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Is the FINDRISC Tool Useful in Screening Type 2 Diabetes and Metabolic Syndrome in an African Setting? Experience among Young Adults in Urban Tanzania

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Abstract: Background: Simple and less costly screening tools are needed to combat the rising non-communicable diseases epidemic. This study aimed to evaluate the utility of The Finnish Diabetes Risk Score (FINDRISC) as a screening tool for prediabetes, T2D, and metabolic syndrome (MetS) in a population of young adults in urban Mwanza, Tanzania. Methods: A cross-sectional community-based study was conducted among participants aged 18–35 years. The FINDRISC questionnaire was used to collect data and compute the FINDRISC scores for each participant. Socio-demographic, anthropometric, blood glucose, and lipid profiles data were collected accordingly. Results: A total of 259 participants were recruited into the study. The median age was 21 years (IQR 19–27), and more than half 60.2% (156) were females. In total, 32.8% (85) of the participants had at least a slightly elevated risk of developing T2D in 10 years' time. Compared to the Oral Glucose Tolerance Test (OGTT), FINDRISC had a sensitivity and specificity of 39.1% and 69.2%, respectively (aROC = 0.5). The FINDRISC score significantly correlated with MetS (p = 0.001). Conclusion: In this study, FINDRISC has shown low sensitivity and specificity in the screening of pre-diabetes/T2D. However, it has potential utility in the screening of MetS in a young-adult population.

Keywords: FINDRISC; prediabetes; diabetes; metabolic syndrome; young-adults

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1. Introduction

Type 2 diabetes mellitus (T2D) is a chronic disease that is characterized by a long pre-diabetic state before the development of a full-blown disease [1]. Prevalence of diabetes, diabetes-related deaths, and social-economic burden due to diabetes continue to rise globally [2]. The International Diabetes Federation (IDF) estimated a diabetes global prevalence of 8.8% in 2015, with a projection to increase to 10.4% in 2040 [2]. Further, the IDF estimated a 6.7% prevalence of Impaired Glucose Tolerance (IGF), 5 million deaths attributed to diabetes, and USD 673 billion global health expenditure in 2015 [2]. For individuals diagnosed early during pre-diabetes, it is possible to institute interventions that will halt the development of full-blown T2D [3]. Standard diagnostic tests, such as the Oral Glucose Tolerance Test (OGTT) and HbA1c, are expensive and difficult to scale up in a large population, especially in resource-limited settings, such as Tanzania [4]. Of late, cheaper and easy-to-use tools have been developed and tested in other countries and have shown to be cost-effective in the diagnosis of pre-diabetes and diabetes mellitus [5,6]. The Finnish Diabetes Risk Score (FINDRISC) is one such affordable and easy-to-use screening tool [7–10].

The FINDRISC questionnaire, originally used as a screening tool in the Finnish Diabetes Prevention Study, was found to be an effective tool in identifying individuals at a

high risk of developing T2D in 10 years' time [5]. Since then, the tool has been validated in several other studies and is used in adult populations for early diagnosis and prevention of overt T2D [7,9,11]. Several studies have been done to test the effectiveness of FINDRISC in screening forT2D and other chronic diseases, with promising results [11,12]. A validation study done in the Greek population, comprising adults less than 45 years to more than 64 years, showed FINDRISC to have high sensitivity as well as specificity in predicting unknown T2D [13]. Besides unknown diabetes, FINDRISC performed well in the cross-sectional detection of Impaired Fasting Glucose, Impaired Glucose Tolerance, as well as MetS [8,11].

Little is known of the utility of FINDRISC in African settings; to our understanding, no longitudinal study has been done in Africa to validate its prediction of the 10-year risk of developing diabetes. Nevertheless, few cross-sectional studies have been done in sub-Saharan Africa (SSA) and its utility has been documented [11,14]. In a recent study done among young adults in Nigeria, 9% of the participants were found to have moderate to high risk of developing diabetes in 10 years, although the predictive value for the current diabetes status was not reported [14]. Another study in Benin also found FINDRISC to be useful in screening for T2D [11]. Despite these findings, no study has described its utility in screening for current diabetes mellitus and MetS among young adult populations in sub-Saharan African settings, whose risk has been increasing [15].

