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Research Article

Simple Risk Score to Identify Population at Risk of Impaired Glucose Tolerance in the Thai Population

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Abstract

People with impaired glucose tolerance (IGT) have increased risk of diabetes mellitus and cardiovascular diseases. To identify this high risk group, it needs an oral glucose tolerance test (OGTT) which is time-consuming and difficult to perform in primary care setting. The risk score could be helpful for selection of only those high risk people for OGTT. The objective of this study was to develop the risk score for prediction of IGT in the Thai population. Data from 857 civil service workers of whom 106 (12.4%) had IGT, were collected. A risk score model was developed using logistic regression analysis and the area-under-ROC curve (AUC) was used to compare each model. Age, history of diabetes in 1st-degree relatives, history of hypertension, BMI, waist, waist-height ratio were significantly associated with IGT. The model with waist-height ratio had slightly higher AUC (0.728; 95%CI 0.680-0.777) than, but was not different from, the model with BMI (0.714; 95% CI 0.665-0.763) or waist (0.713; 95% CI 0.663-0.762).The simple risk score model was age + (5 x history of diabetes in 1st-degree relatives) + (10 x waist-height ratio) + (history of hypertension). Risk scores of at least 98 can be used as a cutoff point to predict IGT with the sensitivity and the specificity of 71.3 and 64.4% respectively. This risk score might be appropriate for risk stratifying in people at risk of IGT in the community.

Keywords: Community; Impaired glucose tolerance; Pre-diabetes; Risk score; Waist to height ratio

Abbreviations

AUC: Area under the ROC Curve; BMI: Body Mass Index; IFG: Impaired Fasting Glucose; IGT: Impaired Glucose Tolerance; OGTT: Oral Glucose Tolerance Test; ROC: Receiver-operating Characteristics; WHt: Waist to Height Ratio

Introduction

The early phase of abnormal control of glucose regulation, before progressing to diabetes, is designated as the pre-diabetes stages (impaired fasting glucose: IFG and impaired glucose tolerance: IGT). The prevalence of IGT in Thailand is unknown. However, the prevalence of IGT in the South-East Asia region as reported by the International Diabetes Federation is more than twice that of diabetes (estimated to be 13.2%) [1]. Identification of people at risk of diabetes or pre-diabetes stage coupled with appropriate diagnostic tests, and lifestyle or pharmacological interventions could be one method to reduce or delay the onset of new diabetes cases.

Using the oral glucose tolerance test (OGTT), a gold standard for IGT diagnosis, is often not practical and is time-consuming to perform in primary care settings. The development of a valid risk score could be helpful for selection of only those people at high risk for OGTT. Currently, there are very few risk scores in the literatures that are developed specifically for IGT. Most of the risk scores are developed for predicting diabetes among people with pre-diabetes [2]. Those that aim to screen for IGT require several blood chemistry measurements, which might not be practical for screening at population level [3,4]. Although it is true that several diabetes and IGT risk scores are presently available [5-8], the diagnostic properties of these risk scores differ when applied to different populations [9]. Therefore, there is a need to develop the IGT risk score aimed specifically for the Thai population. This study aimed to develop a simple risk score specifically for prediction of IGT in the Thai population.

Methods

Data were collected from a consecutive sample of volunteer civil service workers in Khon Kaen province, Thailand from June to December 2009. Pregnant women and people with known diabetes were excluded. The volunteers were advised to fast for at least 8 h on the night before the day of the OGTT. The venous blood samples were in tubes with the standard preservations and kept in ice prior to glucose analysis. The time delay between blood collection and laboratory assay was about 1-3 h. Anthropometric measurements that included weight, height, and waist circumference was collected during the 2 h waiting time. Weights were taken with a digital weight scale using kg unit. Height measurements were taken with a metal scale using cm unit. Waist circumference was measured in cm at midline between lower costal margin and iliac crest. Waist to height ratio (WHt) was calculated as waist circumference (cm) divided by height (cm). Blood pressure were taken twice (at least one minute apart) after 15 min rest. Both systolic and diastolic pressures were recorded as an average between the two measurements as integer numbers. Gender was recorded as either male or female. Age was recorded as an integer number. History of hypertension was obtained by asking “Has your blood pressure ever been higher than 140/90 mmHg?”

