Metabolic Syndrome among Adults in Jordan: Prevalence, Trend, and Associated Factors

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Abstract

Background: Metabolic Syndrome is emerging as a global health challenge in the 21st century. Multiple epidemiological studies were conducted among variety of ethnic groups showed discrepancies in the prevalence of both Metabolic Syndrome and its individual components. The aims of this study were to determine the prevalence of Metabolic Syndrome in Jordan using the ATP III and IDF criteria and assess the changes of Metabolic Syndrome prevalence over time.

Methods: Data from the 2017 cardiovascular risk factors national survey were. The survey collected extensive data from a national population-based sample of Jordanian residents. A structured questionnaire was used to collect sociodemographic variables and clinical data. Blood samples were taken for biochemical measurements. Anthropometric characteristics were measured by the same team of trained field researchers. A total sample of 4,056 aged between 18 and 90 years were included. The findings from the 2017 survey were compared with the findings of the 2009 survey that adopted the same methods and procedures.

Results: The crude prevalence of Metabolic Syndrome was 48.2% (52.9% among men and 46.2% among women; p<0.001) according to IDF criteria. Using the ATP III criteria, the prevalence was 44.1% (51.4% among men and 41% among women, p<0.001). The age standardized prevalence rate of Metabolic Syndrome was 44% (95% CI: 42.7%, 45.4%) and 39.9% (95% CI: 39.6%, 41.2%) using the IDF definition and ATP III criteria, respectively. The kappa measure of agreement showed excellent agreement between the two definitions (k= 81.9%, p<0.001). Of all participants, 41.7% met both the IDF and ATP III diagnostic criteria, 6.6% met the IDF criteria only and 2.5% met the ATP III criteria only. The age-standardized prevalence rate of Metabolic Syndrome was significantly higher in 2017 (45.7% in men and 44.5% in women) than that in 2009 (34.6% in men and 39.8% in women).

Conclusion: The prevalence of Metabolic Syndrome in Jordan is considerably high and increasing. Healthy lifestyle programs encouraging appropriate dietary habits and physical activity are strongly recommended in Jordan.

Background

Non-communicable diseases (NCDs) are emerging as a global health concern with more remarkable increasing trend in low and middle income countries (1). The Global Burden of Diseases reports have shown that metabolic abnormalities are the most important determinants of NCDs all over the world (2). Each metabolic abnormality has its harmful effect but a combination of multiple abnormalities might produce what is known as Metabolic Syndrome (2, 3). Metabolic Syndrome more strongly predicts cardiovascular diseases and increases the risk of developing diabetes mellitus and chronic kidney disease than its individual components do (3, 4). There is an escalating concern regarding Metabolic Syndrome in the past few years due to multiple factors such as epidemiologic transition, life-style changes and burden of nutrition disorders, yet confusion regarding Metabolic Syndrome still exists due to
a lack of a unified definition; debate about its etiology and pathogenesis and lack of a consensus protocol for its treatment contribute to this uncertainty (2, 3, 5–7). The International Federation for Diabetes (IDF) demonstrated a standard definition in 2006 for Metabolic Syndrome as “a cluster of the most dangerous heart attack and cardiovascular diseases risk factors” (3). This definition addresses both clinical and research needs, and provides suitable and accessible tools for diagnosing Metabolic Syndrome status.

Prevalence of Metabolic Syndrome has been increasing worldwide for several decades especially in developing countries (8). It is still hard to provide accurate evaluation of Metabolic Syndrome prevalence due to a variety of definitions used, for instance, the prevalence ranges from 10–84% in worldwide across different countries, ethnic groups, gender and age. Multiple epidemiological studies were conducted among variety of ethnic groups showed discrepancies in the prevalence of both Metabolic Syndrome and its individual components (9, 10).

The importance of studying the prevalence and trend of Metabolic Syndrome stems from the fact that it could potentially be used as an adequate index for detecting people at high risk for NCDs and other cardiovascular diseases (2). The aims of this study were to determine the prevalence of Metabolic Syndrome in Jordan using the Adult Treatment Panel III (ATP III) and IDF criteria and assess the changes of Metabolic Syndrome prevalence over time.

Methods

Study design and sampling

This survey was conducted among Jordanian adults over a period of four months in the year 2017. The survey methods and procedures were described and detailed in other publications (11, 12) and they were similar to those that had been used in the 2009 survey (13). A multistage cluster sampling approach with probability proportional to size random selection method was used to ensure adequate coverage of the entire target population. A city/village was selected from each of the 12 governorates of Jordan. The sample of households was chosen in two stages. In the first stage, well-defined geopolitical areas (clusters) were selected from each city/village. At least one cluster was selected from each city/village at random using computer-generated random numbers. The second stage of household selection involved choosing a random sample of households from a list of households in a selected area. The households from each cluster were selected at random using a systematic sampling technique. A team of two (a female and a male) visited and invited selected households to report to the health center in that site, fasting in a given day after explaining the study for them. Subjects were asked not to take their medications during that day and to bring them along with them to the health center. Subjects aged ≥ 18 years were eligible for inclusion in the study. To encourage participation, the team worked on weekends and holidays and provided free transport for those who asked for it. The overall response rate was 78.1%. The study was approved by the Ethical Committee at the National Center for Diabetes,
Endocrinology, and Genetics, Amman, Jordan. An informed consent was obtained from each participant. Data were treated with strict confidentiality and used only for scientific purposes.

