Journal of Medical Laboratory Science, 2021; 31 (4): 34-46
http://jomls.org; info@jomls.org
http://doi.org/10.5281/zenodo.5802227

The Impact of Lager Beer Alcoholic Beverage Consumption on Glycated Haemoglobin Levels in Apparently Healthy Male Subjects in Kubwa Metropolis Abuja, Nigeria

Nancy Chiatogu Ibeh*[1], Geraldine Amarachi Ibeh[1], Zacchaeus Aworte Jeremiah[2]
1.Department of Medical Laboratory Science, College of Health Sciences, Nnamdi Azikiwe University, Nnewi, Anambra State. 2. River State University, Port Harcourt, Rivers State.

ABSTRACT

Introduction: There is ongoing debate on whether lager beer – a type of alcoholic beverage commonly consumed in Nigeria influences glycated haemoglobin (HbA1c) levels. **Objective:** This study seeks to determine possible impact of lager beer consumption on HbA1c levels in relation to volume consumed, age of the participants and body mass index (BMI). **Method**: Six hundred and twenty-eight (628) blood donors who consume lager beer regularly for at least 3 months and non-alcohol consumers who served as the control group were studied. The lager beer consumers were categorize into moderate and heavy consumers. Standard methods were used to determine BMI, HbA1c, and Haemoglobin levels, while a structured questionnaire was used to obtain information on the lager beer consumption status and age of the subjects. **Results:** The lager beer consumers mean HbA1c value (5.24±0.76%) was significantly higher ($t = 3.70$; $p<0.001$) compared to control group (5.01±0.72%). However, there was no significant difference ($t = 0.33$; $p = 0.739$) in the mean HbA1c levels of moderate consumers (5.23±0.67%) compared with that of the heavy consumers (5.25±0.65%). Significant positive correlations were observed between age and HbA1c ($r = 0.297$; $p < 0.001$) and also age and BMI ($r = 0.483$; $p < 0.001$) among the control group and similar pattern was also observed in the lager beer consumers (age and HbA1c ($r = 0.397$; $p < 0.001$) and BMI ($r = 0.492$; $p < 0.001$). There was a significant positive association ($p < 0.001$) between BMI and HbA1c among the beer consumers and the control group. Pre-diabetes was more among the heavy consumers (16.2 %) followed by the moderate consumers (14.8 %) and lest among control (11.9 %). While heavy consumers had diabetes prevalence of 2.7%, the moderate had 2.6% and control group 1.9%. **Conclusion:** This study concludes that HbA1c levels was elevated in lager beer consumer (although the raised value was still within the reference range) the elevation was not dependent on the quantity consumed however, increasing age and BMI played important roles in influencing the rise in HbA1c levels. This implies that larger beer consumption has a negative impact on HbA1c which in the long run may predispose the subjects to metabolic disorder.

Key words: Glycated Haemoglobin, Larger Beer Consumption, Body Mass Index, Age.

***Correspondence:** nc.ibeh@unizik.edu.ng; +2348061167681; **ORCID**: 0000-0001-7751-3013
Author's contributions: This work was carried out and approved in collaboration between all the authors who take responsibility for its intellectual contents, accuracy and integrity. NCI designed the study; GAI, NCI & ZAJ sourced for funding; NCI wrote the protocol; GAI & NCI contributed in literature search; GAI did Lab experiments; GAI did the statistical data analysis; GAI, NCI & ZAJ contributed in the discussions; NCI drafted the manuscript; NCI & ZAJ supervised the study; NCI Proof-read the galley proof for final publication

Received: September/13, 2021; **Accepted**: November/10, 2021; **Published**: December/26, 2021.
Citation: Ibeh NC, Ibeh GA, Jeremiah ZA. The Impact of Lager Beer Alcoholic Beverage Consumption on Glycated Haemoglobin Levels in Apparently Healthy Male Subjects in Kubwa Metropolis Abuja, Nigeria. **J Med Lab Sci, 2021; 31 (4): 34-46**

