Metabolic syndrome in the 1982 Pelotas cohort: effect of contemporary lifestyle and socioeconomic status

Síndrome metabólica na coorte de 1982 da cidade de Pelotas: efeito do estilo de vida contemporâneo e situação socioeconômica

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ABSTRACT

Objectives: Describe the prevalence of metabolic syndrome, and its association with contemporary lifestyle factors. Subjects and methods: In 2004-2005, 4,296 subjects of the 1982 Pelotas Birth Cohort were evaluated, and metabolic syndrome (MetS) was assessed in 3,599 according to the NCEP-ATP III and IDF criteria. Results: Prevalence of MetS was 5.9% and 6.7% for NCEP-ATP III and IDF, respectively. Smoking, alcohol intake, and physical activity were not associated with MetS. Among men, the body mass index (BMI) was associated with MetS – overweight [RR: 3.14 (95% CI, 1.97-5.00)] and obese subjects [RR: 17.41 (95% CI, 11.85-25.60)]. In women, family income and schooling were inversely associated with MetS, overweight increased the risk of MetS 7.73 (95% CI, 3.65-16.38) times and obesity 40.67 (95% CI, 20.85-79.33) times. Conclusions: MetS was more prevalent among men according to NCEP-ATP III criteria, and obesity was the main risk factor. Arq Bras Endocrinol Metab. 2010;54(4):390-7

Keywords
Metabolic syndrome; risk factors; birth cohort

INTRODUCTION

The metabolic syndrome (MetS) is characterized by the presence of a set of cardiovascular risk factors related to resistance to insulin. Prevalence of MetS increases with age, and is greater in populations with high prevalence of obesity such as that of the United States, where about 25% of adults have MetS, ranging from 7% at age 20 to 44% at 70 years of age (1). Recently, with...
the increase in prevalence of obesity MetS began to be reported also among children and adolescents (2).

In Brazil, among 12 to 18-year-old girls from public schools in Niteroi, Rio de Janeiro State, the prevalence of MetS according to NCEP-ATPIII was 3.2% and increased to 21.4% (95% CI, 9.86-33.00) among obese subjects (3). In the Ribeirão Preto cohort which used the same criteria prevalence was of 10.7% among men and 4.8% among women aged 23-25 years (4).

The pathogenesis of metabolic syndrome is multifactorial; insulin resistance and obesity are the major risk factors. Physical inactivity, advanced age, hormonal changes, and genetic alterations are known to exacerbate prevalence, but the role of each of these factors may vary according to ethnicity (1).

Prevalence of MetS is higher among low socioeconomic status subjects (5-8) and this association is mediated by differences in diet, physical activity, obesity, and smoking, in addition to the greater deposition of abdominal fat related to high emotional stress (7).

This study was aimed at assessing the prevalence of MetS according to NCEP-ATP III (9) and IDF (10) criteria in the 1982 Pelotas birth cohort at age 22-23 years, and to evaluate its association with contemporary risk factors.

SUBJECTS AND METHODS

In 1982, all children born alive in hospitals in the city of Pelotas, Southern Brazil, and whose family lived in the urban area of the city were examined (n = 5,914), and mothers were interviewed on socioeconomic, demographic and health-related variables. Weight at birth was measured by the hospital staff using pediatric scales that were calibrated weekly. Gestational age was estimated from the maternal recall of their date of the last menstrual period. The subjects have been followed-up and examined on several occasions and the study methodology has been described elsewhere (11).

Between August 2004 and August 2005, a census was taken in the city in search of residents born in 1982. In addition to the census other tracing strategies were also employed (11). Following the interview, individuals were invited to donate blood which was collected at an outpost set by the research team. Those subjects who did not show up were visited at home. At the time of collection, blood glucose was measured from fingertip blood using an Accu-Check Advantage (Roche) glucose meter which is accepted worldwide in community based diabetes screening (12,13).

Information on the time of the last meal and of blood collection were recorded so that the time elapsed since the last meal could be estimated. Blood samples (5 mL) were collected from each subject by venous puncture. Colorimetric enzymatic methods were used for determining triglycerides (TG); HDL-cholesterol was measured using an ultrasensitive direct method, both using a Selectra 2 analyzer (Merck).

In the 2004-2005 visits, weight was measured using a portable scale (Seca UNICEF) with 100 g precision. Weight of clothing was subtracted from the obtained value based on a table of weights of clothing items. Height was assessed using a standardized aluminum anthropometer, with the subject’s head in the Frankfurt plan (14).

