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Assessment of the risk of developing cardiovascular disease in prediabetic and diabetic subjects with Insulinaemia

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Abstract

Introduction: This examination investigated the risk of developing cardiovascular disease in pre-diabetic and diabetic subjects with insulinaemia. The assessment solidified the human diabetic subjects in the evaluation of the model and took the blood analytes to screen for diabetes.

Methodology: 120 male and female human subjects containing forty subjects each for control, pre-diabetics and diabetics facilitated for age, sex, height, weight, and BMI were enrolled into the assessment reliant upon decided measures. All of the three sets of human subjects were males and females independently. Every illustration of blood serum and plasma was explored using Randox and Accubind packs and an autoanalyser to test for various biochemical and hematological limits.

Results: The overall results revealed a colossal differentiation ($p \leq 0.05$) in the limits except for that of Na^+. The 500mg/kg body weight part of the concentrate was ideal while there was a much basic development in the HOMA-IR with potential gains of 0.94±0.04, 2.28±0.17, and 3.25±0.44 for the three sets. The HOMA-IR is an alluring model, as compared to various models previously investigated. This assessment revealed that HOMA-IR works best in the management of diabetes in connection with various models.

Keywords: Insulinaemia; Pre-Diabetic; Diabetic; Cardiovascular; Risk; Assessment

1. Introduction

Insulin is released from the pancreatic ß-cells postprandially, signaling the fed state and directly stimulating glucose disposal into peripheral insulin target tissues, as well as, suppressing hepatic glucose output (HGO). Interference with any of these actions of insulin, such as, impairment of insulin sensitivity at a peripheral or hepatic level, will alter plasma glucose elevating effect. At an early stage in the pathophysiological process, this may be compensated for by an increase in ß-cell insulin output which maintains normoglycaemia. When the insulin secretion is no longer sufficient to maintain normoglycaemia, then hyperglycemia and diabetes develop [1].

Insulin resistance is the reduced ability of insulin to exert its biological effects on target tissues, which include; adipose tissue, skeletal muscle and liver. Regarding blood glucose concentration, insulin resistance is inappropriately high level of insulin for the level of glycaemia [2]. Both insulin resistance and sensitivity are continuous variables, making it difficult to define cut-off levels for insulin resistance, thus, considering each individual as lying along the continuum

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between very high and very low insulin sensitivity. This concept is important in considering techniques used to assess insulin sensitivity [2].

Insulin resistance is generally accepted as a major risk factor in the etiology of type 2 diabetes mellitus [3]. Other risk factors, such as, obesity, physical inactivity, body fat distribution, age and hyperinsulinemia, may be considered markers of insulin resistance. Insulin resistance is a predictor for developing type 2 diabetes mellitus even with normal glucose tolerance. It is also associated with the development of metabolic syndrome [4], which represents a cluster of cardiometabolic risk factors that promote the development of cardiovascular disease and type 2 diabetes [5,6], and is characterized by the excess release of insulin to lower plasma glucose levels. The resultant hyperinsulinemia accounts for peripheral reduction of insulin sensitivity [7]. The condition increases the risk of prediabetes, type 2 diabetes and other health problems and complications, including heart attack, stroke, kidney disease, eye problem and cancer. Symptoms signaling insulin resistance include extreme thirst or hunger, feeling hungry even after a meal, and increased or frequent urination.

IR is one of the main problems in type 2 diabetes mellitus (T2DM). Treatment with natural herbs is likely to be fraught with lesser side effects compared to presently used synthetic oral anti-diabetic agents. Dexamethasone (Dex), a synthetic glucocorticoid with anti-inflammatory and immunosuppressant properties has serves wide therapeutic applications. Its major drawback is glucose intolerance and reduction of insulin sensitivity in vulnerable patients, depending on the dose and frequency of administration, which could cause diabetes mellitus [8]. Apart from its clinical uses, it is widely used in research to induce insulin resistance in animals and humans [9,10,11,12].

Diabetes is a lifestyle non-communicable disease of mankind that represents one of the most significant global health challenge afflicting both young and old irrespective of gender [13]. It is a metabolic condition occasioned by inability to produce or utilize insulin, leading to decline in the quality of human life. Nigeria has the highest number of diabetics in Africa with 3,921,500 cases reported and prevalence of 4.99% [13]. Type 2 diabetes (T2D) accounts for 95% of all diabetes cases reported [13,14]. The causes of T2D are multi-factorial, genetic and environmental elements that affect the β-cell function and insulin sensitivity [15,16].

