Abdominal obesity is strongly associated to blood pressure in young Mexicans

La obesidad abdominal está fuertemente asociada a la presión arterial en jóvenes mexicanos

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Abstract

Objective: The objective of this study was to determine associations between abdominal obesity (AOb) and the other components of metabolic syndrome (MetS) in young Mexicans in a cross-sectional survey completed during a 4 year period.

Methods: This cross-sectional study reports on components and prevalence of MetS by using Alberti et al. (16) criteria, as well as association between AOb and elevated blood pressure (BP) of 2,993 Mexican university students, ages 17 to 25 years (66% women) from central and northern Mexico, over a 4-year survey (2010-2013).

Results: The most prevalent MetS components in the total sample were low HDL-C concentration (43.6%) and AOb (41.1%). MetS prevalence was 11.8%, more men than women were classified with MetS (14.3% vs. 10.5%, p < 0.01). BP was the MetS component with the lowest prevalence (8.6%). A strong association between AOb and altered BP was found in both men and women (OR 4.3, IC95% 2.5-7.4).

Conclusions: Even BP was the component with the lowest prevalence, AOb was more strongly associated with it. This fact, could explain the prevalence of hypertension among young Mexican adults.

Resumen

Objetivo: el objetivo de este estudio fue determinar la asociación entre la obesidad abdominal (OAb) y los otros componentes del síndrome metabólico (SMet) en jóvenes mexicanos a través de una encuesta transversal completada durante un periodo de 4 años.

Métodos: este estudio transversal informa sobre los componentes y la prevalencia del SMet usando los criterios de Alberti y cols. (16), así como la asociación entre OAb y la presión arterial (PA) elevada de 2,993 estudiantes universitarios mexicanos, con edades de 17 a 25 años (66% mujeres), procedentes del centro y norte de México, a través de una encuesta de 4 años (2010-2013).

Resultados: los componentes del SMet de mayor prevalencia en la muestra total fueron baja concentración de HDL-C (43.6%) y OAb (41.1%). La prevalencia de SMet fue del 11.8%, mayor en hombres que en mujeres (14.3% vs. 10.5%; p < 0.01). La PA elevada fue el componente del SMet con la prevalencia más baja (8.6%). Se encontró una fuerte asociación entre OAb y PA elevada, tanto en hombres como en mujeres (OR 4.3; IC 95% 2.5 a 7.4).

Conclusiones: a pesar de que la PA elevada fue el componente con menor prevalencia, la OAb estuvo más fuertemente asociada con esta, hecho que podría explicar la prevalencia de hipertensión entre los adultos jóvenes mexicanos.
INTRODUCTION

Metabolic syndrome (MetS) is a clustering of symptoms associated with obesity that include abdominal obesity (AOb), increased blood pressure (BP), altered glucose metabolism, and dyslipidaemia. This syndrome strongly predicts the future development of both cardiovascular disease (CVD) and diabetes (1,2).

The MetS and its individual components have been widely studied in adults (3-5), as well as in younger ages (6,7); however, association between AOb measured by waist circumference and elevated BP, has not been examined comprehensively in young university students of Mexico. Our group estimated a national wide prevalence of MetS of 15.8% in young people from Mexico (7).

In this regard, young adults entering university are making their own lifestyle behaviors that could impact in their health, even in short-term (8,9). This conversion into adulthood is a good opportunity to adopt healthy lifestyle, since dietary intake and lack of physical activity can affect all MetS components. If poor lifestyle habits are adopted during this stage, young adults will likely carry them through adulthood and progress to negatively impact the individual’s health status (9).

Screening young adults, especially first-year university students, regarding MetS components and related risk factors is vital to decrease the risk of future chronic diseases development. First-year university students experience faster weight gain than the average adult, up to 11 times faster (10,11).

In 2012 reports of the Mexican National Health and Nutrition Survey in young adults (20-29 y) found a prevalence of AOb of 53.3% (12), which could represent a high degree of physical inactivity. In relation to diet, a study in college students from northern Mexico reported only 13.2% of fruits and 15.6% of vegetables daily consumption (13). In addition, in 2008 the overall prevalence of risk factors for eating behaviour disorders in a Mexican university of the US-Mexico border was higher in women (8.5%) than men (3.3%) (14). Given these high rates of overweight/obesity and poor diet, young adult populations may be at risk, which is relevant to consider since an increase in body weight augments the probability of developing MetS, and consequently CVD and type 2 diabetes. Thus, risk identification early in life may support healthier and better choices, based upon personalized information during an age when lifestyle changes may be transformed into lifelong behaviours (15).

