Original

Occupational Predictors of Metabolic Profiles in Type 2 Diabetes. A Cross-Sectional Study in Nigeria

[1]Ala OA, [2]Uduagbamen PK, [1]Yusuf AO, [1]Bamikefa TA, [1]Odeyemi AO, [3]Adedire A, [4]Soyoye DO, [1]Adeyeye AG, [4]Kolawole B

[1]*Department of Medicine, College of Health Sciences, Osun State University, Osogbo, Nigeria*
[2]*Division of Nephrology and Hypertension, Department of Internal Medicine, Bowen University/Bowen University Teaching Hospital, Iwo/Ogbomosho, Nigeria*
[3]*Department of Surgery, College of Health Sciences, Osun State University, Osogbo, Nigeria*
[4]*Department of Medicine, College of Health Sciences, Obafemi Awolowo University, Ile-Ife, Nigeria.*

Corresponding author: Peter Uduagbamen, *Division of Nephrology and Hypertension, Department of Internal Medicine, Bowen University/Bowen University Teaching Hospital, Iwo/Ogbomosho, Nigeria; petr.uduagbamen@gmail.com; +2348065505539*

Article history: Received 20 June 2024, Reviewed 3 September 2024, Accepted for publication 10 September 2024

Abstract

Background: The prevalence and burden of type 2 diabetes have continued to rise globally, particularly in developing countries, driven by a growing tendency to a westernized lifestyle characterized by low physical activity and increased fat intake. The study assessed the association of on the metabolic profile of type 2 diabetic patients.

Method: The analysed data included the socio-demographic, anthropometric and clinical findings, and laboratory (metabolites) results of 187 patients with diabetes. Continuous and categorical variables were compared using student's t-test and Chi square (or Fisher's exact test) respectively. A p-value <0.05 was statistically significant.

Result: The mean age of the 187 (94 males and 93 females) participants was 57.85 ± 5.17 years. In participants with paid employments, the mean fasting plasma insulin and HOMA were the highest. The unemployed had the lowest levels of triglycerides and LDL-C. the eGFR was highest in the artisans and lowest in the retired population. The smokers had poor glucose control (p = 0.01). The atherogenic index of plasma was higher in poorly controlled diabetes, p=0.04. Smoking (OR-2.58, 95% CI-2.14-5.04, p=0.04) and elevated HOMA (OR-1.9, 95% CI-1.47-4.23, p-0.03), were independently associated with high physical activity.

Conclusion: High physical activity had a beneficial impact on diabetes control. This benefit, coupled with an improved lipid profile, was however overwhelmed by smoking, which increased the levels of atherogenic markers and potentially the risk of cardiovascular disease and events.

Keywords: Diabetes, occupation, metabolomics, physical activity, atherogenic index of plasma, cardiac risk ratio, kidney function, homocysteine.

How to cite this article:

Ala OA, Uduagbamen PK, Yusuf AO, Bamikefa TA, Odeyemi AO, Adedire A, Soyoye DO, Adeyeye AG, Kolawole B. Occupational Predictors of Metabolic Profiles in Type 2 Diabetes. A Cross-Sectional Study in Nigeria. The Nigerian Health Journal 2024; 24(3):1486 – 1495. https://doi.org/10.60787/tnhj.v24i3.855

Introduction

Type 2 diabetes has continued to rise globally, particularly in developing countries, accompanied by a rising tendency toward a westernized lifestyle characterized by inactivity and increased dietary fats.[1] Metabolism is dependent on several factors, ranging from genetic and gender-related hormonal function, the pattern and profile of physical activity and food intake. The metabolomics entails the assessment of the cellular/tissue metabolic compounds, their metabolites and derivatives in the serum, urine or other body fluid. The blood glucose, glycated haemoglobin, lipids and measures used in determining their concentration, cellular effects, tissue complications are the parameter often assessed in the metabolomics. The primary basis for occupational impact on the metabolomics is its relationship with diet and physical activity.[2] While the diet can influence the levels of plasma glucose, amino acids, and fatty acids, the level of physical activity influences the generation and efficient utilization of these digestive end-products.[2]

The 2024 American Diabetes Association (ADA) recommendations emphasize the need for all health care professionals to refer diabetics for individualized medical nutrition therapy (MNT).[3] The MNT is given by a registered dietician and nutritionist (RDN) post diagnosis. It has been estimated that about half of the diabetic population in the United States fails to follow recommendations aimed at achieving optimal blood glucose control and meeting their health care needs.[3] Physical activity not only enhances the utilization of glucose, amino acids, and fatty acids, but also enhances the digestive, absorptive, and assimilatory functions of cells and tissues, forming the foundation of MNT.[3,4] Low physical activity has a significant impact on cellular function, leading to poor glucose utilization, diabetes (or worsening the glycemic profile), suboptimal fatty acid metabolism, dyslipidemia, fatty acid peroxidation, and atherosclerosis.[5] This impact is based on its association with altered physiologic processes, which could lead to insulin resistance, muscle wasting with reduced exercise capacity, and altered energy balance.[6]