Data collection

Trained interviewers administered a comprehensive structured questionnaire specifically prepared for the purpose of the study. Main data obtained included sociodemographic variables, diabetes and other cardiovascular disease risk factors. Blood pressure was measured in a standardized way by trained researchers as explained in the 2009 survey (13). Three blood samples were drawn from a cannula inserted into the antecubital vein and used for the different laboratory measurements. Tubes containing sodium fluoride potassium oxalate were used for glucose measurement. Samples were centrifuged within 1 hour at the survey site and transferred by separate labeled tubes in ice boxes to the central laboratory of the National Center of Diabetes, Endocrinology, and Genetics in Amman, Jordan. All biochemical measurements were carried out by the same team of laboratory technicians using the same method throughout the study period. Fasting plasma glucose and lipid measurements were performed according to the manufacturers’ instructions, using COBAS autoanalyzer (Roche Diagnostics, Basel, Switzerland).

Anthropometric measurements

Weight was measured, while subjects were minimally clothed and not wearing shoes using digital scales (seca). Height was measured using a portable stadiometer (SECA 214 portable stadiometer). Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared (14). Waist circumference (WC) was measured at the midway between the iliac crest and the lower rib margin, over light clothing, using un-stretchable tape (seca 203), without any pressure to body surface. Waist to hip ratio (WHR) was calculated as WC divided by hip circumference and waist to height (WHtR) was calculated as WC divided by height in centimeters. All measurements were taken by the same team of well-trained persons using the same tools.

Definitions

Being overweight or obese were classified as proposed by WHO for diagnosing overweight (BMI of 25–29.9 kg/m$^2$) and obesity (BMI of 30 kg/m$^2$ or more) in adults (15). Metabolic syndrome was defined according to IDF criteria and ATP III diagnostic criteria. Diabetes was defined according to IDF Diabetes Atlas 8th edition diagnostic criteria (16).

Statistical Analysis

Data were entered and analyzed using the Statistical Package for Social Sciences software “SPSS IBM version 24”. The raw data file for 2009 were re-analyzed using the same variable definitions to assess the time-trends in Metabolic Syndrome prevalence. Proportions were used to estimate the prevalence of Metabolic Syndrome. Overall and age-specific prevalence rates were obtained and reported separately for each gender. We derived age-standardized prevalence rates in order to permit comparison between the
different surveys and with studies in other countries, using the world population as a standard population. Chi-square was used to compare proportions. Multivariate binary logistic regression was conducted to determine factors associated with metabolic Syndrome. A p-value of less than 0.05 was considered to be statistically significant.

Results

Socio-demographic characteristics

This study included 4056 participants [1193 (29.4%) men and 2863 (70.6%) women] aged 18 years or more. About 26.5% of them were between 40–49 years old. Men were significantly older than women; the mean (SD) age was 47.5 (14.6) year for men and 42.2 (13.7) year for women (p < 0.001). The majority of participants (94%) were Jordanians while 6% were Syrians. Table 1 shows the socio-demographic characteristics of participants according to gender.
Table 1
Socio-demographic characteristics of 4056 participants according gender, Jordan 2017

|                  | Men (n = 1193) | Women (n = 2863) | Total (N = 4056) | p value |
|------------------|---------------|------------------|------------------|---------|
|                  | n (%)         | n (%)            | n (%)            |         |
| Age (year)       |               |                  |                  | < 0.001 |
| 18–29            | 155 (13)      | 582 (20.4)       | 737 (18.2)       |         |
| 30–39            | 180 (15.1)    | 626 (21.9)       | 806 (19.9)       |         |
| 40–49            | 313 (26.3)    | 758 (26.5)       | 1071 (26.5)      |         |
| 50–59            | 294 (24.7)    | 557 (19.5)       | 851 (21)         |         |
| 60–69            | 154 (12.9)    | 249 (8.7)        | 403 (10)         |         |
| ≥70              | 95 (8)        | 84 (2.9)         | 179 (4.4)        |         |
| Marital status   |               |                  |                  | < 0.001 |
| Single           | 144 (12.1)    | 462 (16.1)       | 606 (14.9)       |         |
| Married          | 1049 (87.9)   | 2401 (83.9)      | 3450 (85.1)      |         |
| Nationality      |               |                  |                  | 0.942   |
| Jordanian        | 1117 (94)     | 2669 (93.9)      | 3786 (93.9)      |         |
| Syrian           | 71 (6)        | 173 (6.1)        | 244 (6.1)        |         |
| Smoking status   |               |                  |                  | < 0.001 |
| Current          | 395 (33.1)    | 189 (6.6)        | 584 (14.4)       |         |
| Past             | 206 (17.3)    | 46 (1.6)         | 252 (6.2)        |         |
| Never            | 592 (49.6)    | 2628 (91.8)      | 3220 (79.4)      |         |