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Family history of diabetes within 1st-degree relatives was obtained by asking "Have your parents or siblings ever been diagnosed with diabetes?" Smoking history was obtained by asking "Have you ever been a regular smoker?" Drinking history was obtained by asking "Do you currently drink more than 1 alcoholic drink per day or not?" The answers to these questions were recorded as dichotomous variables. Average carbohydrate intake per day was estimated using the Thai nutritional division portion size [10]. Number of min per week of moderately active activities or exercise was recorded and the level of activity was classified using the metabolic equivalent time classification [11]. Coffee drinking was recorded as the number of cups per day. People who reported drinking more than one cup per day were considered to be coffee drinkers. For the analysis of risk factors, the outcome was classified as negative or positive for IGT. By this definition, the negative for IGT included all the normal OGTT glucose results and IFG.

Statistical methods

IGT risk score was calculated by the stepwise logistic regression approach using the results from OGTT as a gold standard. Data were analyzed with STATA 10. After all risk factors were individually analyzed for crude odds ratio and to make sure that no important factors were missed, those with odds ratio more than one and p-value of less than 0.20 were selected for the multivariate model. Factors associated with obesity (waist circumference, BMI, and WHt) were taken out and reintroduced into the model one at a time. The receiver-operating characteristics (ROC) curve was constructed for each model. The area under the ROC curve (AUC) was computed and was used to compare each model. The model with AUC near one is considered to have high performance. The AUC near 0.5 is considered to have poor performance.

Ethical consideration

The study was approved by Khon Kaen University Ethics Committee for Human Research. Each participant was assigned a unique study identification not corresponding to their names or hospital numbers. The result of the OGTT was reported to each participant in a private confidential letter.

Results

Of 1,160 people who were verbally asked and signed written consented forms to participate in the study, 897 had a complete data set and underwent OGTT. After exclusion of people with diabetes, there were 857 subjects available for analysis. The characteristics and OGTT results of subjects were shown in Table 1. Fifty-six percent was female, mean age and BMI were 39.2 years (SD 12.05) and 23.9 kg/m^2 (SD 3.77) respectively. Of 857 subjects, only 106 (12.4%) had IGT (Table 1). The crude odds ratios for each factor were shown in Table 2. Factors with p-value < 0.20 were age, waist circumference, weight, height, BMI, WHt, history of diabetes in 1st degree relatives, currently on treatment of hypertension or known to have high blood pressure. Weight and height were drop because they were already included as part of other anthropometric factors. The model's estimation and the corresponding AUCs were shown in Table 3. When the factors associated with obesity (BMI, waist circumference, and WHt) were introduced into the model one at a time, AUC of the model that included WHt was slightly higher (0.7285; 95% CI 0.680-0.777) than that of model that included BMI (0.7137; 95% CI 0.665-0.763) or waist circumference (0.7129; 95% CI 0.663-0.762). However, none were significantly different. In the final model, the beta coefficients were rounded up to the nearest integer which had negligible effect on the AUC (0.728; 95% CI 0.679-0.777). The final equation was as follows:

Risk score for IGT = age (year) + (5 x positive history of diabetes in 1st degree relatives) + (10 x WHt) + (positive history of hypertension).

At the cutoff score of 98, this model had the sensitivity and the specificity of 71.3 and 64.4% respectively.

Table 1: Characteristics of the participants.

