ejpmr, 2022,9(8), 21-27

SJIF Impact Factor 6.222

EUROPEAN JOURNAL OF PHARMACEUTICAL AND MEDICAL RESEARCH

www.ejpmr.com

Research Article

ISSN 2394-3211

EJPMR

DISTRIBUTION OF DIABETES CO-MORBIDITIES AND TREATMENT OUTCOME OF HYPERTENSION AT A TERTIARY LIFESTYLE MEDICAL CENTRE IN ILE-IFE, OSUN STATE NIGERIA: A 5 –YEAR RETROSPECTIVE STUDY

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Article Received on 25/05/2022 **Article Revised on 14/06/2022** **Article Accepted on 05/07/2022**

ABSTRACT

Introduction: Diabetes is a lifestyle disorder that is of global public health concern. The comorbidities associated with diabetes often predispose to early mortality. Available conventional medications often elicit limited therapeutic activity, except when combined with ideal lifestyle modifications. This study aimed at investigating how diabetes patients responded to intensive lifestyle changes including diet and exercise. **Method**: This was a five-year retrospective study of diabetic subjects who underwent ten days of intense lifestyle changes. The patient's hospital record was retrieved. Data were analysed using paired t-test on graph pad prism (version 5.0). **Results:** The most common comorbidity among diabetic patients was hypertension, affecting 86 (54.8%) of them. At the onset of admission to the lifestyle ward, there were 12 (7.6%), 19 (12.1%), 42 (26.8%), and 13 (8.3%) diabetic patients with elevated blood pressure, stage 1, 2, and 3 hypertension, respectively. On discharge, 85 (54.1%) of the patients had normal blood pressure, while 42 (26.8%), 27 (17.2%), and 42 (26.8%) had elevated, stage 1 and 2 hypertension, respectively. The mean fasting blood glucose (FBG) obtained was 13.24 mol/L, body mass index (BMI) was 27.10, systolic blood pressure (SBP) was 193.3mmHg, while mean diastolic blood pressure (DBP) was 120.34mmHg. After the lifestyle intervention mean FBG (6.23 mmol/L), BMI (21.73), SBP (118.3 mmHg), and DBP (95.57 mmHg) were all significantly ($p < 0.05$) lower. **Conclusion:** The implementation of a whole food plant-based diet and exercise resulted in a considerable remission of diabetes mellitus and its most common comorbidity, hypertension, according to this study.

KEYWORDS: Diabetes, Hypertension, Lifestyle, Exercise, Whole Food Plant-Based (WFPB) Diet.

INTRODUCTION

Diabetes mellitus (DM) is a deadly non-communicable disease which occurs due to impaired glucose metabolism. In Nigeria, diabetes is affecting about 3.9 million adults has diabetes.[1] As a result, Nigeria is having the highest prevalence of diabetes in Sub – Saharan Africa. As a global public health concern, diabetes is currently understood as a lifestyle disorder owing to the implications of lifestyle factors in its pathogenesis. Aside from age, gender, obesity, urbanization, and physical inactivity, a western nutritional lifestyle is an independent and modifiable risk factor.[2] In cow milk, the β – casein protein serves as a signalling molecule for the autoimmune biochemical cascades that lead to type 1 diabetes (T1DM).[3] Meanwhile, a Western dietary lifestyle consisting of processed foods, saturated fat, and a high-calorie diet has been linked to a higher risk of type 2 diabetes (T2DM).[4] In a prospective Adventist health study with over 41,000 people, those who rigorously adhered to more whole plant foods had a much lower chance of acquiring diabetes, but those who consumed omnivorous diets of various kinds had a higher risk.[5] A plethora of comorbidities are exacerbated by the diabetes epidemic. Hypertension is one of the most common consequences of diabetes mellitus.[6] Hypertension caused by diabetes is fairly prevalent, and it usually worsens the disease's prognosis. Unfortunately, standard drugs for controlling diabetes complications are sometimes contraindicated due to a variety of drug interactions.[7] Despite the use of

conventional medications, the global fatality rate in relation to diabetic complications is increasing, necessitating the implementation of better treatment methods. Surprisingly, there is a growing body of research suggesting that diabetes mellitus can be prevented and remitted with the right lifestyle changes.[8] Therapeutic lifestyle modification is frequently recommended for diabetics as the first line of treatment in modern clinical practice before prescribing conventional medicines.[9] For the therapy of certain illnesses, lifestyle intervention entails the therapeutic application of diet (a whole food plant-based diet), exercise, and abstinence from disease risk factors.[10] The American Diabetes Association[11] and the American College of Lifestyle.[12] have both suggested intensive lifestyle intervention incorporating food and exercise as a unique method for reaching diabetes mellitus treatment goals.

