



Original/Síndrome metabólico

Prevalence of metabolic syndrome in young Mexicans: a sensitivity analysis on its components

Miguel Murguía-Romero^{1,2}, J. Rafael Jiménez-Flores^{2,3}, Santiago C. Sigríst-Flores³, Diana C. Tapia-Pancardo¹, Arnulfo Ramos-Jiménez⁴, A. René Méndez-Cruz^{2,3} and Rafael Villalobos-Molina^{1,2}

¹Unidad de Biomedicina. ²Laboratorio Nacional en Salud: Diagnóstico Molecular y Efecto Ambiental en Enfermedades Crónicas-Degenerativas. ³Carrera de Médico Cirujano, Facultad de Estudios Superiores Iztacala, Universidad Nacional Autónoma de México. ⁴Instituto de Ciencias Biomédicas, Universidad Autónoma de Ciudad Juárez, Chih, México.

Abstract

Introduction: obesity is a worldwide epidemic, and the high prevalence of diabetes type II (DM2) and cardiovascular disease (CVD) is in great part a consequence of that epidemic. Metabolic syndrome is a useful tool to estimate the risk of a young population to evolve to DM2 and CVD.

Objective: to estimate the MetS prevalence in young Mexicans, and to evaluate each parameter as an independent indicator through a sensitivity analysis.

Methods: the prevalence of MetS was estimated in 6063 young of the México City metropolitan area. A sensitivity analysis was conducted to estimate the performance of each one of the components of MetS, as an indicator of the presence of MetS itself. Five statistical of the sensitivity analysis were calculated for each MetS component and the other parameters included: sensitivity, specificity, positive predictive value or precision, negative predictive value, and accuracy.

Results: the prevalence of MetS in Mexican young population was estimated to be 13.4%. Waist circumference presented the highest sensitivity (96.8% women; 90.0% men), blood pressure presented the highest specificity for women (97.7%) and glucose for men (91.0%). When all the five statistical are considered triglycerides is the component with the highest values, showing a value of 75% or more in four of them. Differences by sex are detected for averages of all components of MetS in young without alterations.

Conclusions: Mexican young are highly prone to acquire MetS: 71% have at least one and up to five MetS parameters altered, and 13.4% of them have MetS. From all the five components of MetS, waist circumference presented the highest sensitivity as a predictor of MetS, and triglycerides is the best parameter if a single factor

PREVALENCIA DEL SÍNDROME METABÓLICO EN JÓVENES MEXICANOS: ANÁLISIS DE SENSIBILIDAD DE SUS COMPONENTES

Resumen

Introducción: la obesidad es una epidemia mundial y la alta prevalencia de diabetes tipo II (DM2) y de enfermedad cardiovascular (ECV) es, en gran parte, consecuencia de esta epidemia. El síndrome metabólico (SMet) es una herramienta útil para estimar el riesgo de que una población de jóvenes evolucione a DM2 y ECV.

Objetivo: estimar la prevalencia del SMet en jóvenes mexicanos, y evaluar cada parámetro como un indicador independiente mediante análisis de sensibilidad.

Métodos: se estimó la prevalencia del SMet en 6.063 jóvenes del área metropolitana de Ciudad de México. Se realizó un análisis de sensibilidad para estimar la eficiencia de cada uno de los componentes del SMet como un indicador de la presencia del mismo SMet. Se calcularon cinco estadísticos del análisis de sensibilidad para cada uno de los componentes del SMet y otros parámetros, incluidos: sensibilidad, especificidad, valor predictivo positivo, valor predictivo negativo y precisión.

Resultados: la prevalencia del SMet en la población de jóvenes mexicanos se estimó en 13.4%. La circunferencia de la cintura presentó la sensibilidad más alta (96.8% mujeres; 90.0% hombres); en las mujeres, la presión arterial presentó la más alta especificidad (97.7%) y en los hombres la glucosa (91.0%). Cuando se consideran los cinco estadísticos, los triglicéridos son el componente con los valores más altos, con valores del 75% o mayores para cuatro de estos. En los jóvenes sin alteraciones se detecta diferencia entre sexos para los promedios de todos los componentes del SMet.

