NIGERIAN JOURNAL OF LIFE SCIENCES

NJLS

ISSN 2276-7029
Volume 12, Number 1, 2022
Pages 9-13

Finnish Diabetes Risk Scores Positively Correlates Some Anthropometric Parameters in Young Adult Nigerians

[1]Nnamudi,* A. C.. [2]Orhue, N.E.J and [3]Ijeh, I. I.
Department of Biochemistry, PAMO University of Medical Sciences, Port Harcourt, Nigeria
Department of Biochemistry, University of Benin, Benin City, Nigeria
Department of Biochemistry, Michael Okpara University of Agriculture, Umudike, Nigeria

* Correspondence: annamudi@pums.edu.ng; https://doi.org/10.52417/njls.v12i1.281

Abstract
The prevalence of diabetes mellitus is increasing steadily. The Finnish Diabetes Risk Score (FINDRISC) was developed for the identification of individuals at risk of developing diabetes mellitus. The relationship between FINDRISC and biochemical and anthropometric parameters in young adult Nigerians has not been investigated, thus creating a knowledge gap. The aim of this study was to determine the relationship between FINDRISC and biochemical and anthropometric parameters in young adult Nigerian populations. A prospective cross-sectional study was conducted amongst 240 young adults (aged 15-35 years) without a previous diagnosis of diabetes, in an urban and rural location in Delta State. Participants filled out the FINDRISC questionnaire prior to a fasting blood glucose test while other biochemical and anthropometric measurements were done following standard protocols. Pearson correlation analysis was used to analyze the relationship between FINDRISC and the parameters of interest. FINDRISC had a significant ($p < 0.05$) positive correlation with Body Mass Index [$r = +0.596$ (rural); $r = +0.620$ (urban)]; Waist Circumference [$r = +0.609$ (rural); $r = +0.587$ (urban)] and Fasting Blood Sugar [$r = +0.364$ (urban)] in the study population. All other biochemical parameters did not show a significant correlation with FINDRISC. These findings provide compelling evidence to suggest that anthropometric parameters could play significant roles in the prediction of future diabetes risk in the population.

Keywords: FINDRISC; anthropometric; biochemical; correlation; young adults

Introduction
Diabetes mellitus is a chronic and progressive disease of multiple aetiologies involving defects in insulin secretion and/or action. Type-2 diabetes mellitus is the most common type. This metabolic disorder is hallmarked by sustained elevated blood glucose levels manifesting as chronic hyperglycemia (Nnamudi *et al.,* 2020). This is what potentiates the myriad of complications affecting bodily organs and tissues that is often associated with the condition (WHO, 2016). The socio-economic and financial burden of the disease is enormous. Global healthcare expenditure on people with diabetes amounting to USD 966 billion amply justifies the enormity (IDF, 2021). The increasing global prevalence of the disease in recent years is even more worrisome. In a period spanning over two decades (2000-2021), the global burden of diabetes estimated at 151 million in 2000 has more than tripled to reach 537 million in 2021 (IDF, 2000; 2021). This is a reflection of the dramatic rise from 425 million in 2017 to 463 million in 2019 and to the latest figure of 537 million released by the International Diabetes Federation in 2021 (IDF, 2017; 2019; 2021). This dramatic rise is not impressive. Sadly, even adolescents and young adults are not exempted from this dramatic rise in the global prevalence of diabetes mellitus (Lascar *et al.,* 2018).

There is a long intermediate latent prediabetes stage preceding the onset of the diabetes condition (Malindisa *et al.,* 2021) although all the individuals in the prediabetes state may not eventually progress along the continuum of dysglycemia to develop diabetes (Punthakee *et al.,* 2018). Identification of high-risk individuals can forestall the progression. This explains why individuals at increased risk of developing type-2 diabetes mellitus are major targets of interventions that are aimed at preventing the development of the disease (Lindström and Tuomilehto, 2003). There are widely available tools for the identification of individuals at risk of developing type-2 diabetes mellitus. The Finnish Diabetes Risk Score (FINDRISC), developed in Finnish population cohorts from 10-year prospective data (Lindström and Tuomilehto, 2003), is one of such diabetes risk assessment tools that is receiving enormous attention. FINDRISC is a reliable, inexpensive, non-invasive and quick tool that is easy to implement in the identification of individuals at high risk of diabetes susceptibility (Nnamudi *et al.,* 2020).

