ARTICLE 9

Auteurs : C. G. Metonnou-Adanhoume, V. Agueh, **C.S.Azandjeme,** C. J. Sossa, A. Kpozehouen, J. Hessou, J. Darboux, M. N. Paraïso.

Titre: Optimal Threshold of the Finnish Diabetes Risk Score (Findrisc) for Screening at-Risk Adults in an African Population in Southern Benin.

Références : Universal Journal of Public Health. 2019, volume 7, numéro 2, pages: 63 - 72

URL de l'article :
http://www.hrpub.org/journals/article_info.php?aid=7905

DOI :

Indexation:NLM Catalog, ProQuest, EBSCO A-to-Z, J-Gate, JournalTOCs, WorldCat, Academickeys, Google Scholar

Facteur d'Impact :

ISSN-ISBN : 2331-8880

Site web : http://www.hrpub.org/journals/jour_info.php?id=76

Universal Journal of Public Health

Horizon Research Publishing Corporation

Universal Journal of Public Health

Universal Journal of Public Health is an international peer-reviewed journal that publishes original and high-quality research papers in all areas of public health. As an important academic exchange platform, scientists and researchers can know the most up-to-date academic trends and seek valuable primary sources for reference.

ISSN: 2331-8880 (Print)
ISSN: 2331-8945 (Online)

Contact Us: ujph.editor@hrpub.org or editor@hrpub.org
Website: http://www.hrpub.org/journals/jour_info.php?id=76

Indexing

NLM Catalog
The NLM Catalog provides access to NLM bibliographic data for journals, books, audiovisuals, computer software, electronic resources and other materials. It contains detailed MEDLINE indexing information for the journals in PubMed and other NCBI databases.

NSD - Norwegian Centre for Research Data
NSD is one of the largest archives for research data of its kind and provides data to researchers and students in Norway and abroad. Additionally, NSD is a resource centre, which assists researchers with regard to data gathering, data analysis, and issues of methodology, privacy and research ethics.

EBSCO A-to-Z
As the most complete resource listing service available, EBSCO A-to-Z ensures users can access a library's entire online collection including e-journals, titles in full-text databases and e-journal packages, and e-books.

J-Gate
J-Gate is an electronic gateway to global e-journal literature and provides seamless access to millions of journal articles available online offered by 12,307 publishers. It presently has a massive database of journal literature, indexed from 40,690 e-journals with links to full text at publisher sites.

JournalTOCs
JournalTOCs is the largest, free collection of scholarly journal Tables of Contents(TOCs). It is for researchers, students, librarians and anyone looking for the latest scholarly articles.

Ulrich
Ulrichsweb helps librarians and patrons avoid the frustration and time-consuming process of gathering serials information in bits and pieces from multiple sources. Only Ulrichsweb brings together the latest bibliographic, provides details you need in one location and delivers the highest level of serials coverage, across 383,000 serials, 977 subject areas and 200 languages.

WorldCat
WorldCat is the world's largest network of library content and services. WorldCat libraries are dedicated to providing access to their resources on the Web, where most people start their search for information.

Journals Information

Special Issues Information

Academickeys
Academic Keys maintains a database of academic journals for many academic disciplines.

Google Scholar
Google Scholar provides a simple way to broadly search for scholarly literature. It helps you find relevant work across the world of scholarly research.

Geneva Foundation for Medical Education and Research
Geneva Foundation for Medical Education and Research provides a remarkably detailed section of links to information on the full spectrum of practices in traditional and alternative medicine.

Electronic Journals Library
Electronic Journals Library is a cooperative service of currently more than 550 libraries and institutions. It offers easy and convenient access to electronically published scientific journals in full text.

Researchbib
Research Bible is open access with high standard indexing database for researchers and publishers.

Berlin Social Science Center
The WZB library is oriented primarily towards social and economic sciences. Extensive services complement and facilitate access to numerous print and electronic information sources.

Information Matrix for the Analysis of Journals
Information Matrix for the Analysis of Journals is a comprehensive, collaborative and transparent tool with an integrating approach that provides an up-to-date journal database.

Polish Scholarly Bibliography
Polish Scholarly Bibliography is a portal of the Polish Ministry of Science and Higher Education, collecting information on publications of Polish scientists and Polish and foreign scholarly journals.

Horizon Research Publishing Corporation

Universal Journal of Public Health

Universal Journal of Public Health is an international peer-reviewed journal that publishes original and high-quality research papers in all areas of public health. As an important academic exchange platform, scientists and researchers can know the most up-to-date academic trends and seek valuable primary sources for reference.

ISSN: 2331-8880 (Print)
ISSN: 2331-8945 (Online)

Contact Us: ujph.editor@hrpub.org or editor@hrpub.org
Website: http://www.hrpub.org/journals/jour_info.php?id=76

Journals Information

Special Issues Information

Editorial Board

Editor-in-Chief

Prof. Fatma Hassan
Faculty of Medicine, Suez Canal University, Egypt

Editorial Board

Prof. Andrew Hund
United Arab Emirates University, United Arab Emirates

Prof. Irène Georgescu
University of Nice, Business School, France

Prof. Doug Dix
University of Hartford, USA

Prof. Kris Wong
Faculty of Science and Technology, Technological and Higher Education Institute of Hong Kong, China

Prof. Danila De Vito
University of Bari, Italy

Prof. Ould Dehah Cheikh Mohamed El Hafed
Université des Sciences de Technologie et de Médecine, Mauritania

Prof. Ibrahim Kabbash
Department of Public Health & Community Medicine, Faculty of Medicine, Tanta University, Egypt

Prof. Faris Al Lami
Baghdad College of Medicine, Iraq

Prof. Hamid Hussain
Faculty of Medicine, Dubai Residency Training Program, University of Baghdad, Iraq

Prof. Khadiga Dandash
Suez Canal University, Egypt

Prof. Mona Mohamed Abou El khair Al Sadek Radwan
Department of Public Health, Medicine Faculty, Zagazig University, Egypt

Prof. Amrinder Singh
Guru Nanak Dev University, India

Prof. Tahani Elfaham
Faculty of Pharmacy, Assiut University, Egypt

Prof. Nailya Almagambetova
School of Nursing & Health Studies, Faculty of Public Health & Health Education, College of Health and Human Sciences, Northern Illinois University, USA

