Predicting type 2 diabetes mellitus among fishermen in Cape Coast: a comparison between the FINDRISC score and the metabolic syndrome

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RESEARCH ARTICLE

Predicting type 2 diabetes mellitus among fishermen in Cape Coast: a comparison between the FINDRISC score and the metabolic syndrome

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Abstract

Background Studies over the past decades have observed a sharp rise in the prevalence and incidence of type 2 diabetes mellitus (T2DM). A highly sensitive and specific predictive tool for risky populations is essential. This study assessed two significant diabetes mellitus predictive tools for effectiveness and accuracy among people living in fishing communities in Cape Coast, Ghana.

Method In April 2019, we recruited one hundred and thirty-five (135) fishermen from three fishing communities in Cape Coast in the Central Region of Ghana. Each participant underwent a standard metabolic procedure including clinical examination as well as taking of anthropometric variables such as weight, height, waist and hip circumference were also measured. The FINDRISC questionnaire was used to gather data from the respective participants. Serum glucose and lipids were estimated with enzymatic techniques, and metabolic syndrome (MetS) screened with the international diabetes federation (IDF) criteria.

Results Of the 135 participants, 71 (52.6%) were women. The average age of study participants was 52 ± 16 years with females averagely older (56.6 ± 15.0) than the males (47.3 ± 15.0). This study recorded 31.1% and 8.9% prediabetic and diabetic fishermen respectively. Frequency of both prediabetes and diabetes was significantly predominant among females (71.4% vs 83.3%) than males (26.2% vs 25.0%) ($p < 0.001$) respectively. Prevalence of MetS according to the IDF criteria was 18.5%, significantly higher among females (92.0%) than recorded among the males (18.5%). The discriminatory accuracy of FINDRISC [aROC = 0.76 (95% CI 0.68 to 0.83); sensitivity = 58.3% and specificity = 86.9%; $p = 0.003$; optimal cut-off point = 13.50] and the MetS [aROC = 0.74 (95% CI 0.66 to 0.81); sensitivity = 75.0% and specificity = 71.5%; $p = 0.002$] despite demonstrating a significantly good capacity to detect T2DM were statistically comparable [aROC = 0.018 (95% CI -0.152 to 0.189); $p = 0.834$] in our study.

Conclusion Our findings indicate that both FINDRISC (with a suitable cut-off value of 13.5) and MetS screening tools possess a good predictive capacity for the detection of T2DM. Additionally, FINDRISC can be employed to detect MetS in a high-risk population.

Keywords Diabetes · Metabolic syndrome · FINDRISC · Fishing communities

Introduction

Available data indicates that in 2006, approximately 250 million people globally had diabetes, and this is projected to increase to 380 million by the year 2025 [1, 2]. The prevalence of type 2 diabetes mellitus (T2DM) accounts for 85–95% of the total cases of diabetes mellitus as of 2015 [3]. This proportion, according to the International Diabetes Federation (IDF), is estimated to rise drastically from 415 to 642 million by 2040 [1, 4–6]. Currently, a fasting plasma glucose (FPG) of ≥7.0 mmol/l or 2 h post 75 g oral glucose load ≥11.1 mmol/l is

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diagnostic of diabetes mellitus [7]. T2DM poses a long asymptomatic pre-clinical pre-diabetic phase of mild to moderate hyperglycaemia. About 20–30% of T2DM patients develop microvascular and macrovascular complications. These complications include retinopathy, nephropathy, neuropathy and cardiovascular disease and pose a threat to the affected individual's quality of life [4]. Unfortunately, a significant number of people, about 80–90% remained undiagnosed [2]. Since T2DM often starts as asymptomatic, it is prudent to have early detection tools for screening purposes [8]. Patients with glucose intolerance or type 2 diabetes mellitus most likely present with metabolic syndrome (MetS). This is a condition defined as a cluster of insulin resistance and disturbed glucose metabolic states, overweight and abdominal fat distribution, dyslipidaemia and high blood pressure [9, 10]. The widely used tools for assessing T2DM are the Finnish Diabetes Risk Score (FINDRISC), and metabolic syndrome [6]. The FINDRISC is widely used compared to the MetS, because it is less expensive, less labour intensive, and less invasive [11]. The FINDRISC consists of eight questions on age, body mass index (BMI), waist circumference (WC), physical activity, dietary consumption of fruits, vegetables, and berries, use of antihypertensive medication, history of high blood glucose, and family history of diabetes [12]. In contrast, metabolic syndrome requires measuring waist circumference, triglyceride, HDL cholesterol, blood pressure, and fasting plasma glucose [13]. Many studies have delved into the diagnostic accuracy of the two screening criteria together or singly with different results reported [4, 6, 11]. This study, determined and compared the predictive capacities of the two screening instruments to detect T2DM among apparently healthy fishermen.

