Waist–thigh Ratio: A Surrogate Marker for Type 2 Diabetes Mellitus in Asian North Indian Patients

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Abstract

Introduction: Diabetes is a major world-wide healthcare problem. Cost effective markers for screening and diagnosis of T2DM are the need of the day especially in developing and under-developed countries. Simple anthropometric measurements may help us in identifying individuals likely to have diabetes. **Material and Methods:** Data from 1055 North-Indian subjects was analysed. **Results:** Out of several anthropometric measurements studied, Waist-Thigh ratio (WTR) correlated significantly and positively with all three measures of diabetes i.e. FPG, RPG and PPG. ($P < .0001$) suggesting that it is the best predictor of diabetes. Subjects with diabetes had greater WTR (mean 2.088) than those without (mean1.842). ($P < .0001$). A thresh-hold effect was evident at a cut-off WTR of 2.3. Out of those subjects who were diagnosed to have diabetes by AACE/AHA guidelines, 82% had WTR greater than this value ($P < 0.001$). **Conclusion:** WTR may prove to be a simple and inexpensive marker for detecting Type 2 diabetes. Larger studies are required to develop population norms.

Keywords: Anthropometric measurements, Type 2 diabetes mellitus, waist-thigh ratio

Introduction

Diabetes is a major challenge being faced by clinicians worldwide. An estimated 415 million people suffered from diabetes worldwide in 2015. This may reach a staggering figure of 642 million by 2040 if this current trend continues. South East Asian diabetics may go up from 78.3 million in 2015 to 140.2 million by 2040.[1] Of greater concern is the fact that almost half of these diabetics are undiagnosed. Mere diagnosis and treatment of diabetes will prove to be futile and uneconomical, unless we identify those at risk from it as early as possible and develop strategies that prevent disease (primary prevention) and complications (secondary prevention). For this, we require simple and inexpensive screening tools that can be used easily, wherever and whenever required by the clinician.

There is an independent association of waist circumference (WC) and waist–hip ratio (WHR) with glucose tolerance, insulin resistance, and type 2 diabetes mellitus (T2DM) that has been demonstrated by a number of observers.[2-5]

Thigh circumference (TC) has been recognized recently as a relevant anthropometric measure that identifies individuals with increased risk of premature morbidity and mortality from cardiovascular diseases early in the disease.[6] Strong relationships with fasting and postprandial plasma sugar level have been demonstrated.[7]

Insulin resistance syndrome is associated with excessive visceral abdominal fat. Recent evidence links low subcutaneous fat, especially in the thighs, with adverse glucose and lipid metabolism. Insulin resistance also depends on muscle mass. Less muscle mass, especially in the lower extremity, is inversely related to the development of T2DM.[7,8]

A thin thigh with low TC and low muscle mass and a greater waist–thigh ratio (WTR) may predict the risk for T2DM. Asian Indians exhibit the "Asian Indian Phenotype," i.e., a "thin-fat Indian with a large abdominal girth, excessive visceral and subcutaneous abdominal fat, thin thighs, low muscle mass, and less subcutaneous fat."[9] This difference in body fat

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distribution leads to a higher propensity for Asians to develop insulin resistance and T2DM compared to their Caucasian counterparts who exhibit overall adiposity. Thus, the current study, on Asian Indians, assumes greater significance.

Materials and Methods

The study consists of retrospective analysis of data obtained from 1055 patients presenting to a single-care center in the city of North India from March 2013 to September 2016.

Data from patients with type 1 diabetes mellitus (T1DM), younger than 18 years, older than 90 years, femoral entrapment neuropathy, proximal myopathy, history of recent trauma (within 6 months), malnutrition, other endocrine disorders, ascites, diabetic neuropathy, and athletes were excluded from the study.

Patients' history, physical examination, and investigations have been included in the analysis. Investigations include complete blood count, fasting plasma glucose (FPG) and post-prandial plasma glucose (PPG) estimation, glycosylated hemoglobin, kidney function tests, liver function tests, fasting lipid profile, c-reactive proteins, and urine examination. Serum insulin assay, C-peptide levels, antiglutamic acid decarboxylase antibodies, and IA-2A antibody estimation were used to exclude T1DM wherever required. Venous plasma glucose levels were measured using the glucose oxidase method.

Body weight was measured to the nearest 0.1 kg with an electronic standard weight scale machine, with participants wearing underwear or light clothing. Body height was measured without shoes to the nearest 1 cm using a stadiometer.

Thigh, waist, and hip circumferences (HCs) were measured when the patient was upright and weight was evenly distributed. TC was measured at the level of the midpoint on the lateral surface of the right thigh, midway between trochanter and the lateral border of the head of the tibia to the nearest 0.1 cm. WC was measured using a standard flexible inelastic measuring tape to the nearest 0.1 cm in the horizontal plane, midway between the inferior rib margin and the iliac crest,[10] whereas HC was measured at a point over the buttocks yielding the maximum circumference. All anthropometric measurements were in accordance with the WHO standards.[11] Three readings of all the anthropometric measurements were taken, and the average value was used for calculations.