Prof. Dan Clement Kaseje
Great Lakes University of Kisumu, Kenya

Prof. Rowshan Begum
Department of Reproductive & Child Health, Bangladesh University of Health Sciences, Bangladesh

Prof. Tsan Yang
Department of Health Business Administration, Meiho University, Taiwan

Prof. Saleh Rahman
Department of Medical Education UCF College of Medicine, USA

Dr. Dongying Ma
National Institute of Allergy and Infectious Diseases, USA

Dr. Gihane Endrawes
University of Western Sydney, Australia

Dr. Hayri Baran Yosmaoglu
Department of Physiotherapy, Faculty of Health Science, Baskent University, Turkey

Dr. Annesha Lovett
Mercer University, USA

Dr. Stella Kwok
Industrial Liaison Office, Technological and Higher Education Institute of Hong Kong, Hong Kong

Dr. Caroline Barakat
University of Ontario Institute of Technology, Canada

Dr. Rustom Jafari
Ministry of Health, Syria

Dr. Nagah Selim
Department of Public Health, Cairo University, Egypt

Dr. Sami Ali
Dubai Health Authority, United Arab Emirates

Dr. Fadia Albuhairan
King Saud bin Abdulaziz University for Health Sciences, Saudi Arabia

Dr. Mamdouh El Bahnasawy
Military Institute of Health and Epidemiology, Military Medical Academy, Egypt

Dr. Raed Bahelah
Department of Epidemiology, Robert Stempel College of Public Health and Social Work, Florida International University, USA

Dr. Yousef Mohammad
King Saud University, Saudi Arabia

Dr. Ghazi Sharkas
Arab Board of Community Medicine, Jordan

Dr. Qusay Abdulateef Abood
Basrah Health Directorate, Iraq

Horizon Research Publishing Corporation

Universal Journal of Public Health Vol. 7(2), pp. 63 - 72
DOI: 10.13189/ujph.2019.070204
Reprint (PDF) **(222Kb)**

Optimal Threshold of the Finnish Diabetes Risk Score (Findrisc) for Screening at-Risk Adults in an African Population in Southern Benin

C. G. Metonnou-Adanhoume [1,*], V. Agueh [1], C. S. Azandjeme [1], C. J. Sossa [1], A. Kpozehouen [2], J. Hessou [1], J. Darboux [1], M. N. Paraïso [1]

[1] Department of Health Promotion, Regional Institute of Public Health, University of Abomey, Benin

[2] Department of Epidemiology and Biostatistics, Regional Institute of Public Health, University of Abomey, Benin

Journals Information

Aims & Scope
Editorial Board
Guidelines
Submit Manuscript

ABSTRACT

Universal Journal of Public Health 7(2): 63-72, 2019 http://www.hrpub.org
DOI: 10.13189/ujph.2019.070204

Optimal Threshold of the Finnish Diabetes Risk Score (Findrisc) for Screening at-Risk Adults in an African Population in Southern Benin

C. G. Metonnou-Adanhoume[1,*], V. Agueh[1], C. S. Azandjeme[1], C. J. Sossa[1], A. Kpozehouen[2], J. Hessou[1], J. Darboux[1], M. N. Paraïso[1]

[1]Department of Health Promotion, Regional Institute of Public Health, University of Abomey, Benin
[2]Department of Epidemiology and Biostatistics, Regional Institute of Public Health, University of Abomey, Benin

Copyright©2019 by authors, all rights reserved. Authors agree that this article remains permanently open access under the terms of the Creative Commons Attribution License 4.0 International License

Abstract This study aims to determine the performance of the FINDRISC tool for screening adults at risk for type2 diabetes in an African population in southern Benin. This retrospective study included 536 subjects aged 25 to 65 years. The FINDRISC questionnaire score was calculated using seven components: age, body mass index, waist circumference, regular practice of 30 minutes of physical activity, regular consumption of five portions of fruits and vegetables, the family history of diabetes and the presence of high blood pressure. The performance of the tool was determined from the FINDRISC score and fasting blood glucose The "Receiver Operator Characteristic" (ROC) Curve of the FINDRISC score was used to define the optimal cut-off value of the tool for. The FINDRISC threshold-optimal value for detecting T2D risk in southern Benin was 8.5 with 77% sensitivity, 89% specificity, 45% positive predictive value and 71% negative predictive value. The area under the ROC curve was 0.86 (95% CI: 0.81-0.90). This study revealed that the optimal threshold value for detecting the medium or high risk of T2D observed in Benin is lower than Finland's one. Further studies including larger and more representative samples need to be carried out to confirm this finding.

Keywords Optimal Threshold, FINDRISC Score, Prevention, Type2 Diabetes, Benin

1. Introduction

The prevalence of type2 diabetes (T2D) is increasing worldwide to reach nearly epidemic proportions. As populations age and urbanization intensifies, the threat of T2D will continue to grow [1]. Diabetes is expected to reach 642 million people worldwide by 2040 [2]. In 2015, the International Diabetes Federation (IDF) has estimated that 9.5 to 29.3 million people live with diabetes in the African Region of which, ¾ are undiagnosed [2]. According to IDF, 80% of people with diabetes live in low- and middle-income countries. T2D represents 90% of cases and is associated with several complications, leading to morbidity, disability and premature mortality [2, 3]. Diabetes also carries a heavy economic burden for patients, households and health care systems [4, 5]. Prevention remains the best cost effective intervention to counteract this disease. Many studies have shown that interventions at pre-diabetic stage based on lifestyle changes [6-10] or medications [11] can prevent, or at least delay the progression of the disease. This means that early identification of people at high risk of T2D is necessary to enable faster implementation of preventive measures in order to reduce risk [12, 13]. The prevention of the disease is very cost-effective [14, 15]. Fasting blood glucose, 2h oral glucose tolerance test (OGTT) and glycated hemoglobin levels (HbA1c) are the recommended methods for diabetes screening [16]. However, those methods are expensive for mass screening. Several risk scores are available and can help to identify subjects at risk for type2 diabetes. Before being used in practice, performance and validity of the tools should be evaluated in the population of interest [17]. The FINDRISC for the Screening of Subjects at Risk for Type2 Diabetes is a powerful and valid tool in several Northern countries [18-22].