Materials and methods

Study design and setting

This study employed a cross sectional design conducted in April 2019. It included one hundred and thirty-five (135) fishermen from three fishing communities in the Central Region of Ghana, West Africa. The communities had a total population of 31,968 comprising 1039, 7375 and 23,554 for Duakor, Ola, and Moree, respectively [14–16]. Ola and Duakor are located in the Cape Coast Metropolitan Assembly while Moree is located in the Abura-Asebu-Kwamankese District. These three towns were conveniently selected for this study because they were a few metres from the shores of the Gulf of Guinea. Prior to the study, authors sampled few of the potential participants in the selected communities to probe certain information authors deemed significant for purposes of inclusion criteria. Majority of the fishermen and women as well was retired fishermen and women when asked how long it would take for one to fully become abreast with the nitty-gritties of the fishing business indicated that three months was enough for any person to go up sea alone for fishing. Retired fishermen and women on the other hand indicated that owing to the fact that fishing in itself was a tedious affair it required that people dealing in the business had to put in a great deal of physical strength to be able to carry on with their duties as far as the work was concerned. As a consequence, post retiring, three months sitting in the house was enough a period to grow fatigue, weak and sometimes developing certain adverse health conditions they never thought of. Based on the above reasons, authors therefore postulated that for a levelled baseline data to be obtained such that all participants do not differ in terms of exposure to the physical environment, temperature, etc., the periodic bracket of stay in the and exit from the fishing business should be three months and beyond and three months or less respectively. Therefore, in this study, participants who either had fishing or fish related business as the primary occupation within that fishing community for three months or more and those who had retired from the fishing activity for not more than three months were included.

Sample calculation

Using the online instrument 'Check Market Sample Size Calculator' (CMSSC) [17] with an assumed fishermen population of 180 (no existing statistical data on fishermen population in the districts), 5% margin of error and a confidence interval of 95%, a minimum sample size of 123 fishermen was obtained however 135 fishermen were recruited in this study.

Ethical consideration

Ethical clearance was obtained from the Institutional Review Board of the University of Cape Coast with the ethical clearance identification number UCCIRB/CHAS/2019/76. Written informed consent was also obtained from each participant who agreed to participate in the study.

Questionnaire

The questionnaire contained two parts giving the appropriate divisions to allow data collection for both the MetS and the FINDRISC. Two new questions regarding alcoholism and smoking status of the participants were added to the eight (8) FINDRISC questions. They were purposely added to enrich the data as alcohol and smoking are linked to T2DM [18, 19].

Anthropometric measurements

Anthropometric measurements of all participants excluding laboratory tests were performed in the morning with participants in their fasting states. The set of questionnaires was given to each participant and subsequently completed with the assistance of a trained medical laboratory scientist. Multipurpose weight and height scale (Yonkang Zhezhong Weighing Apparatus, China) was used to measure bodyweight of the participants to the nearest 0.1 kg and height to the nearest 0.1 cm. These measurements were taken with participants standing erect, back straight, heels together, barefooted, and in light-weighted clothing. Body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2). Waist circumference (WC) (cm) was assessed at the end of expiration, with a Gulick II spring-loaded measuring tape (Gay Mills, WI) midway between the inferior angle of the ribs and the suprailiac crest just below the level of the umbilicus [20]. The body mass index (BMI) of each participant was calculated as the ratio between the weight (kg) and the square of the height (m^2). Waist and hip circumferences were measured according to the techniques used by Meijnikman [6] and the waist to hip ratio (WHR) calculated by dividing the waist circumference (cm) by the hip circumference (cm).

Blood pressure determination

The blood pressure (BP in mmHg) of each participant was determined using the sphygmomanometer and the stethoscope.