Occupations that require frequent travel, both short and long, may result in a greater reliance on food vendors and eateries, whose primary focus is on presenting visually appealing meals, often disregarding the safety of their food products.[7] Similarly, some occupations could be more associated with a sedentary lifestyle, putting their practitioners at risk of deranged metabolomics.[5,6] Isotope-based studies conducted on people on bed rest found an association between bed rest and muscle wasting and poor protein synthesis.[8] The fact that bed rest does not counteract the insulin and diet- (glucose)-dependent inhibition of proteolysis further strengthens this association. Diabetes and bed rest both negatively impact protein feeding, which is essential for muscle growth.[9] Booth et al.[10] found that physical inactivity increases the risk of tissue and organ dysfunction, as well as chronic diseases. This further emphasizes the detrimental effect of physical inactivity on the health of diabetics with poor metabolic profiles. Therefore, adopting exercise as a primary preventive measure against metabolically mediated conditions such as obesity, diabetes, dyslipidemia, hypertension, metabolic syndrome, premature aging, sarcopenia, erectile dysfunction, and premature death becomes more imperative for diabetics compared to the general population.[11]

The relationship between occupation (as it relates to diet and physical activity) and metabolomics has continued to attract wide attention in medicine, given its importance in encompassing cellular, tissue, and organ metabolism. Despite this, the effects of occupation on diet and physical activity have not been fully elucidated, nor its overall impact on metabolomics, particularly in sub-Saharan Africa (SSA). In this prospective cross-sectional study, we investigated the relationship between occupation (as it relates to food choices and physical activity) and metabolomics in a diabetic population in a resource-challenged setting.

Method

Study design

The Obafemi Awolowo University Teaching Hospital Complex in Ile-Ife, Southwest Nigeria, hosted the prospective study, which lasted over nine months.

Study population

This included 187 adult patients (94 males and 93 females) who were 40 years of age or older and received treatment for T2DM. We stratified the participants into five occupation-based groups: retired, unemployed, employed, artisans, and civil servants.

Study inclusion criteria

The study excluded patients with gestational or T1DM diabetes upon hospital admission.

Sample size determination

Using a relevant formula, the minimum sample was arrived at using the prevalence of 5.77% from a similar study, power of 80 and margin of error of 3.5%.[12,13] This gave a sample size of 187 after calculating for attrition.

Sampling method

Published by The Nigerian Medical Association, Rivers State Branch.

Print ISSN: 0189-9287 Online ISSN: 2992-345X

Participants were enrolled into the study through consecutive sampling of diabetic patients presenting for their routine clinic consultations. Those that met the inclusion criteria and gave informed consent were enrolled, of this, those that didn't meet the exclusion criteria were recruited till the minimum sample size was attained.

Data collection

An interviewer administered questionnaire was used to collect demographic data and findings on physical examination. Demographic variables collected were the age, gender, occupation and level of education. The height (m) and weight (kg) were measured without shoes or head cover, and under light clothing using standardized protocols. The body mass index (BMI) was calculated by dividing the participant's weight (kg) by the square of the height (m). The waist circumference was measured to the nearest 0.1 cm (with the patient standing) using a flexible, non-stretch measuring tape at a point halfway between the lower margin of the lowest palpable rib and the top of the iliac crest, in line with the belly button. The tape measure was wrap round the waist loose enough to fit one finger between the skin and the tape. The waist-hip ratio was calculated as the waist circumference in centimeters divided by the hip measurement (the measurement of the wildest part of the hips below the waistline. All anthropometric measurements were made after 12 hours of fasting

Each participant was rested for 5 minutes, with the back and arm rested on a support to measure the blood pressure (BP) which was taken with an Accoson mercury sphygmomanometer according to standardized protocol. The mean of two BP readings and calculated.

Sample collection and analysis

Blood samples for the various investigations were taken on appointed days after adequate education. Blood was sampled after a 12-hour overnight fast; glucose, high density lipoprotein (HDL), low density lipoprotein (LDL), triglycerides (TG), and total cholesterol were measured using standard enzymatic methods. Fasting plasma glucose levels[5] were determined with the spectrophotometer using the glucose oxidase method, while triglyceride and total cholesterol were measured using enzymatic oxidase and peroxidase techniques. After precipitation, HDL was measured using the same methodology as the other cholesterol components. The calculation of low-density lipoprotein (LDL) cholesterol employed the Friedwald equation.[14]

After first standardizing the auto-analyzer with a system check cartridge, the Biorad in-2-it HbA1c auto-analyzer with its cartridges was used to determine glycated haemoglobin.[15]

The insulin resistance (HOMA-IR) was determined using the formula:

HOMA-IR=fasting insulin (μU/ml) x fasting glucose (mmol/l)/22.5

Measured variables were defined as follow:

- The BMI using the National Heart, Lung, and Blood Institute of Health classification.[16]
- BMI: Underweight < 18.5kg/m^2; Normal (18.5-24.9kg/m2); overweight (25.0-29.9); obesity (≥30.0-34.9).
- Elevated waist circumference: males (>94cm), females (≥ 80cm)
- Elevated Waist-hip ratio (obesity): males (≥ 0.90), females (≥ 0.85)[17]
- Hypertension: > 130/80 mmHg[18]
- Poor diabetes control HbA1c ≥ 7 %[16]
- Elevated fasting plasma glucose: ≥6.1 mmol/L[16]
- Elevated total cholesterol: TC ≥ 4.5 mmol/L[16]
- Elevated LDL ≥ 2.6 mmol/L[16]
- Elevated triglyceride: < 1.7 mmol/L[16]
- Elevated HDL > 1.1 mmol/L.[16]
- Insulin resistance and HOMA score: normal (< 3), moderate (3-5), severe (> 5).
- AC (TC-HDL): normal (<3), abnormal (>3)
- AIP (LDL/HDL): Low risk <0.1, medium risk-0.1-0.24, high risk->0.24

Ethical clearance

The study was approved by the Obafemi Awolowo University Teaching Hospital, Ile-Ife, Research and Ethics Committee (NHREC/27/02/2009a).

Data analysis

The SPSS version 25 was used for data analysis. Continuous variables as means (SD) were compared using Students t-test. With more than two groups, a one-way ANOVA was used in analysis. Categorical variables as proportions and frequencies, were compared using the Chi-square or fisher's exact test. The unadjusted odds ratios (ORs) were calculated in the logistic regression analysis to determine correlates of the outcome variables. The univariate analysis was used to determine the relationship between variables and physical activity and variables with p-value <0.02 were entered into the multivariate model to determine variables that were independently related to physical activity in Type 2 diabetics.

Print ISSN: 0189-9287 Online ISSN: 2992-345X

Results

The mean age of the 187 (94 males and 100 females) participants was 57.85 ± 5.17 years. A greater proportion of the young, middle-aged, and elderly were self-employed, civil servants, and retired, respectively (Table 1). The unemployed had the highest WHR and diastolic blood pressure, while the artisans had the highest systolic blood pressure.

Table 1: Characteristics of the Study Population

Variables	Retired n=52	Unemployed n=6	Self Employed n=44	Artisan n=43	CS n=42	P-value
Sex						
Male	25 (48.08)	4 (66.67)	26 (59.09)	19 (44.19) 24	20 (47.62)	0.005
Female	27 (51.92)	2 (33.33)	18 (40.91)	(55.81)	22 (52.38)	
Age, years						
18-44	0 (0.0)	0 (0.0)	7 (15.91)	2 (4.65)	3 (7.14)	<0.001
45-64	12 (23.08)	5 (83.33)	29 (65.91)	32 (74.42)	37 (88.10)	
≥65	40 (76.92)	1 (16.67)	8 (18.18)	9 (20.95)	2 (4.76)	
Mean WHR	0.89 ± 0.10	0.92 ± 0.11	0.89 ± 0.12	0.90 ± 0.11	0.89 ± 0.09	0.8
Mean SBP, mmHg	124.54 ± 13.38	131.10 ± 7.46	131.09 ± 19.19	131.57 ± 20.15	126.11 ± 18.89	0.06
Mean DBP, mmHg	76.54 ± 8.21	80.67 ± 6.89	78.23 ± 8.50	75.33 ± 8.12	73.90 ± 9.90	0.05

CS-civil servants, WHR-waist hip ratio, SBP-systolic blood pressure, DBP-diastolic blood pressure

The mean FPG was higher in the unemployed group than in the other groups (Table 2). Compared to the other groups, the mean fasting plasma insulin and HOMA were higher in civil servants. The artisans had the lowest concentrations of triglycerides and LDL-C, while the unemployed had the highest concentrations.

Table 2: Metabolic indicators in the participants

Variables	Retired n=52	Unemployed n=6	Self Employed n=44	Artisan n=43	CS n=42	P-value
FPG, mmol	5.28±1.93	7.75±3.90	5.82±2.06	6.47 ± 2.50	5.50 ± 2.28	<0.001
Glycated haemoglobin	5.69±1.50	5.90±1.88	6.04±1.89	6.18 ± 2.23	5.64 ± 2.07	0.04
Fasting plasma insulin	5.24±4.39	5.33±2.50	8.86±6.99	9.02 ± 7.10	10.74 ± 8.83	<0.001
HOMA-IR	1.39±1.23	1.84±1.08	2.41±2.13	2.77 ± 2.42	3.25±2.33	<0.001
Triglycerides	1.13±0.35	1.33±0.84	1.11±0.38	1.04±0.35	1.19 ± 0.72	0.001
HDL-C	1.31±1.01	1.15±0.49	1.23±0.88	1.39±1.26	1.33 ± 1.04	<0.001
LDL-C	1.51±0.89	1.74±1.16	1.52±1.11	1.37±1.21	1.66 ± 1.11	0.002
Total cholesterol	3.99±1.4	4.34±1.66	3.72±1.42	3.82 ±1.44	4.06 ± 1.38	0.001

The eGFR was highest among the artisans and lowest among the retired participants (Table 3). The urine ACR was highest among the unemployed and lowest among the retired population. The serum folate and vitamin B12 concentrations were highest in the unemployed.