However, this tool has not been much validated in black populations. Compared to other tools that use some metabolic syndrom components (triglycerides levels, OGTT) to predict T2D in adults [23, 24], FINDRISC score is cost-effective because the questionnaire easy to completed without need of blood test. Also, score calculation and its interpretation is easy. In our study, the FINDRISC score was made by comparing this score to

fasting blood glucose values (mmol/l). The objective of the study was to examine the performance of the FINDRISC tool in selecting adults at risk for T2D in an African population.

2. Materials and Methods

2.1. Setting

The study took place in the economic capital of Benin Republic that is Cotonou, and in urban and rural areas of Ouidah city. These areas are located in the South of the country bordering the Atlantic Ocean. Cotonou city has 13 districts that include 140 neighborhood covering an area of 79 km^2 [25]. The population of Cotonou is estimated at 679012 inhabitants in 2012 [26]. The township of Ouidah is located at 50 km from Cotonou with an estimated population of 162034 inhabitants in 2007, situed on an area of 363 km^2 [26]. The urban area are divided into 70 neighborhood, while the rural area are subdivided into 38 villages.

2.2. Study Design

This was a retrospective study that used data from a previous study performed on cardio-metabolic risk factors, lifestyle and diet in Benin Republic from August 2005 to February 2006. A national survey [27] of the same populations as in this study (sample size = 5126) yielded an average fasting glucose level of 5.17 mmol / l ± 3.27. This average blood glucose level in 2015 compared to the average blood glucose level in this study in 2006, does not show a significant difference between the two means with p-value = 0, 9974. We assume that there is probably no significant difference between the other components of the Findrisc score between 2006 and 2015.

2.3. Study Population

2.3.1. Inclusion and Exclusion Criteria

The study was set for adults, aged 25 to 65 years at the time of the study. Participant were included in condition there are in good health i.e. no cardiometabolic disorders (hypertension, heart disease, diabetes or other metabolic disease), born of black Beninese parents and grandparents and live in Ouidah or Cotonou cities permanently for at less 6 months at the moment of the study. We excluded pregnant and lactating women, people with a critical health condition (bedridden) and those with physical or mental disability.

2.3.2. Sample Size

Minimum sample size

By fixing the error of the first species α at 5% and that of the second species β at 20%, the minimum area under the ROC1 curve at 0.60, the negative case ratio (low FINDRISC) on positive cases (high FINDRISC) at 4 and the area under the ROC curve under the null hypothesis at 0.5, a population of 480 subjects was sufficient to use the area under the ROC curve to assess the performance of the FINDRISC score using the MedCalc software.

For the study 541subjects were randomly selected from Cotonou, the largest city (n = 200), Ouidah, a small town (n = 171) and surrounding rural areas of Ouidah (n = 170).

Out of the 541 subjects, five (05) had high blood glucose levels and were excluded, then 536 subjects remain for the study.

2.4. Sampling

2.4.1. Selection of Subjects during the Study in 2006

Random sampling was performed as described below. In Cotonou, the main urban town, ten out of the 140 neighbourhood were chosen randomly. Per neighbourhood, 20 households were chosen randomly based on the list of households. In each household, an eligible adult was randomly chosen, male and female alternatively. A total of 200 subjects were selected.

In a smaller town, Ouidah as sub-urban area, five out of the 22 neighbourhoods were selected by random. In each neighbourhoods, 34 compounds were randomly selected from the list of compound after assigning number to them. In the household of the compound, an eligible adult is chosen to participate in the study. A total sample of 171 subjects was obtained.

In the rural area of Ouidah, five villages were randomly selected from the 38 existing. A census of the number of hamlets of each selected village was made. The list of families per village has been drawn up. 34 families were drawn randomly from the total list of families in each selected village. The selection of a household per family and then of an adult among the eligible adults of the selected household was done. A sample of 165 subjects was obtained.

2.5. Data Collection

Anthropometric measurements were taken by trained investigators. Venous blood samples were collected in the morning after 12 hours fasting. Those blood samples were kept in ice and centrifuged within two hours. The obtained serum samples were stored at -30 °C until analysis in the biochemistry laboratory of the Institute of Applied Biomedical Sciences (ISBA) of Cotonou.

2.6. Variables and Their Measurements

2.6.1. Age

Age was obtained by interview and has been classified into four groups according to FINDRISC criteria: less than 45 years old=0 point; 45 to 55 years=2 points old=; 55 to 64

years old=3points; 64 years old and more=4 points.

2.6.2. Body Mass Index (BMI)

BMI was calculated using measurements of weight (kg) and height (m). Three groups were set with corresponding FINDRISC score as followed: BMI <25= 0 points; 25-30 =1 point; > 30 =2 points.

2.6.3. Waist Circumference (WC)

WC was measured using a flexible, unstretched graduated measuring tape with an accuracy of 0.1 cm. The tape was placed midway between the last rib and the iliac crest [14]. The IDF thresholds: 94 cm for men and 80 cm for women were used to detect with abdominal obesity. WC has been classified into three groups as followed:

- WC < 94 cm for men and WC <80 cm for women: Findrisk score = 0 points
- WC = 94-102 cm for men and WC =80-88 cm for women: Findrisk score = 3 points
- WC > 102cm for men and WC > 88 for women: Findrisk score = 4 points.

2.6.4. Blood Pressure (BP)

Systolic and diastolic measurements were made using a mercury sphygmomanometer placed on the left arm of each seated subject [28]. Two measurements were taken in 10-minutes intervals with the subject at rest for at least five minutes. For the same individual, the measurements were taken by the same person. The arithmetic mean of the obtained values during the two successive measurements have been used [29]. A harmonized definition was used to define high BP (systolic BP $\geq$ 130 mmHg or diastolic BP $\geq$ 85 mmHg). BP has been classified into two groups: 0 points for normal BP and 2 points for a high BP.