**Anthropometric and Clinical Characteristics**

The mean anthropometric and biochemical characteristics for Jordanians are shown in Table 2. There was a significant difference in the majority of studied parameters. The mean (SD) of BMI was 29.5 (6.0) kg/m², being significantly higher in women than in men (30 (6.4) kg/m² vs. 28.4 (4.8) kg/m²; p < 0.001). The mean systolic and diastolic blood pressure, mean fasting blood glucose and mean triglyceride were significantly higher in men than in women. On the other hand, women have significantly higher cholesterol, HDL and LDL level than men.
Table 2
Anthropometric and clinical characteristics of 4056 participants according gender, Jordan 2017

| Variable                      | Male          | Female        | Total         | P value |
|-------------------------------|---------------|---------------|---------------|---------|
|                               | Mean (SD)     | Mean (SD)     | Mean (SD)     |         |
| Body mass index (kg/m²)       | 28.4 (4.8)    | 30 (6.4)      | 29.5 (6)      | < 0.001 |
| Waist circumference (cm)      | 98.9 (15.1)   | 92.7 (16.6)   | 94.6 (16.4)   | < 0.001 |
| Waist to Hip Ratio            | 0.94 (0.08)   | 0.85 (0.1)    | 0.88 (0.1)    | < 0.001 |
| Waist to Height Ratio         | 0.57 (0.08)   | 0.58 (0.1)    | 0.58 (0.1)    | < 0.001 |
| Systolic blood pressure (mmHg)| 127 (19.6)    | 118.3 (19.7)  | 120.9 (20.1)  | < 0.001 |
| Diastolic blood pressure (mmHg)| 79.5 (11.7) | 75 (11.6)     | 76.3 (11.8)   | < 0.001 |
| Fasting blood glucose (mg/dL) | 123.7 (58.6)  | 106.9 (41.6)  | 111.9 (47.9)  | < 0.001 |
| Total cholesterol (mg/dL)     | 193.3 (45.8)  | 197.5 (41.7)  | 196.2 (43)    | < 0.05  |
| HDL (mg/dL)                   | 38.2 (9.5)    | 48.6 (12.3)   | 45.6 (12.5)   | < 0.001 |
| LDL (mg/dL)                   | 125 (37.3)    | 126.9 (36.3)  | 126.3 (36.6)  | 0.135   |
| Triglyceride (mg/dL)          | 203.8 (209.3) | 147.3 (110.6) | 164 (149)     | < 0.001 |

**Prevalence rate of Metabolic Syndrome**

The crude prevalence of Metabolic Syndrome was 48.2% (52.9% among men and 46.2% among women; p < 0.001) according to IDF criteria. According to the ATP III criteria, the prevalence was 44.1% (51.4% among men and 41% among women, p < 0.001). The age standardized prevalence rate of Metabolic Syndrome was 44% (95% CI: 42.7%, 45.4%) and 39.9% (95% CI: 39.6%, 41.2%) using the IDF definition and ATP III criteria, respectively. The kappa measure of agreement showed excellent agreement between the two definitions (k = 81.9%, p < 0.001). Of all participants, 41.7% met both the IDF and ATP III diagnostic criteria, 6.6% met the IDF criteria only and 2.5% met the ATP III criteria only. Tables 3 and 4 show the crude and age-standardized sex-specific prevalence rates of Metabolic Syndrome and its individual components using the ATP III and IDF criteria.
Table 3
The sex-specific crude prevalence rates of Metabolic Syndrome and its individual components in Jordan, using the ATP III and IDF definitions, Jordan 2017

|                                | Men         | Women       | Total       | P value   |
|--------------------------------|-------------|-------------|-------------|-----------|
|                                | Number (%)  | Number (%)  | Number (%)  |           |
| Metabolic Syndrome             |             |             |             |           |
| IDF definition                 | 625 (52.9)  | 1300 (46.2) | 1925 (48.2) | < 0.001   |
| ATP definition                 | 608 (51.4)  | 1154 (41)   | 1762 (44.12)| < 0.001   |
| Central obesity                |             |             |             |           |
| IDF definition                 | 797 (67.3)  | 2193 (77.8) | 2990 (74.6) | < 0.001   |
| ATP definition                 | 491 (41.5)  | 1772 (62.8) | 2263 (56.5) | < 0.001   |
| Body Mass Index                |             |             |             |           |
| obesity                        | 419 (36.1)  | 1355 (48.2) | 1774 (44.7) | < 0.001   |
| overweight                     | 478 (41.2)  | 819 (29.1)  | 1297 (32.7) | < 0.001   |
| Elevated triglycerides         | 645 (54.5)  | 1031 (36.5) | 1676 (41.8) | < 0.001   |
| Low HDL                        | 727 (61.5)  | 1644 (58.1) | 2371 (59.1) | 0.057     |
| Elevated blood pressure        | 647 (54.5)  | 1077 (38.2) | 1724 (42.9) | < 0.001   |
| High fasting blood glucose     |             |             |             |           |
| IDF definition                 | 560 (47.4)  | 938 (33.4)  | 1498 (37.5) | < 0.001   |
| ATP definition                 | 476 (40)    | 692 (24.2)  | 1168 (28.8) | < 0.001   |
### Table 4
Age standardized sex-specific prevalence rates of Metabolic Syndrome and its components in Jordan, using ATP III and IDF definitions, Jordan 2017