The viability of an intensive lifestyle intervention in a developing country is due to variables such as relative safety, modulation of numerous disease targets, while avoiding the side effects of conventional drugs.[13] In addition, a therapeutic lifestyle approach to managing diabetes and its complications is thought to be more cost-effective and long-term than a drug-based care plan.[14]

Unfortunately, lifestyle-based therapy is rarely available in tertiary healthcare institutions. As a result, management of a lifestyle-related disease like diabetes mellitus is done without formal lifestyle intervention.[15] Many tertiary health centers consider lifestyle intervention to be unconventional or typically unsuitable.[14] However, there is a paucity of empirical data in Nigeria on the use of lifestyle treatments as a complementary approach to reducing diabetes-related indices and cardiovascular problems. The goal of this study was to see how diabetes patients responded to a 10-day whole food plant -based (WFPB) diet and exercise program at the Seventh - Day Adventist Hospital (SDAH) Lifestyle Medicine Centre, a tertiary healthcare center in Ile-Ife, Osun State, Nigeria.

MATERIALS AND METHOD

Source of Data

Following hospital's ethics committee approval, SDA/SERC/20/011B, project was embarked upon.

The current study included 157 diabetes patients who were admitted to the Lifestyle Medicine Centre, Seventh Day Adventist (SDA) Hospital, Ile – Ife, Nigeria, between January 2015 and December 2019. The diabetic patients, both type I and type II, were admitted for a ten-day stay.

Method of Data Collection

The health records of patients were retrieved from the medical records department of the hospital. The data collected included the demographics, blood sugar level, blood pressure values, and other comorbidities at baseline and after intervention. Diabetes was diagnosed according to the recommendation of the American Diabetes Association.[16] The American College of Cardiology approach was used to classify high blood pressure in DM patients.[17]

Inclusion Criteria

The patients who presented with one or more symptoms such as polydipsia, polyuria, polyphagia, weight loss, delayed wound healing and either a fasting plasma glucose (FPG) level ≥ 7 mmol/L (126 mg/dL) or a random plasma glucose level above 11.1 mmol/L (199.8 mg/dL) were included in the study.

Exclusion Criteria

Pregnant women with elevated blood sugar, patients with impaired glucose tolerance, and prediabetes were not included in the study. Patients with prior history of hypertension, renal failure, and hepatic dysfunctions before the onset of diabetes were equally excluded. Those who were unwilling to undergo such a radical dietary/lifestyle transformation were also not included.

Management Plan

The patients were subjected to therapeutic fasting (raw fruits/vegetables/water) for the first three days, and at least, a colon cleansing section. Initially, management was personalized and mostly nutritional. When the reaction was insufficient, traditional blood-sugar-lowering drugs were added. The diet consisted of a whole food plant-based (WFPB) meal plan that may be consumed raw, cooked, or blended. Whole grains, complex carbohydrate foods, legumes, nuts, indigenous green-leafy vegetables, fruits, roots, and tubers were among the food groups. Patients were fed twice a day, with a choice of raw fruit juices or salad for supper (optional). There were no processed foods, artificial sweeteners, or spices utilized in the lifestyle treatment plan. Instead, African locust bean, low salt garlic, ginger, turmeric, and onions were used to season the soup. Honey and high-glycemic-index fruits were not included in the diet. Activated charcoal or honey were used to treat foot ulcers. After regular fitness examinations, all patients were encouraged and mobilized to participate in at least 30-45 minute open-air workouts five days a week.

Statistical Analysis

Statistical analyses were carried out using student t-test on graph pad prism version 5.0. Statistical significance was set at $p < 0.05$. The continuous data of the patients were presented as their mean value. Summary statistics were computed for categorical variables in number (n) and percent (%).