Although there are biochemical changes associated with the diabetes condition, data on these biochemical parameters in participants undergoing diabetes risk assessment are relatively unavailable. Whether these changes reflect on a non-invasive diabetes risk assessment tool such as FINDRISC is worth investigating. Additionally, the relationship between these biochemical parameters and risk scores are not well established, thus creating a knowledge gap. Therefore, the aim of this study was to determine some biochemical and anthropometric parameters and establish the relationship between these parameters and FINDRISC in young adult Nigerian populations.

Materials and Methods
Participants
This study involved young adults (aged 15-35 years) in an urban and rural location in Delta State, Nigeria. Sample size was determined using the Vaughan and Morrow's formular (Vaughan and Morrow, 1989). A total of 240 participants (50.0% rural, 50.0% urban) were selected by convenience sampling. However, participants were excluded from the study based on pregnancy, drug addiction, physical disability that impedes anthropometric measurements as well as a decline of consent.

Ethical Approval and Consent to Participate
This study received ethical approval from Delta State Ministry of Health Research Ethics Committee (MOHREC), Asaba, Nigeria (HM/596/T/55). Additionally, the study followed the guidelines of the 1964 Declaration of Helsinki and later versions. Participants read, understood and signed the informed consent form prior to participating in the study. All

participants' data were treated with anonymity and utmost confidentiality.

Anthropometric Measurement

Waist circumference and hip circumference were measured (in cm) using a non-stretchable measuring tape. Weight (in Kg) and height (in cm) were measured using a weighing scale and stadiometer, respectively. Participants were dressed in light clothing, with bare feet and in an erect posture.

From these measurements;

Waist-to-hip ratio (WHR) was determined as $WHR = \frac{Waist\ Circumference\ (cm)}{Hip\ Circumference\ (cm)}$

Body-mass-index (BMI) was determined as $BMI = \frac{Weight\ (Kg)}{Height\ (m)^2}$

Blood Pressure Measurement

Blood pressure measurement was done by a trained personnel, with participants remaining in a sitting position, having rested for about five minutes. The systolic blood pressure (SBP) and diastolic blood pressure (DBP) were taken at the 1st and 5th Korotkoff sounds, respectively. Two separate readings were taken per participant after an interval of two minutes and the average reading was eventually recorded.

Risk Scoring

Risk scoring was done using the Finnish diabetes risk scoring (FINDRISC) tool that consists of eight variable components. Component 1 was scored as 0; 2; 3 or 4 points if a participant was < 45 years; 45-54 years; 55-64 years or >64 years, respectively. Component 2 was scored as 1; 3 or 4 points if a participant had a BMI < 25 kg/m^2; 25-30 kg/m^2 or > 30 kg/m^2, respectively. Component 3 was scored as 0; 3 or 4 if a participant had a waist circumference < 94 cm (for men) < 80 cm (for women); 94-102 cm (for men) 80-88cm (for women) or > 102 cm (for men) > 88 cm (for women), respectively. Component 4 was scored as 0 or 2 points if a participant had at least 30 minutes of physical activity or less than that that, respectively. Component 5 was scored as 0 or 1 point if a participant had a consumption of vegetables, fruits or berries every day or not every day, respectively. Component 6 was scored 2 or 0 points if a participant regularly used anti-hypertensive drugs or not, respectively. Component 7 was scored 5 or 0 points if a participant had a previous diagnosis of high blood glucose or not, respectively. Component 8 was scored as 5; 3 or 0 points if a participant had a first degree relative diagnosed of diabetes; second degree relative diagnosed of diabetes or no family relative diagnosed of diabetes, respectively. Participants total risk score was determined as the sum of the scores from the different components.