INTRODUCTION

HbA1c is a form of haemoglobin that is measured primarily to identify the average plasma glucose concentration over prolonged periods of time. Lyons and Basu (1) described it as biomarker with an advantage that a single measurement is suitable to classify individuals according to their long-term blood glucose concentrations. It is therefore useful screening tool for diabetes and pre-diabetes (2). It is formed in a non-enzymatic glycation pathway by Hb's exposure to plasma glucose. Normal levels of glucose produce a normal amount of HbA1c. As the mean plasma glucose increases, the fraction of HbA1c increases in a predictable way (3). Nigeria currently ranks 27th globally in respect of adults alcohol drinking (age 15+) in liters per year (4), and has the second largest beer market in Africa, after South Africa making it one of the leading African countries in alcohol consumption (5,6). These ranking excludes unregistered illegal production and consumption of illicit and locally made alcoholic beverages sold freely (7). Beers are alcoholic beverages obtained by the yeast fermentation of malted cereal grains, to which hops and water have been added (6, 8). They comprises of different types which include: ale, stout, lager and cider. Lager beer is the most commonly consumed type of beer in Nigeria with different brand names and is the focus of this study.

Alcohol appear to be the most commonly used drug in Nigeria characterized by "heavy episodic drinking" (8). The situation is worsened by rapidly changing socio-political and economic developments in Nigeria, giving rise to new norms of alcohol use (9). Sadly, excessive drinking has been linked to metabolic syndrome, including obesity, hypertension, and type 2 diabetes mellitus (10). Although, reports on outcome over the consumption volume and HbA1c has been inconsistent. While some report heavy consumption as a risk factor for diabetes (11, 12) some others studies suggest otherwise that it rather reduces the risk of diabetes (13). The later argument was based on an association of lower HbA1c and alcohol consumption in their various studies (14, 15) independent of plasma glucose (16, 17, 18, 19, 20). Increased insulin sensitivity was suggested to be the mechanism through which alcohol consumption lowers HbA1c (21). This present study therefore sets out to determine possible influence of lager beer consumption on HbA1c levels and to access the role of volume consumed, age, BMI on such influence in our population.

MATERIALS AND METHODS

Study Area

The study was conducted at General Hospital Kubwa Abuja Nigeria - a secondary Health facility serving patients of middle and low socioeconomic status. Kubwa is one of the major suburbs within the metropolitan area of Abuja and located within latitude 9.1596° N and longitude 7.3386° E

Study population

The study population comprised a total of 628 male subjects comprising of 210 non-alcohol consumers, 209 moderate and 209 heavy lager beer consumers who have been drinking for at least 3 months and presented at Kubwa General Hospital as voluntary blood donors. They were aged 20-50 years. Those who consumed other alcoholic beverages different from lager beer, confirmed diabetics, smokers, those on steroids and anti-hypertensive were excluded.

Experimental design

In this cross sectional study, the subjects were grouped according to their drinking patterns as heavy drinkers (consume up to 4 bottles/day or more than 14bottles/week. Moderate drinkers: (consume at least 2 bottles/day or 7 to 14 bottles/ week and non-consumers as controls.

Ethical clearance and informed consent: Ethical clearance was obtained from the institution ethics committee and written informed consent obtained from the subjects before data collection.

Data collection/ Blood sample analysis

A structured questionnaire was used to capture the age, quantity of alcohol consumed, medical and social history of the subjects. Two milliliters of blood sample (2mls) was collected into EDTA bottle at a concentration of 1.50 mg/ml of blood for Hb estimation by Haemiglobincyanide (HiCN) method and HbA1c by Ichroma ^{TM}. Body weight and height measurements were taken using a stadiometer (Health-O-Meter ProSeries, USA) and BMI calculated by dividing the weights of the subjects in kilograms (Kg) by the square of their heights in meters (m^2).

All data were analyzed using Statistical Package for Social Sciences (SPSS) version 22 (SPSS Inc. Chicago, IL, USA). Prevalence was depicted with Bar chart. Independent t-test was used to test the differences between two variables and Pearson bivariate was employed for correlation. P-value <0.05 was considered statistically significant.

