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Evaluation of non-invasive screening measures to identify individuals with prediabetes

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Abstract

Aims—Because blood-based screening to identify those with prediabetes to take part in Diabetes Prevention Program (DPP) translation efforts can be costly and time-consuming, non-invasive methods are needed. The aims of this paper are to evaluate the ability of the American Diabetes Association (ADA) risk test in identifying individuals with prediabetes, as well as the use of body composition measures for this purpose. In addition the utility of these alternate methods to ascertain the presence of the metabolic syndrome was assessed.

Methods—Potential participants were recruited from a worksite and three community centers to take part in a DPP translation study. Participants completed onsite screening where anthropometric measures, fasting lipids and glucose, and hemoglobin A1c were assessed. Those with a BMI $\geq 24\text{kg/m}^2$ and prediabetes and/or the metabolic syndrome were eligible to participate. Non-invasive screening methods were evaluated for their ability to identify those with prediabetes and the metabolic syndrome based on clinically measured values.

Results—All non-invasive methods were highly sensitive (68.9% to 98.5%) in the detection of prediabetes, but specificity was low (6.7% to 44.5%). None of the alternatives evaluated achieved acceptable discrimination levels in ROC analysis. Similar results were noted in identifying the metabolic syndrome.

Conclusions—The non-invasive methods evaluated in this study effectively identify participants with prediabetes, but would also allow for enrollment of a large number of individuals who do not have prediabetes. Deciding whether to use these alternatives, blood-based measures, or a combination of both will ultimately depend on the purpose of the program and the level of flexibility regarding participant eligibility.

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Conflict of Interest

The authors declare that they have no conflict of interest.

Keywords

screening; prediabetes; lifestyle intervention

1. Introduction

The Centers for Disease Control and Prevention (CDC) currently estimate that 25.8 million people in the United States (US) have diabetes, and an additional 79 million people are at high-risk with prediabetes, identified by impaired fasting glucose, impaired glucose tolerance or hemoglobin A1c[1]. The prevalence of the metabolic syndrome, a constellation of risk factors that increase the risk for diabetes has also been persistently increasing during the past decade[2]. It is estimated that nearly one third of the US population will have diabetes by 2050 due to increases in diabetes incidence and low mortality rates[3].

The US Diabetes Prevention Program (DPP) demonstrated that type 2 diabetes could be prevented or delayed through intensive lifestyle intervention, with the goals of moderate weight loss and increased physical activity levels [4]. The success of the DPP has led to a variety of translations of its lifestyle intervention that have been conducted in urban and rural areas, within the health care setting, through community groups, and at worksites and academic institutions across the US. Each has demonstrated some level of success in regard to reducing weight, increasing physical activity levels and even improving risk factors for diabetes and cardiovascular disease [11-16].

Accurate identification of high-risk individuals who will benefit the most from taking part in these diabetes prevention translation efforts is essential. In the DPP, eligibility criteria included age ≥ 25 years, Body Mass Index (BMI) ≥ 24 kg/m² or ≥ 22 kg/m² for Asian Americans, and impaired glucose tolerance diagnosed by a single 75-g oral glucose tolerance test (OGTT) [17]. However, the criteria used to identify high-risk participants who meet program eligibility among community translations of the DPP lifestyle intervention has varied considerably (Table 1) [18]. A common theme among these translation efforts was use of a BMI cut point (≥ 24 kg/m² or ≥ 25 kg/m²), combined with at least one of the previously mentioned measures of diabetes risk listed in Table 1, including having the metabolic syndrome to determine eligibility [11-16, 19-26].