Conclusiones: los jóvenes mexicanos son altamente propensos a adquirir SMet: el 71% tiene cuando menos uno y hasta cinco parámetros del SMet alterados, y el 13.4% de ellos tiene SMet. De los cinco componentes del SMet, la circunferencia de la cintura presentó la más alta sensibilidad como predictor del SMet, y los triglicéridos es el mejor parámetro predictor en jóvenes

Correspondence: Miguel Murguía-Romero.
Unidad de Biomedicina, FES Iztacala.
Universidad Nacional Autónoma de México.
Ave. de los Barrios 1, Los Reyes Iztacala.
Tlalnepantla 54090, México.
E-mail: miguelmurguia@ciencias.unam.mx

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is to be taken as sole predictor of MetS in Mexican young population, triglycerides is also the parameter with the highest accuracy.

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Key words: *Young Mexicans. Insulin resistance. Diabetes mellitus risk factors. Metabolic syndrome.*

Introduction

Obesity is nowadays a worldwide epidemic, and one of the consequences of this metabolic impairment and other associated impairments —such as dyslipidemia, hypertension, and hyperglycemia, among others— is its evolution to diabetes mellitus type 2 (DM2) and cardiovascular disease (CVD). The latter two diseases are the main causes of death in Mexico. Precisely, the metabolic syndrome (MetS) is an entity proposed as a tool to evaluate risk of CVD, and also DM2¹. These facts joined to the panorama of high prevalence of obesity and DM2 in Mexico, and considering that these diseases are chronic, invite to propose the hypothesis that one or more of the components of MetS are present among the young population. The prevalence of MetS among young Mexicans (17-24 years old) has been estimated in 15.8%, which implies that near 2.6 millions of young bear MetS². As MetS is a complex entity, i.e., it is an aggregation of several factors that in conjunction is used as a risk factor to develop CVD, it is useful to disaggregate the prevalence of each component, and also to know the performance of each parameter as a classifier of MetS using statisticals from sensitivity analysis, namely: sensitivity, specificity, precision, negative predictive value, and accuracy.

As MetS is a tool to assess risk for to acquire CVD, then it is plausible to analyze the performance of atherogenic index (total cholesterol/HDL-cholesterol) as a

mexicanos si solo se considera un factor predictor del SMet; también los triglicéridos son el parámetro con la más alta precisión.

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surrogate of MetS in young Mexicans. Also other simple indexes have been proposed recently as predictors of MetS, particularly the TG/HDL-C has been studied in Mexican young population to assess CVD risk³.

To choose the best set of parameters to use as a test to predict MetS will depend on the specific objectives of a health campaign. The statistical measurement of the performance of each parameter as a classifier or test to detect MetS, should help to make the decision. Each statistical measurement of the performance of a parameter as a classifier maximizes the correct detection of type of cases, such as positive cases, negative cases, or both. We propose the next interpretation rules that will help to choose the sensitivity analysis^{4,5} to statistical maximize the correct detection of type of cases (see Figure 1):

- **Sensitivity.** If the objective is to maximize the number of participants bearing MetS, no matter whether in the group are included participants without MetS, then the appropriate statistical to maximize is the sensitivity.
- **Specificity.** If the objective is to maximize the number of participants that do not bear MetS, no matter whether in the group are included participants with MetS, then the appropriate statistical to maximize is the specificity.
- **Precision.** If the objective is to maximize the number of participants that bear MetS, mini-

	Participants with disease	Participants without disease	TOTAL
Test is positive	a	b	Total positive tests (a+b)
Test is negative	c	d	Total negative tests (c+d)
TOTAL	Total number of patients with disease (a+c)	Total number of patients without disease (b+d)	Total number of patients (a+b+c+d)

Performance measurements:
Sensitivity: Proportion of people with disease who will have a positive result: $a/(a+c)$.
Specificity: Proportion of people without the disease who will have a negative result: $d/(b+d)$.
Positive predictive value (PPV or Precision): Proportion of people with a positive test result who actually have the disease: $a/(a+b)$.
Negative predictive value (NPV): Proportion of people with a negative test result who do not have disease: $d/(c+d)$.
Accuracy: Proportion of correctly identified cases, both, people with disease and people without disease: $(a+d)/(a+b+c+d)$.

Fig. 1.— Synopsis of statistical measurements of the performance of tests based on binary classification. Box: Binary classification of cases; Text: Some statistical measurements of the performance of a clinical test, based on binary classification of cases.

mizing the number of false positives, i.e., those participants in the group without MetS, then the statistical appropriate to maximize is the positive predictive value (PPV) or precision.