RESULTS

As shown in figures 1 and 2 as well as tables 1 and 2 show the demographic characteristics of the study subjects. Figure 1 depicts the DM types' sex-matched predominanc. Seventy six (76) (48.4%) of the 157 diabetes patients included in this study were males, while

81 (51.6%) were females. There were 19 (12.1%) people who had type 1 diabetes, with 11 (7%) men and 8 (5.1%) females. There were also 138 T2DM cases, 65 (41.4%) of which were men and 73 (46.5%) of which were females. The domiciliary of DM patients is depicted as shown in Figure 2. Rural residents accounted for 53 (33.8 %), with 9 (5.7 %) having T1DM and 44 (28.1 %) having T2DM. Among the 104 (66.2 %) urban inhabitants, T1DM affected ten people (6.4 %), while T2DM affected 94 people (59.9%). Diabetes was found to be most prevalent in adults aged 50 to 60 (table 1.0). Hypertension was the most prevalent consequence, while diabetes kidney disease (DKD) was the least common, as indicated in table 2.0. In the meantime, table 3.0 shows the mean fasting blood glucose (FBG), body mass index (BMI), and blood pressure measurements before and after the lifestyle intervention. Table 4 also demonstrates the impact of the intervention on different phases of hypertension. Blood glucose control, body mass index, and hypertension were all impacted by the lifestyle intervention.

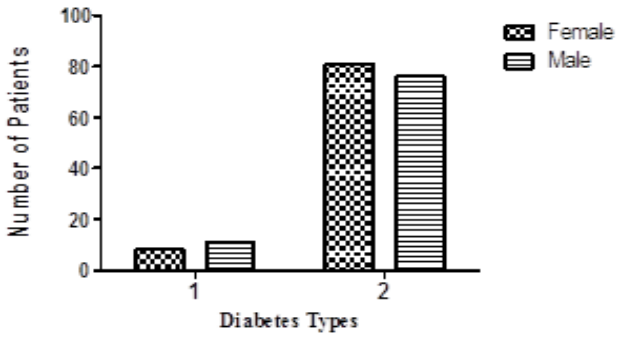

Figure 1.0: Classification of Diabetes type according to sex. More males presented with type 1 diabetes while more females had type 2 diabetes.

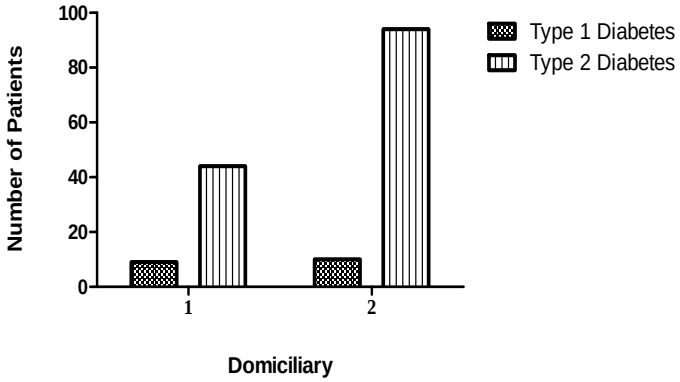

Figure 2: Showing classification of Diabetes based on Domiciliary of patients. About 53 (33.8%) of the diabetic patients are rural dwellers while only 104 (66.2%) are urban dwellers.

Table 1: Distribution of Diabetes Among the Age and Sex Groups.

Age Range	Male n (%)	Female n (%)	Total n (%)
0 – 10	0 (0)	2 (1.3)	2 (1.3)
11 – 20	1 (0.6)	2 (1.3)	3 (1.9)
21 – 30	2 (1.3)	1 (0.6)	3 (1.9)
31 – 40	7 (4.5)	6 (3.8)	13 (8.3)
41 – 50	16 (10.2)	14 (8.9)	30 (19.1)
51 – 60	18 (11.5)	23 (14.7)	41 (26.1)
61 – 70	17 (10.9)	19 (12.1)	36 (22.9)
71 – 80	14 (8.9)	11 (7)	25 (15.9)
81 – 90	1 (0.6)	1 (0.6)	2 (1.3)
91 – 100	0 (0)	2 (1.3)	2 (1.3)
Total	**76 (48.4)**	**81 (51.6)**	**157 (100)**

The highest proportion of diabetes mellitus was found among patients in the 51 – 60 age group, while more than 84% are found among patients who are 40 years and above.

Table 2: Distribution of Diabetes Complications Among the Study Subjects.