Table 3: Kidney function indices in the participants

Variables	Retired n=52	Unemployed n=6	Self Employed n=44	Artisan n=43	CS n=42	P-value
Systolic BP	124.54±13.38	125.00±7.46	131.09±19.19	131.47±20.15	126.19±18.89	0.06
Diastolic BP	76.54±8.21	80.67±6.89	78.23±8.50	75.33±8.12	73.90±9.90	0.04
Mean eGFR mL/min	86.41±14.43	88.47±30.15	91.38±16.58	92.46±18.71	92.30±17.60	<0.001
Mean UACR, mg/mmoL	0.39±0.22	0.95±0.85	0.57± 0/45	0.89±0.71	0.54±0.42	<0.001
Mean homocysteine	15.63±10.31	18.50±17.89	17.71±15.97	20.71 ±14.31	17.58 ±11.97	0.002
Mean serum folate	14.38±5.16	18.33±5.32	16.14±5.68	15.19 ±5.70	16.88 ± 5.85	0.004
Mean Vit B12	336.12±130.23	447.17±193.26	83.80±145.98	361.30±134.41	369.40± 281	<0.001

CS-civil servants, SBP-systolic blood pressure, DBP-diastolic blood pressure, ACR- albumin creatinine ratio. eGFR-estimated glomerular filtration rate.

The smokers were more likely to have poor diabetes control than non-smokers (p = 0.01) (Table 4). Participants with poor diabetes control were more likely to have elevated levels of the atherogenic index of plasma, hyperhomocysteinemia, and fasting insulin, with p-values of 0.001, 0.001, and 0.001, respectively. The degree of diabetes control positively correlated with the kidney function (p = 0.04).

Table 4: Relationship between variables and diabetic control (glycated haemoglobin)

Variables	Glycated Hb Good control (n=147)	Glycated Hb Poor control (n=40)	p-value
Age, years, mean ± SD	59.02 ± 14.33	54.30±11.58	0.04
Sex			
Males (n, %)	72 (76.60)	22 (23.40)	0.8
Females (n, %)	75 (80.64)	18 (19.36)	
WHR M>0.9; F>0.85 (n, %)	5.33 ± 1.88	7.67 ± 1.92	0.03
Smokers (mean ± SD)	4.67 ± 0.05	6.22 ± 1.32	0.01
Systolic hypertension (n, %)	53 (36.05)	24 (60.00)	0.03
Diastolic hypertension (n, %)	56 (38.10)	26 (65.00)	0.02
Elevated FPG (n, %)	27 (18.37)	16 (40.00)	0.001
LDL/HDL >2.4	0 (0.00)	4 (10.00)	<0.001*
Elevated serum creatinine μmol/L	13 (8.84)	5 (12.50)	0.06
eGFR, mean (IQR)	88.58 (77-100)	79.05 (57-90.21)	0.04
Mean urine ACR (mean ± SD)	6.40 ±.0.41	3.75 ± 0.04	0.06
Elevated Homocysteine	14.55 ± 3.59	25.00 ± 7.42	<0.001
Elevated fasting insulin	7.54 ± 6.36	9.58 5.82	0.05
Elevated insulin resistance	2.04 ± 1.28	3.32 ± 1.52	<0.001
Elevated cardiac risk ratio (>3.3)	5.56 ± 1.72	6.29 ± 2.01	0.03
Elevated Atherogenic coefficient (>3.0)	5.64 ± 1.73	6.31 ± 2.08	0.04

WHR-waist hip ratio, FPG-fasting plasma glucose, LDL-low density lipoprotein, HDL-high density lipoprotein, eGFR-estimated glomerular filtration rate, ACR-albumin creatinine ratio

The univariate analysis revealed that participants who engaged in high physical activity had a lower likelihood of experiencing poor diabetes control, p = 0.04 (Table 5). Individuals who engaged in minimal physical activity were more likely to be older, p<0.001.

Table 5: Univariate analysis showing the relationship between the variables and physical activity

Variables	**High physical activity n=129**	**Low physical n=58**	**p-value**
Age, years	53.66 ± 9.83	67.17 ± 11.74	<0.001
Sex			
Males	65 (69.15)	29 (30.85)	0.91
Females	64 (68.82)	29 (31.18)	
WHR M>0.9; F>0.85 (n, %)	0.90 ± 0.11	0.89 ± 0.11	0.87
Smokers			
Yes	15 (83.33)	3 (16.67)	0.001
No	114 (67.46)	55 (32.54)	
Systolic hypertension (mean ± SD)	124.55±10.31	129.23±19.31	0.04
Diastolic hypertension (mean ± SD)	77.42 ± 7.2	75.13 ± 8.82	0.06
Elevated FPG (n, %)	30 (23.62)	16 (27.59)	0.09
Glycated haemoglobin	5.87 ± 2.56	5.90 ± 3.17	0.07
LDL/HDL >2	22 (17.05)	7 (12.07)	0.08
Elevated serum creatinine μmol/L	11 (8.53)	6 (10.34)	0.07
eGFR, median (IQR)	92.70 (40.0-130.0)	80.44 (40.0-120.5)	0.04
Serum folate	14.82 ± 5.24	16.05±5.74	0.04
Vitamin B12	337.31 ± 161.33	371.81±135.1	0.002

