Prevalence of Abnormal Glucose Tolerance in Khon Kaen Province and Validity of Urine Stick and Fasting Blood Sugar as Screening Tools

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Abstract

Three hundred and fifty-five individuals, 152 males and 203 females, aged between 30 and 74 years, were randomly selected in a two stage selection process from rural communities in three districts of Khon Kaen Province, Northeast Thailand. The prevalence of impaired glucose tolerance (IGT) and non-insulin dependent diabetes mellitus (NIDDM) in the rural area of Northeast Thailand were measured. In addition, the validity of the urine stick and fasting blood sugar as screening tools against the two hours glucose loading test as golden standard were determined. The survey was conducted in July 1995. The glucose loading test was performed on 277 individuals. IGT and NIDDM were classified according to current World Health Organization suggestions. Prevalence rates for IGT were 18.1 per cent and for NIDDM 11.9 per cent. No difference was found between males and females, also when controlled for age. NIDDM prevalence increased with age but IGT rates already were high in the younger age groups. This finding suggests that IGT precedes NIDDM in Thailand. The validity of the urine stick as a screening tool in communities was insufficient, with a sensitivity of less than 20 per cent. When using fasting blood sugar as a screening test, the sensitivity was close to 44 per cent and the specificity 90 per cent. It is concluded that the urine stick is not a useful screening tool and the method of using blood sugar concentrations for screening have to be improved before it can be applied within communities.

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Marked changes in the disease pattern can be observed in countries located in the tropical and sub-tropical zones of Asia, Africa and Latin America including Thailand. This phenomenon, sometimes called "health-" or "epidemiological transition" is characterised by the rising of chronic diseases, i.e. cardio-vascular diseases, hypertension, cancer, diabetes mellitus among others[1-3]. Non-insulin dependent diabetes mellitus (NIDDM) is probably one of the most challenging problems for the health delivery system. Previously thought to affect mainly the more affluent population in the urban areas, it now appears, that an increasing proportion of the more disadvantaged groups in rural areas are also suffering from NIDDM. However, population based surveys assessing the prevalence rates of NIDDM are rare.

Most patients are not aware that they are suffering from NIDDM for some time. Usually the disease is recognised only when the patient turns up at the hospital or dispensary, complaining of complications. Early diagnosis by screening vulnerable population groups and successive adequate treatment might prevent the early occurrence of complications and considerably improve life expectancy and quality of life for the diseased[4,5].

This study was undertaken to estimate the prevalence of NIDDM in a representative sample of the population in one of the more disadvantaged regions of the country. In addition, fasting blood sugar and the urine stick were tested as possible screening tools.

SUBJECTS AND METHOD

The survey was conducted in July 1995 in the Chumpae, Phupaman and Srichompu districts of Khon Kaen Province. Three hundred and fifty-five individuals, 152 males and 203 females, aged between 30 and 74 years, were randomly selected for the study by a two-stage selection process. Random samples were drawn from villages with 100 households and more. The number of villages selected per district were proportional to the total population of each of the participating districts. Within each of the selected villages a random sample from the target group was drawn. Not all individuals selected randomly agreed to participate in the survey. From the first morning urine glucose excretion were determined by using the Uristix® (AMES/Bayer Diagnostics, Australia). Venous blood samples were taken before breakfast to measure fasting blood glucose levels. After that a glucose loading test with 75 g glucose was performed and blood was taken again after two hours. The procedure followed the recommendations laid down for the 75 g glucose loading test by WHO[6]. Blood samples were drawn into fluoridated tubes, kept in a cooling box and were transported to a laboratory. The plasma was separated within 6 hours and stored at -70°C for further processing. Glucose levels were determined from frozen plasma through the glucose oxidase method[7]. From those individuals who participated in blood-taking for fasting blood glucose not all finished the glucose loading test. This is due to the fact that a number of persons were not available during the second time of blood-taking. Others did not comply because of side effects such as dizziness, vomiting or they did not follow the standard procedure during the loading test. Some of the samples taken from fasting blood sugar could not be determined because they were hemolysed. From the originally selected 355 subjects 7.6 per cent dropped out, leaving 328 individuals for the determination of fasting blood glucose concentrations. From this group 15.5 per cent dropped out again. The remaining 277 persons co-operated in performing the glucose loading test. From those originally sampled, 78 per cent participated in the glucose loading test. For the investigations, whether fasting blood sugar and the urine stick are suitable as screening tests, for only 258 and 276 individuals respectively both values, fasting blood sugar and urine stick results respectively as well as and blood sugar concentrations after glucose loading, were available. There was no indication that these circumstances resulted in a selection bias as will be pointed out successively.