- **Negative Predictive Value.** If the objective is to maximize the number of participants that do not bear MetS, minimizing the number of false negatives, i.e., those participants in the group with MetS, then the appropriate statistical to maximize is the negative predictive value (NPV).
- **Accuracy.** If the objective is to maximize the number of correctly classified participants, maximizing the number of true positives (correctly identified with MetS) plus true negatives (correctly identified without MetS), then the appropriate statistical to maximize is the accuracy.

The objectives of this study were, a) to estimate the prevalence of MetS among young Mexicans, b) to disaggregate MetS into the prevalence of each of its components, and c) to evaluate the performance of each one as a classifier to identify MetS through sensitivity analysis.

Methods

Subjects

Participants were Mexican undergraduate students of first grade of the Faculty of Higher Studies Iztaca-

la campus of the National Autonomous University of México (UNAM) (at north of the México City metropolitan area), and from México City Autonomous University (UACM, at the east). All young were invited to participate in the project, and signed an informed consent. The project studied samples of young (17-24 years old) in annual basis, from 2007 to 2014. A total of 6063 participants were considered in the analysis, all perceived themselves as healthy. The average age was 18.9 years old (women) and 19.2 (men) (Table I), with an average height of 157.7 cm (women) and 169.6 cm (men), average of weight of 59.5 kg (women) and 70.5 kg (men), and average of body mass index of 23.9 kg/m² (women) and 24.4 kg/m² (men). Medical history was recorded, and fasting blood samples were taken, and analyzed by Grupo Diagnóstico PROA S.A. de C.V., an international reference laboratory. Anthropometrics were recorded by physicians of our team the day of blood sampling, following the Official Mexican Norm (NOM-008-SSA3-2010, Mexican Ministry of Health): diastolic and systolic blood pressure (BP) values were obtained by replicated measurements, i.e., after resting in a sitting position for 5 min and determination of the maximum inflation level, then BP readings were obtained with a standard aneroid sphygmomanometer (Model DS44, Welch Allyn). Height and waist circumference were recorded to the nearest 0.1 cm using a wall stadiometer (Seca mod. 208, México City), and a metallic flexible anthropotape (Rosscraft, USA). Body weight was recorded to the nearest 0.1 kg using a digital scale (Seca 700)⁶.

Table I
Characteristics of the population studied according whether the MetS is present or not

<i>n</i>	<i>Women</i>			<i>Men</i>		
	<i>All</i>	<i>wo/MetS</i>	<i>w/MetS</i>	<i>All</i>	<i>wo/MetS</i>	<i>w/MetS</i>
	<i>4131</i>	<i>3601</i>	<i>530</i>	<i>1932</i>	<i>1660</i>	<i>272</i>
Age (years)	18.94 ± 1.5	18.90 ± 1.5	19.2 ± 1.7	19.23 ± 1.6	19.19 ± 1.6	19.5 ± 1.8
Weight (kg)	59.5 ± 11.6	57.9 ± 10.4	70.7 ± 12.8	70.5 ± 14.2	67.6 ± 11.9	88.1 ± 14.4
Height (cm)	157.7 ± 6.0	157.6 ± 5.9	158.6 ± 6.1	170.0 ± 6.3	169.6 ± 6.3	172.1 ± 6.3
BMI (kg/m ²)	23.9 ± 4.2	23.3 ± 3.8	28.1 ± 4.4	24.4 ± 4.3	23.5 ± 3.7	29.7 ± 4.2
Waist circumference (cm)	80.4 ± 10.7	78.8 ± 9.9	91.1 ± 9.9	84.3 ± 11.6	81.9 ± 9.8	99.1 ± 10.9
Systolic BP (mm Hg)	104.6 ± 10.9	103.4 ± 10.3	112.3 ± 11.7	114.4 ± 11.8	112.8 ± 11.0	124.3 ± 11.7
Diastolic BP (mm Hg)	70.6 ± 8.7	69.7 ± 8.0	77.0 ± 10.2	76.5 ± 8.8	75.4 ± 8.3	83.0 ± 9.0
Glucose (mg/dL)	88.3 ± 8.9	87.5 ± 7.3	93.3 ± 14.6	91.0 ± 11.2	90.0 ± 9.0	97.1 ± 18.7
Triglycerides (mg/dL)	107.7 ± 50.4	96.9 ± 36.1	176.9 ± 70.4	120.0 ± 87.2	105.5 ± 47.5	205.5 ± 174.6
HDL-cholesterol (mg/dL)	49.2 ± 9.8	50.4 ± 9.7	41.5 ± 6.7	45.0 ± 9.0	46.2 ± 8.6	38.0 ± 8.3
Total cholesterol (mg/dL)	165.9 ± 29.8	163.7 ± 28.8	179.8 ± 32.4	163.8 ± 30.3	160.8 ± 27.8	181.2 ± 37.5
Insulin* (μUI/mL)	10.9 ± 6.4	10.0 ± 5.0	16.7 ± 10.5	8.8 ± 5.2	7.9 ± 4.4	14.2 ± 6.5
HOMA-IR*	2.4 ± 1.5	2.2 ± 1.1	3.9 ± 2.5	2.0 ± 1.3	1.8 ± 1.1	3.4 ± 1.6