S/N	Comorbidities	Male n (%)	Female n (%)	Total n (%)
1	DM only	2 (1.3)	15 (9.6)	17 (10.8)
2	HTN	2 (1.3)	84 (53.5)	86 (54.8)
3	DKD	0	2 (1.3)	2 (1.3)
4	Foot Ulcer	11 (7.0)	14 (8.9)	25 (15.9)
5	DM Retinopathy	0	9 (5.7)	9 (5.7)
6	Hepatic Damage	0	9 (5.7)	9 (5.7)
7	Osteoathritis	4 (2.6)	5 (3.2)	9 (5.7)
	Total	**19 (12.2)**	**138 (87.9)**	**157 (100)**

Hypertension was the most prevalent complication observed.
Abbreviation: DM (Diabetes mellitus); HTN (hypertension); DKD (Diabetic kidney disease).

Table 3: Distribution of Blood glucose, Body Mass Index and Blood Pressure before Admission and Before Discharging From Lifestyle Clinic.

Parameters	Before admission to lifestyle Clinic	Before discharging from lifestyle Clinic	P - Value
Mean FBG (mmol/L)	13.24	6.23*	0.0349
Mean BMI	27.10	21.73*	0.0217
Mean Systolic blood pressure (mm/Hg)	193.30	118.3*	0.0099
Mean Diastolic blood pressure (mm/Hg)	120.34	95.57*	0.0091

Results are presented as mean of actual values. Groups were compared using paired t-test ($p<0.05$). *FBG, BMI, Systolic blood pressure, and diastolic blood pressure were significantly lower at the point of discharge from lifestyle ward relative to values obtained before admission to lifestyle. Abbreviation: Fasting blood glucose (FBG), Body mass index (BMI).

Table 4: Distribution of Hypertension Among Diabetic Subjects Before Admission and Before Discharging from Lifestyle Clinic.

Stage of Hypertension	Before admission to lifestyle Clinic n (%)	Before discharging from lifestyle Clinic n (%)
Normal	71 (45.2)	85 (54.1)
Elevated	12 (7.6)	42 (26.8)
Stage 1	19 (12.1)	27 (17.2)
Stage 2	42 (26.8)	3 (1.9)
Stage 3	13 (8.3)	0
TOTAL	**157 (100)**	**157 (100)**

DISCUSSION

We found a lower prevalence of diabetes type 1 (T1DM) than type 2 (T2DM) among patients admitted for ten days at the Seventh Day Adventist Lifestyle Medicine Centre throughout a five-year period in the current study. T2DM alone is thought to be responsible for more than 80% of the global diabetes burden.[18] Before being admitted, none of the diabetic patients had ever followed a diet that was entirely made up of minimally processed whole plant foods. Unfortunately, all types of animal diets have been linked to the development of diabetes mellitus.[19] According to the Adventist Health Study 2, which enrolled over 61,000 people, the risk of T2DM increased in direct proportion to the amount of animal-based nutrition consumed.[5]

Despite the fact that male T1DM patients outnumbered females in this study, T2DM was more common among females. This finding is consistent with current evidence from population-based research indicating that T2DM is more common in women than in men.[20] Meanwhile, the pattern of DM prevalence appears to be progressing with increasing age in the current study. In the current investigation, individuals aged 40 to 80 years old had the highest prevalence of both DM categories. This may be due to the fact that as people get older, the differentiation of pancreatic -cell mass decreases.[21] Diabetes is well recognized to be more prevalent in cities than in rural settings.[22] In consistence with this fact, the current study also found that type 1 and 2 diabetes was substantially more common among city dwellers than among country dwellers.

Unfortunately, hypertension was observed to be more prevalent than other diabetes related complications in this study. Hypertension developed in more than half of

the diabetic subjects prior to admission to the lifestyle medical centre.