Impaired glucose tolerance (IGT) and NIDDM was classified according to current World Health Organization suggestions (WHO 1994). To assess the validity of fasting blood glucose as a screening test, the glucose concentration of $\geq$ 140 mg/dl was taken as positive result of the test.

For data processing and statistical analysis, the statistical software programs Minitab®[8] and Epi Info®[9] were used. To evaluate the difference in age and fasting blood sugar between males and females, and for differences in proportion of high fasting blood glucose values, the Mann-Whitney test and the Chi-square test were applied respectively. For IGT and NIDDM proportions, the Chi-

square test for trends were applied. As far as the prevalence of IGT and NIDDM in different age groups and for both sexes is concerned, the Mantel-Haenszel test was done. Confidence intervals (C.I.) for proportions are given as Fleiss quadratic 95 per cent C.I. using Epi Info®. The 95 per cent achieved C.I. for the median was calculated using the Minitab® program.

RESULTS

The age of all individuals originally sampled randomly and of subgroups as well as the values of fasting blood sugar are given in Table 1 as medians and range together with the achieved 95 per cent C.I. for males and females separately. According to the selection criteria, all subjects studied were middle-aged. Females were slightly younger than the males. The median of age of all randomly selected persons and those of the subgroups finally co-operating did not differ much. When tested by the Mann-Whitney test no statistically significant differences between the age of the randomly selected population and subgroups were detected. These tests were performed for males and females separately. The median of the fasting blood sugar concentration was significantly higher for males than for females.

However, when the results for fasting blood sugar were broken down to normal and high (≥ 140 mg/dl) concentrations, the proportion of males and females did not differ significantly (Table 2). Thirteen per cent of the total population had high fasting blood glucose concentrations.

Assessed by the results of a glucose loading test, no difference was observed between males and females as far as the prevalence of IGT and NIDDM was concerned (Table 3).

Eighteen per cent of the population surveyed had IGT and over 11 per cent suffered from NIDDM. None of the individuals diagnosed as NIDDM were aware of the disease. A breakdown of IGT and NIDDM according to age groups showed, that with increasing age the prevalence of NIDDM increases as well (Fig. 1).

In the age group between 30 and 39 years, 16 per cent had IGT. This increased to 20 per cent

Table 1. Median, range and 95 per cent confidence interval of age from total population and subgroups as well as fasting blood sugar concentrations for males and females.

Variables	Total			Male			Female			p value*
	N	Median (Range)	95% C.I.	N	Median (Range)	95% C.I.	N	Median (Range)	95% C.I.	
Age (y) of individuals from random sample	355	46 (30-74)	44-47	152	48 (30-74)	46-50	203	43 (30-74)	41-46	0.0006
Age (y) of individuals fasting blood was taken	328	45 (30-68)	44-47	141	48 (30-68)	45-49	187	42 (30-64)	40-45	0.0012
Age (y) of individuals co-operating in loading test	277	46 (30-74)	44-48	103	49 (31-74)	47-54	174	43 (30-64)	40-46	0.0000
Fasting blood sugar (mg/dl)	328	87.0 (44.0-304.0)	83.8-92.5	141	92.0 (44.0-242.0)	84.8-102.6	187	84.0 (44.0-304.0)	77.0-89.4	0.0137

* Mann-Whitney Test between males and females

Table 2. Proportion of individuals with normal and high (≥ 140 mg/dl) fasting blood glucose concentration.