RESULTS

Table 1 shows that the subjects were aged matched ((t=0.35; p=0.721). The lager beer consumers HbA1c value (5.24±0.76%) was significantly higher (t=3.70; p<0.001) compared with the control group (5.01±0.72%). However, there was no significant difference (t = 0.33; p = 0.739) in the HbA1c levels of moderate consumers (5.23±0.67%) compared with that of the heavy consumers (5.25±0.65%) as shown in Table 2. Significant positive correlation was observed between age and HbA1c (r = 0.297; p < 0.001) as shown in Table 3 and also between age and BMI (r = 0.483; p < 0.001) among the control group (Table 4). The same similar finding was observed among the beer consumers (HbA1c (r = 0.397; p < 0.001) BMI (r = 0.492; p < 0.001) shown in Table 4. Furthermore significant positive association (p < 0.001) was observed between age and HbAIc (Fig 1) and also a positive correlation between age and BMI in both the beer consumers and the control group (Fig 2). Pre-diabetes (defined as HbA1c values between 5.7 – 6.4%) was more among the heavy consumers (16.2 %) followed by the moderate consumers (14.8 %) and lest among control (11.9 %). Diabetes was defined as HbA1c values > 6.4%, while heavy consumers had prevalence of 2.7%, the moderate had 2.6% and control group 1.9%. Data suggested that the least prevalence in both pre-diabetes and diabetes occurred among control group followed by the moderate drinkers with the highest prevalence occurring among heavy consumers (Fig 3).

Table 1. BMI, HbA1c and Hb levels of lager beer consumers compared with the control group

Variables	Non-Drinkers(n = 210)	Drinkers(n = 418)	t - test	P-Value
Age (years)	34.86 ± 9.11	35.05 ± 8.87	0.26	0.794
BMI (kg/m^2)	25.95 ± 4.47	28.05 ± 3.80	4.11	<0.001*
HbA1c (%)	5.01 ± 0.72	5.24 ± 0.76	3.70	<0.001*
Hb (g/dl)	14.21 ± 0.95	14.19 ± 1.10	0.28	0.774

Keys: BMI = body mass index, HbA1c = glycated haemoglobin, Hb = haemoglobin concentration *= significant at P<0.05

Table 2: BMI, HbA1c and Hb concentration based on drinking habits

Variables	Moderate consumers (n = 209)	Heavy consumers (n = 209)	t- test	P-Value
Age (years)	35.21 ± 9.06	34.90 ± 8.70	0.35	0.721
BMI (kg/m^2)	28.02 ± 3.67	28.04 ± 3.95	0.01	0.990
HbA1c (%)	5.23 ± 0.67	5.25 ± 0.65	0.33	0.739
Hb (g/dl)	14.15 ± 1.06	14.22 ± 1.14	0.654	0.513

Keys: BMI = body mass index, HbA1c = glycated haemoglobin, Hb = haemoglobin concentration

Table 3: Pearson's bivariate correlation between HbA1c and BMI of the drinkers and non-drinkers

Parameter	Control group		Beer consumers	
	Coefficient (r)	P-Value	Coefficient (r)	P-Value
HbA1c (%)	0.297	<0.001*	0.397	<0.001*
BMI (kg/m^2)	0.483	<0.001*	0.492	<0.001*

Keys: BMI = body mass index, HbA1c = glycated haemoglobin, * = significance at p< 0.05

Table 4: Pearson's bivariate HbA1c and Hb levels of the drinkers and non-drinkers

Parameter	Control group	Beer consumers

	Coefficient (r)	P-Value	Coefficient (r)	P-Value
HbA1c (%)	0.346	<0.001*	0.457	<0.001*
Hb (g/dl)	0.123	0.075	0.077	0.116

Keys: BMI = body mass index, HbA1c = glycated haemoglobin, Hb = heamoglobin concentration * = significant at p< 0.005