2.6.5. Fruit and Vegetable Consumption

The level of fruit and vegetable consumption has been assessed from three non-consecutive 24h reminders according to WHO standards [30]. For the FINDRISC questionnaire, this variable was classified into two groups: 0 points for daily consumption of fruits and vegetables > 400g and 1 point for daily consumption of fruits and vegetables <400g.

2.6.6. Regular Physical Exercises

Physical exercises data were collected using a questionnaire inspired by the WHO Chronic Disease Monitoring Questionnaire. The intensity of physical exercises is evaluated according to the energy consumption induced. Thus, low, medium and high intensity exercises are distinguished [31]. According to the WHO recommendations witch required 30mn of physical exercise per day [32], subjects are divided into two groups: the least active subjects and the active subjects. A physical exercise score of 0 points and 2 points was assigned to each of those groups.

2.6.7. Family History of Diabetes

This variable was documented by completing the questionnaire. The subjects are classified into three groups: 0 points for subjects with no family history of diabetes; 3 points for subjects with a family history of diabetes related to 2nd rank parents (grandparents, uncle, aunt, cousin); 5 points for subjects with a family history of diabetes related to first rank parents (father, mother, brother, sister)

2.6.8. Determination of the FINDRISC Score

The FINDRISC score is calculated by summing the scores attributed to the variables: age, BMI, waist circumference, blood pressure, regular consumption of fruit and vegetables, regular practice of 30 minutes of physical exercise, family history of diabetes and history of treatment of High blood pression. History of diabetes treatment was removed from the score calculation. The total score of each subject (maximum of 21) provides the level of T2D risk. This total score were rank as followed: very low (<7), low (7-11), moderately high (12-14), high (15-20) and very high.

2.6.9. Measurement of Blood Glucose

Blood glucose test was done in the laboratory of biochemistry of the Institute of Applied Biomedical Sciences (ISBA) of Cotonou. Venous blood samples (10 ml) were drawn after an over-night fast of 12 hours and were centrifuged within two hours. Fasting plasma glucose was determined using the glucose oxidase method. Serum concentrations of high-density lipoprotein Cholesterol (HDL) and Triglycerides were analyzed by enzymatic methods with certified laboratory standards from the USA. The blood glucose was classified according to the IDF/WHO standards: normal (<6.1 mmol/l), High blood glucose for fasting glucose (6.1-6,9 mmol/l) and intolerance glucose (6,9-7 mmol/l [31, 33].

2.7. Data Analysis

The data were analysed with IBM SPSS Statistics 21 (IBM United States 2012) and Stata/SE 11.0 (StataCorp 2009). The quantitative variables were expressed as the mean followed by the standard deviation. Qualitative variables were expressed as a percentage. The Receiver Operator Characteristic (ROC) curve was used to determine the performance of the FINDRISC tool in selecting subjects at risk for T2D in this study compared to the fasting blood glucose test. FINDRISC threshold-optimal was determined by the point corresponding to the maximum value of the sensitivity. Using the Youden index calculated by the formula (sensitivity+ specificity – 1) [34], we determined the risk score thresholds for both maximum sensitivity and specificity predicting the onset of type 2 diabetes. The statistical significance level for the tests was set at $p < 0.05$.

2.8. Ethical Considerations

In the previous study, the data used was approved by the ethics committees of the Faculty of Medicine of University of Montreal and the Benin Ministry of Health. Written informed consent was obtained from each participant prior to his/her admission into the study.

3. Results

3.1. Sample Description

The general features of the participants were described in Table 1. The mean age was 3.06 ± 10.01 for men and 38 ± 10.05 for women. Comparing women to men had, a BMI (26.0 vs 22.3), waist circumference (88.0 vs 82.2) and HDL (1.48 vs 1.38) higher. However, men had higher triglycerides (0.81 vs 0.68).

3.2. Participant's FINDRISC Score in Different Study Areas

Subjects with high FINDRISC were almost twice as numerous in urban areas as in peripheral areas with p = 0.000 (Table 2).

3.3. Classification of Participants

Women have a significantly higher risk score than men, when considering subgroups moderately high (74.2% vs. 25.97%), high (81.81% vs. 18.18%) and very high (66.66% vs. 33.33%) (Table 3**).**

Table 1. Socio-demographic, biological and clinical characteristics of participants by sex

	Men (n= 269)		Women (n= 267)		p-value
	%	Mean	%	Mean	
Area					
Rural	36.5		39.3		0.062
Sub-urban	37.7		38.1		
Urban	25.8		22.6		
Tobacco					
Current smokers	8.1		0.4		0.257
Former smokers	12.9		0.7		
No smoking	79.0		98.9		
Alcohol consumption					
High consumption	10.0		6.3		0.362
Moderate consumption	55.7		30.4		
Non consumption	34.3		63.3		
Age (years)		37.06±10.01		38.77±10.05	0.271
BMI (kg/m^2)		22.3 ± 3.8		26.0 ± 6.1	**0.002**
Waist circumference (cm)		82.2 ± 10.4		88.0 ± 13.7	**0.001**
Systolic BP (mmHg)		124.0 ± 16,9		125.7 ± 21.4	0.376
Diastolic BP (mmHg)		76.9 ± 11,4		77.5 ± 12.3	0.695
Glycemia (mmol/l)		4.82 ± 0,8		4.83 ± 0.8	0.959
Triglyceridemia (mmol/ l)		0.81 ± 0,5		0.68 ± 0.3	**0.001**
HDL- C (mmol/l)		1.38 ± 0,5		1.48 ± 0.4	**0.009**

Table 2. Participant's FINDRISC Score by gender

	Men n (%)	Women n (%)	p
FINDRISC (score)			**0.001**
Very low (<7)	222 (60.65)	144 (39.34)	
Low (7- 11)	22 (27.84)	57 (72.15)	
Moderately high (12-14)	20 (25.97)	57 (74.02)	
High (15-20)	2 (18.18)	9 (81.81)	
Very high (>20)	1 (33.33)	2 (66.66)	

Table 3. Participant by areas

	Rural areas of Ouidah n (%)	Sub-urban areas of Ouidah n (%)	Urban areas of Cotonou n (%)	p
Gender				**0.062**
Male	36.5	37.7	25.8	
Female	39.3	38.1	22.6	
FINDRISC Score				**0.001**
High	47 (21.5)	69 (37.2)	103 (47)	
Low	118 (37.2)	102 (32.2)	97 (30.6)	