Routine fasting blood sugar test is indicative of the present glycaemic state, but subject to diurnal fluctuations. Glycated haemoglobin (HbA1c) test, on the other hand, reveals the fasting blood sugar (FBS) level of past 1 to 3 months. High HbA1c, predisposes to long-term complications [17]. Current research trends favour predictive markers of diabetes mellitus (DM). Such measures detect DM at its pre-diabetic state. It would mean then, that once any of such markers begin to rise, it indicates that the individual is at risk of developing diabetes or any cardiovascular disorder (CVD) [18]. Therefore, such markers could be employed to ascertain the onset of DM.

Different assessment models for insulin resistance exists, such as Homeostasis model assessment of insulin resistance (HOMA-IR) index, Triglyceride and glucose (TYG) index and Triglyceride/high density lipoprotein (TG-HDL) cholesterol ratio, with their respective benefits and demerits, but HOMA-IR index was selected for this study, owing to its advantages over others. Previous studies indicated that TyG index is associated with carotid atherosclerosis, coronary artery calcification and high risk of CVD, while associations with TG-HDL cholesterol ratio outweighing it [1,2]. The HOMA-IR possesses the merit of detecting the presence and extent of insulin resistance, making it valuable for both baseline blood sugar and responsive hormone analysis.

Metabolic health lies in the space between insulin and glucose sensitivity [19,20]. Low HOMA-IR means sensitivity to insulin. Increasing HOMA-IR implies more resistance to insulin. Investigating insulin, HbA1c, glucose, lipid profile, thyroid stimulating hormone (TSH), free triiodothyronine (fT3), free thyroxine (fT4), renal function (sodium, potassium, chloride, bicarbonate, urea and creatinine), full blood count (FBC) and assessment of HOMA-IR, TG/HDL-c ratio and TyG indices, is vital for normal and diabetic subjects.

2. Methodology

The study was conducted in Choba community, University of Port Harcourt and University of Port Harcourt Teaching Hospital (UPTH), all in Obio/Akpor Local Government Area and Aluu community in Ikwerre Local Government Area of Rivers State, Nigeria. The area is located in the Niger Delta region, bordering the Atlantic Ocean.

Glasswares such as cannula, cotton wool, micropipette and tips, pipette. plain bottles, sample containers, syringes and needles, test-tubes and racks, and tourniquet were used, while the extracts were of aloe vera, ginger and cinnamon. The reagents are those consistent with the desired investigation. The subjects were sourced from UPTH. They are

individuals presenting for routine monitoring of blood glucose level and insulin resistance over a period of 2 months. Each participant consented before donating an aliquot of blood sample for the study. They were grouped into two; A (control) and B (test), with the B group further divided into two. Thus, the three groups were non-diabetics (control), pre-diabetics and diabetics. The inclusion criterion was 36-76 years and the exclusion criteria were co-infection or presence of other metabolic disorders.

Similarly, plant samples (aloe vera leaves and ginger rhizomes) were purchased from Mile 3 Diobu and Choba markets in Port Harcourt City and Obio/Akpor Local Government Areas respectively of Rivers State, Nigeria. The aloe vera was washed with clean sterile distilled water and allowed to air-dry for one hour after which it was weighed. The epidermis of the leaves was peeled off, and the parenchymatous tissue collected. The colourless, solid mucilaginous gel was cut into pieces, lyophilized and ground. The lyophilized gel powder was packed into soxhlet apparatus and extracted with 90% ethanol at 90° C for four (4) hours. The ethanol containing the extract was filtered and concentrated using rotary evaporator and was stored at 90°C. The outer covering of the ginger was manually peeled off, washed and extracted. Aqueous ginger extract was prepared according to methods previously reported by Onyeagba *et al.* [21] . The homogenate ginger extract was filtered with a sterile, muslin cloth, blended, dried and finely ground to powder. 100g of the ground ginger was mixed with one liter of sterile deionized water and kept in a water bath at 60ºC for five hours, then filtered through sterile filter paper. The filtrate was exposed at 40 ºC to a hot air oven for evaporation of water. The residue after drying was kept in a refrigerator at 4 ºC until use [26].