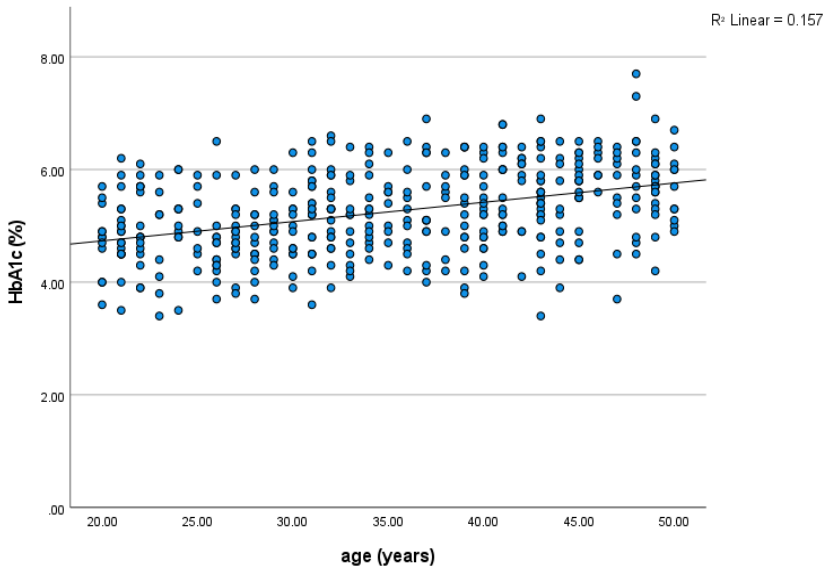

Figure 1. Simple scatterplot showing correlation of age with HbA1c of consumers

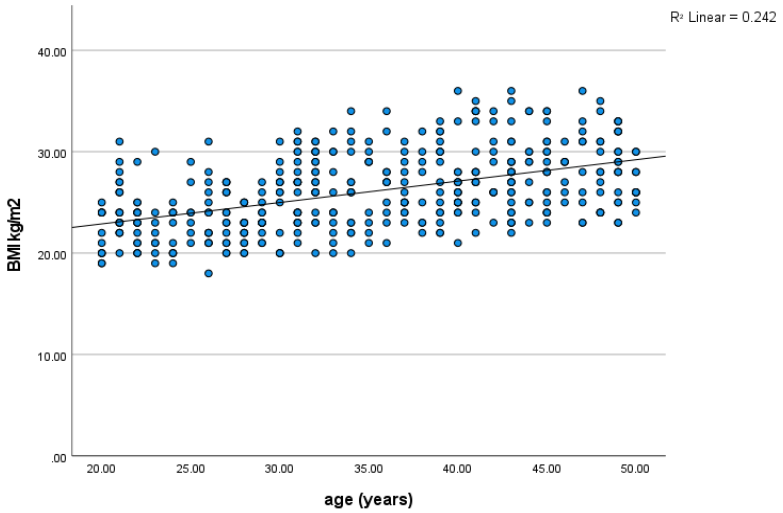

Figure 2. Simple scatter plot showing correlation of age with BMI of beer consumers

Figure 3. Prevalence of pre-diabetes/diabetes according to the drinking status of the subjects

DISCUSSION

This study investigated the influence of lager beer consumption on HbA1c levels among blood donors at the Kubwa General Hospital, Abuja. This study found a significantly increased BMI among lager beer consumers compared with the non-beer consumers aged matched controls. Several studies had reported increase in BMI in different population namely, Coulson *et al.*, (22) who studied among alcohol consumers,

Booranasuksaku and colleagues among university students in Thailand (23) and Shelton & Knott (24) among obese. However, in a study in a Korean population no weight gain was recorded except in girls (25) even though the study population was boys and girls and not adults. Mechanism of weight gain from alcohol intake has been explained in one of following ways: Firstly, alcohol is a source of energy containing 7.1 kcal/g, this energy is converted into calorie and creates a positive energy balance (26). Besides this, several metabolic studies suggests lipid oxidation suppression by alcohol, leading to improvement of a positive fat balance with non-oxidized fat deposited differently in the abdominal area (26). Secondly, alcohol alters fat distribution in the body by decreasing fat breakdown but stimulating its synthesis and deposition (27, 28). Thirdly, alcohol may increase appetite for food (29) as evidenced by weight gain in the subjects in this study.

There was no alteration of Hb among the consumers in this present study contrary to some earlier reports. Milman and Perderson (30) and Milman *et al* (31) reported a 1.3% rise among heavy drinkers, but none in moderate drinkers. One would not obviously be surprised at this conflicting patterns of Hb results, although lager beer brewed from grains possess nutrients such as B vitamins, riboflavin, niacin, zinc, potassium, calcium, phosphorus and other minerals essential necessary for haemopoiesis, there may be enhanced red cell destruction and concomitant morphological changes as seen in other alcoholic beverages. In fact NHANES data showed that alcohol consumption alters daily dietary pattern by displacing carbohydrate, protein, and fat (32). It is also common for heavy drinkers to have poor nutrition and in some cases become severely malnourished (33).

