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Correlates of the Metabolic Syndrome Among a Sample of Women in the San Juan Metropolitan Area of Puerto Rico

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Abstract

Background: The metabolic syndrome is an interaction of risk factors that may lead to cardiovascular disease and type 2 diabetes.

Methods: Given the need for data in Puerto Rico, this cross-sectional study aimed to determine the association between demographic, lifestyles, and reproductive characteristics and the metabolic syndrome among a sample of women ($N = 564$) in the San Juan Metropolitan Area. The metabolic syndrome was defined based on the revised National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) criteria.

Results: In multivariate logistic regression models, women aged 40–59 and 60–79 years were 3.03 [95% confidence interval (CI), 1.70, 5.40] and 7.05 (95% CI, 3.69, 13.49) times more likely, respectively, to have the metabolic syndrome as compared to those aged 21–39 years. A dose–response relationship was also observed between body mass index (BMI) and metabolic syndrome. Physical activity reduced the odds for metabolic syndrome [prevalence odds ratios (POR) = 0.64; 95% CI, 0.41, 1.01]; however, this association was marginally significant ($P = 0.05$). Among reproductive characteristics, only women who had a history of gestational diabetes (GDM) were 2.14 (95% CI, 1.02, 4.51) times more likely to have metabolic syndrome.

Conclusions: Consistent with previous studies, increased age and BMI, physical inactivity, and GDM are associated with the metabolic syndrome in this population. This information is relevant for the development of preventive interventions for the metabolic syndrome.

Introduction

The metabolic syndrome is an interaction of risk factors that may lead to cardiovascular disease (CVD) and type 2 diabetes mellitus. This syndrome has also been described as a risk factor for other chronic diseases, including certain cancers, such as colorectal, prostate, and postmenopausal breast cancer.[1]

The biological mechanisms underlying the metabolic syndrome are not fully understood; however, its pathophysiology is thought to be related to increased visceral adiposity and insulin resistance.[2] Sex differences in the occurrence of the metabolic syndrome and its individual components exist,[3] suggesting sex-specific differences in the physiological mechanisms of disease and in the risk factors for disease occurrence. Men and women also differ in their clinical experience of diabetes mellitus[4]; for example, women with diabetes have a higher risk of death from CVD and experience more symptoms of hyperglycemia than their male counterparts. Factors strongly associated with the metabolic syndrome in both men and women include increasing age and body mass index (BMI) and physical inactivity.[5] Particularly in women, reproductive and hormone-related factors, such as postmenopausal status, decreased parity, and history of maternal gestational diabetes (GDM) have also been shown to increase the risk of the condition.[3,5–7] In the case of menopause, for example, the biological plausibility of this relationship is explained by the fact that with menopause, women experience changes characteristic of the metabolic syndrome, including increased abdominal adiposity, hyperglycemia, hyperinsulinism, and dyslipidemic changes.[2]

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In the United States, the prevalence of the metabolic syndrome in Mexican-American women is 1.5 times higher than among Whites.[3,5] This fact is of particular relevance because Hispanics constitute the largest minority group in the United States. Thus, understanding health issues affecting this group is crucial to improving the public health status of the population in general. Also, Hispanics are disproportionately affected by overweight and obesity, and, at each BMI level, Hispanics have a higher prevalence of diabetes than non-Hispanic Whites.[8] A recent study regarding the prevalence of the metabolic syndrome among postmenopausal Latin American women concluded that 35% of the population surveyed had metabolic syndrome.[9] Studies have been performed in Mexicans, Peruvians, Argentines, and other Hispanic minorities,[9] yet little has been done to explore the metabolic syndrome status of Puerto Ricans residing in the continental United States and in the island. Puerto Ricans are the second leading Hispanic subgroup in the United States after Mexican Americans[10] and are underrepresented in research regarding studies investigating the impact of ethnic, genetic, biologic, or cultural markers on the incidence of certain illnesses.[11] In addition, Puerto Ricans are at high risk for CVD and diabetes, the first and third leading causes of death in the island, respectively.[12] Furthermore, the prevalence of diabetes in Puerto Rico in 2008 [12.4%; 95% confidence interval (CI), 11.3%, 13.4%] was higher than in all states and territories of the United States, and increasing prevalence trends have been reported in recent years in both of these populations.[13]