Print ISSN: 0189-9287 Online ISSN: 2992-345X

Variables	High physical activity n=129	Low physical n=58	p-value
Mean urine ACR, (mean ± SD)	1.93 ± 0.73	2.25 ± 1.01	0.05
Mean Homocysteine, (mean ± SD)	17.23 ± 4.22	18.99 ± 4.82	0.04
Elevated fasting insulin, (mean±SD)	8.68 ± 4.41	7.33 ± 4.26	0.04
Elevated HOMA, (mean ± SD)	3.74 ± 0.17	1.91 ± 0.13	<0.001
Elevated CRR (>3.3)	5.71 ± 1.72	5.72 ± 2.01	0.8
Elevated AIP	5.90 ± 2.63	5.86 ± 2.31	0.07
Elevated AC (>3.0)	5.69 ± 1.73	5.99 ±1.64	0.03

WHR-waist hip ratio, FPG-fasting plasma glucose, LDL-low density lipoprotein, HDL-high density lipoprotein, glomerular filtration ratio, ACR-albumin creatinine ratio, HOMA-homeostatic model assessment, CRR-cardiac risk ratio, AIP-atherogenic index of plasma, AC-atherogenic coefficient.

When variables with a p-value <0.02 in the univariate analysis were added to the multivariate model (Table 6), age and gender were considered, smoking (OR-2.58, 95% CI-2.14-5.04, p-0.04) and high HOMA (OR-1.9, 95% CI-1.47–4.23, p-0.03) were found to be independently linked to poor diabetic control.

Table 6: Multivariate analysis with independent associates of physical activity in diabetics

Variables	aOR	95% CI	P-value
Smoking	2.58	2.14 - 5.04	0.04
Elevated FPG	1.3	1.02 - 1.95	0.06
Elevated LDL/HDL >5	1.5	0.94 - 2.57	0.05
Elevated HOMA-IR	1.9	1.47 - 4.23	0.03

LDL-low density lipoprotein, HDL-high density lipoprotein, HOMA-insulin resistance

Discussion

The study assessed the impact of occupation (as it relates to food intake and physical activity) on the serum concentrations of cellular metabolic compounds, their metabolites and measures useful in determining deficiencies and excesses and their complication in Type 2 diabetic patients. Women had better diabetic control than men. A positive association was found between some deranged metabolites in diabetics and low physical activity. There was a positive relationship between smoking, and elevated HOMA-IR with the level of physical activity. The glycated haemoglobin and fasting plasma glucose were higher in participants involved with low physical activity. Elevated serum concentrations of the cardiac risk ratio and the atherogenic coefficient were more likely to be associated with low physical activity. These findings mirror findings in rural farmers who presented with better metabolomics compared with other rural and city dwellers.[19] The high physical activity group in this study, which included farmers and artisans, engaged in non-mechanized field work, thereby reinforcing the negative correlation with derangement in the metabolic profile.

The more favourable markers of cardiovascular function in the physically active group is further confirmatory of the impact of exercise and dietary choices on the cardio-metabolic and renal profile of the participants. It is documented that physical activity plays a major contributory role in maintaining an ideal metabolic profile evidenced by a tendency towards lower LDL/HDL levels, a lower risk of atherosclerosis and an expectedly lower risk of cardiovascular diseases and events.[20-22]

The impact of the occupation (as it relates to dietary choices and physical activity) of an individual on the metabolomics is further evidenced in this study by the higher prevalence of elevated homeostatic model assessment, fasting plasma glucose and glycated haemoglobin in the low physical activity group.[23] Despite well-known documentation of the negative impact of hyperhomocysteinemia on cardio-metabolic profile, we however found a negative relationship between diabetic control and the levels of homocysteine.[24] This is in agreement with findings by Majumder et al[25] who reported that hyperhomocysteinemia was less likely with worsening diabetic control. This relationship could be explained by the fact that diminished renal excretion is a most prevalent cause of hyperhomocysteinemia. Even though the kidney function (GFR) of most of the participants were relatively better compared to a typical CKD population, it is worth noting that even a slight functional decline could be associated with a comparatively lowered insulin clearance and the resultant improvement in glycemic control as found in the study.[24,25]

The better diabetic control in females agrees with previous findings that women tend to achieve better

Print ISSN: 0189-9287 Online ISSN: 2992-345X

diabetes control (with lower fasting glucose and glycated haemoglobin) than men.[25] The greater hepatic insulin sensitivity, higher stimulated insulin secretion and higher skeletal muscle bulk in females particularly premenopausal women coupled with the fact that a greater proportion of the artisans were women could have contributed majorly to this finding. Women are more likely to comply with dietary advice, avoid fatty food and adopt weight losing strategies. Furthermore, women are more likely to prepare their meals and comply with dietary prescription unlike men who are more likely to eat from eateries and food vendors while outdoor. This can significantly compromise men's compliance with dietary recommendations.[26,27]

The tendency of the physically active to consume refined (westernized) meals is quite low compared to the civil servants, this coupled with the higher physical activity in them, would therefore be expected to have an improved cardiovascular risk profile compared with those lacking this synergistic features.[21-23] This was demonstrated in this study where the physically active had lower levels of LDL cholesterol and higher levels of HDL cholesterol compared with the participants with low physical activity.[20]