Given the high numbers of people at risk for diabetes, a simple, inexpensive method, such as a paper risk test or anthropometric measurement, is needed to facilitate the identification of individuals with prediabetes who could subsequently benefit from lifestyle intervention. Published DPP translation efforts that employed a paper risk test have reported using the 7 question American Diabetes Association (ADA) paper risk assessment developed by Herman et al. in 1995[11, 14, 27]; however the ADA paper risk assessment was created to identify individuals at risk for undiagnosed diabetes, not those with prediabetes. The CDC National Diabetes Prevention Recognition Program (DPRP) guidelines focus on blood-based screening for identification of those with prediabetes for inclusion in diabetes prevention programs. However, while the DPRP standards and operating procedures require that at least half of those enrolled in diabetes prevention programs have documented prediabetes, the guidelines also include use of the ADA paper risk test [28] as an alternative screening

method for up to half of enrolled individuals, likely due to a lack of viable, non-invasive screening methods [29]. To date, the ADA risk test has not been evaluated for its ability to identify those with prediabetes in the context of a diabetes prevention translation study.

In other efforts, anthropometric measurements such as BMI[30-33], waist circumference[30, 31, 33], and waist to height ratio[30, 31, 33, 34] have been investigated for their ability to provide details about an individuals' future risk for type 2 diabetes. However, to the authors' knowledge, none of these anthropometric measurements have been evaluated for their ability to identify high risk participants in the context of a lifestyle intervention for the prevention of type 2 diabetes.

Therefore, the aims of this paper are to evaluate the ability of the ADA paper risk assessment test incorporated by the CDC DPRP as well as other non-invasive body composition measures to identify individuals with prediabetes. In addition the utility of these alternate screening methods to ascertain the presence of the metabolic syndrome is assessed. It is anticipated that the availability of alternative accurate non-invasive methods to identify those at high risk for diabetes will facilitate enrollment of these individuals in community diabetes prevention efforts.

2. Methods

2.1. Participant Recruitment and Eligibility

Participants were recruited from a local worksite and three community centers in Allegheny County, Pennsylvania to take part in a National Institutes of Health funded effort evaluating delivery of a DPP-based lifestyle intervention translation, the Group Lifestyle Balance (GLB) program, in a variety of community settings. In the GLB program, which retains the same weight loss and physical activity goals as the DPP, participants are encouraged to self-monitor diet, physical activity and weight, as well as focus on healthy food choices and increasing physical activity levels [16]. Notification of the upcoming intervention was disseminated via email, print advertisements, mass mailing, health fairs and information sessions at each of the four sites. Interested participants were first screened over the phone or in person at health fairs and information sessions to determine initial eligibility criteria.

The initial screening insured participants were adults 18 years of age, without diagnosed diabetes, with a BMI $\geq 24\text{kg/m}^2$ ($\geq 22\text{kg/m}^2$ for Asians), were not pregnant or breastfeeding, and were not planning to move away from the area during the projected study time period. Participants who answered "no" to all of these questions and were interested in taking part in the intervention were scheduled to attend an onsite in-person screening.

At the onsite screening, assessment of participants' blood pressure, height, weight and waist circumference were completed following standard protocol. The Cholestech LDX system was used to measure total cholesterol, High-density lipoprotein cholesterol (HDL-C), Low-density lipoprotein cholesterol (LDL-C), triglycerides and glucose after a minimum 8-hour fast, and hemoglobin A1c was measured using a Siemens/Bayer DCA 2000 by a certified research assistant. Additional information collected for each participant included date of birth, gender, family history of diabetes and heart disease, smoking status, race/ethnicity,

employment status, physical activity level, education level, prescription medication use for blood pressure, dyslipidemia and dysglycemia and other female risk factors for diabetes including history of giving birth to an infant >9 lbs. (4.1kg), history of gestational diabetes (GDM) and Polycystic Ovary Syndrome (PCOS). Participants also completed the 7 question ADA risk test [27, 29].

Intervention eligibility criteria included: BMI $\geq 24\text{kg/m}^2$ or $\geq 22\text{kg/m}^2$ for Asians, prediabetes (fasting glucose of 100-125mg/dl and/or A1C of 5.7%-6.4%), and/or the metabolic syndrome (National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) criteria or hyperlipidemia and 1 additional component of the metabolic syndrome) [35, 36].