Laboratory measurements

After an overnight fast (8–12 h) venous blood sample of about 4 ml was collected from the median cubital vein of the study participants into a gel (serum separator tube) tube. Fasting blood glucose (FBG) was determined using the glucometer (Sinocare, China) and the glucose strip. The collected venous blood sample was allowed to clot and subsequently centrifuged at 3000 g for 4 min using a centrifuge (Centurion Scientific Ltd., UK). The serum was stored at -4 °C until assayed for lipids [total cholesterol (TC), triglyceride (TG) and high-density lipoprotein cholesterol (HDL-C)] using a spectrophotometer. Low-density lipoprotein cholesterol (LDL-C) was then calculated using the Frederickson-Friedwald's formula; $\text{LDL-C} = \text{TC} - \frac{TG}{2.2} - \text{HDL-C}$ [21]. The methods adopted for the determination of the above parameters (TC, TG and HDL-C) were predetermined by the reagent manufacturer (Medsource Ozone Biomedicals Pvt. Ltd., India).

Metabolic syndrome criteria

This study employed the International Diabetes Federation (IDF) criteria to diagnose metabolic syndrome among the study participants. In the new definition by the IDF [22], metabolic syndrome can be diagnosed if central obesity (waist measurement >90 cm for men or > 80 cm for women) is accompanied by any 2 of the following four factors: (1) TG levels of 1.7 mmol/L or higher, (2) an HDL cholesterol lower than 1.03 mmol/L for men or lower than 1.29 mmol/L for women, (3) a blood pressure (BP) of 130/85 mmHg or higher or treatment of previously diagnosed hypertension, and (4) a fasting blood glucose (FBG) of 5.6 mmol/L or greater or previously diagnosed T2DM.

Data analysis

Unique codes were assigned to each participant to ensure data security and confidentiality. Variables were expressed as mean ± standard deviation. Comparisons of parameters were performed using unpaired tests and Mann–Whitney test where appropriate. A < 0.05 was considered as statistically significant for all analyses. Data were analysed using the SPSS statistical software version 22.00, GraphPad Prism statistical software version 6 and Microsoft Excel 2016. Receiver-operating characteristic (ROC) curve was used to show the relationship between the sensitivity and specificity of the FINDRISC in the prediction of T2DM. The area under the ROC curve (AUC) was used to compare the ability of the FINDRISC in predicting pre-diabetic and diabetic participants. A perfect test with no false positive and false negative rates records an AUC curve value of 1.0. The same evaluation was done for the comparative ability of the MetS.

Results

Of the 135 participants, 71 (52.6%) were women. The average age of study participants was 52 ± 16 years with females averagely older (56.6 ± 15.0) than the males (47.3 ± 15.0). Except for participant's weight, waist-to-hip ratio, systolic blood pressure and triglyceride levels, the gender-based variations in the biochemical and anthropometric variables considered were statistically significant (Table 1).

This study recorded 31.2% and 8.9% pre-diabetic and diabetic fishermen, respectively. Frequency of both prediabetes and diabetes was significantly predominant among females (71.4% vs 83.3%) than males (26.2% vs 25.0%) ($p < 0.001$) respectively. Prevalence of MetS, according to the IDF criteria was 18.5%, significantly higher among females (92.0%) than among the males (18.5%). Frequency of the components of MetS syndrome were significantly higher among the female group than the male group except for high SBP and DBP, which were statistically similar between the males and females (Table 2).