Table 4. Participant's FINDRISC Score by glycaemic status

	FINDRISC score n (%)					
	Very low (<7)	Low (7- 11)	Moderately high (12-14)	High (15-20)	Very high (>20)	p
Glycaemic status						**0.01**
Normal glycemia	366(100)	78(98.74)	70(90.90)	5(45.45)	0(0.0)	
Abnormal glycemia	00(0.0)	1(1.26)	3(3.90)	0(0.0)	0(0.0)	
Glucose Intolerance	00(0.0)	00(0.0)	4(5.20)	6(54.55)	3(100)	

3.4. FINDRISC Score According to the Subjects' Glycaemic Status

All subjects with a very low FINDRISC score had low glycaemic status, but all subjects with a very high FINRISC score all had glucose intolerance with p = 0.01 (Table 4).

3.5. Performance of FINDRISC Compare to Glycemia in Detection of at-Risk Subjects

Findrisc score have high performance to detect at-risk subjects as identified by the blood glucose test. The area under the ROC curve of the test was 0.86 (95% CI: [0.81-0.90]) as shown in Figure 1, with sensitivity of 77%, specificity of 89%, positive predictive value of 45% and a negative predictive value of 71%. The optimal risk score for identifying at-risk subjects was 8.5. The Youden index is 0.655. (Table 5).

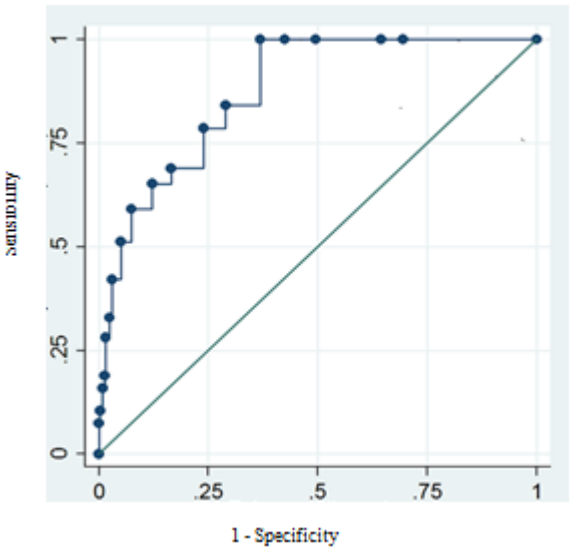

Figure 1. ROC curve of the FINDRISC score

Table 5. FINDRISC threshold values obtained according to specificity, sensitivity and Youden index

FINDRISC Score	Specificity	Sensitivity	Youden index
-0.0	0.0	1.000	0.000
0.5	0.246	1.000	0.246
1.5	0.338	1.000	0.338
2.5	0.446	1.000	0.446
3.5	0.509	1.000	0.509
4.5	0.574	1.000	0.504
5.5	0.662	0.844	0.506
6.5	0.727	0.826	0.553
7.5	0.796	0.771	0.564
8.5	**0.887**	**0.768**	**0.65**
9.5	0.896	0.622	0.518
10.5	0.912	0.489	0.401
11.5	0.941	0.400	0.341
12.5	0.967	0.289	0.256
13.5	0.980	0.244	0.224
14.5	0.992	0.178	0.170
15.5	0.994	0.089	0.083
16.5	0.996	0.067	0.061
17.00	0.998	0.022	0.022
20.00	1.000	0.022	0.020
23.00	1.000	0.000	0.000

4. Discussion

This study is one of the first in sub-Saharan Africa trying to evaluate the performance of the FINDRISC score in the detection of subjects at risk for type2 diabetes. Apart of the validation of the tool, the study identified the threshold-optimal point for the type2 diabetes risk score. The results showed that the optimal threshold of the FINDRISC score for detection of high blood glucose is 8.5 with high sensitivity of 77%, high specificity of 77%. Potential subjects at risk of autoimmune diabetes are reported to be very poorly represented in this study because age of study subjects is between 25 and 65 years of age and type 1 diabetes (T1D) is often diagnosed in children and adolescents [33, 35]. In addition, it has been shown that type 2 diabetes covers 90% of diabetes [29]. In addition, it is increasingly recognized that type 1, autoimmune diabetes can occur at older ages [36, 37]. With the increase in the prevalence of obesity in the world, more young people develop TD2, and many cases of TD1 become obese [38]. The emergence of adults with type 1 diabetes requires the adoption of new strategies for managing the disease [39]. Deficiencies of essential nutrients are thought to be involved in the onset of type 1 diabetes and cardiovascular disease [40]. One study suggested that adopting a westernized diet may increase the risk of diabetes especially in the high-risk population [41].In the case of pancreatitis, type 3c diabetes appears most often after the diagnosis of pancreatitis [42]. It is not always easy to diagnose and classify a patient with type 3c diabetes mellitus properly. A review of studies currently available on this topic suggests a prevalence of 5% to 10% for type 3c diabetes mellitus among all cases of diabetes mellitus in Western populations [43].

Nutrition education and lifestyle delay the onset of diabetes whatever the nature of diabetes, consideration of at-risk individuals of any type of diabetes is necessary to delay or prevent the appearance of the disease. Of course, these other types of diabetes are very poorly represented in the general population. For the present study, at-risk subjects considered are mainly for type 2 diabetes. Other types of diabetes have not been explored

4.1. The Performance of the FINDRISC Tool in Identifying Subjects at Risk for Type2 Diabetes

The research of an optimal threshold ideally requires to take into account epidemiological (disease prevalence) and medico-economic data (treatment cost, cost of adverse effects of treatment) [32]. In those conditions, when disease has an expensive treatment and serious side effects, the number of false positives should be reduced as possible,

so a high sensitivity should be chosen. In opposite, some diseases have serious complications that can be avoided if simple treatment is set up early, so the test would have high specificity. The principle was respected for the threshold value of type2 diabetes risk score obtained in our study. The threshold-value has a higher specificity than sensitivity. This can be explained by the fact that diabetes has serious complications that can be avoided with early treatment [33].