2.2. Non-Invasive Screening Measures Evaluated

The DPRP guidelines suggest using a score of ≥ 9 on the ADA risk test for participant inclusion criteria, [29] therefore this cut point was evaluated for its ability to identify participants with prediabetes and those meeting study eligibility criteria. Anthropometric measures (BMI, waist circumference and waist to height ratio) were evaluated singularly and in combination with other diabetes risk factors (e.g. family history, physical inactivity) for their ability to identify eligible participants with prediabetes. In addition, all methods were examined for their ability to identify those with the metabolic syndrome. A BMI cut-point of $\geq 27\text{kg/m}^2$ is reported on because it is the point at which an individual is considered to be at increased risk according to the BMI question on the ADA risk test [29, 37]. Waist circumferences of >102 centimeters (40 inches) for men and >88 centimeters (35 inches) for women, based on the NCEP ATP III guidelines for metabolic syndrome [35] and waist to height ratios of ≥ 0.5 and ≥ 0.6 , selected based on previous investigations, were evaluated [33, 38, 39]. This project was approved by the University of Pittsburgh Institutional Review Board.

2.3. Data Analysis

Differences among screening characteristics between sites were evaluated using two sample independent t-tests for normally distributed variables and Wilcoxon-Mann-Whitney test for variables not normally distributed. The Chi-square test or Fisher's exact test were used to test for differences in proportions. Sensitivity and specificity were calculated for the non-invasive screening measures in relation to 3 diagnostic criteria using the PROC FREQ procedure to generate 2x2 tables and receiver operating characteristic (ROC) curves were calculated for all 5 screening tests using the PROC LOGISTIC procedure.

Data analyses were conducted using Statistical Analysis Software Version 9.3 (Cary, NC).

3. Results

A total of 364 participants were screened onsite, 64% (233) were female, mean age was 55.8 ± 12.5 years, mean BMI was $33.4 \pm 6.2\text{ kg/m}^2$ and mean weight was 93.3 ± 20.1 kgs. (Table 2). Forty-seven percent of participants reported a family history of diabetes, 45% reported a family history of heart disease, and 22% reported both a family history of diabetes and heart disease (Table 2). Participants were predominately white (92.5%), 89% had at least some

college or technical school at screening and 93% were either never or former smokers (Table 2).

Because of the diversity of the study sites, demographic characteristics are presented by screening site. Those screened at the worksite were significantly younger, had a significantly lower BMI, waist circumference and hemoglobin A1c than those screened at the community sites (Table 2). Community site screening participants had significantly lower total cholesterol, LDL cholesterol and diastolic blood pressure than those screened at the worksite. Other significant differences between the sites included the percent of female participants, level of education and smoking status (Table 2).

Of the 364 screened participants 72% (261) met GLB study eligibility criteria with 55% (200) determined to have prediabetes (criteria: fasting glucose of 100-125mg/dl and/or A1C of 5.7%-6.4%). A score of 9 on the ADA risk test identified 89% (323) of screening participants as eligible, and a BMI cut point of 27kg/m^2 identified 86% (313) of screening participants as eligible. Further, the selected waist circumference criteria identified 78% (285) of screening participants as eligible, a waist to height ratio of 0.5 identified 96% (350) screening participants as eligible and a waist to height ratio of 0.6 identified 62% (227) screening participants as eligible. The frequency of those meeting eligibility criteria and screening positive for the non-invasive methods are also presented stratified by intervention site to display similarities. Table 4 provides the sensitivity and specificity results for the ADA risk test and the other methods in identifying those with prediabetes. The ADA risk test score of 9 was highly sensitive (93.5%) in the identification of participants with prediabetes, but specificity was also very low (17.1%). Subsequently higher scores on the ADA risk test decreased sensitivity and increased specificity with the greatest balance occurring at a risk score of 12 in the identification of prediabetes (sensitivity=64.5%, specificity=48.8%).