The minimum sample size was calculated using the formula below by (Anderson *et al.*, 1991): $N = Z^2 (pq) / e^2$, where N = minimum sample size, Z = 1.96 at 95% confidence limits, p = prevalence of increased normal (6.80%) and diabetic subjects (10.20%) ((6.80 + 10.20)/2)% = (17.00/2)% = 8.50%, percentage average q = 1-p, e = error margin tolerated at 5% = 0.05. N = ((3.8416(0.0850 x 0.9150))/0.0025 = 119.51 ≈ 120.

For bio-chemical analysis, bio-data comprising blood pressure (systolic and diastolic) using the oscillometric method and BMI using height and weight were used. Also, lipid profile, renal profile and blood glucose were analysed using Randox kits (RANDOX, USA). In the haematologic analysis, full blood count (FBC) comprising the red blood cell (RBC) count and its components alongside platelet levels, and white blood cell (WBC) count and its components were analysed. These were done for both human and animal subjects.

For the HOMA-IR, IR is calculated as insulin × glucose ÷ 405, with optimal number as 1.0, while the range is 0.5 – 1.4. Less than 1.0 is insulin-sensitivity, which is optimal, above 1.9 indicates early insulin resistance and above 2.9 indicates significant insulin resistance.

Statistical analysis was performed using SPSS version 21 (IBM, U.S.A), employing one-way analysis of variance (ANOVA), while significant differences were determined using post-Hoc Duncan multiple comparison test ($p<0.05$) and confidence level set at 95%.

3. Results

The bio-data for the subjects shows that the height of the non-diabetic and diabetic groups was not significantly different (176.20±1.25cm and 173.47±0.93cm), but the height of the pre-diabetics (170.82±1.09cm) was significantly different ($p<0.05$) from the other 2 groups. The weight of pre-diabetics was higher but not statistically different from that of non-diabetics, while the weight of the diabetics (76.27±2.13kg) was statistically higher ($p<0.05$) than that of non-diabetics (70.77±0.89kg) and pre-diabetics (72.32±1.24kg). BMI analysis did not show statistical difference ($p<0.05$) in pre-diabetics (25.10±0.43) and diabetics (25.34±0.10), but both groups were significantly higher than that for non-diabetics (22.88±0.43). Both systolic and diastolic blood pressure of diabetics (119/75 mmHg) were significantly ($p<0.05$) higher than that of the non-diabetics (110/72 mmHg). Systolic pressure of the diabetics was also statistically higher ($p<0.05$) than that of pre-diabetics but the diastolic pressure was not statistically different ($p>0.05$), 119/75 mmHg and 112/74 mmHg respectively.

Most values of lipid profile (CHOL, TG, and LDL) increased progressively from the non-diabetic, pre-diabetic to the diabetic group having values of 4.41±0.13 mmol/l, 5.05±0.12 mmol/l, 5.22±0.15 mmol/l for CHOL; 1.46±0.08 mmol/l, 1.83±0.11 mmol/l, 2.45±0.11 mmol/l for TG; and 2.60±0.10 mmol/l, 3.21±0.10 mmol/l, 3.37±0.12 mmol/l for HDL respectively. There was statistical difference ($p<0.05$) between all groups for the CHOL, similar to outcome for pre-diabetic and diabetic groups in TG and HDL, but no significant difference ($p<0.05$) between pre-diabetic and diabetic groups for the LDL Table 2 below.

Table 1 Bio-data of non-diabetic, pre-diabetic and diabetic groups.

Group	Sex		Age (years)	Height (cm)	Weight (kg)	Systolic (mmHg)	Diastolic (mmHg)	BMI
	F	M						
Non-diabetic	20±0.03	20±0.04	50.70±1.16^{c}	176.20±1.25^{b}	70.76±0.89^{c}	110.12±1.59	71.77±0.89	22.88±0.43^{c}
Pre-diabetic	21±0.13	19±0.11	54.87±1.67^{a}	170.82±1.09^{c}	72.32±1.24^{c}	111.52±1.96	74.07±0.94	25.10±0.43^{a}
Diabetic	20±0.00	20±0.00	56.12±1.62^{a}	173.47±0.93^{b}	76.27±2.13^{ab}	119.77±1.96	75.70±0.88	25.34±0.10^{a}

Data are expressed as mean ± standard deviation (SD). Values in the same column with similar superscript letter a, were significantly higher ($p<0.05$) than that of the non-diabetic, those with superscript b were significantly higher ($p<0.05$) than that of the pre-diabetic, while those with superscript c, were significantly lower ($p<0.05$) than that of the diabetic group.