The present study shows that lager beer consumers have significantly higher HbA1c compared with non-consumers and the rise is not depend on the quantity consumed. though, the values obtained are within the reference interval 4.0% -5.9% for ages 35-40 years as our study population as determined by Igila and Aaron (34) in Port Harcourt, Nigeria. We thus report in this present study that alcoholism was associated with increased HbA1c. Surprisingly, our result pattern was contrary to previous findings notably that of Harding *et al.* (14), and Gulliford and Ukoumunne (15), Hong *et al*. (16), Inada and Koga (17) and Wiss (21). These later reports suggest that alcohol consumption leads to improved insulin sensitivity with lower blood glucose concentrations, leading to lower HbA1c levels. However, many factors could have contributed to a reverse in HbA1c levels seen in this study compared to the findings of these researchers. Firstly, the studies were all carried out in developed nations, therefore, the impact of African race which has been documented as a strong predictor of HbA1c could had been a strong factor in our population. A meta-analysis provided a strong support to our result pattern that HbA1c values are higher in blacks, Asians, and Latinos compared with whites (35). Other factors which may have caused an increase in the levels of HbA1c in our studied population may also include: poor physical activity among the study participants. Our study population lack of physical activity as a result of pressure of routine work. Decreased physical activity energy expenditure had been reported as an independent risk factor for metabolic syndrome (36). Reduced physical activity enhances increased BMI which has been positively associated with increased levels of HbA1c.

A significant positive correlation between age and HbA1c was seen in our study population. This observation is consistent with several erstwhile studies, notably that of Chi-Chang et al., (37); Davidson and Schriger, (38); Qinglin *et al*., (39); Masuch *et al*., (40) and Ani *et al*., (41) but not with that of Gebel (42); *Guo* and *Garvey* (43) and Carls *et al.*(44) who found no association. Our study tends to align with the former since degenerative changes are associated with increasing age and BMR usually decreases by 2% per decade of adult life (45). In addition, we found a positive correlation between age and BMI in the population studied (consumers and non-consumers). Several reason could explain this, ranging from increase in adiposity with age with concomitant leanness in mass and decrease in bone mineral density, changes in fat distribution where fat mass tends to be preferentially distributed in the abdominal region. There was no significant correlation between BMI and Hb level of our subjects. The works of Ghadiri-Anari *et al.* (46) and that of Ugwuaja *et al*. (47) supports this assertion. The prevalence of prediabetes and diabetes are positively influenced by quantity of lager beer consumed. Our finding suggested that the least prevalence in both prediabetes and diabetes occurred among non-consumers followed by the moderate drinkers with the highest prevalence occurring among heavy drinkers. Studies investigating the effect of alcohol consumption on the risk of developing type 2 diabetes are highly inconsistent. Liu *et al.* (48) has argued that whether moderate alcohol intake could help decrease diabetic risk warrants further investigation. A systematic review and meta-analysis by Adeloye *et al.* (49) showed that the prevalence of DM in Nigeria had steadily increased from 2.0% in 1990 to 5.7% in 2015. While International Diabetes Federation puts it at 1.7% for ages 20-69 years (50). Studies have revealed that considerable number of people in the prediabetic stage will go on to develop type 2 diabetes (51, 52). Studies in India had strengthen believe and added that 40-55% of the people at prediabetic stage would develop type 2 diabetes mellitus over a period of 3-5 years (53, 54).

CONCLUSION: This study concludes that HbA1c levels was elevated in lager beer consumer (although the raised value was still within the reference range), the elevation was not dependent on the quantity consumed however, increasing age and BMI played important roles in influencing the rise in HbA1c levels. This implies that larger beer consumption have a negative impact on HbA1c which in the long run may predispose the subjects to metabolic disorder.

REFERENCES

1. Lyons T, Basu A. Biomarkers in Diabetes: Hemoglobin A1c, Vascular And Tissue Markers. *Translational Research.* 2012; 159 (4): 303 – 312.

2. Gebel E. The start of something good: the discovery of HbA1c and the American Diabetes Association Samuel Rahbar Outstanding Discovery Award. *Diabetes Care*. 2012; 35(2): 2429–2431.