|                       | Males                        | Females                      | Total                        |
|-----------------------|------------------------------|------------------------------|------------------------------|
|                       | Age-standardized rate (95% CI) | Age-standardized rate (95% CI) | Age-standardized rate (95% CI) |
| **Metabolic Syndrome**|                              |                              |                              |
| IDF definition        | 45.7 (42.9, 48.5)            | 44.5 (43.0, 46.1)            | 44 (42.7, 45.4)              |
| ATP III definition    | 43.9 (41.2, 46.5)            | 39.5 (37.9, 41.0)            | 39.9 (38.6, 41.2)            |
| **Central obesity**   |                              |                              |                              |
| IDF definition        | 60.4 (57.6, 63.2)            | 75.6 (74.2, 77.0)            | 70.9 (69.6, 72.3)            |
| ATP III definition    | 36.5 (33.8, 39.3)            | 60.7 (59.1, 62.2)            | 52.7 (51.2, 54.1)            |
| **Body Mass Index**   |                              |                              |                              |
| Obesity               | 32.8 (30, 35.5)              | 46.2 (44.5, 47.9)            | 41.4 (39.9, 42.9)            |
| Overweight            | 39.4 (36.3, 42.4)            | 28.8 (27.1, 30.5)            | 32.3 (30.8, 33.8)            |
| Overweight & Obesity  | 77.2 (69.4, 74.9)            | 74.5 (72.9, 76.0)            | 73.7 (72.4, 75.1)            |
| Elevated triglycerides| 50.1 (47.3, 53.1)            | 35.1 (33.4, 36.7)            | 38.5 (37.1, 39.9)            |
| Low HDL               | 59.2 (56.2, 62.3)            | 57.4 (55.5, 59.2)            | 57.7 (56.1, 59.3)            |
| Elevated blood pressure| 46.7 (44.0, 49.5)          | 37.7 (36.2, 39.2)            | 39.8 (38.5, 41.1)            |
| **High fasting blood glucose** |                        |                              |                              |
| IDF definition        | 39.2% (36.6, 41.8)          | 32.4% (30.9, 33.9)          | 34.2 (32.9, 35.5)          |
| ATP III definition    | 32.1% (29.7, 34.5)          | 23.9% (22.5, 25.3)          | 26.1 (25, 27.3)              |

### Age-specific prevalence rate of Metabolic Syndrome

The age-specific prevalence of Metabolic Syndrome for men and women is shown in Fig. 1 and Fig. 2 using IDF definition and ATP III definition, respectively. In both definitions, the prevalence of Metabolic Syndrome increased significantly with age in both men and women (P < 0.001). With the IDF definition, the prevalence rose from 13.1% from men aged 18–29 years to 66.9% for those aged 60–69 years and then declined to 60.6% in those aged 70 years and above. While the prevalence rose from 11.7% in women aged 18–29 years to 81% in women aged 70 years and above.
With the ATP III definition, the prevalence rose from 10.5% for men aged 18–29 years to 73.4% for those aged 60–69 years and then declined to 56.4% in those aged 70 years and above. While the prevalence rose from 8% in women aged 18–29 years to 77.4% in women aged 70 years and above.

**Prevalence of metabolic syndrome according to socio-demographic characteristics**

Tables 5 and 6 show the prevalence of metabolic syndrome according to socio-demographic characteristics using the IDF and ATP III criteria, respectively.
Table 5
Prevalence of Metabolic Syndrome by age categories, smoking status, marital status, region and nationality among Jordanians using IDF definition, Jordan 2017

| Variables         | Men                      | Women                  |
|-------------------|--------------------------|------------------------|
|                   | No          | Yes   | Number (%)              | No          | Yes   | Number (%)              |
|                   | P value     |       |                         | P value     |       |                         |
| Age (years)       |             | < 0.001 |                         |             | < 0.001 |                         |
| 18–29             | 133 (86.9) | 20 (13.1) | 506 (88.3) | 67 (11.7) |             |                         |
| 30–39             | 95 (53.4)  | 83 (46.6) | 445 (72.5) | 169 (27.5) |             |                         |
| 40–49             | 132 (42.6) | 178 (57.4) | 364 (48.3) | 390 (51.7) |             |                         |
| 50–59             | 109 (37.2) | 184 (62.8) | 145 (26.7) | 399 (73.3) |             |                         |
| 60–69             | 51 (33.1)  | 103 (66.9) | 36 (14.8)  | 207 (85.2) |             |                         |
| ≥70               | 37 (39.4)  | 57 (60.6) | 16 (19)    | 68 (81)    |             |                         |
| Smoking status    |             | < 0.001 |                         |             | 0.05     |                         |
| No                | 280 (47.6) | 308 (52.4) | 1413 (54.6) | 1174 (45.4) |             |                         |
| Past              | 68 (33.3)  | 136 (66.7) | 20 (43.5)  | 26 (56.5)  |             |                         |
| Current           | 211 (53.8) | 181 (46.2) | 81 (43.5)  | 105 (56.5) |             |                         |
| Marital status    |             | < 0.001 |                         |             | < 0.001 |                         |
| Single            | 126 (89.4) | 15 (10.6) | 380 (83.3) | 76 (16.7)  |             |                         |
| Married           | 433 (41.5) | 610 (58.5) | 1134 (48)  | 1229 (52)  |             |                         |
| Region            |             | < 0.001 |                         |             | < 0.001 |                         |
| North             | 179 (46)   | 210 (54) | 459 (50.4) | 451 (49.6) |             |                         |
| Middle            | 261 (55.8) | 207 (44.2) | 753 (58.5) | 534 (41.5) |             |                         |
| South             | 119 (36.4) | 208 (63.6) | 302 (48.6) | 320 (51.4) |             |                         |
| Nationality       |             | 0.045   |                         |             | 0.043    |                         |
| Jordanian         | 517 (46.7) | 591 (53.3) | 1422 (54.2) | 1204 (45.8) |             |                         |
| Syrian            | 41 (57.7)  | 30 (42.3)  | 81 (47.1)  | 91 (52.9)  |             |                         |
Table 6  
Prevalence of Metabolic Syndrome by age categories, smoking status, marital status, region and nationality among Jordanians using ATP III definition, Jordan 2017