Because of the challenges in accessing treatment for T2D and other non-communicable diseases in resource-limited settings in SSA, such as Tanzania, preventive measures are paramount [4]. For effective intervention, timely screening for diabetes is the key to diagnosing diabetes at the early stages and administering preventive measures before disease complications [16,17].

Using a community-based cross-sectional design, this study aimed to explore the utility of FINDRISC in predicting current diabetes mellitus and MetS among the young-adult population in an urban setting of Tanzania.

2. Materials and Methods

2.1. Study Design and Study Setting

This was a community-based cross-sectional study conducted between May and August 2018 in an urban setting of Mwanza city, Tanzania. The sample size was estimated using the Kish and Leslie formula [18], at a 95% confidence interval, 5% margin of error, and 80% sensitivity from a referred validation study [13]. The minimum required sample size was adjusted upwards to 252 participants to account for a 10% non-response rate. Using a multistage random sampling, three representative districts were randomly selected from 7 districts of the Mwanza region, and each district, two representing urban wards, and then four streets were randomly selected. Community leaders were utilized to announce to the public three days before review day, and all those who turned up at the survey center during the review day, met the inclusion criteria, and gave informed consent were randomly selected to participate in the study. A final total of 259 participants were enrolled, aged 18–35 years, who were not known to have the clinical diagnosis of diabetes at the time of enrollment.

2.2. Data Collection

2.2.1. Socio-Demographics and FINDRISC Characteristics

An investigator-administered structured questionnaire captured the socio-demographic data, including age, sex, education level, occupation, and employment status. The FINDRISC questionnaire was used to collect data on age group, body mass index (BMI) categories, waist circumference categories, physical activity status, vegetable eating behavior, history of hypertension and high blood glucose, as well as family history of diabetes mellitus, as indicated on the tool (details published elsewhere [19]). A total score was obtained by adding up scores for all parameters, and every participant had their FINDRISC scores recorded. Risk categories were categorized as per FINDRISC standard groups of

low risk (<7), slightly elevated (7–11), moderate (12–14), high (15–20), and very high risk (>20) [5,20].

2.2.2. Blood Pressure and Anthropometry

Clinical measurements included measurement of the systolic and diastolic blood pressure blood pressures taken three times at 5-min intervals using a calibrated digital sphygmomanometer (CH-432B, Citizen Systems Japan Co., Ltd., 6-1-12 Tanashi-cho, Nishi-Tokyo-Shi, Tokyo 188-8511, JAPAN). Mean arterial pressure (MAP) was calculated using the equation: MAP = DBP +1/3(SBP-DBP) [21]. Hypertension was defined as systolic blood pressure (SBP) $\geq$ 140 mmHg or diastolic blood pressure (DBP) $\geq$ 90 mmHg or a prior diagnosis of hypertension currently on anti-hypertensive therapy [22]. Weight, height, hip, and waist circumference were measured using a calibrated stadiometer and tape measure under WHO protocols [23]. The waist:hip ratio (WHR) was interpreted according to the WHO guidelines; in males, the ratio of $\geq$0.90 and females $\geq$0.84 were regarded as substantially increased [22]. BMI was calculated as weight (kg)/height^2 (m^2). Overweight was defined as a BMI of 25 kg/m^2–30 kg/m^2 and obesity as a BMI of more than 30 kg/m^2 [22]. MetS were defined based on the IDF criteria, which are the presence of central obesity plus any two of the following: raised triglycerides $\geq$ 1.7 mmol/L or history of specific treatment for this; reduced HDL cholesterol: <1.03 mmol/L in males, 1.29 mmol/L in females, or history of specific treatment; raised blood pressure $\geq$ 130 mmHg systolic and/or $\geq$ 85 mmHg diastolic or on antihypertensives; and raised FBG $\geq$ 7.0 mmol/L or previously diagnosed type 2 diabetes mellitus [24].