Table 2 Lipid profile of non-diabetic, pre-diabetic and diabetic groups

GROUP	Chol(mmol/l)	TG(mmol/l)	HDL(mmol/l)	LDL(mmol/l)
Non-diabetic	4.41±0.13^{bc}	1.46±0.08^{bc}	1.10±0±0.03^{bc}	2.60±0.10^{bc}
Pre-diabetic	5.05±0.12^{c}	1.83±0.11^{a}	1.01±0.03^{a}	3.21±0.10^{a}
Diabetic	5.22±0.15^{b}	2.45±0.11^{a}	0.94±0.02^{a}	3.37±0.12^{a}

Data are expressed as Mean ± Standard deviation (SD), n=120 where n represents the number of human subjects. Values in the same column with similar superscript letter a, were significantly lower ($p<0.05$) than that of the non-diabetic. Values with the superscript b, were significantly lower ($p<0.05$) than that of the pre-diabetic. Values with the superscript c, were significantly lower ($p<0.05$) than that of the diabetic group

Table 3 Renal function in non-diabetic, pre-diabetic, and diabetic groups

Group	Na^+ (mmol/l)	K^+ (mmol/l)	Cl^- (mmol/l)	HCO_3^- (mmol/l)	Urea (mmol/l)	Creatinine (mmol/l)
Non- diabetic	141.75±2.48	3.78±0.06^{bc}	97.05±0.53^{b}	26.15±0.43^{b}	3.93±0.18^{bc}	86.47±3.43^{bc}
Pre-diabetic	138.80±0.78	4.03±0.07^{ac}	94.65±5.82^{a}	23.57±5.76^{a}	4.52± 0.21^{ac}	111.37±4.33^{ac}
Diabetic	138.55±0.97	4.50±0.09^{ab}	93.88±0.63^{a}	22.85±0.51^{a}	4.89± 0.19^{ab}	120.13±4.39^{ab}

Data are expressed as Mean ± Standard deviation (SD), n=120 where n represents the number of human subjects. Values in the same column with similar superscript letter a, were significantly higher ($p<0.05$) than that of the non-diabetic. Values with the superscript b, were significantly lower ($p<0.05$) than that of the pre-diabetic. Values with the superscript c, were significantly lower ($p<0.05$) than that of the diabetic group.

There was progressive increase in the value of Na^+ from the non-diabetic to the diabetic group, but no significant difference ($p>0.05$) across the groups. The values for K^+ were significantly higher ($p<0.05$) compared in ascending order with values of 3.78±0.06 mmol/l (non-diabetics), 4.03±0.07 mmol/l (pre-diabetics) and 4.50±0.09 mmol/l (diabetics). Urea and creatinine concentrations were significantly higher ($p<0.05$) non-diabetic to diabetic group (86.47±3.43 mmol/l, 111.37±4.33 mmol/l and 120.13±4.39 mmol/l). Cl^- had trend of decreasing linearity from non-diabetic to diabetic; 97.05±0.35 mmol/l, 94.65±5.82 mmol/l and 93.88±0.63. H_2CO_3 level was highest in non-diabetics (26.57±5.76 mmol/l) then pre-diabetics (23.57±5.76 mmol/l) and diabetics (22.85±0.51 mmol/l).

Table 4 Glucose, Insulin and Thyroid Function profile

Group	GLU mmol/l	INS mIU/L	TSH mU/ml	fT3 pmol/L	fT4 ng/dL
Non-diabetic	4.49±0.08^{bc}	4.77±0.19^{bc}	1.55±0.15^{bc}	3.22±0.11^{bc}	1.11±0.05^{c}
Pre-diabetic	6.00±0.11^{ac}	8.48±0.59^{a}	3.97±0.09^{a}	3.05±0.12	1.07±0.06
Diabetic	10.84±0.96^{a}	7.13±0.73^{ab}	3.72±0.08^{ab}	2.61±0.09^{ab}	0.97±0.05^{ab}

Data are expressed as Mean ± Standard deviation (SD), n=120 where n represents the number of human subjects. Values in the same column with similar superscript letter a, were significantly higher ($p<0.05$) than that of the non-diabetic. Values with the superscript b, were significantly lower ($p<0.05$) than that of the pre-diabetic. Values with the superscript c, were significantly lower ($p<0.05$) than that of the diabetic group.