Biochemical Analysis

Blood sample collection for biochemical analysis was preceded by an overnight fast of 10-12 hours. The concentration of fasting blood glucose was determined by the glucose oxidase method (Washako and Rice, 1961). The concentration of total cholesterol, HDL-cholesterol and triglycerides were determined by enzymatic colorimetric methods (Allain *et al.,* 1974; Lopes-Virella *et al.,* 1977; Tietz, 1990). LDL-cholesterol was determined by calculation (Friedewald *et al.,* 1972). Atherogenic index of plasma (AIP) was determined by calculation (Dobiásová and Frohlich, 2001). Atherogenic coefficient and cardiac risk ratio were determined by calculation (Ikewuchi and Ikewuchi, 2009; Frohlich and Dobiášová, 2003). Glycated hemoglobin was measured using immunoturbidimetric method while C-reactive protein was analyzed using enzyme-linked immunosorbent assay (ELISA) technique.

Statistical Analysis

Statistical analysis was done using *Statistical Package for the Social Sciences* (SPSS) version 23.0 (SPSS Inc Chicago IL). Descriptive statistics were expressed as Mean ± Standard Error of Mean (SEM) for continuous variables and as proportions for categorical variables. Differences in variables between genders were calculated using an independent samples t-test for continuous variables and a Chi-square test for categorical variables. Pearson's linear correlation analysis was used to assess the relationship between FINDRISC and other variables at a 95% confidence level. Statistical significance was fixed at $p < 0.05$.

Results

Although the females in the population had higher mean values of fasting blood sugar, BMI, WHR, Cholesterol and LDL-cholesterol, the values were not statistically significantly at the $p < 0.05$ level. Also, the mean values of systolic blood pressure, diastolic blood pressure and glycated hemoglobin was significantly ($p < 0.05$) higher in males relative to females (Table 1).

In Table 2, the females in the population had higher mean values of fasting blood sugar, triglycerides, atherogenic index of plasma, glycated hemoglobin, BMI, waist circumference and diastolic blood pressure relative to the males. These differences were not statistically significant at the $p < 0.05$ level.

In Table 3, the result of the Pearson correlation analysis showed that only BMI, WC and FBS had a significant positive correlation with FINDRISC. BMI was the most strongly positively correlated variable to FINDRISC, ($r\,(61) = +0.620$, $p < 0.001$).

In Table 4, the result of the Pearson correlation analysis showed that only BMI and WC had a significant positive correlation with FINDRISC. WC was the most strongly positively correlated variable to FINDRISC, ($r\,(19) = +0.609$, $p < 0.05$).

Table 1: Anthropometric and Biochemical Parameters of Urban Participants

Parameters	Total (n = 120)	Male (n = 55)	Female (n = 65)	*t*-test	*p* value
FBS (mg/dL)	101.09 ± 0.84	98.81 ± 1.09	102.91 ± 1.20	- 1.760	0.084
BMI (kg/m^2)	24.85 ± 0.40	24.30 ± 0.44	25.32 ± 0.65	- 1.626	0.106
Systolic BP (mmHg)	124.31 ± 1.50	133.96 ± 2.14	116.64 ± 1.55	4.768	< 0.001
Diastolic BP (mmHg)	77.22 ± 0.89	80.29 ± 1.47	74.79 ± 1.01	2.249	0.028
WC (cm)	84.57 ± 0.86	85.07 ± 1.28	84.17 ± 1.18	0.367	0.715
WHR	0.86 ± 0.005	0.86 ± 0.007	0.87 ± 0.006	- 0.420	0.676
Cholesterol (mg/dL)	251.30 ± 4.37	241.23 ± 6.13	259.30 ± 6.06	- 1.479	0.144
Triglycerides (mg/dL)	113.30 ± 3.79	116.87 ± 6.42	110.46 ± 4.50	0.597	0.553

Parameters	Total (n = 120)	Male (n = 55)	Female (n = 65)	*t*-test	*p* value
HDL-C (mg/dL)	93.60 ± 2.54	91.74 ± 4.77	95.07 ± 2.54	- 0.461	0.646
LDL-C (mg/dL)	135.04 ± 5.01	126.10 ± 7.33	142.13 ± 6.84	- 1.135	0.261
CRP (mg/dL)	2.72 ± 0.03	2.80 ± 0.08	2.65 ± 0.06	0.210	0.834
HbA1c (%)	3.89 ± 0.08	4.17 ± 0.11	3.67 ± 0.11	2.268	0.027
AIP	0.07 ± 0.0009	0.11 ± 0.0054	0.05 ± 0.0025	1.071	0.288
AC	1.92 ± 0.01	2.01 ± 0.06	1.85 ± 0.06	0.519	0.606
CRR	2.92 ± 0.01	3.01 ± 0.06	2.85 ± 0.06	0.519	0.606
FINDRISC	6.25 ± 0.33	4.76 ± 0.06	7.66 ± 0.42	- 6.361	< 0.001