The BMI cut point of 27kg/m^2 was also highly sensitive (89.0%) in the identification of participants with prediabetes, but also had very low specificity (17.7%). The BMI cut point of 27kg/m^2 in combination with a family history of diabetes had a sensitivity of 47.6% for the identification of participants with prediabetes, but demonstrated better specificity than any of the other screening methods (62.8%). A BMI cut-point of 30kg/m^2 reduced sensitivity (68.5%) and increased specificity (37.2), but specificity still remained quite low and progressively higher BMI values did not improve the measure further.

A waist to height ratio 0.5 had similar issues to the BMI cut point of 27kg/m^2 and the ADA risk test score 9 in the identification of participants with prediabetes (sensitivity=98.5% and specificity=6.7%); however, a waist to height ratio of 0.6 was moderately sensitive (68.0%) and moderately specific (44.5%). The waist circumference criteria performed similarly to the waist to height ratio of 0.6 in identification of prediabetes (sensitivity 82.0% and specificity 26.2%) (Table 4). Non-invasive methods performed similarly across intervention sites. The addition of family history of diabetes to waist circumference reduced sensitivity to 47.0% or less, with increases in specificity (data not shown). Excluding A1c criteria from the category of prediabetes and using only IFG did not have a remarkable influence on sensitivity and specificity (data not shown).

ROC curve results demonstrated that a waist to height ratio of 0.6 was the most effective in the identification of prediabetes, but the difference was not significantly different from either a BMI cut point, waist circumference criteria or the ADA risk test (data not shown). None of the area under the curve (AUC) values for any screening criteria evaluated were within the acceptable discrimination range (i.e. a score of >0.70) described by Hosmer and Lemeshow.[40] Results were not different when stratified by site.

4. Discussion

This is the first study to report on the sensitivity and specificity of the ADA risk test and other non-invasive measures in the identification of prediabetes confirmed by fasting blood glucose or hemoglobin A1c in diabetes prevention translation. The ADA risk test score of 9, BMI cut-point of 27kg/m² and waist to height ratio of 0.5 all effectively identified participants who had prediabetes and, but they all suffered from low specificity. In the current study, if any non-invasive method were used exclusively to identify eligible participants without confirmatory blood-based screening methods, the result would have been enrollment of a large number of participants without prediabetes. Similar results were true in the identification of the metabolic syndrome by the non-invasive methods evaluated.

Although the ADA risk test has not been evaluated for identification of prediabetes, it has been assessed for its ability to identify undiagnosed diabetes and dysglycemia by Rolka and colleagues who noted a score 10 to be highly sensitive (69%), but limited by low specificity (54%) [28]. Sensitivity (93.5%) was higher in the current study, but specificity (17.1%) was markedly lower using the CDC DPRP recommended score of 9. The study by Rolka and colleagues occurred before prediabetes criteria changed from IFG = FPG 110-125mg/dL to IFG= FPG 100-125mg/dL, and the differences in sensitivity and specificity from our study may partially reflect this change [41]. The same study also found the risk score to perform better, with increased specificity, when associated with a casual capillary blood glucose (CCBG). However, this combination method was contrary to the recommendations at the time, stating that the ADA risk score be employed prior to any glycemic tests [42]. Subsequent evaluation of the ADA risk test also reported that when combined with a logistic regression equation including blood glucose concentration the specificity of the measure improved [37].

The DEPLOY study used the combined method (ADA risk test + CCBG) discussed by Rolka and colleagues to identify eligible participants, but did not report sensitivity or specificity[11, 28]. A more recent translation of the DPP lifestyle intervention by Barham et al. used the current ADA risk score to identify high risk employees, but they too did not report on sensitivity and specificity [26]. Although the discriminative ability of the ADA risk test is improved in combination with measures of blood glucose, this detracts from its application as a simple, paper and pencil risk assessment for the identification of people with prediabetes. In the identification of the metabolic syndrome ADA risk test results were similar to those for prediabetes.