| Variables     | Men          |        | Women          |        |
|---------------|--------------|--------|----------------|--------|
|               | No (Number (%)) | Yes (Number (%)) | P value | No (Number (%)) | Yes (Number (%)) | P value |
| Age (years)   |              |        |                |        |              |        |< 0.001 | < 0.001 |
| 18–29         | 137 (89.5)   | 16 (10.5) |                |        | 527 (92)    | 46 (8) |        |        |
| 30–39         | 101 (56.7)   | 77 (43.3) |                |        | 488 (79.5)  | 126 (20.5) |        |        |
| 40–49         | 144 (46.5)   | 166 (53.5) |                |        | 411 (54.5)  | 343 (45.5) |        |        |
| 50–59         | 110 (37.5)   | 183 (62.5) |                |        | 165 (30.3)  | 379 (69.7) |        |        |
| 60–69         | 41 (26.6)    | 113 (73.4) |                |        | 48 (19.8)   | 195 (80.2) |        |        |
| ≥70           | 41 (43.6)    | 53 (56.4) |                |        | 19 (22.6)   | 65 (77.4) |        |        |
| Smoking status|              |        |                | < 0.001 | < 0.05 |        |        |
| Never         | 295 (50.2)   | 293 (49.8) |                |        | 1541 (59.6) | 1046 (40.4) |        |        |
| Past          | 76 (37.3)    | 128 (62.7) |                |        | 24 (52.2)   | 22 (47.8) |        |        |
| Current       | 205 (52.3)   | 187 (47.7) |                |        | 95 (51.1)   | 91 (48.9) |        |        |
| Marital status|              |        |                | < 0.001 | < 0.001 |        |        |
| Single        | 126 (89.4)   | 15 (10.6) |                |        | 398 (87.3)  | 58 (12.7) |        |        |
| Married       | 450 (43.1)   | 593 (56.9) |                |        | 1262 (53.4) | 1101 (46.6) |        |        |
| Region        |              |        |                | < 0.001 | < 0.001 |        |        |
| North         | 169 (43.4)   | 220 (56.6) |                |        | 517 (56.8)  | 393 (43.2) |        |        |
| Middle        | 267 (57.1)   | 201 (42.9) |                |        | 821 (63.8)  | 466 (36.2) |        |        |
| South         | 140 (42.8)   | 187 (57.2) |                |        | 322 (51.8)  | 300 (48.2) |        |        |
| Nationality   |              |        |                | < 0.001 | 0.081 |        |        |
| Jordanian     | 527 (47.6)   | 581 (52.4) |                |        | 1555 (59.2) | 1071 (40.8) |        |        |
| Syrian        | 48 (67.6)    | 23 (32.4) |                |        | 92 (53.5)   | 80 (46.5) |        |        |

**Prevalence rate of individual components of Metabolic Syndrome**
The prevalence of obesity in Jordan was 44.7% and significantly higher in women (48.2%) compared to men (36.1%) \( (p < 0.001) \). The age-standardized prevalence of obesity was 41.4% (95% CI: 39.9%, 42.9%). Among components of metabolic syndrome, abdominal obesity was the most prevalent metabolic abnormality. According to the IDF definition, women had higher prevalence of abdominal obesity (77.8%) compared to men (67.3%) \( (p < 0.001) \). Low HDL cholesterol was the second most common metabolic abnormality in both men and women. Elevated triglycerides and low HDL level prevalence rates were 41.8% and 59.1%, respectively. The difference between men and women was statistically significant in elevated triglycerides level \( (p < 0.001) \) but not in low HDL level \( (p = 0.057) \). High fasting blood sugar prevalence rates were 37.5% and 28.8% using the IDF and ATP III definitions. Men had significantly higher prevalence of high fasting blood sugar using both IDF and ATP III definitions (47.4% and 40% respectively) compared to women (33.4% and 24.2% respectively). The relative frequencies of the number of metabolic abnormalities according to the IDF and ATP III measurements are shown in Fig. 3 and Fig. 4.