2.2.3. Oral Glucose Tolerance Test (OGTT)

Participants were contacted one day before the clinic visit and were instructed to come following overnight fasting. Upon arrival and before glucose testing, participants were asked if they had taken any food except water for at least 8 h before visiting the clinic to ascertain fasting. Those fasting were requested to provide venous blood for fasting blood glucose (FBG) measurement (ONCALL-PLUS device, ACON Laboratories, Inc., San Diego, CA, USA). Subsequently, participants were given 82.5g of dextrose monohydrate (equivalent to 75g of anhydrous glucose) diluted in 250 mls of drinking water to drink within 5 min for the Oral Glucose Tolerance Test (OGTT), and blood samples were collected after 2 h. FBG and 2-h postprandial glucose were recorded. Impaired Glucose Tolerance or pre-diabetes was defined as a fasting blood glucose of 5.8 mmol/L to 7.0 mmol/L or 2-h postprandial blood glucose levels of 7.8 mmol/L to 11 mmol/L. Diabetes mellitus was defined as fasting blood glucose of more than or equal to 7.1 mmol/L or 2-h postprandial blood glucose level of more than or equal to 11.1 [25].

2.2.4. Lipid Profile

A sample of fasting venous blood was collected for assessment of the lipid profiles at the clinic and was transferred in a cool box to Bugando Medical Center (BMC) hematology laboratory, and was stored at -20 °C before analysis. Under standard operating procedures, lipid profile tests were done using an ERBA XL Automated Chemistry Analyzer (Erba Lachema s.r.o, Brno, Czechia), where the fasting total cholesterol, low-density lipoprotein (LDL), high-density lipoprotein (HDL), and triglyceride were analyzed. Dyslipidemia was defined as the presence of either total cholesterol of more than 5.2 mmol/L, LDL of more than 3.3 mmol/L, triglycerides of more than 1.7 mmol/L, or HDL of less than 1.03 mmol/L in males or less than 1.29 mmol/L in females.

2.3. Statistical Analysis

Data were transferred from questionnaires to Microsoft Excel for cleaning and exported to STATA 13 (64-bit; StataCorp LLC 4905 Lakeway Drive College Station, TX 77845-4512, USA) for analysis. Continuous variables were summarized into frequency, means with standard deviations, or median with inter-quartile ranges based on distribution.

Categorical variables were presented as frequencies and proportions. The International Diabetes Federation (IDF) criteria were used to obtain the MetS traits and MetS of the study participants. Association between categorical variables was done using Pearson's correlation or Fisher's exact test where appropriate. Associations between the FINDRISC score and clinical as well as biochemical parameters that are not featured in the FINDRISC questionnaire were ascertained using linear regression. Two-side *p*-values of equal or less than 0.05 were considered statistically significant.

The predictive value of FINDRISC in detecting prediabetes and diabetes was evaluated using FINDRISC scores as a test and OGTT as the gold standard. FINDRISC scores of 7 and above (at least slightly elevated risk) were regarded as positive and those below 7 were regarded as negative. Participants with 2 h OGTT values of more than 7.8 mmol/L were regarded as having deranged blood glucose (inclusive of pre-diabetes and diabetes) while those with scores less than 7.8 mmol/L were regarded as not deranged (having normal blood glucose). From these values, the sensitivity, specificity, positive and negative predictive values, area under the receiver operator (ROC) curve, and their respective 95% confidence intervals were calculated.

3. Results

3.1. Background Characteristics of Study Participants

A total of 259 participants were enrolled in this study; the response rate of the recruited study participants was 100%. The median age was 21 (19–27) years and 60.2% (156) of the study participants were females. The majority of the study participants were university students 66.8% (173) (Table 1). The overall prevalence of hypertension, impaired glucose tolerance, diabetes, obesity, central obesity, dyslipidemia, and MetS were 35.1% (91), 15.5% (38), 7.8% (19), 8.1% (21), 14.7% (38), 44.4% (115), and 4.3%(11), respectively (Table 1). The Mean FINDRISC score was 5.2 ± 3.6, with a minimum score of 0 and a maximum score of 22. More than half of the participants had a low risk of developing diabetes mellitus in 10 years, while 32.8% of the participants had at least slightly elevated to a very high risk of T2D in 10 years (Table 2).

Table 1. Socio-demographic and clinical characteristics of the study participants.