Glucose showed significantly increasing trend with values of 4.49±0.08 mmol/l, 6.00±0.11 mmol/l, and 10.84±0.96 mmol/l for non-diabetics, pre-diabetics and diabetics respectively, and is similar to insulin levels; 4.77±0.19 mIU/L, 8.48±0.59 mIU/L, and 7.13±0.73 mIU/L. There was progressive decrease in the values for fT3 and fT4: 3.22±0.11 pmol/L, 3.0±0.12 pmol/L and 2.61±0.09 pmol/L for fT3; and 1.11±0.05 ng/dL, 1.07±0.06 ng/dL and 0.97±0.05 ng/dL for fT4, across the non-diabetics, pre-diabetics and diabetics.

Table 5 Homeostatic model indices

Group	HOMA-IR
Non- diabetic	0.94 ± 0.04^{c}
Pre-diabetic	2.28 ± 0.17^{ac}
Diabetic	3.25 ± 0.44^{ab}

Data are expressed as Mean ± Standard deviation (SD), n=120 where n represents the number of human subjects. Values in the same column with similar superscript letter a, were significantly higher ($p<0.05$) than that of the non-diabetic. Values with the superscript b, were significantly higher ($p<0.05$) than that of the pre-diabetic. Values with the superscript c, were significantly lower ($p<0.05$) than that of the diabetic group. The HOMA-IR values were 0.94±0.04, 2.28±0.17 and 3.25±0.44 for non-diabetics, pre-diabetics and diabetics respectively, showing progressive increase.

Table 6 RBC, WBC counts and their components alongside PLT count

Group	Non-diabetic	Pre-diabetic	Diabetic
RBC ($\times10^{6}$ cells/cmm)	4.29 ± 0.07^{c}	4.38 ± 1.05^{c}	4.90 ± 0.11^{ab}
Hb (g/dL)	13.98±0.51	14.03±0.17	14.12±0.29
PCV (%)	42.30±0.75	43.70±0.53	43.92±0.84
PLT ($\times10^{9}$/L)	186.95 ± 6.04^{c}	206.70 ± 8.72^{ac}	229.97 ± 11.21^{ab}
WBC ($\times10^{9}$/L)	5.52±0.13	5.60±0.20	5.68±0.37
NEU ($\times10^{9}$/L)	25.20 ± 0.59^{c}	26.37 ± 1.48^{c}	29.47 ± 8.63^{ab}
LYMP ($\times10^{9}$/L)	64.55 ± 0.66^{c}	65.42 ± 1.70^{c}	68.52 ± 2.35^{ab}
MONO ($\times10^{9}$/L)	6.10 ± 0.20^{c}	6.32 ± 0.28^{ac}	6.82 ± 0.46^{b}
EOS ($\times10^{9}$/L)	3.25 ± 0.11^{c}	3.62 ± 0.16^{a}	3.80 ± 0.15^{a}
BAS ($\times10^{9}$/L)	0.15±0.07	0.15±0.05	0.10±0.04

Data are expressed as Mean ± Standard deviation (SD), n=120 where n represents the number of human subjects. Values in the same column with similar superscript letter a, were significantly higher ($p<0.05$) than that of the non-diabetic. Values with the superscript b, were significantly higher ($p<0.05$) than that of the pre-diabetic. Values with the superscript c, were significantly lower ($p<0.05$) than that of the diabetic group.

The RBC and platelet counts were significantly higher ($p<0.05$) in the diabetic subjects and similar to that of platelets. The values were 4.29±0.07 mL, 4.38±1.05 mL and 4.90±0.11 mL for the non-diabetic, pre-diabetic and diabetics respectively for RBC and 186.95±6.04 mL, 206.70±8.72 mL and 229.97±11.21 mL respectively for platelets. Hb and PCV were not statistically different ($p>0.05$) across the groups. WBC count was slightly increased in pre-diabetic and diabetic groups, but was not statistically significant. Neutrophil count for diabetics was statistically higher ($p<0.05$) than that of non-diabetics and pre-diabetics; 25.20±0.59 cells/µL, 26.37±1.48 cells/µL and 29.47±8.63 cells/µL respectively. Lymphocytes counts also increased progressively from non-diabetic to diabetic but was only significant ($p<0.05$) in the diabetic group. Eosinophil count increased progressively from diabetic to non-diabetic, while monocyte count significantly increased from non-diabetic to diabetic; 6.10±0.20 cells/µL, 6.32±0.28 cells/µL and 6.82±0.46 cells/µL respectively and basophil count was the same across all groups.