**Changes in the metabolic syndrome rate between 2009 and 2017**

The 2017 sample had a higher mean age compared to the 2009 sample (43.8 (14.2) year and 41.8 (13.3) years, respectively). Table 7 shows the difference in the anthropometric and clinical characteristics between 2017 and 2009 samples. A comparison in the sex-specific age-standardized prevalence rates of Metabolic Syndrome between 2009 and 2017 surveys is shown in Table 8. The age-standardized prevalence rate of Metabolic Syndrome was significantly higher in 2017 (45.7% in men and 44.5% in women) than that in 2009 (34.6% in men and 39.8% in women). Among men and women, the age-standardized rates of abdominal obesity and high fasting blood glucose were higher in 2017 than those in 2009. The 2009 survey showed higher prevalence rates of elevated blood pressure, elevated triglycerides and low HDL level.
|                               | 2017       | 2009       |
|-------------------------------|------------|------------|
|                               | Mean (SE)  | Mean (SE)  |
| Body mass index (kg/m²)       | 29.5 (0.1) | 29.6 (0.1) |
| Waist circumference (cm)      | 94.6 (0.2) | 88.5 (0.3) |
| Systolic blood pressure (mmHg)| 120.9 (0.3)| 124 (0.3)  |
| Diastolic blood pressure (mmHg)| 76.3 (0.2) | 80.3 (0.2) |
| Fasting blood glucose (mg/dL) | 111.9 (0.7)| 105.1 (0.9)|
| Total cholesterol (mg/dL)     | 196.2 (0.7)| 199.9 (0.9)|
| HDL (mg/dL)                   | 45.6 (0.2) | 40.4 (0.2) |
| LDL (mg/dL)                   | 126.3 (0.6)| 116 (0.7)  |
| Triglyceride (mg/dL)          | 164 (0.3)  | 181 (2.2)  |
|                          | 2017               | 2009               |
|--------------------------|--------------------|--------------------|
|                          | Age-standardized prevalence rate (95% CI) | Age-standardized prevalence rate (95% CI) |
| Metabolic Syndrome       |                    |                    |
| Male                     | 45.7 (42.9, 48.5)  | 34.6 (31.4, 37.8)  |
| Female                   | 44.5 (43.0, 46.1)  | 39.8 (38.1, 41.5)  |
| Total                    | 44 (42.7, 45.4)    | 38.0 (36.5, 39.5)  |
| Central obesity          |                    |                    |
| Male                     | 60.4 (57.6, 63.2)  | 41.5 (38.0, 45.1)  |
| Female                   | 75.6 (74.2, 77.0)  | 60.1 (58.2, 61.9)  |
| Total                    | 70.9 (69.6, 72.3)  | 55.2 (53.5, 56.9)  |
| High fasting blood glucose |                  |                    |
| Male                     | 39.2 (36.6, 41.8)  | 28.7 (25.8, 31.6)  |
| Female                   | 32.4 (30.9, 33.9)  | 23.9 (22.3, 25.5)  |
| Total                    | 34.2 (32.9, 35.5)  | 25.1 (23.7, 26.4)  |
| Elevated blood pressure  |                    |                    |
| Male                     | 46.7 (44.0, 49.5)  | 47.2 (43.5, 50.8)  |
| Female                   | 37.7 (36.2, 39.2)  | 38.6 (37.0, 40.3)  |
| Total                    | 39.8 (38.5, 41.1)  | 40.2 (38.7, 41.6)  |
| Elevated triglycerides   |                    |                    |
| Male                     | 50.1 (47.3, 53.1)  | 54.4 (50.4, 58.3)  |
| Female                   | 35.1 (33.4, 36.7)  | 40.0 (38.1, 42.0)  |
| Total                    | 38.5 (37.1, 39.9)  | 42.7 (41.0, 44.4)  |
| Low HDL                  |                    |                    |
| Male                     | 59.2 (56.2, 62.3)  | 70.0 (66.1, 73.8)  |
| Female                   | 57.4 (55.5, 59.2)  | 64.7 (62.7, 66.7)  |
Factors associated with metabolic syndrome

Multivariate logistic regression analysis was conducted to determine factors associated with Metabolic Syndrome (Tables 9 and 10). Defined by the IDF diagnostic criteria, many factors were associated with Metabolic Syndrome including gender, age, occupation, region and marital status.