Each value is represented as Mean ± SEM

FBS = Fasting Blood Sugar; BMI = Body Mass Index; BP = Blood Pressure; WC = Waist Circumference; WHR = Waist-to-Hip Ratio; HDL-C = High Density Lipoprotein-Cholesterol; LDL-C = Low Density Lipoprotein-Cholesterol; CRP = C-reactive protein; HbA1c = Glycated Hemoglobin; AIP = Atherogenic Index of Plasma; AC = Atherogenic Coefficient; CRR = Cardiac Risk Ratio.

Table 2: Anthropometric and Biochemical Parameters of Rural Participants

Parameters	Total (n = 120)	Male (n = 53)	Female (n = 67)	*t*-test	*p* value
FBS (mg/dL)	97.89 ± 0.65	96.28 ± 1.02	96.83 ± 0.88	– 0.737	0.471
BMI (kg/m^2)	20.76 ± 0.28	19.56 ± 0.32	21.45 ± 0.40	– 1.322	0.204
Systolic BP (mmHg)	119.52 ± 0.87	121.14 ± 1.33	118.58 ± 1.19	0.554	0.587
Diastolic BP (mmHg)	76.94 ± 0.93	76.00 ± 2.03	77.50 ± 0.87	– 0.301	0.767
WC (cm)	75.42 ± 0.58	72.00 ± 0.82	77.41 ± 0.71	– 1.935	0.070
WHR	0.84 ± 0.003	0.86 ± 0.004	0.83 ± 0.004	1.734	0.101
Cholesterol (mg/dL)	148.94 ± 2.37	159.30 ± 3.59	142.89 ± 3.05	1.359	0.192
Triglycerides (mg/dL)	137.88 ± 2.06	132.03 ± 2.36	141.30 ± 3.09	– 0.856	0.404
HDL-C (mg/dL)	64.77 ± 0.83	66.99 ± 1.51	63.47 ± 0.97	0.809	0.430
LDL-C (mg/dL)	56.59 ± 2.28	65.90 ± 2.84	51.16 ± 3.22	1.263	0.224
CRP (mg/dL)	2.14 ± 0.07	2.14 ± 0.11	2.14 ± 0.10	0.003	0.998
HbA1c (%)	4.11 ± 0.06	4.07 ± 0.08	4.14 ± 0.76	– 0.212	0.834
AIP	0.32 ± 0.009	0.29 ± 0.014	0.34 ± 0.093	– 0.899	0.381
AC	1.31 ± 0.03	1.39 ± 0.04	1.27 ± 0.05	0.726	0.477
CRR	2.31 ± 0.03	2.39 ± 0.04	2.27 ± 0.10	0.726	0.477
FINDRISC	3.58 ± 0.22	2.89 ± 0.30	4.65 ± 0.34	– 4.491	< 0.001

Each value is represented as Mean ± SEM

FBS = Fasting Blood Sugar; BMI = Body Mass Index; BP = Blood Pressure; WC = Waist Circumference; WHR = Waist-to-Hip Ratio; HDL-C = High Density Lipoprotein-Cholesterol; LDL-C = Low Density Lipoprotein-Cholesterol; CRP = C-reactive protein; HbA1c = Glycated Hemoglobin; AIP = Atherogenic Index of Plasma; AC = Atherogenic Coefficient; CRR = Cardiac Risk Ratio.