Mean ± S.D.; *n (women) = 2145 (1861 wo/MetS; 284 w/MetS); n (men) = 1013 (864 wo/MetS; 149 w/MetS). P<0.05 wo/MetS vs. w/Mets for all parameters.

Metabolic syndrome definition

The identification of MetS in young were according to Alberti et al.⁷ definition, that establishes that MetS is identified when three or more of the following alterations are present: 1) central obesity (waist circumference ≥ 80 cm in women, ≥ 90 cm in men), 2) hypertension (≥ 130 mm Hg for systolic blood pressure, or ≥ 85 mm Hg for diastolic blood pressure), 3) hyperglycemia (≥ 100 mg/dL), 4) low HDL cholesterol (< 50 mg/dL in women, < 40 mg/dL in men), and 5) hypertriglyceridemia (≥ 150 mg/dL). Prevalence was calculated separately for women and men, and by age from 17 to 24 years old. Spearman coefficient was calculated to investigate if MetS prevalence is correlated with age.

Insulin resistance, atherogenic index, and TG/HDL index

Insulin resistance was determined through the homeostasis model assessment (HOMA-IR)⁸. The cut-off points to discriminate between normal and altered values for insulin and HOMA-IR were considered as those proposed for young Mexicans: values of insulin were consider altered when > 14.0 mU/ml (women) and > 10.8 mU/ml (men), and for HOMA-IR > 2.9 (women), and > 2.3 (men)⁹.

Atherogenic index (AI) was calculated as total cholesterol (mg/dL) divided by HDL-cholesterol (mg/dL). The cut-off points to decide an altered value of AI were determined as the percentile 95% value of those young of the sample with none altered value of the parameters considered in the MetS definition, referred here as 'healthy' young. The same method was used to determine the cut-off point for the TG/HDL index³. Thus, values of AI were consider altered when > 3.6 mg/dL (women) and > 4.3 mg/dL (men), and for TG/HDL index when > 2.35 (women), and > 2.93 (men).

Statistical analyses and sensitivity analysis

Differences between averages of young with MetS compared to those without MetS were tested with a z-test. Also, z-tests were applied to investigate differences in the proportions of altered values between women and men for all MetS parameters.

A sensitivity analysis was performed to evaluate the performance of each component as a classifier to identify MetS. The frequencies of true positives, true negatives, false positives, and false negatives were calculated for each MetS component, for insulin, and for three indexes: HOMA-IR, total cholesterol/HDL-C, and TG/HDL-C. Five statistical measures of efficiency were calculated: sensitivity, specificity, positive predictive value (precision), negative predic-

tive value, and accuracy. Confidence intervals at 95% were calculated for MetS prevalence.

Results

Averages of MetS parameters

Averages of all parameters showed differences for young with MetS compared to those without MetS (Table I): WC, BP, GLU, TG were higher in young with MetS, while for HDL-C the relation was inverted ($P < 0.001$ for WC, BP, GLU, TG, HDL-C, for both, women and men).

Differences between women and men of young without MetS are registered for all MetS parameters ($P < 0.001$ for WC, BP, GLU, TRI, HDL-C).