The present research includes a detailed investigation of first-year students from three universities located in central and northern Mexico.

As it is known that abdominal obesity prevalence in young Mexicans is high (53.3%) (12), and may indicate the beginning of metabolic alterations in young, the objective of this study was to determine the relative association between AOb and the other components of MetS, and the next most probable altered components given that AOb is one of the first metabolic alterations in young.

METHODS

DESIGN AND POPULATION

The study sample consisted of first-year Mexican university students, ages 17 to 25 years. Data were obtained by the Multidisciplinary Group to Investigate Health and Academic Performance (GMISARA), from Facultad de Estudios Superiores Iztacala, Universidad Nacional Autonoma de México (UNAM), Universidad Autonoma de la Ciudad de México (UACM), and Healthy University Program (Medical Services) from Universidad Autonoma de Ciudad Juárez (UACJ). This cross-sectional, observational study reports on MetS prevalence, and relative associations of AOb and the other MetS components of 2.993 (66% women) university students from central (n = 2,387, UNAM and n = 271, UACM from Mexico City) and northern (n = 335, UACJ from Ciudad Juárez, Chihuahua) Mexico, over a 4-year survey (2010-2013). All first year students were invited to participate in the ‘Healthy University’ program, so that no inclusion neither exclusion criteria were adopted since before the study; participants were voluntary and none of the students reported any illness, and no metabolic disorders were diagnosed by a physician.

In the four surveys conducted at the 3 universities (2010, 2011, 2012 and 2013), trained personnel (physicians, biochemists and anthropometrists) conducted the interviews to assure reliable demographic, socioeconomic, and health related data. After explaining the nature, objectives and risks inherent to the study, all subjects signed an informed consent (when the student was 17 years old, authorization of his (her) parent was obtained). The protocol was approved by the Facultad de Estudios Superiores Iztacala UNAM, and UACJ ethics committees (5).

BIOCHEMISTRY

Healthy University Medical Services (UACJ) and Grupo Diagnóstico Médico PROA, S.A. de C.V. (UNAM/UACM), internationally accredited laboratories, were responsible for sample collection, biochemical analysis and laboratory data handling. Students came to laboratory facilities, either to the UACJ, UNAM or UACM, between 7-10 AM after overnight fasting. Plasma glucose (GLU), triacylglycerol (TAG), and HDL-cholesterol (HDL-C) were assayed by automatized enzymatic-colorimetric methods.

BLOOD PRESSURE AND ANTHROPOMETRICS

BP and anthropometric techniques have been described elsewhere (5). In brief, diastolic and systolic BP values were obtained twice, i.e., after resting quietly 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).
Anthropometric data were obtained following the Official Mexican Norm (NOM-008-SSA3-2010, Mexican Ministry of Health). All measurements were performed by trained study staff and were obtained using standard procedures: height and waist circumference (WC) were recorded to the nearest 0.1 cm using a wall stadiometer (Seca mod. 208, Mexico City), and a flexible anthropotape (Ross Craft, USA). Body weight was recorded to the nearest 0.1 kg using a digital scale (Seca 700). Body mass index (BMI) was calculated by dividing weight in kilograms by the square of height in meters. Subjects were classified as obese if BMI was ≥ 30 kg/m² and overweight if BMI was ≥ 25 and < 30 kg/m². Waist circumference was measured in supine position at the level of the umbilicus. Hip circumference was measured in standing position at the level of the greater trochanters.

**METABOLIC SYNDROME CLASSIFICATION**

The updated Alberti et al. (16) criteria were used to determine MetS prevalence. The criteria included increased abdominal fat measured by WC (≥ 80 cm for women and ≥ 90 cm for men), elevated TAG (≥ 150 mg/dL), low HDL-C (< 40 mg/dL for men and < 50 mg/dL for women), elevated fasting glucose (≥ 100 mg/dL), and hypertension (≥ 130 mmHg systolic blood pressure [SBP] or ≥ 85 mmHg diastolic blood pressure [DBP]). Subjects bearing 3 or more of the components were classified with MetS (16).