Table 1 Basic characteristics of study participants recruited in this study

Parameters	Total	Gender		
		Males	Females	*p* value
	135 (100.0%)	64 (47.4%)	71 (52.6%)	
Age (years)	52 ± 16.0	47.3 ± 15.0	56.6 ± 15.0	0.0023
Weight (kg)	69.3 ± 13.1 s	70 ± 11.8	68.8 ± 14.3	0.6277
Height (m)	1.7 ± 0.1	1.7 ± 0.1	1.6 ± 0.6	< 0.00-01
BMI (kg/m^2)	25.5 ± 4.8	23.8 ± 3.5	26.9 ± 5.3	0.0001
FBG (mmol/L)	5.8 ± 1.6	5.3 ± 0.6	6.2 ± 2.0	0.0002
SBP (mmHg)	130 ± 19	127.6 ± 18.7	131.5 ± 19.6	0.2335
DBP (mmHg)	87 ± 12	87.3 ± 12.7	86.7 ± 11.4	< 0.00-01
WC (cm)	89.8 ± 11.9	85.3 ± 9.6	93.9 ± 12.4	< 0.00-01
HC (cm)	101 ± 10.1	97.0 ± 8.1	104.5 ± 10.5	< 0.00-01
W/H ratio	0.9 ± 0.1	0.9 ± 0.5	0.9 ± 0.7	0.0824
TG (mmol/L)	1.1 ± 0.8	0.9 ± 0.4	1.2 ± 0.9	0.2433
TC (mmol/L)	3.3 ± 1.9	2.8 ± 1.3	3.8 ± 2.2	0.0025
FINDRISC marks	8 ± 5	5.2 ± 3.8	10.5 ± 4.7	< 0.00-01

Results are expressed as mean ± standard deviation. BMI (Body Mass Index), FBG (Fasting Blood Glucose), SBP (Systolic Blood Pressure), DBP (Diastolic Blood Pressure), WC (Waist Circumference), HC (Hip Circumference), W/H (waist/hip), TG (Triglycerides), TC (Total Cholesterol).

Participant's multiple response to FINDRISC questions

In this study, 3 (2.2%) of the participants were smokers, while 47,4% of them consumed alcohol. Twenty percent of them had a relative with a history of diabetes, while 5.2% and 29% had a history of hyperglycemia and regularly took medication for HBP, respectively. Regular fruits and vegetable consumption were documented among only 28.9% of the participants, while 61.5% reported engaging in regular physical activity (fig. 1).

Findings from this study

Using the FINDRISC predictive tool, 122 (90.4%) of the participants were classified into low to moderate risk range, i.e. they had a 1–17% chance of developing T2DM in ten (10) years. Nine percent were 33% more likely to develop T2DM in ten (10) years; thus, as they fell within the high-risk range for the condition. Approximately 2% of the participants were smokers, and about 47% were alcoholics. The FINDRISC score increased with increasing blood glucose vis-à-vis 6 (95% CI 0–20) for non-diabetics, 10 (95% CI 0–19) for prediabetes and 13.5 (95% CI 4–21) for diabetic and age thus, 1.0 (95% CI 0–10) for <30 years, 3.5 (95% CI 0–16) for 31–40 years, 7.0 (95% CI 1–19) for 41–50 years, 10.0 (95% CI 1–16) for 51–60 years and 11.0 (95% CI 4–21) for the participants aged greater or equal to 61 years (Fig. 2).

The comparative ability of the FINDRISC for identifying the participants with T2DM, evaluated by the aROC curve was 0.76 (95% CI 0.61–0.92P; $p = 0.03$). The cut-off point of the FINDRISC for identifying diabetes mellitus using the ROC curve was 13.50 with a sensitivity of 50% and a specificity of 92%. The aROC curve of the FINDRISC instrument to predict metabolic syndrome in participants according to the

Table 2 Frequency of Diabetes, MetS and Components of MetS According to IDF Criteria

Parameters	Total	Male	Female	Chi-square (*p* value)
Diabetes Status				
Normal	81(60.0)	50 (61.7)	31 (38.3)	17.19 (<0.001)
Prediabetes	42 (31.1)	12 (28.6)	30 (71.4)	
Diabetes mellitus	12 (8.9)	2 (16.7)	10 (83.3)	
MetS (IDF)	25 (18.5)	2 (8.0)	23 (92.0)	19.11 (<0.001)
High TG (mmol/L)	20 (14.8)	5 (25.0)	15 (75.0)	4.73 (0.025)
Low HDL-C (mmol/L)	42 (31.1)	8 (19.0)	34 (81.0)	19.67 (<0.001)
High WC (cm)	80 (59.3)	19 (23.8)	61 (76.3)	44.08 (<0.001)
High FBG (mmol/L)	54 (40.00)	14 (25.93)	40 (74.07)	15.25 (<0.001)
High SBP (mmHg)	72 (53.33)	31 (43.06)	41 (56.94)	1.17 (0.181)
High DBP (mmHg)	80 (59.26)	36 (45.00)	44 (55.00)	0.456 (0.308)

Data are presented as frequency and percentage in parenthesis. FBG (Fasting Blood Glucose), SBP (Systolic Blood Pressure), DBP (Diastolic Blood Pressure), WC (Waist Circumference), TG (Triglycerides), HDL-C (High-Density Lipoprotein Cholesterol).