Abdominal circumference was measured with the subject standing, arms relaxed alongside the body, and the tape measure placed at the level of the natural waist, at the narrowest part of the trunk, between the lowest rib and the iliac crest, at the end of a normal expiration, and without compressing the skin. Measurements were taken using a thin inextensible measure tape, with 0.1 cm precision. Blood pressure was measured twice, at the beginning and at the end of the interview, using a digital wrist sphygmomanometer (Omron HEM 629). In the present analysis we used the mean value of these two measurements.

The following criteria were used to define metabolic syndrome:

NCEP-ATP III (National Cholesterol Education Program (NCEP)-Adult Treatment Panel III), defined by the presence of at least three of the following factors: abdominal circumference > 102 cm for men and > 88 cm for women; triglycerides ≥ 150 mg/dL; blood pressure ≥ 130/85 mmHg; HDL-cholesterol < 40 mg/dL for men and < 50 mg/dL for women; fasting blood glucose ≥ 110 mg/dL (> 100 mg/dL may be used).

International Diabetes Federation (IDF): abdominal circumference ≥ 94 cm for men and ≥ 80 cm for women, in addition to two of the following: triglycerides ≥ 150 mg/dL or under treatment; blood pressure ≥ 130/85 mmHg or under treatment; HDL-cholesterol < 40 mg/dL for men or < 50 mg/dL for women or under treatment, fasting blood glucose ≥ 100 mg/dL, or glucose intolerance or diabetes (10).

The following risk factors were evaluated in 2004-2005:

Obesity: defined as body mass index ≥ 30 kg/m².

Overweight: defined as body mass index between 25 and 29.9 kg/m².
Current diet: based on the frequency of intake (daily, weekly and monthly) of 70 food items. Block score was used for assessing the consumption of fiber and fat (15). Low fiber consumption was considered if the amount of fiber in the diet was less than 20 g a day. Scores of 25 or higher were considered as high for fat. Carbohydrate (CH) intake, expressed as a percentage of total daily or annual kilocalories was another measure of diet pattern. The percentage of total caloric intake from CH was categorized as high (> 60%), middle (50%-60%), and low (< 50%).

Physical activity: leisure time physical activity was evaluated using the International Physical Activity Questionnaire long version (16). Weekly scores of physical activity were estimated by the sum of time of walking and moderate physical activity plus time spent on vigorous activities multiplied by two. Those subjects whose scores were lower than 150 minutes of leisure time were classified as sedentary (17).

Family income: the total income of the family members in the month before the interview (in minimum wages).

Achieved schooling: the highest school grade successfully completed by the subject, divided into 4 categories: < 4 years, 5 to 8 years, 9 to 11 years, and ≥ 12 years.

Smoking: those subjects who reported smoking every day in the last week were considered as smokers.

Alcohol consumption: reported as number of doses of alcoholic beverages a day.

Skin color: the subjects self-referred their skin color after hearing the options: white, black, mixed, Asian or indigenous. As the number of subjects was too small in the last two groups, they were mixed in the analysis.

Data analysis was carried out using Stata 9.0 software. In the bivariate analysis, the chi-squared test was used. Since the prevalence of some outcomes was higher than 10%, and in this situation the odds ratio overestimates the prevalence rate, we used the Poisson regression with robust adjustment of the variance in the multivariate analysis to estimate the prevalence ratio (18). Multivariate analysis was done according to a hierarchical model in which socioeconomic and demographic factors determine diet and habits (alcohol intake, smoking, and physical activity) and those habits interfere with current BMI and in the outcome metabolic syndrome. Backward selection of the variables was used; variables with p ≤ 0.20 were maintained in the model. Fasting time was not associated with metabolic syndrome, and therefore estimates were not controlled for fasting time.

The study protocol was approved by the Federal University of Pelotas Research Ethics Committee; all subjects provided written consent for the interview and for blood collection and analysis.

RESULTS

In 2004-2005, we interviewed 4,296 subjects (77.4% followed-up, including the 282 registered deaths). Of the interviewed subjects, 3,832 provided a blood sample (71% of the original cohort, and 91% of interviewed subjects). Compared to the original cohort, subjects in the extreme income groups were less likely to be traced (19). We excluded from the metabolic syndrome analysis 103 women who were pregnant at the time of the interview.