The appeal of the ADA risk test is that it does not require clinical measurements or prior knowledge of clinical risk factors, making it easy for those implementing prevention

programs to use for screening and for those being screened to complete [27, 28]. For a similar reason, the use of a BMI cut-point to identify participants with prediabetes was evaluated. Assessment of BMI only requires the measurement of height and weight and a standard calculation. Our results indicate that the BMI cut-point of 27kg/m^2 is highly sensitive, but suffers from low specificity in the identification of prediabetes. Similar results were noted in the identification of the metabolic syndrome. Other investigations suggest BMI is associated with future type 2 diabetes risk, but measures of central adiposity have a more robust association [33, 34, 43].

In the current study, waist circumference and waist to height ratio 0.6 demonstrated the best balance between sensitivity and specificity in identification of prediabetes, but were not significantly different from a BMI cut-point 27kg/m^2 or the ADA risk test in ROC analysis. Considering metabolic risk, a study evaluating different waist circumference cut points ($\text{WC} > 90\text{cm}$ for men, 80cm for women) found the measures to have low sensitivity (57% men, 31.9% women) and high specificity (74.9% men, 96.4% women) in identification of individuals at high metabolic risk (3 to 8 metabolic risk factors) [31]. In contrast, among participants in the current study, sensitivity was much higher for our selected waist circumference criteria, but specificity was reduced in identification of the metabolic syndrome. Unlike the ADA risk test and self-reported BMI, measures of central adiposity would require clinical measurement of height and waist circumference, but they cost less and are easier to assess than blood-based screening methods.

Limitations of this study include the relatively small sample size that was screened compared to other studies evaluating diabetes screening methods and a lack of racial or ethnic diversity among screened participants, with 92.5% of individuals being Caucasian.

The current study demonstrates that while non-invasive alternatives to blood-based testing exist, they may not be appropriate in all settings. According to the CDC DPRP standards, a program applying for recognition may enroll up to 50% of its participants based on a score of 9 on the ADA risk test without confirmatory blood-based testing or history of gestational diabetes [29]. In our study, all evaluated alternatives identified more than 50% (range 57-60%) of participants as having a confirmatory blood-based test indicating prediabetes, thus meeting the 50% standard set by the DPRP. However, if identification of the most high-risk participants (i.e. with prediabetes) is the primary goal then none of the measures evaluated, including the ADA risk test, are satisfactory and blood-based testing is the only reliable option.

Due to the lack of acceptable discriminative ability associated with all measures evaluated in this study, it may be more appropriate to use these screening tools initially as part of a sequential screening format, followed by confirmatory blood glucose and lipid values to verify eligibility. This has been suggested in previous guidelines for diabetes screening [42] and at the present time may also be the best approach for translation to the community. Confirmatory values could come from a variety of sources depending on the nature of the intervention, including physician referrals, participant medical records, and worksite, community or practice-based screenings. Further study is needed to determine the most efficient, cost effective method to identify individuals who have prediabetes or meet

additional program specific eligibility criteria like the metabolic syndrome and may include recent advances in technology such as skin fluorescence spectroscopy[44].

In conclusion, the alternative screening methods evaluated here effectively identify participants with prediabetes, but would also allow for enrollment of a large number of individuals who do not have prediabetes. Deciding whether to use these alternatives, blood-based measures, or a combination of both will ultimately depend on the purpose of the program and level of flexibility regarding participant eligibility.

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Methods used to identify eligible participants and the order in which they were used if a stepped approach was employed.