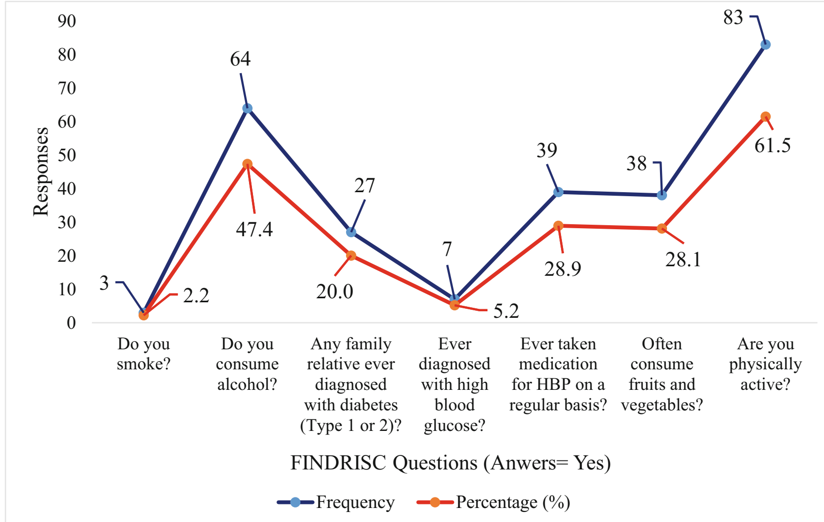


Fig. 1 Participant's Multiple Response to FINDRISC Questions. Note: Q denotes Question. Q1 and Q2 are not FINDRISC questions

IDF criteria was 0.69 (95% CI 0.61–0.77; $p = <0.001$). The comparative ability of the metabolic syndrome instrument in identifying participants with T2DM as evaluated by the aROC curve was 0.74 (95% CI 0.66–0.86; $p = 0.002$) with 75.0% and 71.5% sensitivity and specificity respectively. The aROC of the FINDRISC is statistically comparable to the aROC of the metabolic syndrome ($p = 0.834$) (Table 2). It is worth noting that further data exploration revealed that the FINDRISC can also be used to predict MetS [aROC = 0.69 (95% CI 0.61 to 0.77); sensitivity = 84.00% and specificity = 57.27%; $p < 0.001$; optimal cut-off point >7].

Comparatively, biochemical and anthropometric variables studied except for participant's age, height, weight, total cholesterol, triglyceride and FBG concentrations, waist-to-hip ratio and FINDRISC score differed significantly ($p < 0.05$) between participants without MetS and with FINDRISC score less than thirteen. However, participants diagnosed with metabolic syndrome and with FINDRISC score greater or equal to thirteen shared similar biochemical and anthropometric parameters except for waist-to-hip ratio and FINDRISC score which varied significantly between the groups (Table 3).

Discussion

This study determined and compared the predictive capacities of two screening instruments (FINDRISC and MetS) to detect T2DM among apparently healthy fishermen in the Cape Coast metropolis. To the best of our knowledge, this work is novel to our settings as such limits the scope of comparative discussions. Nonetheless, a similar study elsewhere by Meijnikman, De Block [6], unlike our study which recruited apparently healthy but highly at-risk individuals due to their smoking and alcohol consumption habits, they recruited subjects