The authors have previously reported a high age-adjusted prevalence of the metabolic syndrome in men (42.1%) and women (36.4%) aged 21–79 years living in the San Juan Metropolitan area of Puerto Rico[14]; these prevalence estimates are higher than the age-adjusted prevalence estimates of metabolic syndrome reported for men and women in the United States.[3,15] Among women, the age-adjusted prevalence of metabolic syndrome in Puerto Rico is higher than that of Whites (31.5%), similar to African Americans (36.4%) but lower than for Mexican Americans (44%). Despite the high burden of metabolic syndrome and related co-morbidities in Puerto Rico, information on factors associated with the metabolic syndrome in this population is scarce. For women in Puerto Rico, a recent study reported a strong association between obesity and metabolic syndrome, although it found no significant associations between reproductive/hormonal factors and metabolic syndrome in an age-adjusted analysis.[16] Meanwhile, a small clinic-based study reported a high prevalence (44%) of metabolic syndrome among polycystic ovarian syndrome (PCOS) patients in Puerto Rico,[17] suggesting an association between these conditions. Given the lack of population-based data regarding risk factors for metabolic syndrome occurrence in Puerto Rican women, we aimed to determine the association between demographic, lifestyles, and reproductive characteristics and metabolic syndrome in a sample of women residing in the San Juan Metropolitan area of Puerto Rico.

Materials and Methods

Study population and data collection procedures

The study population consisted of women aged 21–79 years who participated in the population-based cross-sectional study Prevalence of the Metabolic Syndrome in San Juan, Puerto Rico.[14] The sampling design and data collection procedures of this study have been described in detail elsewhere.[14] In brief, the sampling design was based on a cluster design for household surveys using the census tracts of the San Juan Metropolitan area.[18] All men and women aged 21–79 years from each selected household were eligible to participate in the study and asked to undergo a personal interview, physical exam, and biochemical measurements. An interviewer administered a questionnaire that collected information on demographic characteristics, lifestyles, and medical and reproductive history. From the 859 men and women who participated in this study, we selected all women ($N = 564$) for this analysis.

Anthropometric measurements were taken in duplicate following the *National Health and Nutrition Examination Survey III* (NHANES III) Anthropometric Video Procedures, and the average of the two measures was used.[19] Waist circumference was determined with a measuring tape at the high point of the iliac crest at minimal respiration. A Cardinal Detecto digital scale (Cardinal/Detecto, Webb City, MO) was used to measure current body weight in kilograms, and a portable Seca stadiometer (Seca Corporation, Hanover, MD) was used to determine height in meters.

Three blood pressure measurements were taken 10 minutes apart using an appropriate cuff size and a standard aneroid sphygmomanometer. Blood pressure status was based on the average of three measurements. Fasting blood samples were collected by a research nurse and concentrations of total cholesterol, triglycerides, high-density lipoprotein cholesterol (HDL-C), and fasting plasma glucose were determined using commercial enzymatic colorimetric kits (Bayer Diagnostics, Tarrytown, NY). This study was approved by the Institutional Review Board of the University of Puerto Rico Medical Sciences Campus. Informed consent was obtained from all subjects prior to their participation in the study.

Study variables

The metabolic syndrome was defined based on the American Heart Association/National Heart, Lung, and Blood Institute (AHA/NHLBI) revised definition of the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) report.[20] Demographic characteristics included age in years (21–39, 40–59, 60–79), years of education (<12 vs. ≥12), health insurance coverage (private, government-sponsored, none), marital status (single, married/living together, divorced/separated/widowed), and family income (<$10,000, $10,000–$19,999, $20,000–$29,999, ≥$30,000). Lifestyle characteristics included physical activity (sedentary vs. physically active), current smoking status (smoker, former smoker, never smoker), and current alcohol consumption (yes vs. no). Women were classified as meeting national guidelines on physical activity if they reported participation in moderate-intensity activities for a minimum of 30 minutes on 5 days per week or vigorous-intensity activity for a minimum of 20 minutes on 3 days per week.[21] Women were considered current smokers if they reported having smoked at least 100 cigarettes during their lifetime and were still smoking; those who reported at least one drink of any type of alcohol during the past 30 days were considered current drinkers. BMI categories were defined as underweight/

normal (≤24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), and obese (≥30.0 kg/m^2).