|              | 2017          | 2009          |
|--------------|---------------|---------------|
| Total        | 57.7 (56.1, 59.3) | 65.7 (64.0, 67.5) |
| HDL high-density lipoprotein |               |               |
Table 9
Multivariate logistic regression model of the factors associated with Metabolic syndrome, using the IDF criteria, Jordan 2017

|                | OR (95% CI) | P value |
|----------------|-------------|---------|
| Gender         |             |         |
| Men            | 1 (Ref)     |         |
| Women          | 1.42 (1.10, 1.83) | < 0.05  |
| Age (years)    |             |         |
| 18–29          | 1 (Ref)     | < 0.001 |
| 30–39          | 2.53 (1.79, 3.57) | < 0.001 |
| 40–49          | 5.78 (4.16, 8.03) | < 0.001 |
| 50–59          | 12.44 (8.73, 17.73) | < 0.001 |
| 60–69          | 14.54 (9.42, 22.42) | < 0.001 |
| ≥70            | 10.45 (6.26, 17.44) | < 0.001 |
| Occupation     |             |         |
| Field Work     | 1 (Ref)     | < 0.05  |
| Unemployed     | 1.38 (1.02, 1.86) | < 0.05  |
| Retired        | 0.95 (0.67, 1.35) | 0.758   |
| Office Work    | 1.01 (0.76, 1.36) | 0.925   |
| Region         |             |         |
| North          | 1 (Ref)     | < 0.001 |
| Middle         | 0.66 (0.54, 0.80) | < 0.001 |
| South          | 1.14 (0.90, 1.44) | 0.282   |
| Marital status |             |         |
| Single         | 1 (Ref)     |         |
| Married        | 2.26 (1.61, 3.18) | < 0.001 |
Table 10
Multivariate logistic regression model of the factors associated with Metabolic syndrome, using the ATP III criteria, Jordan 2017

|                  | OR (95% CI)     | P value |
|------------------|-----------------|---------|
| Age (years)      |                 |         |
| 18–29            | 1 (Ref)         | < 0.001 |
| 30–39            | 2.65 (1.80, 3.90) | < 0.001 |
| 40–49            | 7.00 (4.85, 10.11) | < 0.001 |
| 50–59            | 17.11 (11.60, 25.22) | < 0.001 |
| 60–69            | 20.62 (13.00, 32.72) | < 0.001 |
| ≥70              | 12.20 (7.18, 20.71) | < 0.001 |
| Occupation       |                 |         |
| Field Work       | 1 (Ref)         | < 0.001 |
| Unemployed       | 1.76 (1.32, 2.35) | < 0.001 |
| Retired          | 1.17 (0.81, 1.68) | 0.400   |
| Office Work      | 1.14 (0.84, 1.54) | 0.400   |
| Region           |                 |         |
| North            | 1 (Ref)         | < 0.001 |
| Middle           | 0.63 (0.52, 0.76) | < 0.001 |
| South            | 1.10 (0.86, 1.40) | 0.457   |
| Marital status   |                 |         |
| Single           | 1 (Ref)         |         |
| Married          | 2.00 (1.39, 2.89) | < 0.001 |

Woman had increased odds of Metabolic Syndrome compared to men (OR: 1.42 (95% CI: 1.1, 1.83) (p < 0.05)). Increased age was significantly associated with increased odds of Metabolic Syndrome. Unemployed persons were more likely to have Metabolic Syndrome (OR: 1.38 (95% CI: 1.02, 1.86) (p < 0.05)) compared to those who had field work. Compared to those who were living in the north of Jordan, those who lived in the middle of Jordan were less likely to have Metabolic Syndrome [OR: 0.66 (95% CI: 0.54, 0.80) (p < 0.001)]. Married people were more than twice (OR: 2.26) likely to have Metabolic Syndrome compared to singles.
Discussion

This study reports the prevalence of Metabolic Syndrome and its individual components among adults in Jordan using the IDF and ATP III definitions and compares the findings with the findings of a previous study conducted with the same methodology in 2009.

When the IDF diagnostic criteria was used, the age-standardized prevalence rates of Metabolic Syndrome in Jordan was 44% (45.7% in men and 44.5% in women). This rate is slightly higher than what had been reported in the US population (40%) (17), and much higher than that in the Australian population (29.1%) (10), the European population (from 10 to 30%) (10), and the Iranian people (37.4%) (18). Compared to Arab countries, the age standardized prevalence of Metabolic Syndrome was higher than the prevalence in Saudi Arabia in 2009 and 2014 (31.6% and 28.3%, respectively) (19, 20). However, Aljabri et al. in 2018 reported a high prevalence rate (64.4%) among Saudis (21). The prevalence rates among the populations of Qatar and Kuwait were 37% and 36.2%, respectively (22, 23). The Metabolic Syndrome prevalence in Emirates using the IDF criteria was reported in two studies (40.5% and 48.7%) conducted in 2008 and 2012, respectively (24, 25). The Lebanese population had a lower prevalence (31.2%) than what was found in Jordan (26). The prevalence in Jordan is very close to the prevalence reported among Turkish adults (44%) (18).

According to the ATP III criteria, the age-standardized prevalence rate of Metabolic Syndrome 39.9% (95% CI: 38.6, 41.2) was lower than the prevalence defined by IDF criteria. The two definitions almost have the same components, but the difference in prevalence was mainly linked to the difference in waist circumferences which measures the abdominal obesity and being an obligatory component for the IDF in contrast to being one of five components for the ATP III definition.