Adeniyi et al[27] reported that people in paid employment were more likely to live sedentary lives in occupations associated with low physical activity, homocysteine, fasting plasma insulin, insulin resistance are expected to be markedly elevated, in a negative association with plasma folate, vitamin B12 and kidney function.[28] The strength of the various associations were dependent on factors such as age gender and anthropometric parameters. The relationship between serum levels of homocysteine and glucose control has been describe in previous studies as positive, none and negative.[24,25,29]

The synergism between diet and physical activity in addition to cultural, and behavioral factors are the major determinants of the development and perhaps progression of diabetes, in association with genetic enablement.[24,26,30] Similarly, the bimodal relationship between homocysteine and blood glucose, being dependent on kidney function status, would therefore impact the cardiovascular function. Cardiovascular dysfunction and/or events play leading roles in the mortality of patients with chronic kidney disease.[31] The import of this could be hinged on the presence or otherwise of renal hyperfiltration, an early occurrence in diabetic kidney disease compared to the later stages of diabetic nephropathy where there is the cessation or reversal of hyperfiltration.[32]

Diabetics without nephropathy are more commonly encourage to take moderate protein-containing meal. The possibility of a supra-implementation of this do exist and could lead to hyperuricemia particularly with animal protein.[33] It is worth noting that good compliance with restrictions on intake of sweetened drinks and honey in diabetics could mitigate this effect. Tissue bimodal metabolic course of hyperuricemia can further worsen its inflammatory profile.[34] Obesity could be associated with a chronic inflammatory course thereby heralding a slowly atherogenic course.[35] Though there was no significant difference in the prevalence and severity of obesity between participants with and without high physical activity, the higher prevalence of atherogenic markers in the physically active participants could be attributed to the higher prevalence of smokers among them. The pro-atherogenic role of smoking is partly attributable to the toxicity of nicotine to the blood vessels particularly the endothelium which precedes atherosclerosis and arteriolosclerosis.[36]

Implications of the findings of this study

The gender differences in diabetes control evidenced by lower fasting plasma glucose and glycated haemoglobin in women than men could open new frontiers of research relating to hormonal impact on the physiologic and pathologic processes in both genders. A knowledge of the depth of the atherogenicity risk associated with smoking is essential to further drive the campaign against smoking. Knowing the relative strength of associations between diabetes control and the various measures of assessing the metabolomics could help physicians to priotise the scale of the investigation panel in diabetes in resource-challenged setting considering the huge cost of some of these tests.

Strengths and Limitations of the Study

Limitations of this study included the inability to do a cardiovascular profile assessment for the participants and the non-inclusion of inflammatory markers like the erythrocyte sedimentation rate (ESR) and the high-sensitivity C-reactive protein. The single-center design and a relatively small sample size were also limitations.

Print ISSN: 0189-9287 Online ISSN: 2992-345X

However, the study is strengthened by the very large number of metabolism-related parameters that were assessed. This is particularly so considering the financial burden of assaying some of the parameters in a resource-challenged setting, a condition that has partly limited the scope of related studies in the past.

Conclusion

The occupation of an individual, including diabetics, could determine their degree of physical activity and dietary habits, and this can impact their serum cellular metabolic profile. High physical activity was beneficial in diabetes; however, smoking overshadowed this advantage by elevating the levels of atherogenic markers, potentially raising the risk of cardiovascular disease and events. The higher dependence of homocysteine levels on renal excretion rather than physical activity could account for the observed lack of association between high physical activity and good energy balance. Adequate physical activity, combined with good dietary discretion, could go a long way in improving diabetes care, subsequently lowering the morbidity and mortality rates.

Declarations

Ethical Consideration: The study was approved by the Obafemi Awolowo University Teaching Hospital, Ile-Ife, Research and Ethics Committee (NHREC/27/02/2009a).

Authors' Contribution: All authors contributed equally to the study

Conflict of interest: The authors declare no conflict of interest.

Funding: There was no funding

Acknowledgment: We appreciate the nurses and supporting staffs of the endocrine division of the hospital.