Characteristics	Median (IQR)/*n* (%)
Number of subject enrolled, *N*	259
Age in years, Median (IQR)	21 (19–27)
Female Sex	156 (60.2)
Education level, *N* (%)	
None	1 (0.4)
Primary	33 (12.7)
Secondary	29 (11.2)
College and higher	196 (75.7)
Occupation, *n* (%)	
Employed	38 (14.7)
Not employed	9 (3.5)
Self employed	39 (15.0)
Students	173 (66.8)
Diabetes mellitus	19 (7.76)
Prediabetes	38 (15.51)
Hypertension	91 (35.1)
Obesity	21 (8.1)
Overweight	44 (17)
Dyslipidemia	115 (44.4)
Central obesity	38 (14.7)
Metabolic syndrome (MetS)	11 (4.3)

Table 2. Summary of FINDRISC.

Parameter			FINDRISC Points	*N* (%)
Age-groups (years)	<45		0	259 (100)
	45–54		2	-
	54–64		3	-
	>64		4	-
BMI categories (kg/m^2)	<25		0	192 (74.1)
	25–30		1	45 (17.4)
	>30		3	22 (8.5)
Waist circumference (cm)	Men	Women		
	<94	<80	0	162 (62.6)
	94–102	80–88	3	59 (22.8)
	>102	>88	4	38 (14.7)
Physically active?	Yes		0	65 (25.1)
	No		2	194 (74.9)
Eating vegetables daily	Yes		0	187 (72.2)
	No		1	72 (27.8)
Personal history of hypertension	No		0	247 (95.4)
	Yes		2	12 (4.6)
Personal history of hyperglycemia	No		0	249 (96.1)
	Yes		5	10 (3.9)
Family history of diabetes, *n* (%)	No		0	188 (72.5)
	Yes, first-degree relative		3	49 (18.9)
	Yes, second-degree relative		5	22 (8.6)
FINDRISC score	<7 (low risk)		0–6	174 (67.2)
	7–11 (slightly elevated risk)		7–11	74 (28.6)
	12–15 (moderate risk)		12–15	6 (2.3)
	15–20 (high risk)		15–20	4 (1.5)
	>20 (very high risk)		20–26	1 (0.4)

3.2. FINDRISC as a Predictor of Glucose Intolerance and Diabetes Mellitus

Comparing the FINDRISC score to the OGTT as a gold standard diagnostic test, the sensitivity and specificity of FINDRISC were 39.1% and 69.2% respectively, and the area under the ROC curve was (0.5, 95% CI: 0.47, 0.6), suggesting a weak ability of the FINDRISC to discriminate young adults with and without pre-diabetes or diabetes mellitus (Table 3).

Table 3. Diagnostic accuracy of the FINDRISC score for impaired blood glucose.

		95% Confidence Interval	
Prevalence	24.70%	19.60%	30.40%
Sensitivity	39.10%	27.10%	52.10%
Specificity	69.20%	62.20%	75.60%
ROC area	0.54	0.47	0.61
Positive likelihood ratio	1.27	0.88	1.84
Negative likelihood ratio	0.88	0.71	1.09
Odds ratio LR	1.44	0.81	2.59
Positive predictive value	29.40%	20.00%	40.30%
Negative predictive value	77.60%	70.70%	83.50%

FINDRISC scores were compared to the Oral Glucose Tolerance Test results. Participants with 7 points and above(slightly elevated risk to very high risk) were regarded as positive and below 7 points (low risk) as negative. OGTT levels less than 7.8 mmol/L were regarded as non-diseased while OGTT levels 7.8 mmol/L and above were considered diseased (with prediabetes and diabetes mellitus).

3.3. Diabetes and Metabolic Syndrome across the FINDRISC Categories

Proportions of Normal Glucose Tolerance, Isolated Fasting Blood Glucose, Impaired Glucose Tolerance, Diabetes Mellitus, MetS, and MetS traits across FINDRISC categories have been presented in (Table 4). Significant associations have been observed between

FINDRISC score with MetS, abdominal obesity, low High-Density Lipoprotein Cholesterol, and Fasting Blood Glucose.

Table 4. Diabetes and metabolic syndrome across the FINDRISC categories.