Prevalence of MetS

The prevalence of MetS in the population studied is 12.8% for women (95% CI: 11.8% - 13.9%), and 14.0% for men (12.5% - 15.7%), with no statistical significance ($P > 0.05$). When combined, weighting each sex by 50% resulted in a prevalence of 13.4%. The components of MetS with higher frequency of altered values were HDL-C (55.0% women, and 28.6% men) and WC (48.8%, and 27.7%, respectively), followed by TG (15.3%, and 21.6%, respectively). The parameter with the less frequency of altered values was BP (5.7%) for women and GLU (13.1%) for men (Figure 2). Only 29% of the young have no altered values in all parameters of MetS, i.e., 71% (4289/6063) of them have at least one parameter altered (3133/4131=76% women; 1156/1932=60% men), that could be interpreted as that 58% (71%-13%) of Mexican young are in high risk to acquire MetS. When compared proportions of altered values of women vs. men, all parameters of MetS showed significant differences ($P < 0.05$), while differences in MetS prevalence, INS and HOMA-IR were not significant.

Nevertheless the prevalence of MetS is lower in women than in men, the proportion of altered values in two parameters (WC and HDL-C) is higher in women than in men (Figure 2).

When grouped cumulatively, the prevalence of MetS alterations resulted in 47% with altered HDL-C, 63% HDL-C or WC, 66% HDL-C or WC or TG, 69% HDL-C or WC or TG or BP, and 71% HDL-C or WC or TG or BP or GLU.

Insulin presented altered values in 9.5% of women and 12.4% of men. Insulin resistance, estimated through HOMA-IR, was present in 12.1% of women, and 15.3% of men (Figure 2).

The prevalence of MetS by age ranged from 11.0% to 26.5% in women, and from 10.9% to 21.9% in men (Table II). Correlation between age and prevalence of

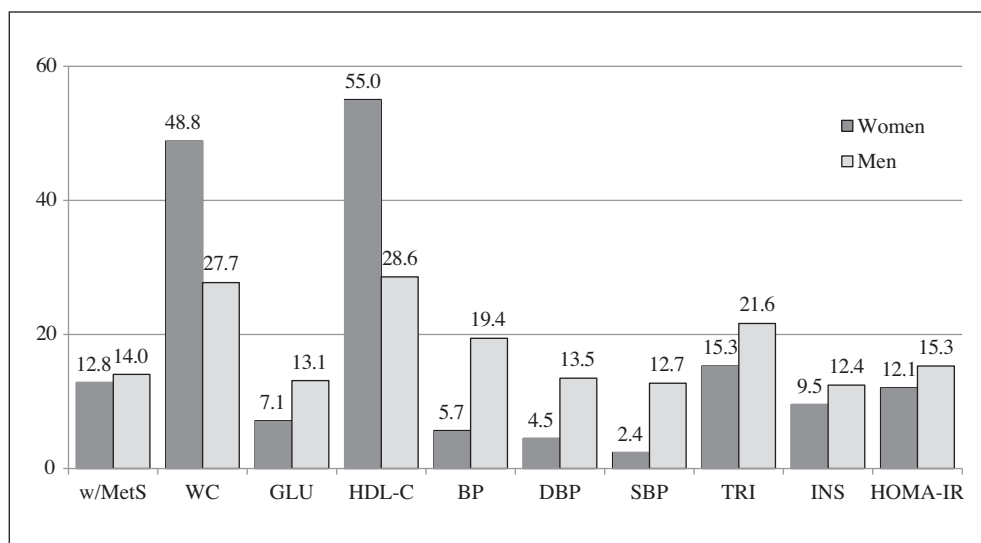


Fig. 2.— Prevalence of MetS and of altered values of insulin, HOMA-IR and MetS parameters in the sample of young Mexicans studied. $P < 0.05$ for all differences, women vs. men, except for MetS prevalence, and INS and HOMA-IR.

MetS for women was 0.98 ($P < 0.01$), whereas for men was 0.36.

Statistical performance of components to detect MetS

The values of five statisticals to evaluate performance for the parameters analyzed are shown in table III.

WC showed the highest values for sensitivity (96.8% women; 90.0% men); HDL-C also showed higher value for women (96.4%) than for men (76%).

SBP showed the highest values for specificity (97.7% women; 92.1% men), and also showed the hi-

ghest PPV (precision) for women (70.4%), and also higher for men (46.7%, after TG with 48.6%).