Subject characteristics	Normal glucose tolerance		Abnormal glucose tolerance	
	Normal	IFG	IGT	IFG&IGT
Number of male/female	319/412	14/6	31/62	9/4
Age (yr)	38.0(12.2)	45.9(8.2)	46.0(10.2)	47.7(7.1)
Weight (kg)	61.2(11.4)	75.6(18.8)	64.5(10.9)	71.5(17.4)
BMI (kg/m2)	23.6(3.5)	27.5(5.0)	25.7(3.7)	26.8(4.4)
Waist (cm)	78.8(10.0)	91.1(14.4)	84.3(10.4)	90.2(11.1)

Data are expressed as mean (SD). IFG = impaired fasting glucose; IGT = impaired glucose tolerance.

Table 2: Crude odd ratios of factors associated with impaired glucose tolerance status.

	Crude OR	P>|z|	[95% CI]
Age in years	1.06	0.000	1.04 - 1.08
Waist circumference (cm)	1.05	0.000	1.03 - 1.07
Body mass index (kg/m2)	1.13	0.000	1.08 - 1.19
Waist to height ratio	14498.55	0.000	657.94 - 319490.8
Weight (kg)	1.02	0.003	1.00 - 1.04
History of diabetes in 1 degree relatives	1.68	0.012	1.12 - 2.53
Currently on treatment of hypertension or known to have high blood pressure	1.96	0.015	1.14 - 3.35
Height (cm)	0.97	0.017	0.94 - 0 .99
Taken more than 8 portion of carbohydrate per day	0.96	0.031	0 .92 - 1.00
Past history of taking more than 4 drinks per day.	0.53	0.053	0 .27 - 1.0
Past history of smoking	0.73	0.245	0.43 - 1.24
Female	1.24	0.299	0.82 - 1.88
Systolic blood pressure (mmHg)	1.00	0.525	1 .00 - 1.00
Drinking at least one cup of coffee per day.	1.03	0.79	0.84 - 1.26
Moderate physical activity (min/week)	.999	0.00	0.9990 - 0.9997

CI = confidence interval; OR = odd ratio.

Discussion

To our knowledge, this is the first report that estimates the risk score for IGT in a Thai population. Even though the study population included only participants from the Khon Kaen area, it can represent the general Thai population in urban areas given its similar lifestyle and working environment. The risk factors that are related to IGT in this study include history of diabetes among 1st-degree relatives, age, history of hypertension and WHt. As expected, these risk factors were similar to those for diabetes as previously reported in many

Table 3 Diagnostic properties of the models.

	Original		Model 1 (BMI)		Model 2 (WC)		Model 3 (WHt)		Simple model
	OR*	β	OR*	β	OR*	β	OR*	β	Score
Age	1.04	0.04	1.05	0.05	1.05	0.05	1.05	0.04	1
WC	2.48	0.91			1.03	0.03			
BMI	2.63	0.97	1.09	0.09					
WHt	0.00	-136.46					920.17	6.82	10
Weight	0.68	-0.39							
Family history of diabetes	1.40	0.34	1.38	0.33	1.39	0.33	1.40	0.33	5
History of hypertension	1.03	0.03	1.05	0.05	1.01	0.01	1.02	0.02	1
Height	0.84	-0.18							
AUC (95%CI)	0.7296		0.7137 (0.665-0.763)		0.7129 (0.663-0.762)		0.7285 (0.680-0.777)		0.728 (0.679-0.777)

AUC = area under ROC curve; β = beta coefficient; BMI = body mass index; CI = confidence interval; OR* = adjusted odd ratio; WC = waist circumference; WHt = waist to height ratio.