FINDRISC Score		0–6	7–11	12–14	15–20	20–26	Total (Row)	* *p*-Value
OGTT		174	74	6	4	1	259	
	NGT(202)	131 (69.3)	48 (25.4)	5 (2.7)	4 (2.1)	1 (0.5)	189	
	Isolated IFG	14 (66.7)	7 (33.3)	0 (0.0)	0 (0.0)	0 (0.0)	21	
	IGT	24 (60.0)	15 (37.5)	1 (2.5)	0 (0.0)	0 (0.0)	40	0.7
	DM	12 (60.0)	8 (40.0)	0 (0.0)	0 (0.0)	0 (0.0)	20	
Metabolic syndrome * (IDF)		2 (18.2)	5 (45.5)	0 (0.0)	3 (27.3)	1 (9.1)	11	0.001
MetS traits abnormality (IDF)	WC (Abd obesity)	18 (22.0)	53 (64.6)	6 (7.3)	4 (4.9)	1 (1.2)	82	0.001
	TG (high trig)	22 (73.3)	7 (23.3)	0 (0.0)	1 (3.3)	0 (0.0)	30	0.7
	HDL-C (Low HDL)	19 (57.6)	10 (30.3)	1 (3.0)	2 (6.1)	1 (3.0)	33	0.01
	BP (High)	61 (67.0)	24 (26.4)	2 (2.2)	3 (3.3)	1 (1.1)	91	0.3
	FPG (High)	4 (57.1)	2 (28.6)	0 (0.0)	0 (0.0)	1 (14.3)	7	0.001

Proportions of Normal Glucose Tolerance (NGT), Isolated Impaired Fasting Glucose (IFG), Impaired Glucose Tolerance (IGT), Diabetes Mellitus (DM), and MetS traits (Abdominal Obesity, triglycerides $\geq$ 1.7 mmol/L, HDL cholesterol: <1.03 mmol/L in males, 1.29 mmol/L in females, blood pressure $\geq$ 130mmHg systolic and/or $\geq$ 85 mmHg diastolic and Fasting Blood Glucose > 7.0 mmol/L) across FINDRISC categories. * Chi-Square.

3.4. FINDRISC as a Predictor of MetS and MetS Traits

Linear regression and analysis of variance were performed between FINDRISC and MetS, WHR, FBG, DBP, SPB, TG, and HDL. In univariable models, the FINDRISC score was significantly associated with Metabolic Criteria 2, 4, 5, and 6, and generally with MetS (Table 5). In the multivariable models, all response variables with p-value < 0.1 were adjusted for age and sex, and a significant association was observed between MetS2, MetS5, and MetS 6 as the outcome variable and the FINDRISC score as the predictor variable (Table 5).

Table 5. Linear regression on the predictive potential of the FINDRISC scores on MetS and IDF MetS traits as response variables.

MetS Criteria	Univariable		Multivariable	
	R^2	*p* Value	Adjusted R^2	*p* Value
MetS 1	0.00	0.96		
MetS 2	0.03	0.005	0.05	0.02
MetS 3	0.00	0.96		
MetS 4	0.04	0.001	0.04	0.07
MetS 5	0.14	0.001	0.13	0.001
MetS 6	0.05	0.001	0.04	0.002
MetS	0.13	0.001	0.13	0.001
WHR	0.12	0.001	0.36	0.001
FBG	0.02	0.05	0.02	0.2
DBP	0.04	0.002	0.14	0.06
SBP	0.00	0.8		
TG	0.00	0.3		
HDL	0.00	0.5		

MetS1:abdominal obesity, triglycerides $\geq$ 1.7 mmol/L, and high-density lipoprotein cholesterol < 1.03 mmol/L in males and < 1.29 mmol/L in females; MetS2: abdominal obesity, triglycerides $\geq$ 1.7 mmol/L, blood pressure $\geq$ 130 mmHg systolic and/or $\geq$ 85 mmHg diastolic; MetS3: abdominal obesity, triglycerides $\geq$ 1.7 mmol/L, FBG $\geq$ 7.0 mmol/L; MetS4: abdominal obesity, high-density lipoprotein cholesterol < 1.03 mmol/L in males and < 1.29 mmol/L in females, FBG $\geq$ 7.0 mmol/L; MetS5: abdominal obesity, high-density lipoprotein cholesterol < 1.03 mmol/L in males, blood pressure $\geq$ 130 mmHg systolic and/or $\geq$ 85 mmHg diastolic; MetS6: abdominal obesity, blood pressure $\geq$ 130 mmHg systolic and/or $\geq$ 85 mmHg diastolic, FBG $\geq$ 7.0 mmol/L; MetS: total, presence of any of the six criteria.