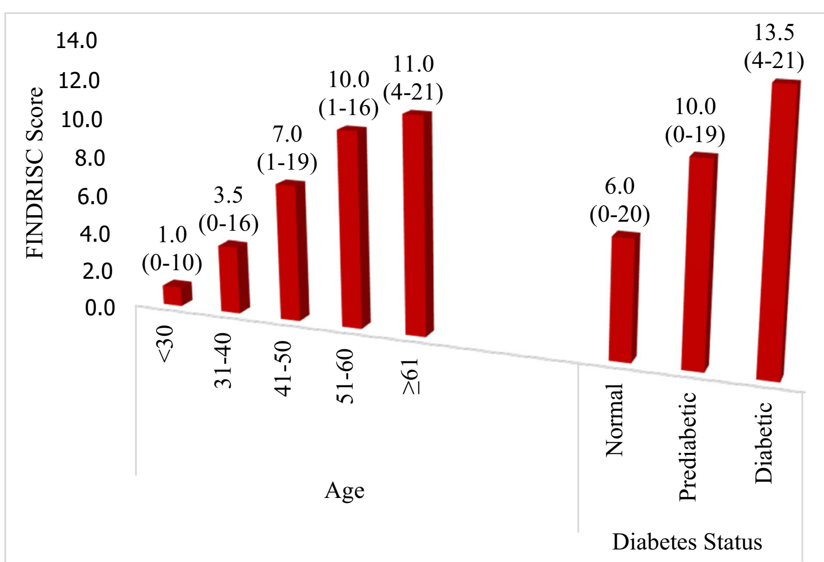
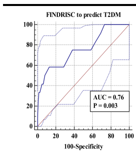
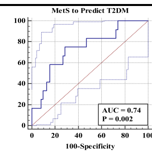


Fig. 2 FINDRISC score distribution stratified by age and diabetes mellitus status

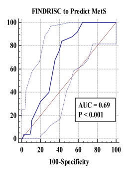
Table 3: Comparative ability for FINDRISC instrument to predict accurately T2DM and MetS and MetS to Predict T2DM. AUC (Area Under the Curve); T2DM (Type 2 Diabetic Mellitus).



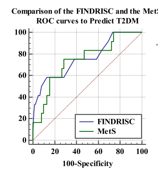
Parameter		95% CI
AUC	0.76	0.68 to 0.83
Sensitivity	58.33	27.70 - 84.80
Specificity	86.99	79.70 - 92.40
p-value	0.003	



Parameter		95% CI
AUC	0.74	0.66 to 0.81
Sensitivity	75.00	42.80 – 94.50
Specificity	71.54	62.70 – 79.30
p-value	0.002	



Parameter		95% CI
AUC	0.69	0.61 to 0.77
Sensitivity	84.00	63.90 – 95.50
Specificity	57.27	47.50 – 66.70
p-value	<0.001	



Parameter		95% CI
ΔAUC	0.018	-0.152 – 0.189
Standard error	0.087	
Z statistic	0.210	
p-value	0.834	

visiting the Obesity clinic for overweight and obese problems but without history of diabetes or on anti-diabetic drugs. Reasons for the choice of participants may be tangential as overweight and obesity in their case as well as smoking and alcoholism in our case has been reported as significant contributors of T2DM [1, 8, 19]. Conclusively, in both cases, apparently healthy risky populations for T2DM were recruited.

The continuous delay and or under-diagnosis of diabetes for that matter T2DM has provoked scientist into research into the diagnostic accuracy of predictive instruments for early diagnosis, especially among risky population. From our findings, the discriminatory accuracy of FINDRISC [aROC = 0.76 (95% CI 0.68 to 0.83); sensitivity = 58.3% and specificity = 86.9%; $p = 0.003$; optimal cut-off point = 13.50] and the MetS [aROC = 0.74 (95% CI 0.66 to 0.81); sensitivity = 75.0% and specificity = 71.5%; $p = 0.002$] despite demonstrating a significantly good capacity to detect T2DM were statistically comparable (ΔaROC = 0.083 (95% CI 0.68 to 0.83); $p = 0.834$). This finding corroborates that of Meijnikman and colleagues [6]. They likewise demonstrated that the predictive capacity of the FINDRISC score and MetS to detect T2DM was comparable when used without any modifications to the diagnostic instrument. In their work, the aROC of the FINDRISC to identify subjects with T2DM was 0.76 (95% CI 0.72–0.82), sensitivity was 64%, and

Table 4 Comparison of participants with a FINDRISC score < 13 versus participants without the MetS and participants with a FINDRISC ≥13 versus participants with the MetS