Patients with type 2 diabetes had a higher prevalence of hypertension, while type 1 diabetics had a higher prevalence of foot ulcers. It is estimated that 4–10% of diabetics, particularly those in the 60–80 age bracket, are at risk of developing a foot ulcer.[23] Interestingly, activated charcoal or honey impregnated wound dressing for foot ulcer is considered suitable alternatives to conventional treatments. Certain comparative clinical control trials have attributed the relatively better treatment outcome of their usage is to lower risk of microbial invasion and increased rate of angiogenesis.[24] [25], Similar to our findings, cardiovascular disease and foot ulcer were reported to be the most common diabetes complications accordingng to previous studies.[18] Hypertension was also more common than other diabetes-related comorbidities at a tertiary health care center in Uyo, Nigeria's south eastern region.[26] Furthermore, diabetic patients with stage 2 hypertension at baseline were more dominating than those with other stages of hypertension in the current study. Aside from genetic predisposition and living in a city, the increased prevalence of HTN in T2DM patients could be due to the patients' early-stage dietary lifestyle, years before the onset of diabetes. This is especially possible because a western diet has the ability to predispose to a variety of disorders, including insulin resistance and vascular disease.[27] Diabetes-related liver impairment is currently being investigated as one of the risk factors for coronary artery disease.[28] In this study, only a few cases of diabetes-related osteoarthritis were found. This type of problem most commonly occurs in diabetics as a result of decreased bone turnover caused by persistent hyperglycemia interfering with calcium homeostasis.[29]

A rising number of studies have shown that plant-based medicinal nutrition therapy is useful in preventing and managing diabetes mellitus and its accompanying vascular problems. A vegan diet has been shown to effectively prevent DKD from advancing to End-Stage Renal Disease in a previous study.[30] The results of the lifestyle intervention were significantly ($p<0.05$) lower than the baseline values for fasting blood glucose, BMI, systolic, and diastolic blood pressure. Patients who saw a significant improvement in their diabetes status following the intervention were advised to follow a strict plant-based diet. Furthermore, among T2DM patients, the dual treatment approach was more effective, evoking overall remission of early-stage hypertension as well as partial remission of stages 2 and 3. These findings are in line with the findings of earlier researchers. In the Japan Diabetes Complications Study, a three-year lifestyle intervention improved glucose control and reduced diabetes-related complications.[30] In another structured lifestyle intervention study, patients who underwent exercise combined with dietary modifications had significantly improved cardiovascular outcomes compared with those in the exercise or dietary modification group.[31]

The combined effects of therapeutic fasting, colon cleansing, exercise and and the whole food plant based, are likely to have contributed to the improved clinical outcome through various biochemical approaches. Most importantly, plant meals are well-known for their ability to modulate a variety of diabetes indices as well as associated vascular complications.[32] Empirical evidence suggests that components of plant based meals may interact with enzyme active sites, receptor complexes, nerve terminal residues and improve insulin signaling. Interestingly, a variety of plant foods are known to be high in naturally occurring bioactive compounds that can help the body's antioxidative defences.[33] As a result, they may be able to suppress oxidative chain reactions in a variety of tissues, including the endothelium vasculature.

Furthermore, the antioxidative mechanisms in plants may inhibit downstream biochemical cascades of inflammatory responses associated with diabetes mellitus.[34] This could explain why vegetarians have a lower risk of developing some pathological symptoms, particularly those that are positively correlated with oxidative stress and inflammation. These findings add to the growing body of evidence that suggests regular exercise and plant dietary plan play important roles in maintaining homeostasis.[35]

CONCLUSION

The diabetic patients maintained at the Lifestyle Medical Centre exhibited considerable improvements in their health at the end of the treatment term, according to our research. More research is needed to determine the impact of a long-term lifestyle change on well-defined clinical indices in people of various health statuses.

ACKNOWLEDGEMENT

The staff of the health record unit at the general out - patient department of the SDA hospital, Ile-Ife are appreciated for their assistance during the course of data retrieval.

REFERENCES

1. Ogurtsova K, da Rocha Fernandes JD, Huang Y, Linnenkamp U, Guariguata L, Cho NH, et al. IDF Diabetes Atlas: Global estimates for the prevalence of diabetes for 2015 and 2040. Diabetes Research and Clinical Practice, Mar 1, 2017; 128.
2. 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., Jun, 2018; 9(3): 1307–16.
3. ul Haq MR, Kapila R, Shandilya UK, Kapila S. Impact of Milk Derived β-Casomorphins on Physiological Functions and Trends in Research: A