Information on reproductive history included parity (0, 1–2, ≥3 live births), history of GDM (yes vs. no), history of having had a macrosomic baby (≥4000 g) (yes vs. no), history of PCOS (yes vs. no), and ever consumption of hormonal contraceptives (yes vs. no) or of hormone therapy (yes vs. no). Menopausal status was defined as: (1) premenopause if menses had occurred in the past 12 months and (2) postmenopause if menses had stopped for at least 12 months without surgery (natural menopause) or as a result of hysterectomy or bilateral oophorectomy (surgical menopause).

Statistical analysis

Univariate analysis was performed to characterize the female population (N = 564) according to demographic, clinical, and lifestyle characteristics. Contingency tables were generated to assess the relationships of the above characteristics with metabolic syndrome. Age-adjusted and multivariate-adjusted logistic regression models, with the use of the generalized estimating equations, were fitted to estimate prevalence odds ratios (POR) with 95% CI to define these relationships.[22] This approach was used to control for the intraclass correlation ($\hat{\rho}_I = 0.034$) among subjects of the same census block. A sandwich estimate of variance was used to determine the standard errors of the logistic regression parameters.[22] Variables at least marginally associated with the metabolic syndrome ($P < 0.10$) in age-adjusted logistic regression models were included in the multivariate logistic regression models. All analyses were performed incorporating the sampling weights to obtain unbiased estimates from the complex sampling design using Stata for Windows release 10.0 (Stata Corporation, College Station, Texas).

Results

The age-adjusted prevalence of the metabolic syndrome among women residing in the San Juan Metropolitan Area of Puerto Rico was 36.4% (95% CI, 32.7%, 40.2%).[14] By examining the distribution of each metabolic syndrome component, the prevalence was significantly higher among women with the metabolic syndrome as compared to those without the condition. Prevalence of individual components ranged from 54.5% to 88.1% among women with metabolic syndrome and from 7.0% to 35.6% among women without metabolic syndrome (Fig. 1). Abdominal obesity was the parameter most frequently found, affecting 88.1% and 30.4% of women with and without the metabolic syndrome, respectively. Only 15.6% of women had none of the components of the metabolic syndrome, 24.5% had one component present, 18.3% had two, 17.9% had three, 16.5% had four, and 7.3% had five components present (data not shown).

Women with metabolic syndrome were significantly ($P < 0.0001$) older (Table 1). The distribution of marital status was significantly different among those with and without metabolic syndrome ($P < 0.0001$), with a higher proportion of women married/living together among those with metabolic syndrome. The distribution of BMI was significantly ($P < 0.0001$) different among women with and without the metabolic syndrome, with a higher distribution of obese women among those with metabolic syndrome. Women with metabolic syndrome were also more likely to have

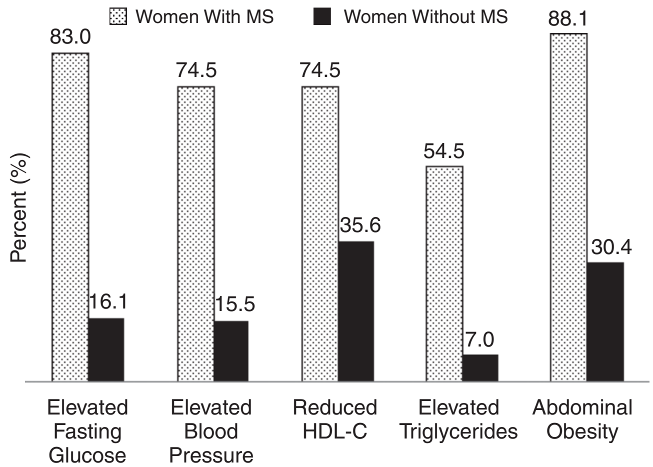

FIG. 1. Prevalence of individual components of the metabolic syndrome among women (N = 564) by metabolic syndrome status, San Juan metropolitan area, Puerto Rico, 2005–2007. Significant differences ($P < 0.05$) between groups was found for all individual components of the metabolic syndrome tested using the chi-squared test. HDL, high-density lipoprotein; MS, metabolic syndrome.

private insurance, be sedentary, former smokers, to report no current alcohol consumption, have had a macrosomic baby, and to be postmenopausal ($P < 0.0001$). Women with metabolic syndrome were also more likely to have had at least three children (P = 0.05) and no history of hormone therapy use (P = 0.08), although these associations were marginally significant (Table 2). No significant differences were found for education, income, GDM, PCOS, and hormonal contraceptives.