Prevalence of metabolic syndrome was 5.9% (N = 213) according to NCEP-ATPIII and 6.7% (N = 240) according to IDF.

Table 1 shows the characteristics of the studied sample, stratified by sex. Approximately 75% of the subjects were white; 48% had between 9 and 11 years of schooling; about one-third of the families had incomes between one and three minimum wages (MW), and other third between 3.1 and 6.0 MW. Prevalence of smoking was 26.0%; low fiber intake was reported by 69% of subjects, while high fat intake was reported by 64%, the latter being greater among men. Consumption of more than one dose of alcohol per day was reported by 23% of the sample (11% of women and 34% of men). Sixty-four percent of the subjects were considered as sedentary during leisure time. Prevalence of obesity was 8.3%, and of overweight, 21%.

Tables 2 and 3 show the distribution of MetS and its components according to socioeconomic and demographic variables. MetS was more prevalent among men, only according to NCEP criteria, in the lowest family income by IDF, and obese subjects by both criteria. As to MetS components, women showed significantly higher prevalence of abdominal obesity, and of altered HDL-cholesterol. Men showed significantly greater prevalence of high blood glucose, triglycerides, and blood pressure. There was significant difference in distribution of MetS components according to skin color: abdominal obesity and systolic blood pressure were more prevalent in non-white, and triglycerides among white subjects. Regarding family income, only low HDL- cholesterol and abdominal circumference were higher among the poorest. Finally, regarding the criteria all components of MetS were significantly more frequent among obese subjects.
Because there was interaction between income and sex \((p = 0.002)\), the analyses were stratified according to sex. Table 4 presents crude and adjusted prevalence ratio for MetS based on the NCEP-ATP III criteria, stratified by sex. In the crude analysis, males had a PR of MetS of 1.56 (95% CI, 1.19-2.05) according to NCEP-ATP III, and 0.88 (95% CI, 0.69-1.13) according to IDF. Among males, skin color, income, and schooling were not associated with MetS. Family income reached the significant threshold for being considered as a confounder and was maintained in the model. None of the behavioral variables (smoking, alcohol intake, diet, and physical activity) was associated with MetS \((p > 0.05)\), both in crude and adjusted analyses BMI was the only variable associated with MetS among men.

In women, family income and schooling were inversely associated with prevalence of MetS. Smoking, fiber, fat and alcohol intake, and physical activity were not significantly associated with MetS. In the last level, overweight showed a PR of 7.73 \((p < 0.001)\) and obesity of 40.67 \((p < 0.001)\) after adjustment for family income and schooling.

The model using MetS as an outcome, as defined by the IDF classification, showed no appreciable differences (Table 5). Among women, higher income and schooling remained as a protective factor, and a higher fiber intake was significantly associated with MetS.

**DISCUSSION**

The high prevalence of cardiovascular risk factors among young adults is alarming, and similar results have been described in other studies \((4,20,21)\). In the present study, using NCEP criteria, MetS was more prevalent among men. This is similar to what has been reported in other Latin-American studies with young adults \((4,21,22)\).

Brunner and cols. \((5)\), in 1997, reported a higher risk of MetS among workers of lower socioeconomic class, irrespective of sex, and suggested that this may explain the inequities in distribution of coronary disease in England, a phenomenon also seen in other studies \((23,24)\). Loucks and cols. \((25)\) detected an interaction between sex and socioeconomic level in the same direction as that found in the present study, the prevalence of MetS was positively related to income among men, but negatively related to women. Salario and cols. \((26)\) also found higher prevalence among lower socioeconomic women, with no association in men. Differences in prevalence of obesity according to sex and income may explain the interaction found in the present study, given that obesity is more frequent among women of lower income, with no difference in men, in our sample. Indeed, after controlling for obesity the term for signifi-
Table 2. Distribution of prevalence of metabolic syndrome and its components defined based on NCEP-ATP III, according to sex, skin color, obesity, and socioeconomic indicators in the 1982 Pelotas cohort, at age 23