References

1. Kolawole BA, Anumah FA, Unachukwu C. Health Resource Utilization among Patients with Type 2 Diabetes Mellitus in Nigeria: An Analysis from the International Diabetes Management Practice Study (IDMPS). West Afr J Med. 2023;40(11):1145-1154.
2. Oyewole OO, Odusan O, Oritogun KS, Idowu AO. Physical activity among type-2 diabetic adult Nigerians. Ann Afr Med. 2014; 13(4):189-94. doi: 10.4103/1596-3519.142290.
3. Ashtekar S, Deshmukh PP, Ghaisas N, Ashtekar C, Upasani S, Kirloskar M, et al. Effect of Two-Only-Meal Frequency and Exercise on HbA1C Outcomes, Weight, and Anti-Diabetic Medication in Type 2 Diabetes in a Popular Lifestyle Change Campaign in Maharashtra, Compared to Conventional Clinical Management: A Quasi-Experimental Multicenter Study in Maharashtra. Indian J Community Med [Internet]. 2023. Jan 1 Available from: /pmc/articles/PMC10112759/ doi: 10.4103/ijcm.ijcm_248_22
4. Blonde L, Umpierrez GE, Reddy SS, McGill JB, Berga SL, Bush M, et al. American Association of Clinical Endocrinology Clinical Practice Guideline: Developing a Diabetes Mellitus Comprehensive Care Plan: 2022 Update. Endocrine Practice. 2022;28(10):923-1049.
5. Elsayed NA, Aleppo G, Aroda VR, Bannuru RR, Brown FM, Bruemmer D, et al. 5. Facilitating Positive Health Behaviors and Well-being to Improve Health Outcomes: Standards of Care in Diabetes-2023. Diabetes Care [Internet]. 2023. Jan 1 [cited 2023 May 25];46(Supple 1):S68–96. Available from: https://pubmed.ncbi.nlm.nih.gov/36507648/
6. Kautzky-Willer A, Harreiter J, Pacini G. Sex and gender differences in risk, pathophysiology and complications of type 2 diabetes mellitus. Endocr Rev. 2016; 37(3):278–316. doi: 10.1210/er.2015-1137.
7. Basiak-Rasala A, Rozanska D, Zatonsk K. Food groups in dietary prevention of type 2 diabetes RoczPanstwZaklHig 2019; 70(4): 347-357.
8. Coker RH, Hays RR, Williams RH, Xu L, Wolfe RR, Evans WJ. Bed rest worsens impairments in Fat and Glucose Metabolism in Older Overweight Adults.JGerontol A BiolSci Med Sci 2014; 69A(3): 363-370 doi:10.1093/Gerona/glt1.00
9. Gungor O, Kara AV, Hasbal NB, Kalantar-Zadeh K. Dietary protein and muscle in chronic kidney disease: new insights Curr Opin Clin Nuyr Metab Care 2023; 26(3): 226-234 doi:

10.1097/MCO.0000000000000903(4): 1351-1402.

10. Booth FW, Roberts CK, Thyfault JP, Ruegsegger GN, Toedebusch RG. Role of Inactivity in Chronic Diseases: Evolutionary Insight and Pathophysiological Mechanisms Physiol Rev 2017; 97
11. Kumar Prabhakar P, Kumar Batiha GES. Potential Therapeutic Targets for the management of Diabetes Mellitus Type 2. Curr Med Chem [Internet]. 2023. May 1 [cited 2023 May 25];30. Available from: https://pubmed.ncbi.nlm.nih.gov/37125833/ [PubMed] [Google Scholar]
12. Charan J, Biswas T. How to calculate sample size for different study designs in medical research Indian J Psychol Med. 2013;35(2):121–6.
13. Uloko AE, Musa BM, Ramalan MA, Gezawa ID, Puepet FH, Uloko AT, et al. Prevalence and Risk Factors for Diabetes Mellitus in Nigeria: A Systematic Review and Meta-Analysis. Diabetes Ther. 2018 ;9(3):1307-1316Jung SH. Stratified Fisher's exact test and its sample size calculation. Biom J. 2014;56(1):129-40. doi: 10.1002/bimj.201300048.
14. National Institute of Health: The practical guide to the identification, evaluation and treatment of overweight and obesity in adult. Obesity Res 1998; 89: 452-461.
15. Jeong TD, Park S, Hong KS. Performance Evaluation of the Bio-Rad D-100 System for Hemoglobin A1c Assay. Clin Lab. 2017 Nov 1;63(11):1923-1928. doi: 10.7754/Clin.Lab.2017.170524.
16. Diabetes Standards of Care: ADA guidelines (2018), Available at: http://diabetesed.net/wp-content/uploads/2017/12/2018-ADA-Standards-of-Care.pdf. Accessed22/4/2020
17. Andreacchi AT, Griffith LE, Guindon GE, Mayhew A, Bassim C, Pigeyre M, Stranges S, Anderson LN. Body mass index, waist circumference, waist-to-hip ratio, and body fat in relation to health care use in the Canadian Longitudinal Study on Aging. Int J Obes (Lond). 2021 Mar;45(3):666-676. doi: 10.1038/s41366-020-00731-z.
18. Chuang SY, Cheng HM, Chang WL, Yeh WY, Huang CJ, Chen CH. 130/80 mmHg as a unifying hypertension threshold for office brachial, office central, and ambulatory daytime brachial blood pressure. J ClinHypertens (Greenwich). 2023 Mar;25(3):266-274. doi: 10.1111/jch.14637.
19. Thelin A, Holmberg S. Type 2 diabetes among farmers and rural and urban referents: cumulative incidence over 20 years and risk factors in a prospective cohort study. Asia Pac J ClinNutr. 2014;23(2):301-8. doi: 10.6133/apjcn.2014.23.2.09.
20. Amanat S, Ghahri S, Dianatinasab A, Fararouei M, Dianatinasab M. Exercise and Type 2 Diabetes. AdvExp Med Biol. 2020; 1228:91-105. doi: 10.1007/978-981-15-1792-1_6.
21. Weng X, Liu Y, Ma J, Wang W, Yang G, Caballero B. An urban-rural comparison of the prevalence of the metabolic syndrome in Eastern China. Public Health Nutr. 2007 Feb;10(2):131-6. doi: 10.1017/S1368980007226023.
22. de Groot R, van den Hurk K, Schoonmade LJ, de Kort WLAM, Brug J, Lakerveld J. Urban-rural differences in the association between blood lipids and characteristics of the built environment: a systematic review and meta-analysis. BMJ Glob Health. 2019 Jan 24;4(1):e001017. doi: 10.1136/bmjgh-2018-001017.
23. Okobi OE, Ajayi OO, Okobi TJ, Anaya IC, Fasehun OO, et al. Diala CS,The Burden of Obesity in the Rural Adult Population of America. Cureus. 2021 Jun 20;13(6):e15770. doi: 10.7759/cureus.15770.
24. vanGuldener C, Stehouwer CD. Diabetes mellitus and hyperhomocysteinemia. SeminVasc Med. 2002 Feb;2(1):87-95. doi: 10.1055/s-2002-23099. PMID: 16222599.
25. Platt DE, Hariri E, Salameh P, Merhi M, Sabbah N, Helou M, Mouzaya F, Nemer R, Al-Sarraj Y, El-Shanti H, Abchee AB, Zalloua PA. Type II diabetes mellitus and hyperhomocysteinemia: a complex interaction. DiabetolMetabSyndr. 2017 Mar 21; 9:19. doi: 10.1186/s13098-017-0218-0.
26. Boettcher C, Tittel SR, Meissner T, et al Sex differences over time for glycemic control,