Variable	Total			Male			Female		
Fasting blood glucose	N	Percent	95% C.I.	N	Percent	95% C.I.	N	Percent	95% C.I.
(<140 mg/dl)	285	86.9		121	85.8		164	87.7	
(≥140 mg/dl)	43	13.1	9.7 - 17.4	20	14.2	9.1 - 21.3	23	12.3	8.1 - 18.1

Chi-square test between males and females 0.25 p<0.616

Table 3. Proportion of impaired glucose tolerance (IGT) and non-insulin dependent diabetes mellitus (NIDDM) after 2 h glucose loading test.

Glucose loading test	Total			Male			Female		
Blood sugar	N	Percent	95% C.I.	N	Percent	95% C.I.	N	Percent	95% C.I.
Normal (<140 mg/dl)	194	70.0		71	68.9		123	70.7	
IGT (140-199 mg/dl)	50	18.1	13.8 - 23.2	19	18.4	11.7 - 27.5	31	17.8	12.6 - 24.5
NIDDM (≥200 mg/dl)	33	11.9	8.4 - 16.5	13	12.6	7.1 - 21.0	20	11.5	7.3 - 17.4
Total	277			103			174		

Chi-square test for trend between males and females 0.111 p<0.738

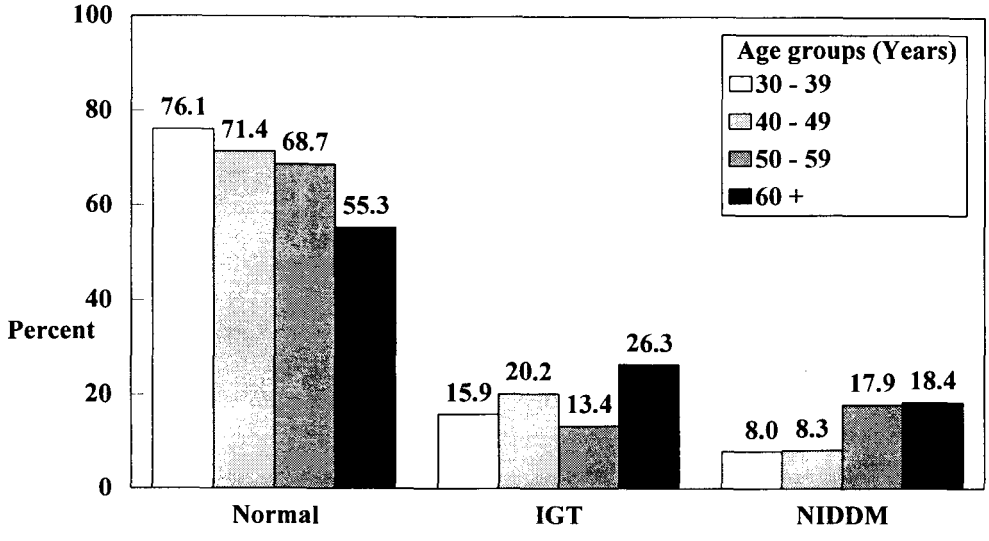

Fig. 1. Age distribution of impaired glucose tolerance (IGT) and non-insulin dependent diabetes mellitus (NIDDM) prevalence.

in the group of 40 to 50 year old individuals. For both age groups NIDDM rates were almost the same at around 8 per cent but increased sharply for the next two age groups to around 18 per cent. No statistically significant differences were found between males and females in the proportion of IGT and NIDDM. For IGT a weighted odds ratio of 1.05 (95% C.I. 0.52 - 2.17) and for NIDDM of 1.00 (95% C.I. 0.43 - 2.40) were calculated when females were considered as the exposed group and age stratification was performed. Similar results were obtained when IGT and NIDDM was combined into one pathological condition.

The results of testing the validity for fasting blood sugar and glucose urine stick against the two hours glucose loading test as gold standard are given in Table 4 and 5.