Table 3: Correlation between FINDRISC and Other Parameters in the Urban Participants

Parameters	FINDRISC	
	Pearson correlation *(r)*	Significance (2-tailed) *(p)*
Fasting Blood Sugar (FBS)	+ 0.364**	0.004
Cholesterol (Chol)	+ 0.006	0.965
Triglycerides (Trig)	– 0.028	0.828
HDL-Cholesterol (HDL-Chol)	+ 0.011	0.932
LDL-Cholesterol (LDL-Chol)	0.004	0.978
Atherogenic Index of Plasma (AIP)	– 0.141	0.279
Atherogenic Coefficient (AC)	– 0.117	0.369
Cardiac Risk Ratio (CRR)	– 0.117	0.369
C-reactive protein (CRP)	+ 0.161	0.215
Glycated Hemoglobin (HbA1c)	– 0.188	0.147
Body Mass Index (BMI)	+ 0.620**	< 0.001
Waist Circumference (WC)	+ 0.587**	< 0.001
Waist to hip ratio (WHR)	+ 0.218	0.092
Systolic Blood Pressure (SBP)	– 0.248	0.054
Diastolic Blood Pressure (DBP)	– 0.044	0.737

*** Correlation is significant at the 0.01 level (2-tailed)*

Table 4: Correlation between FINDRISC and Other Parameters in the Rural Participants

Parameters	FINDRISC	
	Pearson correlation *(r)*	Significance (2-tailed) *(p)*
Fasting Blood Sugar (FBS)	0.216	0.375
Cholesterol (Chol)	-0.170	0.487
Triglycerides (Trig)	0.228	0.348
HDL-Cholesterol (HDL-Chol)	-0.235	0.334
LDL-Cholesterol (LDL-Chol)	-0.133	0.587
Atherogenic Index of Plasma (AIP)	0.284	0.238
Atherogenic Coefficient (AC)	-0.015	0.951
Cardiac Risk Ratio (CRR)	-0.015	0.951
C-reactive protein (CRP)	-0.090	0.715
Glycated Hemoglobin (HbA1c)	-0.079	0.749
Body Mass Index (BMI)	0.596**	0.007
Waist Circumference (WC)	0.609**	0.006
Waist to hip ratio (WHR)	-0.335	0.161
Systolic Blood Pressure (SBP)	-0.203	0.404
Diastolic Blood Pressure (DBP)	0.219	0.368

*** Correlation is significant at the 0.01 level (2-tailed)*

Discussion

The onset of diabetes mellitus is preceded by risk factors that contribute to diabetes risk. These risk factors could be determined as anthropometric or biochemical parameters. The exact role and extent of causal involvement of anthropometric and biochemical parameters in diabetes risk status and onset of diabetes mellitus appear relatively elusive. This holds true since the accurate prediction of absolute risk from diabetes risk scores is still uncertain (Buijsse *et al.,* 2011).

This study reported a significant positive correlation between FINDRISC and anthropometric parameters, especially body mass index and waist circumference. This finding is in tandem with a previous study that reported a positive correlation between FINDRISC and BMI (Mahmoud *et al.,* 2021). Obesity is hallmarked by parameters of adiposity such as BMI and waist circumference. Our finding is therefore not unexpected since obesity contributes to diabetes risk and increasing prevalence of the disease (Nguyen *et al.,* 2011; Haluzík *et al.,* 2020).

The positive correlation between FINDRISC and fasting blood glucose concentration in this study agrees with a recent study (Mahmoud *et al.,* 2021). Despite being also a measure of glycemia, FINDRISC showed no significant positive correlation with glycated hemoglobin in this current study. This is at variance with a recent study which reported that the incorporation of glycated hemoglobin with the FINDRISC test could improve the identification of individuals at risk of diabetes due to their significant association (López-Balderas *et al.,* 2021). Arising from the significant positive correlation between FINDRISC and fasting blood sugar concentration in this study, it may be plausible to compare this finding with a previous study that reported a weak but significant correlation between blood glucose concentration and measures of obesity, with the exception of BMI in males. The study also posited that higher muscle mass in the sampled males may explain the lack of correlation since BMI is not sufficiently effective in distinguishing between bone, muscle and fat mass (Ejike *et al.,* 2015). This is evidenced in both metabolically-healthy-obese and metabolically-obese-normal-weight phenotypes previously reported in adult and young adult Nigerian populations (Ijeh *et al.,* 2010; Nnamudi *et al.,* 2020[b]).