Review. International Journal of Food Properties, Sep 14, 2014; 17(8): 1726–41.
4. Liu S, van der Schouw YT, Soedamah-Muthu SS, Spijkerman AMW, Sluijs I. Intake of dietary saturated fatty acids and risk of type 2 diabetes in the European Prospective Investigation into Cancer and Nutrition-Netherlands cohort: associations by types, sources of fatty acids and substitution by macronutrients. Eur J Nutr., Apr, 2019; 58(3): 1125–36.
5. Tonstad S, Stewart K, Oda K, Batech M, Herring RP, Fraser GE. Vegetarian diets and incidence of diabetes in the Adventist Health Study-2. Nutr Metab Cardiovasc Dis., Apr, 2013; 23(4): 292–9.
6. Wilson M, Keeley J, Kingman M, Wang J, Rogers F. Current clinical utilization of risk assessment tools in pulmonary arterial hypertension: a descriptive survey of facilitation strategies, patterns, and barriers to use in the United States. Pulmonary Circulation [Internet], 2020 Sep [cited 2022 Mar 14]; 10(3). Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7534093/
7. May M, Schindler C. Clinically and pharmacologically relevant interactions of antidiabetic drugs. Ther Adv Endocrinol Metab, Apr, 2016; 7(2): 69–83.
8. Sumamo E, Ha C, Korownyk C, Vandermeer B, Dryden DM. Lifestyle Interventions for Four Conditions: Type 2 Diabetes, Metabolic Syndrome, Breast Cancer, and Prostate Cancer [Internet]. Rockville (MD): Agency for Healthcare Research and Quality (US); 2011 [cited 2022 Mar 15]. (AHRQ Technology Assessments). Available from: http://www.ncbi.nlm.nih.gov/books/NBK254022/
9. American Diabetes Association. Introduction: Standards of Medical Care in Diabetes—2022. Diabetes Care, Dec 16, 2021; 45(1): S1–2.
10. Koenigsberg MR, Corliss J. Diabetes Self-Management: Facilitating Lifestyle Change. Am Fam Physician, Sep 15, 2017; 96(6): 362–70.
11. American Diabetes Association. 4. Lifestyle Management. Diabetes Care, Dec 12, 2016; 40(1): S33–43.
12. Kelly J, Karlsen M, Steinke G. Type 2 Diabetes Remission and Lifestyle Medicine: A Position Statement From the American College of Lifestyle Medicine. American Journal of Lifestyle Medicine, Jul 1, 2020; 14(4): 406–19.
13. Kumari G, Singh V, Dahiya S, Jhingan AK, Chhajer B. Effect of Lifestyle Intervention on Medical Treatment Cost and Health-Related Quality of Life in Type 2 Diabetes Mellitus Patients. Biomedical and Pharmacology Journal, Jun 25, 2018; 11(2): 775–87.
14. Sadiq AAA, Hanif SM, Muhammad DG. Assessment of knowledge, attitude, practice, and barriers to lifestyle modification among individuals with diabetes mellitus in Kano Nigeria. AUJMSR, Dec 29, 2021; 3(2): 100–7.
15. Amere LT, Adesola A O, Olatade MJ, Leslie T D, Magret I O, Kaneng Mary D. Knowledge, Attitude And Practices Regarding Lifestyle Modifications Among Type 2 Diabetes Mellitus Patients Attending Diabetic Clinic At General Hospital, Gbagada, Lagos State. IJSRP, May 18, 2020; 10(05): 558–64.
16. American Diabetes Association. 2. Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes-2018. Diabetes Care., Jan, 2018; 41(1): S13–27.
17. Martínez-Rueda AJ, Olivas-Martínez A, Vega-Vega O, Fonseca-Correa JI, Correa-Rotter R. New 2017 American College of Cardiology/American Heart Association High Blood Pressure Guideline. Hypertension, Jan, 2019; 73(1): 142–7.
18. Adeloye D, Ige JO, Aderemi AV, Adeleye N, Amoo EO, Auta A, et al. Estimating the prevalence, hospitalisation and mortality from type 2 diabetes mellitus in Nigeria: a systematic review and meta-analysis. BMJ Open, May 1, 2017; 7(5): e015424.
19. Azemati B, Rajaram S, Jaceldo-Siegl K, Sabate J, Shavlik D, Fraser GE, et al. Animal-Protein Intake Is Associated with Insulin Resistance in Adventist Health Study 2 (AHS-2) Calibration Substudy Participants: A Cross-Sectional Analysis. Curr Dev Nutr., Apr, 2017; 1(4): e000299.
20. Rasaki SO, Kasali FO, Biliaminu SA, Odeigah LO, Sunday AA, Sule AG, et al. Prevalence of diabetes and pre-diabetes in Oke-Ogun region of Oyo State, Nigeria. Lee A, editor. Cogent Medicine, Jan 1, 2017; 4(1): 1326211.
21. Sabir. Prevalence of diabetes mellitus and its risk factors among the suburban population of Northwest Nigeria [Internet]. [cited 2022 Mar 15]. Available from: https://www.smjonline.org/article.asp?issn=1118-8561;year=2017;volume=20;issue=4;spage=168;epage=172;aulast=Sabir
22. Adamu D, Danjin M. Prevalence of diabetes mellitus in a tertiary health institution in Gombe Metropolis, Nigeria. [cited 2022 Mar 15]; Available from: https://www.academia.edu/31975421/Prevalence_of_diabetes_mellitus_in_a_tertiary_health_institution_in_Gombe_Metropolis_Nigeria
23. Dahiru. A review of population-based studies on diabetes mellitus in Nigeria [Internet]. [cited 2022 Mar 15]. Available from: https://www.ssajm.org/article.asp?issn=2384-5147;year=2016;volume=3;issue=2;spage=59;epage=64;aulast=Dahiru
24. Kerihuel JC. Effect of activated charcoal dressings on healing outcomes of chronic wounds. J Wound Care, May, 2010; 19(5): 208, 210–2, 214–5.
25. Dumville JC, Lipsky BA, Hoey C, Cruciani M, Fiscon M, Xia J. Topical antimicrobial agents for treating foot ulcers in people with diabetes. Cochrane Database Syst Rev., Jun 14, 2017; 2017(6): CD011038.