The variables age, marital status, BMI, physical activity, alcohol consumption, GDM, and having had a macrosomic baby were included in the multivariate logistic regression model, because they were either significantly or marginally associated ($P < 0.10$) to the metabolic syndrome in age-adjusted logistic regression models (Table 3). In multivariate logistic regression models, women aged 40–59 years and those aged 60–79 years were 3.03 (95% CI, 1.70, 5.40) and 7.05 (95% CI, 3.69, 13.49) times more likely, respectively, to have the metabolic syndrome as compared to those aged 21–39 years. A dose–response relationship was also observed between BMI and metabolic syndrome where overweight and obese women were 3.15 (95% CI, 1.54, 6.47) and 14.42 (95% CI, 7.08, 29.37) times more likely to have metabolic syndrome than those with an underweight/normal BMI. Physical activity reduced the odds for the metabolic syndrome (POR = 0.64; 95% CI, 0.41, 1.01), although this association was marginally significant (P = 0.05). Among reproductive characteristics, only women who had a history of GDM were 2.14 (95% CI, 1.02, 4.51) times more likely to have metabolic syndrome compared to those without. Marital status, current alcohol consumption, and having had a macrosomic baby were no longer associated with the metabolic syndrome in multivariate analysis.

Discussion

This is the first study to assess factors associated with the metabolic syndrome in a sample of women living in

Table 1. Demographic and Lifestyle Characteristics of 564 Women by Metabolic Syndrome Status in the San Juan Metropolitan Area, Puerto Rico, 2005–2007

	Women with metabolic syndrome (n = 235) no. (%)	*Women without metabolic dyndrome (n = 329) no. (%)*	*P value*[a]
Demographic data			
Age groups (years)			<0.0001
21–39	31 (13.2)	147 (44.7)	
40–59	100 (42.5)	113 (34.3)	
60–79	104 (44.3)	69 (21.0)	
Education (years)			0.19
<12	70 (29.9)	82 (24.9)	
≥12	164 (70.1)	247 (75.1)	
Health insurance			<0.05
Private	140 (59.6)	151 (45.9)	
Government	80 (34.0)	142 (43.2)	
None	15 (6.4)	36 (10.9)	
Marital status			<0.0001
Single	47 (20.0)	132 (40.1)	
Married/living together	116 (49.4)	132 (40.1)	
Divorced/separated/widowed	72 (30.6)	65 (19.8)	
Annual family income			0.59
<$10,000	109 (52.9)	140 (48.1)	
$10,000–$19,999	42 (20.4)	58 (20.0)	
$20,000–$29,999	23 (11.2)	35 (12.0)	
≥$30,000	32 (15.5)	58 (19.9)	
Lifestyle data			
Smoking status			<0.05
Current smoker	31 (13.2)	69 (21.0)	
Former smoker	38 (16.2)	33 (10.0)	
Nonsmoker	166 (70.6)	227 (69.0)	
BMI			<0.0001
Underweight/normal	12 (5.1)	117 (35.6)	
Overweight	64 (27.2)	127 (38.6)	
Obese	159 (67.7)	85 (25.8)	
Physical activity			<0.05
Sedentary	159 (67.7)	183 (55.6)	
Physically active	76 (32.3)	146 (44.4)	
Current alcohol consumption			<0.0001
Yes	71 (30.2)	147 (44.8)	
No	164 (69.8)	181 (55.2)	

[a]Significant differences between metabolic syndrome status, tested using chi-squared tests for categorical variables.

Abbreviation: BMI, body mass index.