The specificity of both methods was adequate with 89.8 per cent for fasting bloods sugar and 99.6 per cent for the urine stick. The sensitivity was especially low for the urine stick with 18.8 per cent. Also the sensitivity for fasting blood sugar was quite low with 43.7 per cent. The positive predictive value for the urine stick with 85.7 per cent was high, but low for fasting blood sugar with 37.8 per cent.

Table 4. Validity of fasting blood sugar tested against 2 h glucose loading test.

		2h Glucose Loading Test		Total
		Positive (≥200 mg/dl)	Negative (<200 mg/dl)	
Fasting Blood Sugar	**Positive (≥140 mg/dl)**	14	23	37
	Negative (<140 mg/dl)	18	203	221
Total		32	226	258

Sensitivity = 43.7% (26.8 - 62.1)
Specificity = 89.8 % (84.9 - 93.3)
Positive predictive value = 37.8% (22.9 - 55.2)
Negative predictive value = 91.8% (87.2 - 95.0)

Table 5. Validity of glucose urine stick tested against 2 h glucose loading test.

		2h Glucose Loading Test		Total
		Positive (≥200 mg/dl)	Negative (<200 mg/dl)	
Urine stick	**Positive**	6	1	7
	Negative	27	242	269
Total		33	243	276

Sensitivity = 18.18% (7.6 - 36.1)
Specificity = 99.56 %(85.5 - 93.2)
Positive predictive value = 85.71% (42.0 - 99.2)
Negative predictive value = 89.96% (85.6 - 93.2)

The fact that there were differences in the total number of individuals for the different tests, due to missing values, did not result in a selection bias. The proportion of high fasting blood glucose concentration was of the same magnitude, as shown in Table 2 (13%) compared with Table 4 (14%).

DISCUSSION

The results show that IGT and NIDDM present a serious health problem in the Northeast of Thailand. The individuals, who were investigated, originated from a random sample of an ordinary village population. The age of those co-operating in the study did not differ from the age of the original sample. This might be taken as an indication that no selection bias must be assumed for the co-operating groups. Such a bias cannot be ruled out entirely but the investigators were not aware of one and believe that the result especially those from the glucose loading test, are representative for the rural population of the Northeast. The validity of a screening test must not necessarily be assessed in a representative sample of a population. It does not matter whether the samples of the 258 and 276 individuals respectively taken for these investigations are representative for the total population.

Some of the individuals tested had fasting blood sugar exceeding 200 mg/dl. The 95 per cent C.I. were within the limits expected for fasting blood sugar concentrations and the validity of the results were not questioned by the authors. It cannot be ruled out that some of the individuals had eaten before taking blood although they confessed otherwise. Since this survey was undertaken under field conditions and not in a hospital ward, such mistakes cannot be ruled out entirely. It must be kept in mind that the proportion of IGT and NIDDM was calculated from the results of the glucose loading test and not from fasting blood sugar concentrations.

A population based survey in several urban districts in Bangkok undertaken more than a decade ago, by measuring fasting blood sugar from whole blood, revealed an overall prevalence rate of 3.8 per cent[10]. For the study in Bangkok, males and females aged between 20 to 79 years were investigated. Diabetes mellitus was diagnosed by fasting blood sugar, selecting as cut-off point 120 mg/dl and above. A population based investigation in the Pol District of Khon Kaen Province between 1988-89, undertaken with the same target group as for this study and using very similar methods as well, revealed a prevalence rate of newly diagnosed diabetes of 6.7 per cent and a IGT rate of 11.2 per cent[11]. The rates determined for the Pol District were below the 95 per cent C.I. of this study, suggesting that between 1988/89 and 1995 an increase of prevalence rates for IGT and NIDDM might have occurred in the Khon Kaen province. The results of the Bangkok based study were not readily comparable with those from the Northeast of Thailand. Regardless of the differences in the methods and cut-off points applied, the results obtained so far suggest that IGT and NIDDM have become a public health problem of considerable magnitude. Prevalence rates seem to be much higher than those found more than 20 years ago[12]. Recent reported prevalence rates indicate that the proportions for IGT and NIDDM found in the Northeast of Thailand are comparable to those found in countries with a similar economic development. In a population survey of 25 to 74 year old South African Indians, prevalence rates were similar to those from Khon Kaen province with 13 per cent for NIDDM but lower for IGT with 7 per cent[13]. In a randomly selected population between 30 and 69 year olds from Rio de Janeiro, prevalence rates for diabetes were found to be 7.1 per cent and 9 per cent for IGT[14].