<table>
<thead>
<tr>
<th></th>
<th>Sex</th>
<th>Skin color</th>
<th>Family income (terciles)</th>
<th>Obesity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Male</td>
<td>White</td>
<td>Nonwhite</td>
</tr>
<tr>
<td>Blood glucose</td>
<td>12.9</td>
<td>20.9*</td>
<td>16.6</td>
<td>18.0</td>
</tr>
<tr>
<td>HDL-cholesterol</td>
<td>25.9*</td>
<td>13.0</td>
<td>19.2</td>
<td>19.7</td>
</tr>
<tr>
<td>Triglycerides</td>
<td>10.1</td>
<td>22.9*</td>
<td>18.3*</td>
<td>12.0</td>
</tr>
<tr>
<td>Abdominal circumference</td>
<td>10.9*</td>
<td>4.2</td>
<td>6.7</td>
<td>9.4*</td>
</tr>
<tr>
<td>Systolic blood pressure</td>
<td>13.2</td>
<td>35.5*</td>
<td>24.1</td>
<td>27.8*</td>
</tr>
<tr>
<td>Metabolic syndrome</td>
<td>4.6</td>
<td>7.2*</td>
<td>5.9</td>
<td>6.1</td>
</tr>
</tbody>
</table>

*p ≤ 0.001; *p ≤ 0.05.

Table 3. Distribution of prevalence of metabolic syndrome and its components defined based on IDF, according to sex, skin color, obesity, and socioeconomic indicators in the 1982 Pelotas cohort, at age 23

<table>
<thead>
<tr>
<th></th>
<th>Sex</th>
<th>Skin color</th>
<th>Family income (terciles)</th>
<th>Obesity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Male</td>
<td>White</td>
<td>Nonwhite</td>
</tr>
<tr>
<td>Blood glucose</td>
<td>30.1</td>
<td>43.2*</td>
<td>36.4</td>
<td>37.5</td>
</tr>
<tr>
<td>HDL-cholesterol</td>
<td>25.9*</td>
<td>13.0</td>
<td>19.2</td>
<td>19.7</td>
</tr>
<tr>
<td>Triglycerides</td>
<td>10.1</td>
<td>22.9*</td>
<td>18.3*</td>
<td>12.0</td>
</tr>
<tr>
<td>Abdominal circumference</td>
<td>24.5*</td>
<td>10.2</td>
<td>16.3</td>
<td>19.0*</td>
</tr>
<tr>
<td>Systolic blood pressure</td>
<td>13.2</td>
<td>35.5*</td>
<td>24.1</td>
<td>27.8*</td>
</tr>
<tr>
<td>Metabolic syndrome</td>
<td>7.1</td>
<td>6.3</td>
<td>6.5</td>
<td>7.1</td>
</tr>
</tbody>
</table>

*p ≤ 0.001; *p ≤ 0.01.

cance of interaction was reduced (p = 0.11). Another possible explanation would be the higher parity found among women of lower socioeconomic level, since higher parity has been associated with greater abdominal obesity (27).

Contemporary diet, smoking, alcohol use, and physical activity were not associated with MetS, contrary to what has been reported in other studies (28-31), with the exception of higher risk in those women with higher fiber consumption. A possible explanation for these results is the fact that ours is a young population, who may not have been exposed to these factors long enough to have had an effect on the components of MetS. Non-differential information bias is another potential explanation for the lack of an association, given that diet was measured indirectly. Moreover, reverse causality may have minimized the impact of physical activity, with more obese individuals having been more physically active. On the other hand, even within a small sample in which physical activity was evaluated during adolescence (N = 227, data not shown), this variable was not associated with MetS, thus suggesting that reverse causality is not the most plausible explanation for this lack of association.

One of the weaknesses of the present study is that blood collection did not follow a period of prolonged fasting: on average, subjects had eaten their last meal 3.7 hours before blood collection, with a median period of 3 hours. In our sample, there was no association between duration of fasting and altered HDL (p = 0.33) but this variable was associated with altered blood glucose levels (p < 0.001) and triglycerides (p < 0.001). However, the prevalence of metabolic syndrome was not associated with time of fasting (p = 0.13). Therefore, we do not believe that our findings were biased by fasting time.