pump use and insulin dose in patients aged 10–40 years with type 1 diabetes: a diabetes registry study BMJ Open Diabetes Research and
Care 2021;9:e002494. doi: 10.1136/bmjdrc-2021-002494

27. Adeniyi AF, Fasanmade AA, Aiyegbusi OS, Uloko AE. Physical activity levels of type 2 diabetes patients seen at the outpatient diabetes clinics of two tertiary health institutions in Nigeria. Nig Q J Hosp Med. 2010 Oct-Dec;20(4):165-70.

28. Jamal Shahwan M, Hassan NAG, Shaheen RA. Assessment of kidney function and associated risk factors among type 2 diabetic patients. Diabetes MetabSyndr. 2019 Jul-Aug;13(4):2661-2665. doi: 10.1016/j.dsx.2019.07.025. Epub 2019 Jul 11. PMID: 31405691.

29. Majumder M, Mollah FH, Hoque M, Ferdous SA. Serum Homocysteine and its Association with Glycemic Control in Type 2 Diabetic Patients. Mymensingh Med J. 2017 Oct;26(4):921-926.

30. Florez JC, Udler MS, Hanson RL. Genetics of Type 2 Diabetes. In: Cowie CC, Casagrande SS, Menke A, Cissell MA, Eberhardt MS, Meigs JB, Gregg EW, Knowler WC, Barrett-Connor E, Becker DJ, Brancati FL, Boyko EJ, Herman WH, Howard BV, Narayan KMV, Rewers M, Fradkin JE, editors. Diabetes in America. 3rd ed. Bethesda (MD): National Institute of Diabetes and Digestive and Kidney Diseases (US); 2018. Chapter 14. PMID: 33651556.

31. Yu AS, Pak KJ, Zhou H, Shaw SF, Shi J, Broder BI, Sim JJ. All-Cause and Cardiovascular-Related Mortality in CKD Patients with and Without Heart Failure: A Population-Based Cohort Study in Kaiser Permanente Southern California. Kidney Med. 2023 Mar 9;5(5):100624. doi: 10.1016/j.xkme.2023.100624.

32. Premaratne E, Verma S, Ekinci EI, Theverkalam G, Jerums G, MacIsaac RJ. The impact of hyperfiltration on the diabetic kidney. Diabetes Metab. 2015 Feb;41(1):5-17. doi: 10.1016/j.diabet.2014.10.003.

33. Uduagbamen PK, Ogunkoya JO, AdebolaYusuf AO, Oyelese AT. Nwogbe CI. Ofoh, C, Anyaele C. Hyperuricemia in Hypertension and Chronic Kidney Disease: Risk Factors, Prevalence and Clinical Correlates: A Descriptive Comparative Study. Intl J Clin Med, 2021; 12: 386-401.

34. Ikem RT, Enikuomehin AC, Soyoye DO, Kolawole BA. The burden of diabetic complications in subjects with type 2 diabetes attending the diabetes clinic of the ObafemiAwolowo University Teaching Hospital, Ile-Ife, Nigeria - a cross-sectional study. Pan Afr Med J. 2022, ;43:148. doi: 10.11604/pamj.2022.43.148.36586. PMID: 36785682; PMCID: PMC9922079

35. Henning RJ. Obesity and obesity-induced inflammatory disease contribute to atherosclerosis: a review of the pathophysiology and treatment of obesity. Am J Cardiovasc Dis. 2021 Aug 15;11(4):504-529.

36. Jiang Y, Pang T, Shi R, Qian WL, Yan WF, Li Y, Yang ZG. Effect of Smoking on Coronary Artery Plaques in Type 2 Diabetes Mellitus: Evaluation with Coronary Computed Tomography Angiography. Front Endocrinol (Lausanne). 2021 Nov 3; 12:750773. doi: 10.3389/fendo.2021.750773.