3. Herder C, Karakas M, Koenig W. Biomarkers for the prediction of type 2 diabetes and cardiovascular disease. *Clinical Pharmacology and Therapeutics.* 2001; 90(7): 52–66.

4. World Health Organization. Global status report on alcohol and health, Geneva: World Health Organization Press.https://www.who.int/substance

abuse/publications/alcohol 2014/en/ Retrieved Jan, 2020.

5. Obot I. Nigeria: alcohol and society today. *Society for the Study of Addiction*. 2007; 102 (4): 519-522.

6. Olu M. The Nigeria Beer Story. *International Journal of Current Microbiology and Applied Sciences*. 2015; 4 (2): 1037-1052.

7. Obikeze N, Obi I. Alcohol and violence among undergraduate students of Anambra State University. *Research Journal in Organizational Psychology and Educational Studies*. 2013; 2 (1): 18.

8. Chikere EI, Mayowa MO. Prevalence and perceived health effect of alcohol use among male undergraduate students in Owerri, south-east Nigeria: A descriptive cross sectional study. *BMC Public Health*. 2011; 11(4): 118.

9. Dumbili E. Changing Patterns of Alcohol Consumption in Nigeria: An Exploration of Responsible factors and Consequences. *A Journal of the British Sociological Association - Medical Sociology Group*. 2013; 7(1): 1-9.

10. Fan AZ, Russell M, Naimi T, Li Y, Liao Y, Jiles R, Mokdad AH. Patterns of alcohol consumption and the metabolic syndrome. *Journal of Clinical Endocrinology and Metabolism.* 2008; 93(4): 3833–3838.

11. Balkau B, Eschwege E, Ducimetiere P, Richard J L, Warnet J M. The high risk of death by alcohol related diseases in subjects diagnosed as diabetic and impaired glucose tolerant: the Paris Prospective study after 15 y of follow-up. *Journal of Clinical Epidemiology*. 1991; 44(12): 465 - 474.

12. Wei M, Gibbons LW, Mitchell TL, Kampert JB., Blair SN. Alcohol intake and incidence of type 2 diabetes in man. *Diabetes Care.* 2000; 23(6): 18- 22.

13. Koppes L, Dekker JM, Hendriks H, Bouter L, Heine R. Moderate alcohol consumption lowers the risk of type 2 diabetes. *Diabetes Care*. 2005; 28(4): 719–725.

14. Gulliford MC, Ukoumunne OC. Determinants of glycated Haemoglobin in the general population: associations with diet, alcohol and cigarette smoking. *European Journal of Clinical Nutrition*. 2001; 55 (7): 615-23.

15. Harding AH., Sargeant LA., Khaw KT, Oakes AS, Luben RN, Bingham S, Day NE, Wareham NJ Cross-sectional association between total level and type of alcohol consumption and glycosylated haemoglobin level: the EPIC-Norfolk Study. *European Journal of Clinical Nutrition.* 2002; 56 (9): 882-890.

16. Inada S, Koga M. Alcohol consumption reduces HbA1c and glycated albumin concentrations but not 1,5-anhydroglucitol. *Annals of Clinical Biochemistry*, 2016; 54:631–635.

17. Schrieks IC, Heil AL, Hendriks HF, Mukamal KJ, Beulens WJ. The effect of alcohol consumption on insulin sensitivity and glycemic status: a systematic review and metaanalysis of intervention studies. *Diabetes Care*. 2015; 38(7): 723–732.

18. Shai I, Wainstein J, Harman-Boehm I, Raz I, Fraser D, Rudich A, Stampfer M. Glycemic effects of moderate alcohol intake among patients with type 2 diabetes. *Diabetes Care*. 2007; 30(5): 3011–3016.

19. Mackenzie T, Brooks B, O'Connor G. Beverage intake, diabetes, and glucose control of adults in America. *Annals of Epidemiology*. 2006; 16(4): 688–691.

20. Hong JW, Noh JH, Kim D. Association between Alcohol Intake and Hemoglobin A1c in the Korean Adults: The 2011-2013 Korea National Health and Nutrition Examination Survey. *PLos One*. 2016; 11(11): 167-210.