There was no significant correlation between FINDRISC and biochemical parameters in this young adult population. A previous report had also shown that FINDRISC had no significant correlation with parameters such as systolic blood pressure, triglyceride, total cholesterol and HDL-cholesterol. However, apart from the correlation with fasting blood glucose, our findings are at variance with this particular study that conversely reported significant association between FINDRISC and parameters such as waist-to-hip ratio, diastolic blood pressure, LDL-cholesterol and mean arterial pressure (Malindisa *et al.,* 2019).

Beyond the prospect of achieving non-invasiveness in diabetes risk prediction, the lack of correlation of biochemical parameters with FINDRISC may explain why the incorporation of biochemical parameters in risk scoring tools is not commonplace. Indeed, most risk scores do not incorporate these biochemical parameters into their models. Additionally, it is highly probable that metabolic defects sufficient to elicit corresponding metabolic changes in biochemical parameters are yet to occur in these participants. Moreover, the participants in this study are supposedly healthy and may not be having underlying pathological conditions capable of eliciting physiological and biochemical changes.

Conclusion

These findings provide compelling evidence to suggest that some anthropometric parameters could play significant roles in the prediction of future diabetes risk in the population. We theorize the probable usefulness of these anthropometric parameters in diabetes risk prediction. This is a research perspective to be explored in future studies

Acknowledgments:

The Federal Government of Nigeria is hereby acknowledged for the award of a Federal Government Postgraduate Scholarship to Dr. Anthony Chibuzor Nnamudi. The authors are grateful to all the young adults who participated in this study. The authors are equally grateful to Okwukwe Elizabeth Ibegbulem, Ifeoma Agatha Onyeche and Nwachukwu Onyeuteh for their invaluable assistance in data collection.

Funding:
This study was supported by a Federal Government of Nigeria Postgraduate Scholarship (FSBA/FGSS/18/PG/015) awarded to Dr. Anthony Chibuzor Nnamudi.

References

Allain, C.C., Poon, L.S., Chan, C.S.C., Richmond, W. and Fu, P.C. (1974). Enzymatic colorimetric method for cholesterol estimation. *Clinical Chemistry*. 20: 470-475.

Buijsse, B., Simmons, R.K., Griffin, S.J. and Schulze, M.B. (2011). Risk Assessment Tools for Identifying Individuals at Risk of Developing Type 2 Diabetes. *Epidemiologic Reviews.* 33: 46-62.

Dobiásová, M. and Frohlich, J. (2001). The plasma parameter log (TG/HDL-C) as an atherogenic index: correlation with lipoprotein particle size and esterification rate in apoB-lipoprotein-depleted plasma (FER_{HDL}). *Clinical Biochemistry*. 34: 583-588.

Ejike, C.E.C.C., Uka, N.K. and Nwachukwu, S.O. (2015). Diabetes and pre-diabetes in adult Nigerians: Prevalence, and correlations of blood glucose concentrations with measures of obesity. *African Journal of Biochemistry Research*. 9(3): 55-60. https://doi.org/10.5897/AJBR2015.0817.

Friedewald, W.T., Levy, R.I. and Fredickson, D.S. (1972). Estimation of the concentration of LDL cholesterol in plasma, without use of the preparative ultracentrifuge. *Clinical Chemistry*. 18: 499–502.

Frohlich, J. and Dobiášová, M. (2003). Fractional Esterification Rate of Cholesterol and Ratio of Triglycerides to HDL-Cholesterol Are Powerful Predictors of Positive Findings on Coronary Angiography. *Clinical Chemistry.* 49(11): 1873-1880. https://doi.org/10.1373/clinchem.2003.022558.

Haluzík, M., Hrádková, V., Kudláčková, M. and Jakubíková, I. (2020). Obesity treatment in patients both with and without diabetes: current options and perspectives. *Casopís Lékařů Českých*. 159(3-4): 136-140.

Ijeh, I.I., Okorie, U. and Ejike, C.E.C.C. (2010). Obesity, metabolic syndrome and BMI-metabolic-risk sub-phenotypes: A study of an adult Nigerian population. *Journal of Medicine and Medical Sciences*. 1(6): 254-260.

Ikewuchi, C.J. and Ikewuchi, C.C. (2009). Alteration of Plasma Lipid Profiles and Atherogenic Indices by *Stachytarpheta jamaicensis* L. (Vahl). *Biokemistri.* 21(2): 71-77.

