prevalence of pre-diabetes among participants was found to be 5% and no diabetic patient was recorded. Various cardio-metabolic risk factors were not found to be risk factors contributing to pre-diabetes/diabetes among the study participants except total cholesterol and LDL-cholesterol. It was also found that females are more susceptible to diabetes among the youth.

If possible information regarding monthly allowances or expenses should be included in the questionnaires for further studies to be able to identify and determine how socio-economic status contributes to prevalence of diabetes among students.

5. LIMITATION OF THE STUDY

Limitations of this study were the limited time and financial predicament which does not permit the researchers to cover a larger population since the project has to compete for the same time for the normal academic work and also funding predicament. Also the dietary intake of study participants were not recorded as the kind of food one takes in is an environmental factor for predisposing one to pre-diabetes/diabetes.

CONSENT

As per international standard or university standard, participant's written consent has been collected and preserved by the authors.

ETHICAL APPROVAL

As per international standard or university standard, written approval of Ethics committee has been collected and preserved by the authors.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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