4. Discussion

This research is aimed at determining insulin resistance in normal and diabetic subjects employing the homeostatic model. There is correlation between diabetes and body mass index (BMI) of subjects. In fact, obesity is believed to account for about 85% risk of developing type 2 diabetes, while recent research suggests that obese people are times more likely to develop type 2 diabetes than those with BMI <22 [25]. Insulin sensitivity is a continuous variable, thus,

young, lean, physically-fit individuals are likely to be highly insulin sensitive whereas obese subjects with type 2 diabetes will have poor insulin sensitivity [1]. This is supported by the bio-data obtained from the subjects used in this research. The average body weight showed a trend of increase from the non-diabetic, pre-diabetic to the diabetic subjects. The BMI of the pre-diabetic and diabetic subjects were also significantly higher than that of the non-diabetic subjects. There is also a correlation between diabetes and high blood pressure (BP), the latter increased significantly across the normal, pre-diabetic and diabetic subjects in a similar order.

There are a number of factors which can contribute to becoming obese such as eating a high calorie diet (high fat diet), not getting enough physical exercise, genetics, medical conditions and being on medications. Loss of body weight has been shown to improve blood glucose levels [23], and has allowed people with type 2 diabetes to come off or avoid going onto insulin resistance. Obesity is also thought to trigger changes to the metabolism of the body. These changes cause adipose tissue to release fat molecules into the blood which can affect insulin responsiveness in cells and lead to reduced insulin sensitivity. Obesity causes pre-diabetes, a metabolic condition that usually results in type 2 diabetes [3].

Cinnamon has been known to increase insulin sensitivity while Glimepiride and Metformin decrease insulin resistance and the risk of type 2 diabetes [1]. Type 2 diabetes affects the homeostasis of acid-base regulation. High glucose concentration results in an osmotic force that draws water to the extracellular space. This dilutes extracellular sodium and results in lower blood sodium level [24]. In our result, a decrease in blood sodium level was observed as we moved from normal to diabetic subjects, though not statistically significant at $p<0.05$. Also, high plasma glucose concentrations result in potassium efflux to the extracellular space, causing hyperkalemia [24]. This was observed in this study. Diabetic ketoacidosis is a clinically significant assay-based disturbance in diabetes that is linked to increased hepatic ketoacid generation. Bicarbonate ($H2CO3$) degrades to carbon (IV) oxide and water, and anion gap acidosis results. This is evident in the significantly lower bicarbonate levels in the pre-diabetic and diabetic groups. The chloride values also follow the same trend. This study observed significantly increased insulin resistance in the pre-diabetic and diabetic groups with regards to the HOMA-IR index. This agrees with other studies, as it is known that insulin resistance is a major risk factor and predictor of Type 2 diabetes [3]. The hall-mark of Type 2 diabetes is an abnormally high glucose that is unresponsive or only slightly responsive to insulin regulation. Treatment with the standard drugs Glimepiride and Metformin led to improvement in all indices. The herb, Cinnamon compared very well to the standard drugs in improving the indices. Treatment with the extracts of Ginger and Aloe Vera and their mixture also led to improvements in the indices albeit to a less degree.

The thyroid function (TSH, fT3 and fT4) showed that the thyroid function of pre-diabetics and diabetics differed significantly from that of the normal subjects. There was significant increase in the TSH of pre-diabetic and diabetic subjects; the increase was highest in the pre-diabetic subjects, suggesting the initiation of intervention measures. The complications of diabetes reduces with initiation of intervention measures [25]. Contrarily, fT3 and fT4 decreased in the pre-diabetic and diabetic state. This decrease followed the glycaemic state as indicated by the Glucose and HbA1c levels and was lowest in the diabetic subjects. Thyroid dysfunction is widely reported in diabetes [26].