In a highly industrialised country such as Japan, it was found that among 40 to 79 year old residents from Hisayama, prevalence rates of NIDDM was 13 per cent and 9 per cent and for IGT 20 per cent and 19 per cent for males and females respectively[15]. While this study from Thailand showed no differences between males and females, also when controlled for age, this was not so in other countries. Among South African Indians NIDDM and IGT were more common in males than in females[13]. On the contrary, females had higher rates than males in Brazil[14]. In Japan, prevalence of NIDDM but not of IGT was higher in males[15]. The sex differences found in other population based surveys are probably due to differences in life style and eating habits between genders.

The high prevalence rates of IGT even in the age group of 30 to 39 years, probably indicate that IGT precedes the development of NIDDM also in Thailand; a phenomenon commonly known for high risk populations such as the Micronesian

Nauruans or the Pima Indians in U.S.A. among others[16].

The high prevalence rates for NIDDM illustrate the need for primary and secondary preventive measures at community level. It has been pointed out recently, that the problem of introducing and monitoring suitable interventions on a long-term basis in high risk populations in different cultures has yet to be addressed[5]. Probably the most pressing task is to effectively implement a suitable screening method and to implement it in order to control the complications of NIDDM leading to long-term disability and premature mortality. This investigation shows that common tools for screening are inadequate. This especially refers to the urine stick. Sensitivity is so low that more than 80 per cent of those suffering from NIDDM will remain undetected. However, the positive predictive value of 85 per cent indicates that, if the result of the urine stick is positive, there is a high chance that the disease in fact is present.

The use of fasting blood sugar as a means for screening NIDDM is also limited by a low sensitivity of about 45 per cent. In addition, the low positive predictive value of about 40 per cent will produce high numbers of individuals with false positive results. If the test is applied in communities, the health delivery sector have to be prepared not only to deal with an increase in patients suffering from a chronic condition but also to cope with many individuals undergoing a glucose loading test for final diagnosis. Most of the patients would need continuous treatment and guidance for a long time, which the service has to provide.

The ideal screening tool, suitable within communities in Thailand and countries with similar backgrounds still has to be developed. The use of portable reflectance meters, not only in curative settings to control the glucose status of already diagnosed individuals, but also for screening within the communities might enhance the feasibility of screening. In Finland, the portable reflectance meters were tested in an elderly population using random capillary blood glucose tests. The screening test was validated against the oral glucose loading test. Optimal cut-off points were selected separately for males, females and both sexes together. Sensitivity for the total population was 61 per cent, specificity 87 per cent and the positive predictive value 62 per cent[17]. In another attempt it has been suggested recently that taking capillary blood glucose measurements after the subjects have eaten and using age-specific cut-off point values might improve the screening test[18]. Sensitivity and specificity rates of about 80 per cent were reported by using this approach. The modification of the fasting blood sugar test in such a way as described above and conducted with the co-operation of Egyptian subjects, has to be tested under the circumstances present in Thailand to find out, whether it is meaningful to apply it in this country and others with similar conditions.