Table 1

Study Author	Methods to identify prediabetes				Methods to identify other high-risk categories		
	Blood-based screening			Diabetes risk test	Physician documentation	Blood based screening	Documentation of 1 diabetes risk factor
	Random capillary glucose	Fasting Finger Stick	Fasting blood glucose				
Ackermann[11]	X(2)			X(1)			
Amundson[13]							X
Boltri[14]		X(2)	X(3)	X(1)			
Whittemore[15]							X
Kramer[16]					X	X	X
Matvienko[19]					X		X
Merriam[20]					X		X
Katula[21]			X				
Kramer[22]					X		X
Kramer[23]					X		X
Seidel[24]						X	
McTigue[25]							X
Barham[26]				X			

*numbers indicate order in which screening methods were used

Table 2

Characteristics of participants taking part in the on-site screening overall and by site (N=364).

	Mean (SD)		Mean (SD)	
	N=364 unless otherwise noted	Total (N=364)	Worksite (n=160)	Community (n=204)
Age (years)		55.8 (12.5)	49.6 (9.0)	60.7 (12.7) *
Body mass index (kg/m ²)		33.4 (6.2)	32.4 (6.2)	34.1 (6.1) *
Weight (kg)		93.3 (20.1)	93.0 (19.1)	93.6 (20.9)
Waist circumference (cm)		105.4 (14.0)	102.9 (13.5)	107.4 (14.2) *
Total Cholesterol (mg/dl)		193.7 (36.3)	200.9 (39.2)	188.1 (32.9) *
LDL Cholesterol (mg/dl) (n=341)		111.0 (32.2)	116.5 (33.6)	106.9 (30.5) *
HDL Cholesterol (mg/dl) (n=354)		52.8 (15.6)	53.0(16.3)	52.6 (15.0)
Triglycerides (mg/dl) (n=354)		155.6 (90.7)	169.7 (110.6)	144.4(69.2)
		133	138.5	129
Fasting glucose (mg/dl)		97.8 (15.8)	96.4 (14.7)	99.0 (16.6)
Haemoglobin A1c (%)		5.6 (0.5)	5.6 (0.4)	5.7 (0.5) *
Systolic Blood Pressure (mmHg)		119.7 (13.4)	121.1 (13.0)	118.5 (13.6)
Diastolic Blood Pressure (mmHg)		77.0 (10.3)	81.5 (9.9)	73.4 (9.2) *

	% (n)		% (n)	
Gender *				
Male	36 (131)	42.5 (68)	31 (63)	
Female	64 (233)	57.5 (92)	69 (141)	
Education *				
Some High School	1 (3)	0 (0)	1 (3)	
High School Graduate/GED	10 (36)	3 (5)	15 (31)	
Some College or technical school	24 (88)	21 (34)	27 (54)	
College graduate (bachelor's)	34 (124)	41 (66)	28 (58)	
Graduate degree	31 (113)	35 (55)	28 (58)	
Family History of Diabetes	47 (170)	48 (77)	46 (93)	
Family History of Heart Disease	45 (162)	43 (68)	46 (94)	
Family History of both Diabetes and Heart Disease	22 (81)	21 (34)	23 (47)	
History of Gestational Diabetes	4 (9)	3.2 (3)	4.3 (6)	
History of baby > 9 lbs (4.1kg)	16 (37)	12 (11)	18.4 (26)	
Polycystic Ovary Syndrome	2 (5)	3.3 (3)	1.4 (2)	

* indicates p<0.05

Table 3

Frequency of participants meeting study eligibility criteria and screening positive based on the screening methods evaluated for those who took part in the on-site screening overall and by site (N=364).