**STATISTICAL ANALYSIS**

Descriptive data are presented as mean ± SD and percentages. Differences in physical and biochemical characteristics between men and women students were tested by independent Student’s t test. Fisher’s exact Chi-square tests were used to analyse the prevalence of MetS in the total sample by gender and the number of MetS components present by gender. Univariate analysis by using logistic regression was employed to explain association between AOb and MetS components. Data were considered significant when p < 0.05. All analyses were performed using STATA software (version 11.0; Stata Corp, College Station, TX, USA).

**RESULTS**

Table I shows total and gender differences in anthropometric, clinical and biochemical measures. Approximately 66% of the sample were women. The mean age and BMI of the study population were 19 years and 24.0 kg/m², respectively. Average BMI was in the normal range; however 1,059 subjects (35.6%) were either overweight or obese. Comparison by sex showed that men had a significantly greater mean BMI than women (24.3 ± 4.7 vs 23.9 ± 4.5 kg/m², p ≤ 0.01). Men also had a significantly greater mean elevated BP, elevated TAG, low HDL-C, and elevated GLU.

### Table I. Anthropometric, clinical and biochemical characteristics of subjects by sex

<table>
<thead>
<tr>
<th>Variables</th>
<th>All</th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years old)</td>
<td>19.0 ± 1.7</td>
<td>18.9 ± 1.7</td>
<td>19.1 ± 1.8</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>63.7 ± 14.5</td>
<td>59.8 ± 12.3</td>
<td>71.2 ± 15.3</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>162.4 ± 8.5</td>
<td>158.1 ± 5.9</td>
<td>170.8 ± 6.4</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>24.0 ± 4.6</td>
<td>23.9 ± 4.5</td>
<td>24.3 ± 4.7</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>81.3 ± 11.5</td>
<td>79.7 ± 10.8</td>
<td>84.5 ± 12.2</td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>106.9 ± 12</td>
<td>103.4 ± 10.4</td>
<td>113.7 ± 12.1</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>71.8 ± 8.9</td>
<td>69.8 ± 8.1</td>
<td>75.7 ± 9.1</td>
</tr>
<tr>
<td>HDL-cholesterol (mg/dL)</td>
<td>48.1 ± 10.1</td>
<td>49.8 ± 10.1</td>
<td>44.9 ± 9.3</td>
</tr>
<tr>
<td>Triacylglycerol (mg/dL)</td>
<td>107.6 ± 58.1</td>
<td>102.2 ± 50.2</td>
<td>118.2 ± 69.8</td>
</tr>
<tr>
<td>Glucose (mg/dL)</td>
<td>88.8 ± 9.1</td>
<td>88.2 ± 8.6</td>
<td>8.9 ± 9.8</td>
</tr>
<tr>
<td>HOMA-IR</td>
<td>2.3 ± 1.5</td>
<td>2.4 ± 1.6</td>
<td>2.1 ± 1.4</td>
</tr>
<tr>
<td>Insulin (mg/dL)</td>
<td>10.4 ± 6.7</td>
<td>10.9 ± 6.9</td>
<td>9.2 ± 6.2</td>
</tr>
<tr>
<td><strong>BMI class (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Underweight or normal weight</td>
<td>64.4%</td>
<td>65.6%</td>
<td>62.1%</td>
</tr>
<tr>
<td>Overweight</td>
<td>24.9%</td>
<td>25.3%</td>
<td>24.1%</td>
</tr>
<tr>
<td>Obese</td>
<td>10.7%</td>
<td>9.1%</td>
<td>13.8%</td>
</tr>
</tbody>
</table>

Differences between averages of women and men were statistically significant (p ≤ 0.01) for all variables.
The overall MetS prevalence was 11.8%. We observed more men than women classified with MetS (14.3% vs. 10.5%, respectively, p < 0.01). A total of 68.6% of the sample had at least one component for MetS. Although MetS prevalence is higher in men than in women, the percentage of healthy subjects (with none MetS component) is also higher in men than in women (40.7% vs. 26.7%, respectively, p ≤ 0.01; Table II). The most prevalent MetS components in the total sample were low HDL-C concentration (43.6%) and AOb (41.1%). A greater proportion of women had low HDL-C concentration (51.5% vs. 28.1%, p ≤ 0.01), and higher proportion of AOb (47.1% vs. 29.3%, p ≤ 0.01).