Another limitation of the study is the fact we used random capillary blood glucose (RCBG), however this is the most convenient way to reach large numbers of people, and in a publication evaluating the screening tests for type 2 diabetes, the World Health Organization (WHO) found that studies have mostly used RCBG measured with a blood glucose meter and reported a sensitivity between 68%-74% and specificity ranging from 66%-77%, depending on age, with a cut point of 5.6 mmol (100 mg/dL). The same report of the WHO says that although the accuracy of a glucose meter has been questioned, these problems are “not
Table 4. Poisson regression of RR for metabolic syndrome according to NCEP-ATP III criteria; crude and adjusted for demographic, socioeconomic, and behavioral factors, stratified by sex in the 1982 Pelotas cohort at age 23

<table>
<thead>
<tr>
<th>Variable</th>
<th>Men Crude</th>
<th>Women Crude</th>
<th>Men Adjusted</th>
<th>Women Adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin color</td>
<td>p = 0.38</td>
<td>p = 0.96</td>
<td>p = 0.24</td>
<td>p = 0.81</td>
</tr>
<tr>
<td>White</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Nonwhite</td>
<td>0.99</td>
<td>0.99</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>(0.68-1.45)</td>
<td>(0.68-1.45)</td>
<td>(0.69-1.81)</td>
<td>(0.56-1.45)</td>
</tr>
</tbody>
</table>

Family income (terciles)
- Lower: p = 0.18; p = 0.08
- Middle: p = 0.01; p = 0.03
- Upper: p = 0.12

Schooling (years)
- 0 to 4: p = 0.48; p = 0.17
- 5 to 8: p = 0.001
- 9 to 11: p = 0.001
- ≥ 12: p = 0.001

Smoking
- p = 0.001
- p = 0.001

Alcohol intake
- Zero: p = 0.001

Higher fiber intake
- p = 0.001

Physical activity during leisure time (minutes)
- 10-140: p = 0.001

BMI (kg/m²)
- p = 0.001

Table 5. Poisson regression of RR for metabolic syndrome according to IDF criteria; crude and adjusted for demographic, socioeconomic, and behavioral factors, stratified by sex in the 1982 Pelotas cohort at age 23

<table>
<thead>
<tr>
<th>Variable</th>
<th>Men Crude</th>
<th>Women Crude</th>
<th>Men Adjusted</th>
<th>Women Adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin color</td>
<td>p = 0.29</td>
<td>p = 0.47</td>
<td>p = 0.10</td>
<td>p = 0.72</td>
</tr>
<tr>
<td>White</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Nonwhite</td>
<td>0.83</td>
<td>0.85</td>
<td>1.36</td>
<td>1.07</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>(0.54-1.28)</td>
<td>(0.55-1.32)</td>
<td>(0.95-1.96)</td>
<td>(0.74-1.55)</td>
</tr>
</tbody>
</table>

Family income (terciles)
- Lower: p = 0.15; p = 0.16
- Middle: p = 0.001; p = 0.005
- Upper: p = 0.17

Schooling (years)
- 0 to 4: p = 0.08
- 5 to 8: p = 0.67
- 9 to 11: p = 0.17
- ≥ 12: p = 0.17

Smoking
- p = 0.009

Alcohol intake
- Zero: p = 0.009

Higher fiber intake
- p = 0.009

Physical activity during leisure time (minutes)
- 10-140: p = 0.009

BMI (kg/m²)
- p = 0.009

* Adjusted for variables in the first level: skin color, schooling and family income.
* Adjusted for schooling, family income and variables of the second level: smoking, alcohol intake, higher fiber and fat intake and physical activity.
* Adjusted for schooling, family income, higher fiber intake and BMI.
* Adjusted for schooling, family income and BMI.
necessarily insurmountable and the final decision about their use will depend on resources and related practical considerations” (13). The mean blood glucose level in this study was 97.3 ± 15.1 mg/dL and the median was 95.0 mg/dL, similar to a study performed in Vitória, ES, with mean fasting blood glucose of 98.9 ± 19.9 and 95.1 ± 13.7 in men and women without MetS, respectively (26).

Despite this being a young population, obesity was strongly associated with risk of MetS. Countless studies have detected associations between obesity and MetS (32,33); in the Bogalusa Heart Study, childhood obesity was the strongest predictor of MetS in adult life (34) as well as the most important risk factor for cardiovascular disease (35,36), which remains as the major cause of death worldwide, especially in developing countries.

The findings in the present study confirm the need for early intervention against obesity so as to prevent its impact on cardiovascular risk factors. It is necessary that health workers be alerted as to the need for measuring blood pressure, BMI, and abdominal circumference, in addition to metabolic parameters, especially among the obese, at earlier ages. It will also be necessary that health workers orient patients as to leading a healthy lifestyle, by means of adequate nutrition and physical activity. This may help delay or prevent the progression of MetS to diabetes mellitus, cardiovascular disease, and other complications that can affect the survival of future generations.

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