studies. Lower physical activity level which is a risk factor for IGT or diabetes in other studies is not a significant risk in our study [11]. The study recently done in 1,178 Indians by Prasad et al. reported that older age, central obesity, inadequate fruit intake, being hypertensive, and hypertriglyceridemia were correlated with both diabetes and IGT [3]. Those risk factors were similar to ours except for those two factors that we did not include (inadequate fruit intake and hypertriglyceridemia). Since people with pre-diabetes (IFG or IGT) and diabetes share common risk factors, it is plausible that diabetes risk score can be used to screen for pre-diabetes. For example, a Finnish diabetes risk score was tested in a cross-sectional manner among a 4,622 middle-aged Finnish population. The parameters used in the model included age, BMI, waist circumference, physical activity, daily consumption of fruits, berries or vegetables, history of antihypertensive treatment, history of high blood glucose, and family history of diabetes. The AUC for detecting abnormal glucose tolerance (diabetes plus pre-diabetes) in that study was 0.648 for men and 0.659 for women, which was slightly lower than ours [12]. It was also retested in a population that had at least one of the main risk factors for diabetes, the AUC for detecting both pre-diabetes and undiagnosed diabetes was 0.708 [4]. In our study we demonstrated that WHt, a measurement of central obesity, had a slightly better predictive power than BMI or waist circumference in detection of IGT. WHt and waist circumference were found to have similar performance as predictors of diabetes and cardiovascular diseases [13]. A recent work was done in 5,000 Sri Lankans to compare WHt with other anthropometric indices (BMI, waist circumference and waist to hip ratio) for predicting diabetes and cardio-metabolic risks. Similar to our study, it was found that the AUC of WHt for pre-diabetes (both IGT and IFG) was 0.64 which was slightly higher than that of BMI (0.61) or waist circumference (0.63) [14]. In contrast, the study by Zhao et al. in a Chinese population showed that WHt was a strong predictor of diabetes by OGTT only in male but not in female [15]. Why there is a discrepant result between studies is uncertain. The differences of ethnic and the study methodology may be ones of the explanations. The study by Lopatynski et al. in a 1,965 Polish population reported stronger correlation of waist circumference with fasting glucose whereas WHt had better correlation with post-load glucose levels [16]. Given the positive association of WHt with post-load, not fasting glucose levels from Lopatynski's work, it may imply that risk scores that include WHt may have better performance than those that include waist circumference if OGTT, not fasting glucose was used as a diagnostic tool of diabetes. Whether the predictive power of WHt on IGT or diabetes is similar in male and female is uncertain and needs more study with a larger sample size.

Gender was not a significant factor in this study. Thus we did not include gender in the model. This finding contradicts Thai Diabetes Risk Score, which suggests that male gender is a risk factor for diabetes [5]. The discrepancy could be the fact that the population whom Thai Diabetes Risk Score was derived was predominantly male. The significant factors in Thai Diabetes Risk Score include age, male gender, BMI, waist circumference, hypertension and history of diabetes in 1st degree relatives. It should be noted that only sex and anthropometric measures are the different factors between Thai Diabetes Risk Scores and ours. We tested the ability of Thai Diabetes Risk Scores to predict IGT in our cohort. The AUC of Thai Diabetes Risk Score was 0.690 (95% CI, 0.638-0.742) which was inferior to our IGT risk score model. It may imply that Thai Diabetes Risk Score cannot be used to predict IGT in Thai population. Whether WHt works better than BMI or waist circumference in prediction of diabetes in the Thai population needs further exploration.

The advantages of this study are that it is done in community setting in an unselected population; therefore the population of the study may represent the Thai population in general. The parameters used in the risk score are simple, needs no laboratory tests and it is easy to implement as a screening tool in resource-limited community. Furthermore, we carefully performed OGTT and anthropometric measurements in all subjects in accordance with standard recommendations to minimize the erroneous results. However, this study has several limitations. Firstly, this IGT risk score has not been tested with other Thai populations, thus it should be validated prior to generalization. Secondly, this risk score may not be applicable to other different populations. Thirdly, we did not repeat OGTT to confirm the diagnosis of IGT but since the OGTT is carefully performed, we speculate that the false positive or negative results could have been low.

In conclusion, the model of using just 4 factors (age, family history of diabetes, history of hypertension, and waist to height ratio) might be suitable for community screening to identify people at risk of impaired glucose tolerance. This risk score can be used as a self-evaluation tool for high risk populations since it requires only one easy-to-carry instrument: a measuring tape.

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