Although the percentage of men with elevated TAG concentrations was significantly larger than in women (p ≤ 0.01), the same was observed with elevated fasting glucose (13.8% vs. 8.3%, p ≤ 0.01) and elevated BP (17.5% vs. 4.0%, p ≤ 0.01).

## Abdominal Obesity Associations with MetS Components

The magnitude of associations between AOb and the other MetS components in men and women was explored. In both, men and women AOb was significantly associated with all of the MetS components (p ≤ 0.01); the observed association followed the magnitude order BP > TAG > HDL-C > GLU (p ≤ 0.01) (Table III).

When examining MetS components by AOb in both men and women, we observed significant greater mean values in SBP and DBP in obese men than in non-obese (120.2 vs. 111.0 mm/Hg, p ≤ 0.01 and 79.9 vs. 74.0 mm/Hg, p ≤ 0.01, respectively). As expected, a lower mean value in HDL-C concentration was found in obese men when compared with non-obese (40.7 vs. 46.6 mg/dL, p ≤ 0.01). Mean values for glucose were greater in obese than in non-obese (92.2 vs. 89.0 mg/dL, p ≤ 0.01), as well as TAG (158.7 vs. 101.4 mg/dL, p ≤ 0.01) (Table IV).

The same was observed in women, SBP and DBP mean values were significantly greater in obese compared to those in non-obese (106.3 vs. 100.8 mm/Hg, p ≤ 0.01 and 72.2 vs. 67.8 mm Hg, p ≤ 0.01, respectively). With respect to HDL-C, lower value was observed in obese (47.4 mg/dL) than in non-obese (52.0 mg/dL, p ≤ 0.01). Regarding glucose concentration we found significantly lower values in non-obese (87.5 mg/dL) than in obese (88.9 mg/dL, p ≤ 0.01). Even TAG concentration was considered normal in both, obese and non-obese, these values were higher in obese.

## Discussion

The main findings from this study is that a great number of Mexican university students presented unhealthy HDL-C levels and AOb, and a relatively high association of AOb with elevated BP, which could be at risk for developing chronic diseases, including type 2 diabetes and CVD (1,2,8,9). On the other hand, men have higher prevalence of MetS than women; however, the percentage of healthy men (with no MetS components) is also higher in men than in women.

According to the National Health and Nutrition Survey (ENSA-NUT 2012), the prevalence of overweight and obesity was 71.3%
The prevalence of MetS between Mexico, Ecuador, and Argentina, Chile it was 6.0% using the ATPIII-2002 criteria. The difference in young adults of Mexico was 53.3%, in Ecuador 43.2% and compared with that found in college students from developed countries like United States where MetS was identified in 10% of 19-21. The prevalence of MetS in our study is higher, even the reported prevalence was 7.5%, 4.9% and 4.1%, respectively (16). (14.3% in men and 10.5% in women), these values are higher than those found in college students from Latin America countries, including Ecuador, Chile and Argentina where the reported prevalence was 7.5%, 4.9% and 4.1%, respectively (19-21). The prevalence of MetS in our study is higher, even compared with that found in college students from developed countries like United States where MetS was identified in 10% of men and 3% of women (22), and 4.7% (men) 1.6% (women) in first-year college students between 18 and 24 years (23).

It is worth to mention that the prevalence of abdominal obesity in young adults of Mexico was 53.3%, in Ecuador 43.2% and in Argentina 12%, using as reference the IDF criteria; while in Chile it was 6.0% using the ATPIII-2002 criteria. The difference in the prevalence of MetS between Mexico, Ecuador and Argentina, could be explained due to higher differences in the prevalence of abdominal obesity in the studied populations; whereas the differences with Chile are related to a lack of comparability because of the different diagnostic criteria used.

Mean values in all of the related components of the metabolic syndrome through AOb were significantly higher in obese young adults, compared to non-obese (p < 0.01). Among those students who are non-obese, only 1% has the MetS. A similar trend was observed by DuBoise et al., in elementary school children, as well as other studies observed a higher prevalence for each component of the MetS (24,25).