Diabetes is a metabolic disease characterized by hyperglycaemia, dyslipidemia, hypertension and impaired hematological indices. Several changes affecting the RBCs, WBCs and platelets are directly associated with DM [27,28] In this study, PCV, Hb and RBC were all higher in the pre-diabetic and diabetic subjects relative to the controls, though, not statistically, for PCV and Hb. RBC was however significantly higher in the diabetic subjects. In this study, HbA1c of the diabetic patients were also higher than that of the controls. Platelet and WBC counts were elevated in the pre-diabetic and diabetic subjects relative to the normal group. This is in agreement with findings reported in a previous study by Biadgo et al. [27] . Increase in WBC indices in the diabetic group compared with the control group might also be due to increased oxidative stress triggered by the high levels of hyperglycemia in the diabetic patients. In contrast, a study reported a decrease in RBC count, Hb and PCV levels [29].

5. Summary

Insulin resistance is generally accepted to be a major risk factor in the etiology of type 2 diabetes mellitus [3], even among individuals with normal glucose tolerance. Several risk factors, such as obesity, physical inactivity, body fat distribution, age and hyperinsulinemia may be considered markers of insulin resistance. It is thus, important to recognize insulin resistance in the pre-disease stage when therapeutic intervention is likely more successful than in manifest disease [30].

This study proposed a new system where normal and diabetic subjects coming to assess fasting blood glucose will assess their insulin resistance level by employing the HOMA-IR, in order to predict and monitor or control DM. The human model was designed and used to assay various biochemical and haematological parameters and the findings largely corroborated previous studies with few exceptions. In conclusion, the model varied significantly ($p<0.05$) from human diabetic subjects, while noting that therapeutic intervention for diabetes in the pre-disease state is more successful than manifested disease and the model used corroborated previous studies. Also, dyslipidaemia and hyperinsulinaemia was observed in sampled subjects, with risk factors such as obesity, physical inactivity, body fat distribution, age and hyperinsulinemia being considered markers of diabetes. It is therefore, recommended that this research should be furthered with larger population of human subjects, in various geographical locations and the effects of the plants extract should be investigated regarding the intermediary metabolic pathways of diabetes.

This study contributed to the field of knowledge at ascertaining the efficiency of HOMA-IR model in predicting and managing diabetes mellitus.

5.1. Contributions to Knowledge

HOMA-IR model works best at predicting and managing DM.

This research compared the blood analytes of non-diabetics, pre-diabetics, and diabetics in order to monitor the onset of diabetes and proffer possible solutions to enhance early detection and manage diabetes.

6. Conclusion

Insulin resistance is a major factor to the risk of developing diabetes mellitus type and it is important to predict and monitor this disease. However, several methods abound to predict and monitor it, but some are more effective and peculiar to some environments. The HOMA model is proven to be efficient in this regard

Compliance with ethical standards

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Disclosure of conflict of interest

There is no conflict of interest among the researchers regarding his work from its commencement to manuscript drafting and publication.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

References

[1] Greeve, J. Inhibition of the synthesis of apolipoprotein B containing lipoproteins. Handbook of Experimental Pharmacology, 2005; 170: 483–517.

[2] Lee JM Choudhury RP. Prospects for atherosclerosis regression: HDL elevation & other emerging therapeutic technologies. Heart, 2007; 93: 559–564

[3] Bray GA Medical consequences of obesity. Journal of Clinical Endocrinology & Metabolism, 2004l; 89: 2583-2589.

[4] Kahn, SE, Hull, RL, Utzschneider KM. Mechanisms linking obesity to insulin resistance & type 2 diabetes. Nature. 2006.

[5] Malik S, Wong N, Franklin S. Impact of the metabolic syndrome on mortality from coronary heart disease, cardiovascular disease, & all causes in United States adults. Circulation, 2004; 35(3): 191-197.

[6] Ford, ES. Risks for all-cause mortality, cardiovascular disease, & diabetes associated with the metabolic syndrome: a summary of the evidence. Diabetes Care, 2005;28(7), 1769–1778.

[7] Khan SE. The relative contributions of insulin resistance & beta-cell dysfunction to the pathophysiology of type 2 diabetes. Diabetologia, 2003; 46: 3-19.

[8] Biradar KV, Ramesh H, Malipatil M. Effect of L-Ascorbate on dexamethasone induced experimental insulin resistance-Role of oxidative stress. International Journal of Pharmaceutical & Biological Research, 2011; 2: 643-647.

[9] Binnert C, Ruchat S, Nicod N Dexamethasone-induced insulin resistance shows no gender difference in healthy humans. Diabetes & Metabolism, 2004; 30: 321-336.