Olamoyegun and al. have shown that the FINDRISC tool provides an accurate estimate of the risk of type2 diabetes in a black population in Nigeria in 2017 [44]. On the other hand, the tool performs better when the prevalence of diabetes is not high [45].

4.2. Optimal Threshold for the Prediction of Type2 Diabetes with the FINDRISC Tool on Adults in Benin

We observed that the optimal threshold-value of risk score for Benin people is 8.5. Higher FINDRISC score thresholds were found in several studies.

In Algeria in 2014, the threshold-value obtained is 13 for women and 11 men and the FINDRISC score has been validated as a high performance tool with excellent ability to predict type2 diabetes mellitus in the Algerian community [46]. Those FINDRISC score thresholds are high compared with the threshold found in our study.

In addition, the threshold used in Caucasians studies, which ranges from 11 to 15 in most FINDRISC questionnaire validation studies is higher than that of our study. Optimal thresholds used were higher or equal to 11 [20, 21, 47-49].

On the other hand, we have noted optimal thresholds of diabetes risk scores very similar to ours in a few studies aiming the validation of the tool. For example in Bergmann and al.'s study [12] where only six components were used instead of the eight components of FINDRISC, the optimal threshold-value obtained was 9. This finding is similar to the original study of diabetes risk score for the prediction of risk of type2 diabetes where the family history component of diabetes has not been taken into account [18]. In other words, the optimal risk thresholds for type 2 diabetes close to the threshold value observed in our study did not take into account all the current components of the FINDRISC questionnaire as for our study. The higher thresholds observed compared to our threshold could be due to the values of several components of the questionnaire that are different for race and ethnic. For example, for the age component of the tool, several Caucasian studies have reported a mean age greater than that of our study [12, 19, 21, 36]. This increase in age could lead to an increase in the risk score in this population [12, 21, 47, 49]. Several studies conducted in South Africa have suggested threshold values of waist circumference different from those currently used for African populations [50-52]. In addition, a study that looked at the optimal threshold-values of cardiometabolic risk for sub-Saharan Africans in 2015, revealed that the threshold-values of Benin people are different from those used for sub-Saharan Africans. The optimal WC cut-off points to predict the presence of at least one other component of the metabolic syndrome was 80 cm for men and 90 cm in women [53]. This difference in waistline threshold values between different population, especially for black and Caucasian subjects may explain the low diabetes risk score in sub-Saharan black subjects. However, in a study conducted in Nigeria in 2017 on the performance of the FINDRISC questionnaire to screen subjects with dysglycemia and undiagnosed subjects for type 2 diabetes, the threshold-value was 14[44]. This study, therefore pointed out that the FINDRISC questionnaire provide a precise estimate of the absolute risk for screening for type2 diabetes and that the tool should be recommended in poor countries with insufficient resource for diabetes detection.

In North Africa, the FINDRISC score has been validated as a high performance tool with excellent ability to predict the development of type2 diabetes mellitus in the Algerian community with a threshold-value of 13 for women and 11 men in 2014 [46]. Those FINDRISC score thresholds are high compared with the threshold found in our study. This difference could be explained by the difference between the dates of the different studies. In fact, the data used in this study dates back to 2006 when the study conducted in Nigeria used 2012 data and that of Algeria used the 2014 data.

This study has some limitations. It was carried out only in the southern part of Benin and, therefore, the extrapolation of the results to other parts of the country requires some caution. In this study, we did not perform oral glucose tolerance test or glycated hemoglobin test (HbA1C), that are the best tests recommended to detect diabetes. The study was based only on fasting blood glucose levels. The risk factors for type2 diabetes that make up the questionnaire were calculated from a database that measured all those parameters. Larger studies of Africans living in different settings will be needed to advocate for specific risk thresholds for type2 diabetes in black populations.

5. Conclusions

This study conducted in southern Benin showed satisfactory results. The study have validated the Findrisc questionnaire and its score and identified the threshold-optimal value of the risk score for detection of type 2 diabetes in black populations like Beninese population. This threshold-optimal value of risk scores in Benin is lower than the threshold used in Caucasians. In view of the increasing prevalence of T2D and the economic costs of the disease, early identification of high-risk T2D

subjects with simple and valid tool as Findrisc score is a public health priority that must be encouraged in developing countries like Benin Republic. Other studies including larger and more representative samples need to be done to reinforce our study findings.

Acknowledgements

We are very grateful to participants in the study.

Funding

None.

Conflict of Interest

The authors declare no conflict of interest.

REFERENCES

[1] C. C. Cowie, K. F. Rust, E. S. Ford, M. S. Eberhardt, D. D. Byrd-Holt, C. Li, D. E. Williams, E. W. Gregg, K. E. Bainbridge, S. H. Saydah: Full accounting of diabetes and pre-diabetes in the US population in 1988–1994 and 2005–2006**.** Diabetes care, 32,287-294, 2009.

[2] International Diabetes Federation. ATLAS 7th edition. 2015.

[3] M. O'Shea, M. Teeling, K. Bennett: The prevalence and ingredient cost of chronic comorbidity in the Irish elderly population with medication treated type 2 diabetes: a retrospective cross-sectional study using a national pharmacy claims database**.** BMC health services research, 13, 23, 2013.

[4] K. Alouki, H. Delisle, S. Besançon, N. Baldé, A. Sidibé-Traoré, J. Drabo, F. Djrolo, J.-C. Mbanya, S. Halimi: Simple calculator to estimate the medical cost of diabetes in sub-Saharan Africa**.** World journal of diabetes,6,1312, 2015.

[5] J. M. Kirigia, H. B. Sambo, L. G. Sambo, S. P. Barry: Economic burden of diabetes mellitus in the WHO African region**.** BMC international health and human rights, 9,6, 2009.

[6] G. Asaad, D. C. Soria-Contreras, R. C. Bell, C. B. Chan: Effectiveness of a lifestyle intervention in patients with type 2 diabetes: The Physical Activity and Nutrition for Diabetes in Alberta (PANDA) trial. In *Healthcare* Multidisciplinary Digital Publishing Institute; 73, 2016.