26. Umoh VA, Akpan EE, Idung A. Hypertension among Type 2 Diabetic Patients in Uyo, South East Nigeria. Journal of Advances in Medicine and Medical Research, May 9, 2018; 1–6.
27. Luukkonen PK, Sädevirta S, Zhou Y, Kayser B, Ali A, Ahonen L, et al. Saturated Fat Is More Metabolically Harmful for the Human Liver Than Unsaturated Fat or Simple Sugars. Diabetes Care., Aug, 2018; 41(8): 1732–9.
28. Agarwal AK, Jain V, Singla S, Baruah BP, Arya V, Yadav R, et al. Prevalence of non-alcoholic fatty liver disease and its correlation with coronary risk factors in patients with type 2 diabetes. J Assoc Physicians India, Jun, 2011; 59: 351–4.
29. Murray CE, Coleman CM. Impact of Diabetes Mellitus on Bone Health. Int J Mol Sci., Sep 30, 2019; 20(19): E4873.
30. Kramer H. Diet and Chronic Kidney Disease. Adv, Nutr. 1, 2019; 10(4): S367–79.
31. Sone H, Katagiri A, Ishibashi S, Abe R, Saito Y, Murase T, et al. Effects of lifestyle modifications on patients with type 2 diabetes: the Japan Diabetes Complications Study (JDCS) study design, baseline analysis and three year-interim report. Horm Metab Res., Sep, 2002; 34(9): 509–15.
32. Zhang X, Devlin HM, Smith B, Imperatore G, Thomas W, Lobelo F, et al. Effect of lifestyle interventions on cardiovascular risk factors among adults without impaired glucose tolerance or diabetes: A systematic review and meta-analysis. PLOS ONE [Internet], 2017 May 11 [cited 2021 Oct 19]; 12(5): e0176436. Available from: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0176436
33. Nasri H, Shirzad H, Baradaran A, Rafieian-kopaei M. Antioxidant plants and diabetes mellitus. J Res Med Sci., May, 2015; 20(5): 491–502.
34. Sharifi-Rad M, Anil Kumar NV, Zucca P, Varoni EM, Dini L, Panzarini E, et al. Lifestyle, Oxidative Stress, and Antioxidants: Back and Forth in the Pathophysiology of Chronic Diseases. Frontiers in Physiology [Internet]. 2020 [cited 2022 Mar 15];11. Available from: https://www.frontiersin.org/article/10.3389/fphys.2020.00694
35. Arulselvan P, Fard MT, Tan WS, Gothai S, Fakurazi S, Norhaizan ME, et al. Role of Antioxidants and Natural Products in Inflammation. Oxidative Medicine and Cellular Longevity. 2016 Oct 10; 2016: e5276130.