T2DM was diagnosed according to the American Association of Clinical Endocrinologists (AACE)/American Diabetic Association (ADA) recommendations 2007 criteria[12-14] as follows:

- Symptoms of diabetes plus casual plasma glucose (random plasma glucose [RPG]) concentration ≥200 mg/dl (11.1 mmol/L) (casual was defined as any time of day without regard to time since last meal). The classic symptoms of diabetes include polyuria, polydipsia, and unexplained weight loss
- Fasting blood glucose ≥126 mg/dl (7.0 mmol/L) (fasting was defined as no caloric intake for at least 8 h)
- Two-hour postload glucose (PPG) ≥200 mg/dl (11.1 mmol/L) during an oral glucose tolerance test (the test was performed as described by the WHO, using a glucose load containing the equivalent of 75 g anhydrous glucose dissolved in water).

Statistical analyses were performed on IBM SPSS version 21 (IBM Corp, Armonk, New York, USA), and all significance levels were reported at $P < 0.01$. Mean and standard deviations, *t*-test, Pearson's co-relation, cross-tabulation, receiver–operating characteristic (ROC) curves, and Youden's index were applied as required.

Observations

The study, conducted in the North-Indian Indo-Gangetic Plain, consists of data from 1055 patients ranging from 25 to 90 years old (mean 55.4 ± 11.6 years) with 504 females (47.9%) and 550 males (52.1%). A total of 264 females (52.4%) and 270 males (49.1%) had T2DM according to the AACE/ADA criteria mentioned above. The diabetic group comprised of 534 patients, with 270 males (50.6%) and 264 females (49.4%) having a mean age of 55.5 years. The nondiabetic group included 521 patients comprising 280 males (53.7%) and 240 females (46.1%) with a mean age of 54.9 years. The mean body mass index of diabetics was 27.6 ± 4.8 and of nondiabetics 28.0 ± 4.3, and this is statistically insignificant.

WC, TC, HC, WHR, and WTR for diabetics and nondiabetics are tabulated in Table 1.

Diabetics had significantly greater WC (mean 100.7 cm) than nondiabetics (97.6 cm) ($P < 0.0001$). The diabetics and nondiabetics did not differ on HC. Diabetics had lesser TC (48.5 cm) than nondiabetics (53.1 cm) ($P < 0.0001$). WHR in diabetics was higher (mean 0.972) than nondiabetics (mean 0.944) ($P < 0.0001$). WTR of diabetics was also greater (2.08 ± 1.888) ($n = 534$) than nondiabetics (1.84 ± 0.147) ($n = 521$) ($P < 0.0001$).

Results

WHR correlates both significantly and positively with PPG and RPG ($P < 0.0001$) but not to FPG. WTR correlates significantly and positively to all the three measures of diabetes, i.e., FPG, RPG, and PPG ($P < 0.0001$). TC has strong negative correlations with all the three measures of diabetes ($P < 0.0001$).

Compared to WHR, WTR has higher correlations with all measures of diabetes, suggesting that it is a statistically more powerful and better predictor of diabetes [Table 2].

Using the ROC curve, a value of 2.3 for WTR gives us high specificity (0.987) with low sensitivity (0.202). At this cutoff point, 98.7% of nondiabetics and 82% of diabetics according to the AACE criteria can be identified. However, a value of 1.68 for WTR gives us sensitivity (0.996) and specificity (0.111),

Table 1: Anthropometric measurements for diabetics and non-diabetics

Measures	Conditions	*n*	Mean	*t*	*P*
Waist - circumference (WC)	Diabetic	534	100.656	4.23	0.0001
	Non-diabetic	521	97.563		
Thigh - circumference (TC)	Diabetic	534	48.503	-11.49	0.0001
	Non-diabetic	521	53.113		
Hip - circumference (HC)	Diabetic	534	103.908	0.733	0.4640
	Non-diabetic	521	103.331		
Waist-hip ratio (WHR)	Diabetic	534	0.972	6.82	0.0001
	Non-diabetic	521	0.944		
Waist-thigh ratio (WTR)	Diabetic	534	2.088	23.48	0.0001
	Non-diabetic	521	1.843		

Table 2: Co-relations of WC, TC, WHR and WTR with measures of diabetes

Measures	FBG	PPG	RBG
Waist - circumference (WC)	0.025	0.05	0.053
Thigh - circumference (TC)	0.253**	0.242**	-0.198**
Waist - hip ratio (WHR)	0.068	0.111**	0.113**
Waist - thigh ratio (WTR)	0.365**	0.377**	0.324**
Pearson's co-relations	<0.01**		

meaning thereby that though we will pick up 99.6% of patients being confirmed diabetics, we will also have an increase in the number of false positives. The aim of this study is to provide an easy and inexpensive tool that can cut down the costs of investigation and reduce economic burden. Hence, a WTR of 2.3 is more appropriate as it helps to identify 98.7% of the true negatives and they may not require further investigations beyond this point. Thus, we propose to use this value as the cutoff.

The effectiveness of this cutoff point can be greatly improved with further research and larger data volumes.

Conclusions

WTR positively correlates to all measures of diabetes. Out of the anthropometric measurements available to us, WTR is the most powerful predictor of diabetes. A WTR of 2.3 can be used as a quick, noninvasive diagnostic tool for T2DM. Used as a simple screening measurement in the outpatient clinic, the WTR can help us in the early detection of diabetes by identifying those at risk and determining the need for further investigations. This may prove to be of utmost use as a simple and inexpensive diagnostic and screening tool, especially in developing countries such as ours.

However, we need a much larger and varied sample to develop more robust and stable norms that would make this measure more reliable across age groups and with separate criteria for males and females.

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Conflicts of interest

There are no conflicts of interest.

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