[7] Q. Gong, E. Gregg, J. Wang, Y. An, P. Zhang, W. Yang, H. Li, Y. Jiang, Y. Shuai, B. Zhang: Long-term effects of a randomised trial of a 6-year lifestyle intervention in impaired glucose tolerance on diabetes-related microvascular complications: the China Da Qing Diabetes Prevention Outcome Study**.** Diabetologia, 54,300-307, 2011.

[8] T. Orchard, M. Temprosa, E. Barrett-Connor, S. Fowler, R. Goldberg, K. Mather, S. Marcovina, M. Montez, R. Ratner: Long-term effects of the Diabetes Prevention Program interventions on cardiovascular risk factors: a report from the DPP Outcomes Study**.** Diabetic Medicine, 30,46-55, 2013.

[9] S. M. Haffner, S. Lehto, T. Rönnemaa, K. Pyörälä, M. Laakso: Mortality from coronary heart disease in subjects with type 2 diabetes and in nondiabetic subjects with and without prior myocardial infarction**.** New England journal of medicine, 339,229-234, 1998.

[10] S. Sonomtseren, Y. Sankhuu, J. Warfel, D. Johannsen, C. Peterson, B. Vandanmagsar: Lifestyle modification intervention improves glycemic control in Mongolian adults who are overweight or obese with newly diagnosed type 2 diabetes**.** Obesity science & practice, 2,303-308, 2016.

[11] U. Hostalek, M. Gwilt, S. Hildemann: Therapeutic use of metformin in prediabetes and diabetes prevention**.** Drugs, 75, 1071-1094, 2015.

[12] A. Bergmann, J. Li, L. Wang, J. Schulze, S. Bornstein, P. Schwarz: A simplified Finnish diabetes risk score to predict type 2 diabetes risk and disease evolution in a German population**.** Hormone and metabolic research, 39,677-682, 2007.

[13] B. Paulweber, P. Valensi, J. Lindström, N. Lalic, C. Greaves, M. McKee, K. Kissimova-Skarbek, S. Liatis, E. Cosson, J. Szendroedi: A European evidence-based guideline for the prevention of type 2 diabetes**.** Hormone and metabolic research, 42, S3-S36, 2010.

[14] J. Leal, D. Ahrabian, M. Davies, L. Gray, K. Khunti, T. Yates, A. Gray: Cost-effectiveness of a pragmatic structured education intervention for the prevention of type 2 diabetes: economic evaluation of data from the Let's Prevent Diabetes cluster-randomised controlled trial**.** BMJ open, 7, e013592, 2017.

[15] Y. Sun, W. You, F. Almeida, P. Estabrooks, B. Davy: The effectiveness and cost of lifestyle interventions including nutrition education for diabetes prevention: a systematic review and meta-analysis**.** Journal of the Academy of Nutrition and Dietetics, 117,404-421. e436, 2017.

[16] American Diabetes Association: Diagnosis and classification of diabetes mellitus**.** Diabetes care, 37,S81-S90, 2014.

[17] S. R. Barber, M. J. Davies, K. Khunti, L. J. Gray: Risk assessment tools for detecting those with pre-diabetes: A systematic review**.** Diabetes research and clinical practice, 105,1-13, 2014.

[18] J. Lindström, J. Tuomilehto: The diabetes risk score: a practical tool to predict type 2 diabetes risk, Diabetes care, 26,725-731, 2003.

[19] T. Saaristo, M. Peltonen, J. Lindström, L. Saarikoski, J. Sundvall, J. G. Eriksson, J. Tuomilehto: Cross-sectional evaluation of the Finnish Diabetes Risk Score: a tool to identify undetected type 2 diabetes, abnormal glucose tolerance and metabolic syndrome Diabetes and vascular disease research, 2, 67-èé, 2005.

[20] G. Štiglic, N. Fijačko, A. Stožer, A. Sheikh, M. Pajnkihar:

Validation of the Finnish Diabetes Risk Score (FINDRISC) questionnaire for undiagnosed type 2 diabetes screening in the Slovenian working population. Diabetes research and clinical practice, 120, 194-197, 2016.

[21] M. P. Silvestre, Y. Jiang, K. Volkova, H. Chisholm, W. Lee, S. D. Poppitt: Evaluating FINDRISC as a screening tool for type 2 diabetes among overweight adults in the PREVIEW: NZ cohort. Primary care diabetes, 11,561-569, 2017.

[22] S. A. Meijnikman, E. M. C. D. Block, A. Verrijken, I. Mertens, L. F. V. Gaal: Predicting type 2 diabetes mellitus: a comparison between the FINDRISC score and the metabolic syndrome. Diabetology & metabolic syndrome, 10, 2-6, 2018.

[23] M. P. Stern, K. Williams, S. M. Haffner: Identification of persons at high risk for type 2 diabetes mellitus: Do we need the oral glucose tolerance test? Annals of internal medicine, 136,575-581, 2002.

[24] A. M. Kanaya, C. L. W. Fyr, N. d. Rekeneire, R. I. Shorr, A. V. Schwartz, B. H. Goodpaster, A. B. Newman, T. Harris, E. Barrett-Connor: Predicting the development of diabetes in older adults: the derivation and validation of a prediction rule. Diabetes care, 28, 404-408, 2005.

[25] Mairie de Cotonou: Plan de Développemnt Communal consulté le 18 Février 2018 www.ancb-benin.org/pdc-sdac-monographies/PDC/Littoral /PDC_Cotonou.pdf.

[26] Institut National de Statistique et d'Analyse Economique du Bénin: RGPH4 Effectif de la population 2013.

[27] Organisation Mondiale de la Santé: Rapport enquête Stepwise Bénin. Publisher, 2015.

[28] R. D. Feldman, N. Campbell, P. Larochelle, P. Bolli, E. D. Burgess, S. G. Carruthers, J. S. Floras, R. B. Haynes, G. Honos, F. H. Leenen: 1999 Canadian recommendations for the management of hypertension. Canadian Medical Association Journal, 161,S1-S17, 1999.

[29] International Diabetes Fondation: The IDF consensus worldwide definition of the metabolic syndrome. Brussels, Belgium, 2006.