International Diabetes Federation (IDF). (2000). Diabetes Atlas (1st edition). International Diabetes Federation: Brussels, Belgium.

International Diabetes Federation (IDF). (2017). Diabetes Atlas (8th edition). International Diabetes Federation: Brussels, Belgium. https://www.diabetesatlas.org

International Diabetes Federation (IDF). (2019). Diabetes Atlas (9th edition). International Diabetes Federation: Brussels, Belgium. https://www.diabetesatlas.org

International Diabetes Federation (IDF). (2021). Diabetes Atlas (10th edition). International Diabetes Federation: Brussels, Belgium. https://www.diabetesatlas.org

Lascar, N., Brown, J., Pattison, H., Barnett, A.H., Bailey, C.J. and Bellary, S. (2018). Type 2 diabetes in adolescents and young adults. *The Lancet Diabetes & Endocrinology*. 6(1): 69-80. https://doi.org/10.1016/S2213-8587(17)30186-9.

Lindström, J. and Tuomilehto, J. (2003). The diabetes risk score: a practical tool to predict type 2 diabetes risk. *Diabetes Care*. 26(3): 725-731.

Lopes-Virella, M.F., Stone, P., Ellis, S. and Colwell, J.A. (1977). Cholesterol determination in high-density lipoproteins separated by three different methods. *Clinical Chemistry*. 23(5): 882-884.

López-Balderas, N., González, B., Rosas, F., López, E. and Torres, R. (2021). Correlación del Finnish Diabetes Risk Score y la Hemoglobina Glucosilada en la Identificación de Diabetes y Prediabetes en Docentes Universitarios de Ciencias de la Salud. *Ciencia e Innovación en Salud.* 137: 289-297.

Mahmoud, H.H., Kamel, M.F. and Gomaa, A.R. (2021). Screening For Type 2 Diabetes Mellitus In Adult Population in Beni-Suef Governorate. *Egyptian Journal of Medical Research (EJMR)*. 2(2): 1-12.

Malindisa, E.K., Balandya, E., Mashili, F. and Njelekela, M. (2021). Is the FINDRISC Tool Useful in Screening Type 2 Diabetes and Metabolic Syndrome in an African Setting? Experience among Young Adults in Urban Tanzania. *Diabetology*. 2: 240-249.

Nguyen, N.T., Nguyen, X.M.T., Lane, J. and Wang, P. (2011). Relationship Between Obesity and Diabetes in a US Adult Population: Findings from the National Health and Nutrition Examination Survey, 1999–2006. *Obesity Surgery.* 21: 351-355.

Nnamudi, A.C., Orhue, N.E.J. and Ijeh, I.I. (2020). Assessment of the FINDRISC tool in predicting the risk of developing type 2 diabetes mellitus in a young adult Nigerian population. *Bulletin of the National Research Centre.* 44: 186. https://doi.org/10.1186/s42269-020-00440-7.

Nnamudi, A.C., Orhue, N.E.J., Ijeh, I.I., Etim, O.E. and Eke-Ogaranya, I.N. (2020). Obesity, Metabolic Abnormalities, Metabolic Syndrome and BMI-Metabolic-Risk Sub-Phenotypes among Young Adult Nigerians. *Haya: Saudi Journal of Life Sciences.* 5(6): 90-97.

Punthakee, Z., Goldenberg, R. and Katz, P. (2018). Definition, Classification and Diagnosis of Diabetes, Prediabetes and Metabolic Syndrome. *Canadian Journal of Diabetes.* 42: 10-15.

Tietz, N.W. (1990). Clinical guide to laboratory tests. 2nd edition. WB Saunders Company, Philadelphia, USA. pp. 554-556.

Vaughan, J.P. and Morrow, R.H. (1989). Manual of Epidemiology for District Health Management. World Health Organization: Geneva; pp. 126-128.

Washako, M.E. and Rice, E.W. (1961). Determination of glucose by an improved enzymatic procedure. *Clinical Chemistry*. 7: 542-545.

World Health Organization (WHO). (2016). Global Report on Diabetes. Part 1: Global burden of diabetes. World Health Organization: Geneva.