21. Wiss D. The Relationship between Alcohol and Glycohemoglobin: A Biopsychosocial Perspective. *Bio Research Open Access*. 2019; 8 (1): 146–154.

22. Coulson CE, Williams LJ, Brennan SL, Berk M, Kotowicz M A, Lubman DI, Pasco JA Alcohol consumption and body composition in a population-based sample of elderly Australian men. *Aging Clinical and Experimental Research*. 2013; 25(2): 183–192.

23. Booranasuksakul U, Singhato A, Rueangsri N, Prasertsri P. Association between Alcohol Consumption and Body Mass Index in University Students. *Asian/Pacific Island Nursing Journal*. 2019; 4 (1): 57–65.

24. Shelton NJ, Knott CS. Association between alcohol calorie intake and overweight and obesity in English adults. *American Journal of Public Health*, 2014; 104 (4): 629–631.

25. Baek SI, So WY Relationship between obesity in Korean adolescents and the frequency of alcohol consumption, the amount of alcohol consumed, and the frequency of severe alcohol intoxication. *Obesity Research & Clinical Practice*. 2012; 6 (2): 159–166.

26. Suter PM. Is alcohol consumption a risk factor for weight gain and obesity? *Critical Reviews in Clinical Laboratory Sciences*. 2015; 42 (3): 197-227.

27. Cigolini M, Targher G, Bergamo I.A, Tonoli M, Filippi F, Muggeo M, De Sandre G. Moderate alcohol consumption and its relation to visceral fat and plasma androgens in healthy women. *International Journal of Obesity and Related Metabolic Disorders*. 1996; 20 (3): 206 – 212.

28. Puig T, Marti B, Rickenbach M, Dai SF, Casacuberta C, Wietlisbach V, Gutzwiller F. Some determinants of body weight, subcutaneous fat, and fat distribution in 25-64 year old

Swiss urban men and woman. *Sozial-und Praventivmedizin.* 1990; 35 (6): 193-200.

29. Hetherington MM, Cameron F, Wallis DJ, Pirie LM. Stimulation of appetite by alcohol. *Physiology and Behaviour*. 2001; 74 (3): 283-289.

30. Milman N, Pedersen A. Blood haemoglobin concentrations are higher in smokers and heavy alcohol consumers than in non-smokers and abstainers - Should we adjust the reference range? *Annals of Hematology*. 2009; 88 (7): 687-94.

31. Milman N, Pedersen AN, Ovesen L, Schroll M. Hb concentrations in 358 apparently healthy 80-year-old Danish men and women. Should the reference interval be adjusted for age? *Aging Clinical and Experimental Research*. 2008; 20(7): 8 –14

32. Liangpunsakul S. Relationship between alcohol intake and dietary pattern: findings from NHANES III. *World Journal of Gastroenterology.* 2010; 16 (32): 4055-60.

33. Jain H., Beriwal S, Singh S. Alcohol induced ketoacidosis, severe hypoglycemia and irreversible encephalopathy. *Medical Science Monito*. 2002; 8(11):77-79.

34. Igila AF, Aaron CO. Reference Interval of Glycated Hemoglobin in Adults in Port Harcourt, Nigeria. *Asian Journal of Medicine and Health*, 2019; 16(4), 1-6.

35. Cavagnolli G, Pimentel AL, Freitas PA, Gross JL, Camargo JL. Effect of ethnicity on HbA1c levels in individuals without diabetes: Systematic review and meta-analysis. *PLoS One.* 2017; 12 (2): 0171315.

36. Assah FK, Ekelund U, Brage S, Mbanya JC, Wareham NJ. Urbanization, physical activity and metabolic health in sub Saharan Africa. *Diabetes Care*. 2011; 34(2): 491–496.

37. Chi-chang L, Kun-wu T, Shih-ming M, Shan-fan C, Chin-chu W. The relationship between fasting glucose and HbA1c among customers of health examination services. *Formos Journal of Endocrine Metabolism*. 2010; 1 (3): 9-13.

38. Davidson MB, Schriger DL. Effect of age and race/ethnicity on HbA1c levels in people without known diabetes mellitus: Implications for the diagnosis of diabetes. *Diabetes Research and Clinical Practice*. 2011; 87 (3): 415-421.