Puerto Rico. Only 15.6% of women had none of the components of the metabolic syndrome. The prevalence of each of the individual components of the metabolic syndrome was significantly higher among women with the metabolic syndrome as compared to those without the condition. Abdominal obesity was the most common metabolic syndrome component in our population, a result consistent to those from NHANES across all the racial/ethnic groups studied in the United States.[3]

Consistent with previous studies, strong associations of the metabolic syndrome with increasing age and BMI[5,23,24] were observed. In fact, research suggests that BMI and age are the most significant predictors of metabolic syndrome for both men and women.[3] In the case of increased BMI, this association is explained by the fact that obesity is an independent risk factor for type 2 diabetes and CVD because its induces insulin resistance, increased blood pressure, and triglycerides, decreased HDL-C level, and increased low-density lipoprotein cholesterol (LDL-C).[25,26] Higher risk of metabolic syndrome has also been reported among persons with lower household income in the United States,[5] an association not observed in our study population. The homogeneous high prevalence of increased BMI across all household income categories in our study (data not shown) might explain the observed results.

Although some studies suggest a deleterious effect of smoking on metabolic syndrome[5,27] and a protective effect of alcohol consumption,[5] others have failed to observe

Table 2. Reproductive Characteristics of 564 Women by Metabolic Syndrome Status in the San Juan Metropolitan Area, Puerto Rico, 2005–2007

	Women with metabolic syndrome n = 235 no. (%)	*Women without metabolic syndrome n = 329 no. (%)*	*P value*[a]
Reproductive data			
Parity			0.05
0	28 (12.0)	59 (17.9)	
1–2	84 (35.7)	127 (38.6)	
≥ 3	123 (52.3)	143 (43.5)	
GDM			0.12
Yes	25 (11.9)	22 (7.8)	
No	185 (88.1)	261 (92.2)	
Macrosomic baby			0.01
Yes	74 (35.4)	70 (24.7)	
No	135 (64.6)	213 (75.3)	
PCOS			0.54
Yes	6 (2.6)	6 (1.8)	
No	226 (97.4)	322 (98.2)	
Hormonal contraceptives			0.89
Yes	110 (46.8)	152 (46.2)	
No	125 (53.2)	177 (53.8)	
Menopausal status			<.0001
Premenopause	68 (29.4)	196 (60.1)	
Postmenopause	163 (70.6)	130 (39.9)	
Hormone therapy			0.08
Yes	54 (23.0)	56 (17.1)	
No	181 (77.0)	272 (82.9)	

[a]Significant differences between metabolic syndrome status tested using chi-squared tests for categorical variables.

Abbreviations: GDM, maternal gestational diabetes; PCOS, polycystic ovary syndrome.

these associations.[28] Also, recent studies have found that nonsmoking is significantly associated with a lower likelihood of metabolic syndrome only among men.[23,24] In our study, we did not observe significant associations between tobacco or alcohol consumption and the metabolic syndrome. Meanwhile, consistent with previous studies,[5,23,29,30] we observed a protective effect of physical activity with metabolic syndrome, an association that remained marginally significant ($P = 0.05$) in multivariate analysis. This association is explained by the fact that physical activity prevents insulin resistance, glucose intolerance, hypertension, and low HDL-C levels and reduces triglycerides and body weight.[29]

Among reproductive characteristics of women under study, a marginal association between parity and metabolic syndrome was observed in bivariate analysis; however, this association disappeared in multivariate analysis. This is contrary to studies that have reported a direct association between parity and metabolic syndrome, which seems to follow a dose–response relationship, where the odds of metabolic syndrome increase with each additional child.[31,32] Nonetheless, our results are consistent with the results from other studies[32,33] documenting that this association was no longer significant after adjusting by other relevant characteristics and support the previously suggested hypothesis[33] that a combination of lifestyle risk factors and biological changes associated with childbearing may explain the positive association between parity and risk of metabolic syndrome.

Also in agreement with previous studies,[7,34,35] women in our study with history of GDM were more likely to have the metabolic syndrome. A study in Poland linked GDM to the metabolic syndrome and found that all features of the metabolic syndrome occurred more frequently in individuals with a history of GDM.[6] Another study in Switzerland found that even in the absence of prepregnancy obesity, women with a history of GDM had an almost five-fold additional independent risk of developing metabolic syndrome compared to a control group without GDM.[36] This association is explained by the fact that GDM is a carbohydrate intolerance resulting in hyperglycemia that occurs during pregnancy and is also strongly associated with postpartum onset of diabetes.[35] A history of having had a macrosomic baby, a factor related to GDM, was also related to the metabolic syndrome in our bivariate analysis. However, this association did not remain significant after controlling for history of GDM, age, marital status, alcohol consumption, physical inactivity, and BMI.