It is important to notice that the chronological development of AOb increases the cardiovascular risk, which is at the core of metabolic syndrome. In young adults, moderate obesity generally is well tolerated; however, with advancing years, there is a common progressive weight gain, a gradual loss of muscle mass, stiffening of the arterial tree, decline in secretory capacity of pancreatic β-cells, mitochondrial dysfunction, and increased inflammatory changes in adipose tissue as well as other age-related alterations (22). The syndrome often culminates in type 2 diabetes in which risk for vascular disease is markedly raised (1).

With the purpose to establish future interventions aimed to reducing risk factors for MetS development, it is important to know the prevalence of its components. According to the results of this study, low HDL-C was the most frequent, followed by AOb. In 2012, our research group suggested that the binomium HDL/WC is the main prevalence factor and the main predictor of MetS occurrence, since low HDL-C is very frequent in this population (17). However, to increase the effectiveness of these interventions and as a goal of this report, we consider that is more important to know the degree of association of each of these elements on its development. In this study, AOb was selected as one of the most important components of the MetS due to its high prevalence, and other studies have shown that AOb is a factor of high importance for its development (19,26). The degree of association of AOb with the other components of MetS was established and we found that elevated BP was more strongly associated in both men and women. This finding is important because in our university population, high BP is the lowest frequent individual component of MetS, but the importance on its development could

| Table IV. Averages of individual components of MetS by AOb in women and men |
|---------------------------|---------------------------|
|                          | **Women** | **Men** |
|                          | Obese     | Non-obese | Obese | Non-obese |
| n (subjects)             | 932       | 1,047     | 297   | 717       |
| Systolic blood pressure (mmHg) | 106.3 ± 10.3 | 100.8 ± 9.7 | 120.2 ± 11.9 | 111.0 ± 11.1 |
| Diastolic blood pressure (mmHg) | 72.2 ± 8.1 | 67.8 ± 7.6 | 79.9 ± 9.5 | 74.0 ± 8.3 |
| Triglycerides (mg/dL)     | 114.6 ± 59.4 | 91.2 ± 36.9 | 158.7 ± 84.9 | 101.4 ± 54.3 |
| HDL-cholesterol (mg/dL)   | 47.4 ± 9.7 | 52.0 ± 10.0 | 40.7 ± 8.8 | 46.6 ± 8.9 |
| Glucose (mg/dL)           | 88.9 ± 8.4 | 87.5 ± 8.8 | 92.2 ± 10.0 | 89.0 ± 9.5 |

Data (mean ± SD) analyzed using independent samples t test to determine differences by sex. All parameters show differences (p < 0.01) between abdominal obese and non-obese, in women and men.
be greater than biochemical components, including low HDL-C, despite being the most frequent component in this population.

Our results could be very important to public health authorities for the design and implementation of focused preventive policies to reduce MetS and CVD in college students.

As it is known, cross-sectional design limits causal inferences; however, this design allows researchers to obtain the current health status of the desired population at one point in time. Some studies define young adults as 18 to 24 (8,18), others from 20 to 39 (23), as in this study was from 17 to 25 years old, we think a single operational definition for young adults would be beneficial for future data comparisons. Our reported prevalence of MetS in students could not be generalized to all Mexican university students; even, our sample was derived from two universities from central (UNAM and UACM) and one from northern (UACJ) locations, more universities need to be sampled. Yet, to our knowledge no other study of this sample size has examined MetS in young Mexicans.

CONCLUSIONS

Central obesity and low HDL-C are the most prevalent components of MetS, while elevated BP shows the lowest prevalence. Nevertheless, the degree of association between AOb and the other components of MetS was established, and we found that elevated BP is more strongly associated in both men and women. This finding is important because in our Mexican university population, elevated BP is the lowest frequent individual component of MetS, but the importance on its development could be greater than biochemical components, including low HDL-C, the most frequent component in this population.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge to subjects of the study and the support of this study to Universidad Saludable Program at UACJ and Grupo Diagnóstico Médico PROA, S.A. de C.V. This study was funded by FESI-DIP-PAPCA-2014-53, and is part of the Collaboration agreement UACJ/AG/CV-22/2015 and Reg. No. UNAM: 41079-789-7-IV-15.

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