NPV ranged from 88.6% (SBP) to 99.2% (WC) for women, and from 90.1% (GLU) to 98.1% (WC). Because PPV is a statistical dependent on prevalence, and MetS prevalence in population is around 13%, it was expected that present high values.

The maximum accuracy was obtained for TG (91.0% women; 85.4% men). TG was the only parameter that presented values upper than 50% for all five statisticals, and also it maximize the product sensitivity x specificity (Figure 3).

Table II
Prevalence of MetS by age in the sample of young Mexicans studied

n	MetS Prevalence		
	All	Women	Men
	6,063	4,131	1,932
Age (years old)			
17	13.2%	11.0%	18.6%
18	11.9%	12.3%	10.9%
19	12.6%	11.7%	14.6%
20	13.0%	12.7%	13.4%
21	14.3%	13.5%	15.6%
22	20.2%	19.1%	21.9%
23	17.9%	19.2%	16.2%
24	23.4%	26.5%	17.9%
All (17-24)	13.2%	12.8%	14.0%

Spearman coefficient (age vs. prevalence) $\rho = 0.98$ (women; $P < 0.01$), $\rho = 0.36$ (men).

Discussion

Nevertheless all young participant perceived themselves as healthy (100%), 13.4% of them bear MetS, and 71% of them have at least one parameter altered. That contrasts with other studies on the same type of population, i.e., in university students of Ecuador¹⁰, a MetS prevalence of 7.5%, and in students of the United States of America¹¹ a MetS prevalence of 6.8%. In addition, central obesity and low HDL-C, together account for 63% of young with alterations of MetS parameters, i.e., it accounts for 90% of the young that presented alterations in MetS parameters¹². That suggests as a plausible strategy of intervention to prevent or revert MetS to induce young to perform physical activity, since it is known that physical activity improve the levels of HDL-C¹³, or to modify their eating habits, as well as to include or increase the intake of raw vegetables.

The parameter or index to choose as predictor of MetS depends on the objectives of the campaign:

- If the objective is compatible with maximizing the sensitivity, then WC is the best option, and

Table III
Statistical measures of the performance of parameters and indexes to detect MetS

	Women					Men				
	Sensitivity	Specificity	Precision	NPV	Accuracy	Sensitivity	Specificity	Precision	NPV	Accuracy
Waist circumference	96.8%	58.2%	25.4%	99.2%	63.2%	90.0%	82.4%	45.5%	98.1%	83.5%
BP	28.7%	97.7%	65.0%	90.3%	88.9%	57.9%	86.9%	41.9%	92.7%	82.8%
SBP	13.0%	99.2%	70.4%	88.6%	88.1%	42.4%	92.1%	46.7%	90.7%	85.1%
DBP	23.0%	98.3%	65.9%	89.7%	88.6%	39.5%	90.8%	41.2%	90.2%	83.6%
Glucose	27.4%	95.9%	49.3%	90.0%	87.1%	38.4%	91.0%	41.1%	90.1%	83.6%
Triglycerides	74.5%	93.4%	62.6%	96.1%	91.0%	74.9%	87.1%	48.6%	95.5%	85.4%
HDL-Cholesterol	96.4%	51.1%	22.5%	99.0%	56.9%	76.0%	79.2%	37.3%	95.3%	78.7%
Insulin	56.7%	84.4%	36.3%	92.6%	80.7%	69.6%	80.2%	40.0%	93.3%	78.5%
HOMA-IR	66.7%	79.5%	33.7%	93.8%	77.8%	81.9%	74.9%	38.3%	95.6%	76.0%
Atherogenic Index	82.8%	69.6%	28.6%	96.5%	71.3%	73.1%	82.8%	41.0%	95.0%	81.5%
TG/HDL-C	79.6%	76.4%	33.2%	96.2%	76.8%	76.8%	78.7%	37.0%	95.4%	78.4%

- then HDL-C for women and HOMA-IR for men;
- If the objective is compatible with maximizing the specificity, then SBP is the best option and then DBP for women and GLU for men;
- If the objective is compatible with maximizing the precision, then SBP is the best option for women and TG for men;

- If the objective is compatible with maximizing the NPV, then WC is the best option;
- If the objective is compatible with maximizing the accuracy, then TG is the best option;

TG is the only parameter, among the parameters and indexes analyzed in this study that showed values of