[10] Dumas JF, Bielicki G, Renou JP. Dexamethasone impairs muscle energetics, studied by 31P NMR in rats. Diabetologia, 2005; 48: 328-335.

[11] Hans P, Vanthuyne A, Dewandre, P Y. Blood glucose concentration profile after 10 mg dexamethasone in non-diabetic & type 2 diabetes patients undergoing abdominal surgery. British Journal of Anaesthesia, 2006; 97: 164-170.

[12] Rhee MS, Perianayagam, A, Chen P. Dexamethasone treatment causes resistance to insulin-stimulated cellular potassium uptake in the rat. American Journal of Physiology-Cell Physiology, 2004; 287: C1229-C1237.

[13] International Diabetes Federation. IDF Diabetes Atlas. 7th edition. Brussels, Belgium: 2015.

[14] American Diabetic Association. Diagnosis & classification of diabetes mellitus. Position statement. Diabetes Care, 2014; 37(S1): S41-S48.

[15] Willett, WC. Dietary fat plays a major role in obesity. Obesity Reviews, 2002; 3(2): 59-68.

[16] Schaalan M, El-Abhar HS, Barakat M. Westernized-like-diet-fed rats: effect on glucose homeostasis, lipid profile, & adipocyte hormones & their modulation by rosiglitazone & glimepiride. Journal of Diabetes Complications, 2009; 23(3): 199-208.

[17] World Health Organization. Use of Glycated Haemoglobin (HbA1c) in the Diagnosis of Diabetes Mellitus. Abbreviated Report of a WHO Consultation. Geneva. 2011.

[18] Wild S, Roglic G, Green A. Global prevalence of diabetes: estimate for the year 2000 & projections for 2030. Diabetes Care, 2004; 127(5): 1047-1053.

[19] Vogeser, M. Fasting serum insulin & the Homeostasis Model of Insulin Resistance (HOMA-IR) in the monitoring of lifestyle interventions in obese persons. Clinical Biochemistry Zeitschrift, 2007; 40(13): 964-968.

[20] Maurer R. The Blood Code- Unlock the secret of your metabolism. Retrieved from www.thebloodcode.com 2014.

[21] Onyeagba RA, Ugbogu OC, Okeke CU. Studies on the antimicrobial effects of garlic (Allium sativum L.), ginger (Zingiber officinale R.) & lime (Citrus aurantifolia L.). African Journal of Biotechnology, 2004; 3(10): 552-554.

[22] Kannappan S, Jayaraman T, Rajasekar P. Cinnamon bark extract improves glucose metabolism & lipid profile in the fructose-fed rat. Singapore Medical Journal, 2006; 47(10): 858-863.

[23] McGill JB. The Link Between Diabetes & Obesity. American Association of Clinical Endocrinologists. Endocrine, 2005; 6(3): 13.

[24] Palmer BF. Clegg DJ. Electrolyte & Acid-Base Disturbances in Patients with Diabetes Mellitus. New England Journal of Medicine, 2015; 373(6): 548-559.

[25] Greenapple, R. Review of Strategies to Enhance Outcomes for Patients with Type 2 Diabetes: Payers' Perspective. American Health Drug Benefits, 2011; 4(6):377–386.

[26] Ogbonna SU. Ezeani IU. Risk Factors of Thyroid Dysfunction in Patients With Type 2 Diabetes Mellitus. Frontiers in Endocrinology (Lausanne), 2019; 10: 440.

[27] Biadgo B, Melku M, & Abebe SM. Hematological indices & their correlation with fasting blood glucose level & anthropometric measurements in type 2 diabetes mellitus patients in Gondar, Northwest Ethiopia. Diabetes, Metabolic Syndrome, Obesity: Targets & Therapy, 2016; 9: 91-99.

[28] Gkrania-Klotsas, E, Ye., Cooper, AJ Differential white blood cell count & type 2 diabetes: systematic review & meta-analysis of cross-sectional & prospective studies. PLoS One, 2010; 5(10), e13405.

[29] Ezenwaka, CE Jones-LeCointe, A, Nwagbara E. Anaemia & kidney dysfunction in Caribbean type 2 diabetic patients. Cardiovascular Diabetology, 2008; 7:25.

[30] Boden G. Pathogenesis of type 2 diabetes. Insulin resistance. Endocrinology & Metabolism Clinics of North America, 2001; 30: 801-815.