39. Qinglin M, Liu H, Xiang G, Shan W, Xing W. Association between glycated hemoglobin A1c levels with age and gender in Chinese adults with no prior diagnosis of diabetes mellitus. *Biomedical Reports*. 2016; 4(2): 737–740.

40. Masuch A, Friedrich, N, Roth J, Nauck M, Muller UA, Petersmann A. Preventing misdiagnosis of diabetes in the elderly: age-dependent HbA1c reference intervals derived from two population-based study cohorts. *BMC Endocrine Disorders.* 2019; 19: 20.

41. Ani CC, Ojobor CC, Ezeanyika, LU, Obi BC. Influence of age, sex, and body mass index on the levels of glycosylated haemoglobin among Non-Diabetic Nigerian Population. *Asian Journal of Biochemistry, Genetics and Molecular Biology*. 2019; 2 (1): 1-7.

42. Gebel E. The start of something good: the discovery of HbA1c and the American Diabetes Association Samuel Rahbar Outstanding Discovery Award. *Diabetes Care*. 2012; 35(11): 2429–2431.

43. Guo F, Garvey TW. Trends in cardiovascular health metrics in obese adults: National Health and Nutrition Examination Survey (NHANES), 1988–2014. *Journal of American Heart Association*. 2016; 5(1): 003619.

44. Carls G, Huynh J, Tuttle E, Yee J, Edelman SV. Achievement of glycated hemoglobin goals in the US remains unchanged through 2014. *Diabetes Therapy*. 2017; 8(6): 863–873.

45. Chaney S.G. Principles of Nutrition 11 Micronutrients. (In Devlin M.T. Ed.). Textbook of Biochemistry with Clinical Correlations. 6th Ed, Wiley-Liss, New Jersy. 2006, Pp 1072.

46. Ghadiri-Anar A, Narjes NN Vahedian-Ardakani H. Association of Body Mass Index with Hemoglobin Concentration and Iron Parameters in Iranian Population. *International Scholarly Research Notices*. 2014; 52 (53): 1-2.

47. Ugwuja EI, Ogbonnaya LU, Obuna AJ, Awelegbe F, Uro-Chukwu. Anaemia in Relation to Body Mass Index (BMI) and Socio – Demographic Characteristics in Adult Nigerians in Ebonyi State. *Journal of Clinical and Diagnostic*. 2015; 9: (1) 4-7.

48. Liu C, Yu Z, Li H, Wang J, Sun L, Qi Q, Lin X. Associations of alcohol consumption with diabetes mellitus and impaired fasting glycemia among middle aged and elderly Chinese. *BMC Public Health*. 2010; 10(6): 713

49. Adeloye D, Ige JO, Aderemi AV, Adeleye N, Amoo EO, Auta A, Oni G. Estimating the prevalence, hospitalization and mortality from type 2 diabetes mellitus in Nigeria: A systematic review and meta-analysis. *BMJ Open*. 2017; 11:7(5):e015424.

50. Ejike CC, Uka NK, Nwachukwu SO Diabetes and pre-diabetes in adult Nigerians: Prevalence, and correlations of blood glucose concentrations with measures of obesity. *African Journal of Biochemistry Research*. 2015; 9(7): 55-60.

51. Mohan V, Deepa M, Anjana RM, Lanthorn H, Deepa R. Incidence of diabetes and pre-diabetes in a selected urban south Indian population (CUPS-19). *Journal of the Association of Physicians of India*. 2008; 56(6): 152-157.

52. Akter S, Rahman MM, Abe SK, Sultana P. Prevalence of diabetes and prediabetes and their risk factors

among Bangladeshi adults: A nationwide survey. *Bull World Health Organ.* 2014; 92(11):204-213.

53. Viswanathan V, Clementina M, Nair BM, Satyavani K Risk of future diabetes is as high with abnormal intermediate post-glucose response as with impaired glucose tolerance. *Journal of the Association of Physicians of India*, 2007; 55(9):833-837.

54. Ramachandran A, Snehalatha C, Mary S, Mukesh B, Bhaskar A.D, Vijay V. The Indian diabetes prevention programme shows that lifestyle modification and metformin prevent type 2 diabetes in Asian Indian subjects with impaired glucose tolerance (IDPP-1). *Diabetologia.* 2006; 49(8): 289-97.