	% (n)		
	Total (N=364)	Worksite (n=160)	Community (n=204)
Study Eligibility Criteria			
Eligible based on study criteria	72 (261)	67 (107)	75 (154)
Prediabetes *	35 (128)	31 (49)	39 (79)
Prediabetes **	40 (145)	31 (50)	47 (95)
Prediabetes ***	55 (200)	48 (77)	60 (123)
Metabolic syndrome ****	49 (180)	49 (79)	50 (101)
Screening Procedure			
Risk Score 9	89 (323)	84 (135)	92 (188)
BMI 27kg/m ²	86 (313)	81 (130)	90 (183)
BMI + Family History of Diabetes	43 (145)	44 (63)	42 (82)
Waist to height ratio 0.5	96 (350)	93(148)	99(202)
Waist to height ratio 0.6	62 (227)	51(81)	72(146)
Waist circumference (>102 cm men, >88 cm women)	78 (285)	68(108)	87(177)

* prediabetes defined by impaired fasting glucose 100-125 mg/dl

** prediabetes defined by hemoglobin A1C 5.7-6.4%

*** prediabetes including both fasting glucose 100-125 mg/dl and hemoglobin A1C 5.7-6.4%

**** metabolic syndrome defined by NCEP ATPIII criteria

Sensitivity, specificity and positive predictive value for evaluated screening methods in the identification of prediabetes (fasting glucose of 100–125mg/dl and/or AIC of 5.7%–6.4%) and the metabolic syndrome (NCEP ATPIII criteria or hyperlipidemia and 1 component of the metabolic syndrome).

Table 4

Screening Test	All Eligibility				Prediabetes				Metabolic Syndrome			
	Sensitivity (%)	Specificity (%)	Positive Predictive Value	Sensitivity (%)	Specificity (%)	Positive Predictive Value	Sensitivity (%)	Specificity (%)	Sensitivity (%)	Specificity (%)	Positive Predictive Value	Positive Predictive Value
ADA risk test 9	92.3	20.4	74.6	93.5	17.1	57.9	92.2	14.7			51.4	
BMI 27kg/m ²	89.7	23.3	74.8	89.0	17.7	56.9	95.6	23.4			55.0	
BMI + Family History of Diabetes	45.9	64.9	77.2	47.6	62.8	60.7	48.3	62.8			57.9	
Waist to height ratio 0.5	98.5	9.7	73.4	98.5	6.7	56.3	98.3	6.0			50.6	
Waist to height ratio 0.6	69.0	54.4	79.3	68.0	44.5	59.9	79.4	54.3			63.0	
Waist Circumference (>102 cm men, >88 cm women)	83.9	35.9	76.8	82.0	26.2	57.5	93.9	37.0			59.3	
Worksite												
ADA risk test 9	89.7	26.4	71.1	89.6	20.5	51.1	91.1	22.2			53.3	
BMI 27kg/m ²	86.0	28.3	70.8	83.1	20.5	49.2	93.7	30.9			56.9	
BMI + Family History of Diabetes	48.5	66.0	74.6	48.5	60.5	52.4	52.0	65.2			61.9	
Waist to height ratio 0.5	96.3	15.1	69.6	96.1	10.8	50.0	96.2	11.1			51.4	
Waist to height ratio 0.6	57.0	62.3	75.3	53.3	51.8	50.6	70.9	69.1			69.1	
Waist Circumference (>102 cm men, >88 cm women)	73.8	45.3	73.2	68.8	33.7	49.1	88.6	53.1			64.8	
Community												
ADA risk test 9	94.2	14.0	77.1	95.9	13.6	62.8	93.1	8.7			50.0	
BMI 27kg/m ²	92.2	18.0	77.6	92.7	14.8	62.3	97.0	17.5			53.5	
BMI + Family History of Diabetes	44.2	63.8	79.3	47.0	64.9	67.1	45.5	61.1			54.9	
Waist to height ratio 0.5	100	4.0	76.2	100	2.5	60.9	100	1.9			50.0	
Waist to height ratio 0.6	77.3	46.0	81.5	77.2	37.0	65.1	86.1	42.7			59.6	
Waist Circumference (>102 cm men, >88 cm women)	90.9	26.0	79.1	90.2	18.5	62.7	98.0	24.3			55.9	