Regarding menopausal status, NHANES and other studies[5,15] have documented strong associations between menopause and the metabolic syndrome. It has been suggested that the occurrence of the metabolic syndrome after

Table 3. Logistic Regression Models of Factors Associated to the Metabolic Syndrome Among Women ($N = 564$), San Juan Metropolitan Area, Puerto Rico, 2005–2007

Variable	*Age-adjusted POR*	*95% CI*	*Multivariate POR*	*95% CI*
Age groups (years)				
21–39	1.00		1.00	
40–59	4.15	2.59, 6.65	3.03	1.70, 5.40
60–79	7.10	4.34, 11.62	7.05	3.69, 13.49
Marital status				
Single	1.00		1.00	
Married/living together	1.96	1.26, 3.05	1.60	0.92, 2.77
Divorced/separated/widowed	1.70	1.01, 2.86	1.36	0.71, 2.59
BMI				
Underweight/normal	1.00		1.00	
Overweight	2.99	1.24, 7.19	3.15	1.54, 6.47
Obese	9.40	4.06, 21.73	14.42	7.08, 29.37
Physical activity				
Sedentary	1.00		1.00	
Physically active	0.64	0.44, 0.93	0.64	0.41, 1.01*
Current alcohol consumption				
Yes	0.68	0.47, 1.00	1.05	0.66, 1.67
No	1.00		1.00	
GDM				
Yes	2.34	1.21, 4.52	2.14	1.02, 4.51
No	1.00		1.00	
Macrosomic baby				
Yes	1.43	0.95, 2.16	1.32	0.83, 2.10
No	1.00		1.00	

Logistic regression models adjusted for block of residence.

*$0.05 \leq P \leq 0.10$

Abbreviations: CI, confidence interval; POR, prevalence odds ratio; BMI, body mass index; GDM, maternal gestational diabetes.

menopause is explained by estrogen deficiency, because many of the risk factors are more prevalent in postmenopausal women.[37] Also, estrogen replacement improves insulin sensitivity and reduces the risk of diabetes.[37] Even though we did not observe this association, our result is consistent with a previous study performed among another sample of women in Puerto Rico.[16] In our study, results could be partially explained by the high prevalence of overweight and obesity in both premenopausal (68%) and postmenopausal women (85%). Even though many features of the metabolic syndrome emerge with the estrogen deficiency characteristic of menopause,[2] overweight/obesity among premenopausal women may dilute the protective effect of premenopausal estrogen levels on metabolic syndrome development.

PCOS has also been associated with the metabolic syndrome and is related to increased risk of impaired glucose tolerance, type 2 diabetes, and cardiovascular risks.[38] Although an association between PCOS and the metabolic syndrome was not observed, the small number of women ($n = 12$) with this condition in our study sample may have limited our inability to detect such association. Future studies with an interest in women's health should further evaluate the role of PCOS and other reproductive characteristics in metabolic syndrome development. For example, breastfeeding has also shown to have a protective effect for metabolic syndrome among women.[32,39]

There are some study limitations that merit comment. The cross-sectional design of this study does not allow us to establish a causal relationship between identified risk factors and metabolic syndrome in this population. Also, the use of self-reported information on some health-related variables may have introduced some misclassification bias to our study. For example, we assessed self-reported history of known PCOS; even though PCOS is extremely common among reproductive-age women, this condition is often undiagnosed.[38] In addition, the sample size might have limited the statistical power to detect some of the associations of interest, and the results cannot be generalized to the female population aged 21–79 years living in the San Juan metropolitan area of Puerto Rico. Nonetheless, our study used precise anthropometric and biologic measurements for the adequate identification of women with the metabolic syndrome.

Consistent with previous studies performed in other female populations, our study showed that increased age and BMI, physical inactivity, and history of GDM are positively associated with the metabolic syndrome among women living in the San Juan Metropolitan Area of Puerto Rico. This information is relevant for the development of preventive interventions for the metabolic syndrome that could be used by primary care providers and medical specialists in this population. Our results highlight the need for developing public health interventions that reduce modifiable

risk factors for the metabolic syndrome among Puerto Rican women, such as physical inactivity and overweight/obesity. Programs that monitor women with history of GDM should also be implemented to prevent the development of this condition among them.

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Author Disclosure Statement

None of the authors has any potential conflicts of interest.

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