4. Discussions

T2D and other MetS-associated ailments are on the rise and account for significant morbidity and mortality worldwide, including among the young-adult populations. Developing cheap, effective, and easy-to-use screening tools for T2D is a cost-effective approach to control the disease and its complications, particularly in resource-limited settings where access to care is limited. Here, we report an alarmingly high prevalence of T2D, dyslipidemia, overweight, hypertension, and MetS in a young-adult population of sub-Saharan Africa and provide first-time data showing that, although the non-invasive FINDRISC tool was less effective at predicting current pre-diabetes and T2D, the tool significantly predicted MetS traits and MetS. The FINDRISC tool could therefore have utility in screening for MetS among a young adult population.

High levels of DM, hypertension, dyslipidemia, and central obesity have been observed in this study. Similar results have been observed recently in other studies with young adults under 40 years of age [26,27]. Nsanya et al. (2019) reported a 40%prevalence of high blood pressure in young adults and adolescents of Tanzania and Uganda [28], and a significantly higher prevalence of hypertension has been reported from studies done among school children and adolescents in Tanzania and other low-income countries [29,30]. Up to 36% of the young adults in India have been reported to have dyslipidemia from recent studies [31], and data from Tanzania shows a 12.96% prevalence of central obesity in the young-adult population (aged 18 to 30 years) [32]. However, the observed prevalence of diabetes mellitus (7.8%) is higher compared to the recently reported prevalence of diabetes in urban Tanzania (3.2–6.9% for the age group of 20–34 years) [2]. This value approaches the estimated prevalence of 9% projected for the year 2030 [33]. The trend in these diseases in the young population is alarming and indicates forthcoming danger in the absence of active and early interventions.

FINDRISC was developed to predict the 10-year risk for developing T2D [34]. Despite this use, the tool has been adopted for screening for T2D and MetS in different populations following several validation studies [12,13,35]. These studies were done in populations with mixed age groups and showed promising potential for the utility of FINDRISC as a screening tool, with over 80% sensitivity and specificity in screening for T2D and MetS [12,36]. Our study, however, showed lower sensitivity and specificity of FINDRISC as a screening tool for current T2D and this may be attributed to various reasons. Firstly, all participants were below 45 years of age, hence falling under one age category, making it difficult to discriminate a risk score based on age category. Secondly, the types of fruits and vegetables differ in this population compared to the Finnish population; hence, we need to customize the FINDRISC score to the African setting, which may increase its sensitivity. Thirdly, ascertaining family history of diabetes mellitus in a sub-Saharan African setting, as required in the current FINDRISC questionnaire, may not be realistic since most cases of diabetes mellitus remain undiagnosed due to poor health-seeking habits. Modifications of these aspects and validation of the modified tool may therefore increase the usefulness of FINDRISC as a tool for screening the current and future risk of T2D in the Tanzanian context [4,16,37].

Despite its limited utility in predicting current T2D, our study uncovered the potential utility of FINDRISC as a non-invasive screening tool for MetS. Particularly, our study showed significant associations between FINDRISC with the waist-to-hip ratio, diastolic blood pressure, mean arterial pressure, fasting blood glucose, and low-density lipoprotein levels. These findings are concordant with observations made in previous studies that validated FINDRISC as a screening tool to detect the occurrence of MetS [7]. In this study, FINDRISC was shown to significantly predict the current status of these parameters, opening up its potential to be used as a cheap and non-invasive screening tool for MetS in young adults.

Our study had several limitations. Firstly, the majority of study participants were college students, which limits the extension of study findings to the general population. Secondly, due to resource limitations, we were only able to perform OGTT but not HbA1C

for the diagnosis of prediabetes. Furthermore, given the cross-sectional nature of the study, we were only able to validate the utility of FINDRISC as a predictor of current pre-diabetes, T2D, and MetS; large community-based longitudinal studies are recommended to validate FINDRISC over a wider age range and more diverse subpopulations with the suggested modifications above, to be a predictive tool for future risk as well as a screening tool of T2D in sub-Saharan Africa.

5. Conclusions

Although limited in its ability to detect current pre-diabetes or T2D, the FINDRISC showed considerable potential for utility as a non-invasive screening tool for the MetS among young adults in sub-Saharan Africa. Further studies are needed to validate the utility of a modified FINDRISC tool as a predictor of the current and future risk of T2D and metabolic syndrome.

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