SUMMARY

The objective of the study was to measure the prevalence of impaired glucose tolerance (IGT) and non-insulin dependent diabetes mellitus (NIDDM) in a rural area of Northeast Thailand. In addition, the validity of the urine stick and fasting blood sugar as screening tools against the two hour glucose loading test as golden standard were determined. Three hundred and fifty-five individuals, 152 males and 203 females, aged between 30 and 74 years, were randomly selected in a two stage selection process from rural communities in three districts of the Khon Kaen province, Northeast Thailand. The survey was conducted in July 1995. Fasting blood glucose concentration was measured from venous blood samples. Urine sticks were applied in the morning urine in order to single out those with sugar excretion in the urine. The glucose loading test was performed with 277 individuals. IGT and NIDDM were classified according to current World Health Organization suggestions. Prevalence rates for IGT were 18.1 per cent and for NIDDM 11.9 per cent. No difference was found between males and females, also when controlled for age. NIDDM prevalence increased with age but IGT rates were already high in the younger age groups. This finding suggests that IGT precedes NIDDM in Thailand. The validity of the urine stick as a screening tool in communities was insufficient, with a sensitivity of less than 20 per cent. When using fasting blood sugar as a screening test, the sensitivity was close to 44 per cent and the specificity 90 per cent. It is concluded that the urine stick is not a useful screening tool and the method of using blood sugar concentrations for screening have to be improved before it can be applied within communities.

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อัตราความชุกของการบกพร่องความทนน้ำตาลของประชากรใน 3 อำเภอของจังหวัดขอนแก่น ทดสอบโดยใช้แถบตรวจปัสสาวะและตรวจน้ำตาลในเลือด

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คณะผู้วิจัยได้ทำการสำรวจอัตราความชุกของการบกพร่องความทนน้ำตาล (Impaired glucose tolerance, IGT) และผู้ป่วยเบาหวานไม่พึ่งอินซูลิน (Non-insulin dependent diabetes mellitus, NIDDM) ในประชากรในเขตชนบทของภาคตะวันออกเฉียงเหนือ นอกจากนั้นยังได้ทำการตรวจสอบผลจากทั้งการทดสอบระดับน้ำตาลในเลือดและการใช้แถบตรวจน้ำตาลในปัสสาวะเปรียบเทียบกับผลของความทนน้ำตาลในเลือด (Oral glucose tolerance test, OGTT) ของผู้ที่มารับการทดสอบ จำนวน 355 คน เป็นชาย 152 คนและหญิง 203 คน ซึ่งมีอายุระหว่าง 30–74 ปี ตามข้อเสนอแนะขององค์การอนามัยโลก จากการสุ่มตัวอย่างแบบ random ในเขต 3 อำเภอของจังหวัดขอนแก่น ในปีพ.ศ. 2538 พบอัตราการบกพร่องความทนน้ำตาลสูงถึงร้อยละ 18.1 และร้อยละ 11.9 เป็นผู้ป่วยเบาหวานไม่พึ่งอินซูลินโดยตรง โดยไม่พบความแตกต่างระหว่างเพศในกลุ่มอายุเดียวกัน อย่างไรก็ตามอัตราความชุกของผู้ป่วยเบาหวานไม่พึ่งอินซูลินจะเพิ่มขึ้นตามอายุ ในขณะที่อัตราความชุกของการบกพร่องความทนน้ำตาลจะพบมากในกลุ่มที่มีอายุน้อยกว่า คณะผู้วิจัยยังพบความจำเพาะของการตรวจน้ำตาลในปัสสาวะสูงแต่มีความไวในการตรวจเพียงร้อยละ 20 จึงทำให้การใช้แถบตรวจน้ำตาลในปัสสาวะไม่มีประสิทธิภาพในการวินิจฉัยผู้ป่วยเบาหวาน ในขณะที่ความไวของการตรวจน้ำตาลในเลือด (fasting blood sugar) มีประมาณร้อยละ 44 และมีความจำเพาะถึงร้อยละ 90 จากการศึกษาพอจะสรุปได้ว่าการใช้แถบตรวจน้ำตาลในปัสสาวะไม่เป็นวิธีการทดสอบที่เหมาะสม ส่วนวิธีการตรวจน้ำตาลในเลือดจะต้องมีการปรับปรุงให้เหมาะสมกับการที่จะนำเอาไปใช้ทดสอบในชุมชน

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