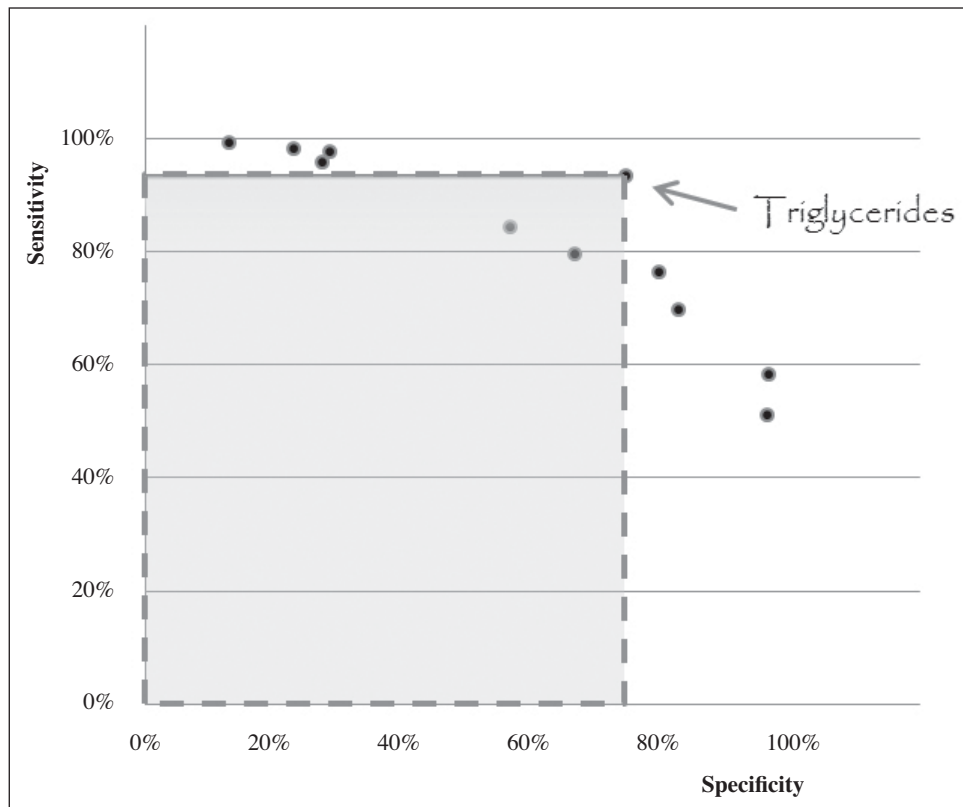


Fig. 3.— Specificity vs. Sensitivity of parameter analyzed showing triglycerides as the parameter that maximized the box area specificity x sensitivity (see Table III).

statistical performance of sensitivity analysis above 50%, i.e., it showed acceptable values for sensitivity, specificity, precision, NPV, and accuracy. Nevertheless, to choose only one or two parameters to predict MetS seems to be a reductionist perspective, in particular situations it could be needed to take decisions based on few parameters, in that situations, if a single parameter has to be taken as sole predictor, and there is not a particular objective for the health/public campaign, based on the results from the sensitivity analysis, TG is the best candidate.

International criteria for cut-off points of MetS parameters differentiate by sex for WC and HDL-C that contrast with the results in this study: differences in averages of MetS parameters of young without MetS are present for all five MetS parameters. That suggests to investigate the convenience of differentiate by sex the cut-off point values for all MetS parameters, and not only for HDL-C and WC; this differentiation could result in a more accurate identification of MetS in young. Also, the high correlation of MetS prevalence with age in young women, and low in men supports that view point of differentiating cut-off points by sex. This difference in correlations could be due to generational factors: a possible explanation is that such generational factors are more variable in men than in women.

Conclusions

MetS is a complex entity that evolves since youth, and that could be an indicator of future prevalence of diabetes mellitus type II and cardiovascular disease. In particular, for the population of Mexican young studied, the prevalence of MetS is 13.4%, and 71% of them presented at least one parameter altered out of five considered in the used definition.

Differences by sex are detected for averages of all components of MetS in young without alterations, which supports the need to differentiate cut-off points by sex.

If a single parameter needs to be taken as sole predictor of MetS in Mexican young population, based on sensitivity analysis statistics, TG is the best candidate.

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