[30] World Health Organization: Diet, nutrition and the prevention of chronic diseases: report of a joint WH. 2003.

[31] World Health Organization: Definition, diagnosis and classification of diabetes mellitus and its complications: report of a WHO consultation. Part 1, Diagnosis and classification of diabetes mellitus. Geneva: World health organization; 1999.

[32] L. Fezeu, B. Balkau, E. Sobngwi, A.-P. Kengne, S. Vol, P. Ducimetière, J.-C. Mbanya: Waist circumference and obesity-related abnormalities in French and Cameroonian adults: the role of urbanization and ethnicity. International journal of obesity,34,446, 2010.

[33] Fédération Internationale de Diabète: Atlas du diabete (8ème édition). 2017.

[34] W. J. Youden: Index for rating diagnostic tests. Cancer, 3, 32-35, 1950.

[35] K. Cerolsaletti, W. Hao, C. J. Greenbaum: Genetics Coming of Age in Type 1 Diabetes, Diabetes care, 42,189-191, 2019.

[36] J. P. Palmer, I. B. Hirsch: What's in a name: latent autoimmune diabetes of adults, type 1.5, adult-onset, and type 1 diabetes. Am Diabetes Assoc; 2003.

[37] R. A. Oram, K. Patel, A. Hill, B. Shields, T. J. McDonald, A. Jones, A. T. Hattersley, M. N. Weedon: A type 1 diabetes genetic risk score can aid discrimination between type 1 and type 2 diabetes in young adults. Diabetes care, 39,337-344, 2016.

[38] R. F. Hamman, R. A. Bell, D. Dabelea, R. B. D'agostino, L. Dolan, G. Imperatore, J. M. Lawrence, B. Linder, S. M. Marcovina, E. J. Mayer-Davis: The SEARCH for Diabetes in Youth study: rationale, findings, and future directions. Diabetes care, 37, 3336-3344, 2014.

[39] J. Saylor, K. M. Hanna, C. J. Calamaro: Experiences of College Students Who Are Newly Diagnosed With Type 1 Diabetes Mellitus. Journal of pediatric nursing, 44,74-80, 2019.

[40] E. Matteucci, S. Passerai, M. Mariotti, F. Fagnani, I. Evangelista, L. Rossi, O. Giampietro: Dietary habits and nutritional biomarkers in Italian type 1 diabetes families: evidence of unhealthy diet and combined-vitamin-deficient intakes. Eur J Clin Nutr, 59,114, 2005.

[41] L. Qi, M. C. Cornelis, C. Zhang, R. M. Van Dam, F. B. Hu: Genetic predisposition, Western dietary pattern, and the risk of type 2 diabetes in men The American journal of clinical nutrition, 89, 1453-1458, 2009.

[42] N. Ewald, P. D. Hardt: Diagnosis and treatment of diabetes mellitus in chronic pancreatitis. World journal of gastroenterology: WJG, 19, 7276, 2013.

[43] Y. Cui, D. K. Andersen: Pancreatogenic diabetes: special considerations for management. Pancreatology, 11,279-294, 2011.

[44] O. A. Michael, O. Rotimi, I. O. Sandra: The Performance of the Finnish Diabetes Risk Score (FINDRISC) Questionaire for Screening Individuals with Undiagnosed Type 2 Diabetes and Dysglycaemia in Nigeria. 2017.

[45] M. Azzouz, L. Yergui, M. Guerchani, A. Meftah, S. Mimouni, A. Boudiba: Evaluation de l'apport du score de risque Finlandais (FINDRISC) seul et combiné à la glycémie à jeun dans l'identification du diabète et du prédiabète. In *Annales d'Endocrinologie* Elsevier Masson; 2014: 403.

[46] M. Azzouz, A. Boudiba, M.-K. Guerchani, Y. Lyes, R. Hannachi, H. Baghous, A. Meftah, S. Mimouni: Apport du score de risque finlandais FINDRISC dans l'identification de la dysglycémie dans une population algéroise, Algérie. Médecine des Maladies Métaboliques,8,532-538, 2014.

[47] A. S. Meijnikman, C. E. Block, A. Verrijken, I. Mertens, L. F. Gaal: Predicting type 2 diabetes mellitus: a comparison between the FINDRISC score and the metabolic syndrome. Diabetology & metabolic syndrome, 10,12, 2018.

[48] T. Saaristo, M. Peltonen, J. Lindström, L. Saarikoski, J. Sundvall, J. G. Eriksson, J. Tuomilehto: Cross-sectional evaluation of the Finnish Diabetes Risk Score: a tool to identify undetected type 2 diabetes, abnormal glucose tolerance and metabolic syndrome. Diabetes and vascular disease research, 2, 67-72, 2005.

[49] G. Štiglic, P. Kocbek, L. Cilar, N. Fijačko, A. Stožer, J. Zaletel, A. Sheikh, P. Povalej Bržan: Development of a screening tool using electronic health records for undiagnosed Type 2 diabetes mellitus and impaired fasting glucose detection in the Slovenian population**.** Diabetic Medicine, 35,640-649, 2018.

[50] W. J. Kalk, B. I. Joffe, A. E. Sumner: The waist circumference of risk in black South African men is lower than in men of European ancestry**.** Metabolic syndrome and related disorders, 9,491-495, 2011.

[51] A. A. Motala, T. Esterhuizen, F. J. Pirie, M. A. Omar: The prevalence of metabolic syndrome and determination of the optimal waist circumference cutoff points in a rural South African community**.** Diabetes care, DC_101921, 2011.

[52] J. Prinsloo, L. Malan, J. De Ridder, J. Potgieter, H. Steyn: Determining the waist circumference cut off which best predicts the metabolic syndrome components in urban Africans: the SABPA study**.** Experimental and Clinical Endocrinology and Diabetes, 119,599, 2011.

[53] C. Sossa, V. D. Agueh, D. E-M. Ouendo, N. M. Paraizo, C. Azandjemè, A. Kpozehouen, C. Metonnou, J. Saizonou, L. T. Ouédraogo, M. Makoutodé: Determination of the optimal waist circumference cut-off points in Benin adults**.** Open Journal of Epidemiology, 5, 2015.