Parameters	Without MetS	FINDRISC <13	*p* value	With MetS	FINDRISC ≥ 13	*p* value
	72(53.3%)	112(83.0%)		63(46.7%)	23(17.0%)	
Age (yrs.)	51 ± 16	50 ± 16	0.310	56 ± 14	61 ± 11	0.202
DBP (mmHg)	86 ± 12	86 ± 12	0.004	91 ± 14	91 ± 13	0.419
SBP (mmHg)	128 ± 17	128 ± 17	0.001	139 ± 27	136 ± 26	0.432
Height (m)	1.7 ± 0.1	1.7 ± 0.1	0.374	1.6 ± 0.1	1.6 ± 0.1	0.391
Weight (kg)	68.0 ± 13.1	67.9 ± 13.1	0.117	75.1 ± 11.0	76.3 ± 11.4	0.533
BMI (kg/m^2)	25.0 ± 4.9	24.7 ± 4.6	0.033	27.7 ± 3.3	29.3 ± 4.0	0.208
TC (mmol/L)	3.38 ± 1.90	3.23 ± 1.84	0.841	3.12 ± 1.72	3.80 ± 2.00	0.552
TG (mmol/L)	0.88 ± 0.43	0.96 ± 0.52	0.205	1.99 ± 1.24	1.49 ± 1.36	0.411
HDL-C (mmol/L)	1.37 ± 0.37	1.37 ± 0.37	< 0.0001	1.35 ± 0.48	1.36 ± 0.43	0.642
FBG (mmol/L)	5.5 ± 1.2	5.4 ± 0.7	0.056	6.9 ± 2.7	7.3 ± 3.1	0.104
WC (cm)	89 ± 12	87 ± 11	0.019	97 ± 8	102 ± 10	0.030
HC (cm)	100 ± 10	99 ± 9	0.035	106 ± 7	110 ± 9	0.129
W/H ratio	0.88 ± 0.07	0.88 ± 0.06	0.202	0.92 ± 0.05	0.93 ± 0.06	0.199
FINDRISC	8 ± 5	6 ± 4	0.439	10 ± 4	16 ± 3	<0.0001

Data are displayed as mean ± standard deviation. BMI (body mass index), FBG (fasting blood glucose), SBP (systolic blood pressure), DBP (diastolic blood pressure), WC (waist circumference), HC (hip circumference), W/H (waist/hip), TG (triglycerides), TC (total cholesterol).

specificity was 63% with 13 as the cut-off point. Adding FBG or HbA1c to FINDRISC, the aROC increased significantly to 0.91(95% CI 0.88–0.95) and 0.93(95% CI 0.90 0.97), respectively ($p < 0.001$). The aROC of the MetS to identify subjects with diabetes was 0.72 (95% CI 0.65–0.78), sensitivity was 75%, and specificity was 55% while the aROC of the FINDRISC + HbA1c was significantly higher than the MetS for predicting T2DM ($p < 0.001$).

Elsewhere in Madrid, Spain in the SPREDIA-2 Study, the FINDRISC predictability accuracy of T2DM also saw a comparable outcome; an aROC of 0.72 (95% CI, 0.69–0.74) with a sensitivity of 63.8% and specificity of 65.1% at an optimal cut-off point of ≥13 [23]. Our findings indicate that both FINDRISC (with a suitable cut-off value of 13.5) and MetS screening tools possess a good predictive capacity for the detection of T2DM. Meanwhile, the FINDRISC per findings from this study can also be employed to detect MetS in a high-risk population ([aROC = 0.69 (95% CI 061–.77); p = <0.001]. In this study, the FINDRISC score increases with increasing age and diabetes status. The spectrophotometer was used in the biochemical analysis of the participants' samples instead of the standard automated analyser, which may affect the general outcome of the results.

The major limitation of this study was the fact that it recruited a small sample of the population which affects the external validity and generalisability of the study results (Table 4).

Conclusion

Both FINDRISC and MetS diagnostic tools for T2DM can be applied to detect T2DM among at-risk fishermen population. The comparative ability of the two diagnostic tools in identifying diabetes mellitus were similar. Finally, the FINDRISC score increases with increasing age and diabetes status.

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Author's contribution RKDE, VOB, JA and AM conceived of the study and participated in its design and coordination. RKDE, VOB, JA and AM were involved in the recruitment of participants, data collection and analysis. RKDE, AAY, GEK and PKK drafted the manuscript. RKDE, AAY and PKK provided analytic and statistical support. All authors read and approved the final manuscript.

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Compliance with ethical standards

Conflict of interest The authors declare that no conflict of interest exists.

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