Compared to the US population, Jordan had a higher Metabolic Syndrome prevalence than what was reported in the US in 2014 (33.8%) using the ATP III criteria (27). Also, it was higher than that in the Australian population (19.3%) (10), the Turkish population (36.6%) (18), and the European population (ranges from 10–30%) (10). Compared to Arab countries, Jordan had a higher prevalence of Metabolic Syndrome defined by ATP III criteria than most Arab countries including Lebanon (26.4%) (28), Oman (23.6%) (29), Tunisia (31.2%) (30), the United Arab Emirates (22%) (31), Qatar (26.5%) (32), Yemen (23.8%) (33) and the Kuwait (18.3%) (34).

On the other hand, two studies conducted in Saudi Arabia utilizing ATP III reported prevalence rates similar to that of Jordan. The first study in 2009 revealed a prevalence of 39.9% and the second in 2005 reported a prevalence of 39.3% (19, 35). In addition, a study in Emirates reported a prevalence of 50.3% in 2012 which is markedly higher than Jordan's prevalence (24), but another study in 2008 revealed a prevalence of 39.6% which is approximately similar to the rate found in this study (25). The considerable discrepancy in the prevalence of Metabolic Syndrome among and across different nations and populations could be a result of the integration of genetics, environmental aspects and factors, epidemiological transition, and differences in life-style. Differences in the definition used and differences
in the sampling approaches and procedures might explain some of the variations in the prevalence rates (23, 24, 25).

Obesity and central obesity may have an effect on this variation across different nations and populations, as central obesity is the most observed component among those diagnosed with Metabolic Syndrome. Obesity increases the risk to develop multiple metabolic abnormalities including hypertension and insulin resistance which logically leads to developing Metabolic Syndrome (36). Consequently, the variation in the Metabolic Syndrome prevalence between Jordan and other countries could be explained by the variation in obesity prevalence. In Jordan, the prevalence of obesity was 41.4% which is higher than what was reported in Egypt (30.1%) (37), Lebanon (28.2%) (38), Syria (38.2%) (39), Saudi Arabia (33%) (40), Emirates (32.3%) (41), Qatar (35.4%) (42), Yemen (8.8%) (43), and Tunisia (25.4%) (44). On the other hand, multiple studies in Saudi Arabia, Kuwait and Libya revealed either higher or similar obesity prevalence rates compared to Jordan. Nadira Al-Baghli reported obesity prevalence of 43.8% among Saudis (45). The prevalence in Kuwaiti people was estimated as 47.5% (23). In Libya, the prevalence was 42.4% (46).

The prevalence of Metabolic Syndrome increased with age in both men and women, using the IDF and ATP III diagnostic criteria. The sharp increase happened after the second decade of life, especially in men. This could be explained by age-related changes in body, insulin sensitivity and fat distribution, and all of which have been mentioned previously to contribute to the increased prevalence of Metabolic Syndrome with age (47). Women were observed to have higher Metabolic Syndrome prevalence than men after the fourth decade of life. This continuously increasing prevalence in women could be a result of menopause. Menopause was reported to have an association with increasing risk of Metabolic Syndrome and affects all of its components (48). On the contrary, the decrease in the prevalence among men after the fourth decade of life could be due to survival bias, where people affected by Metabolic Syndrome die at a comparatively younger age, which leads to a depletion of the older age categories of affected individuals.

In our study men had significantly higher Metabolic Syndrome prevalence than women using both the IDF and ATP III diagnostic criteria. A study in Saudi Arabia supported our findings (19), while other studies did not (13, 20, 47). The significant difference between men and women might be explained by age as men had significantly higher mean age than women. Age is strongly associated with increased prevalence of the Metabolic Syndrome (10, 13, 27, 47). Subsequently, after adjusting for age, occupation, location and marital status, woman had significantly increased odds of Metabolic Syndrome compared to men only with the IDF. The reason might be that women have significantly higher prevalence of abdominal obesity compared to men. On the other hand, data reported from the National Health and Nutrition Examination Survey (NHANES) among the US population from 2007 to 2014 did not show any significant gender differences (27).

For both men and women, abdominal obesity was the most prevalent component of Metabolic Syndrome using the IDF and ATP III definitions. The prevalence rates of hyperglycemia, hypertriglyceridemia and hypertension, despite being less common than abdominal obesity, are still high among this population.
Women had a significantly higher crude and age-standardized prevalence rate of obesity and central obesity using both the IDF and ATP III. The explanation of the large waist circumferences and body mass index in women could be due to genetic and/or hormonal differences, the large number of births and the fact that women in Jordan are less likely to participate in physical activity due to cultural and social limitations (47).

When we compared these findings to a previous study conducted in 2009 in Jordan with the same methodology and Metabolic Syndrome definition (using the IDF diagnostic criteria), we found that the age-standardized prevalence of Metabolic Syndrome in this current study was markedly higher compared to 2009 study. Also, the age-adjusted prevalence rates of abdominal obesity and hyperglycemia in this present population were higher than that in 2009 population. On the other hand, lower age-standardized prevalence for low HDL level was seen in 2017 survey compared to the 2009 study. These variations in the prevalence, could be explained by shifting from traditional dietary habits (diet rich in fibers, vegetables, fruits and cereals) into consuming more animal products and junk food, with high amounts of carbohydrates and saturated fats (13).

**Conclusions**

The prevalence of Metabolic Syndrome in Jordan is considerably high and increasing. With the IDF diagnostic criteria, many factors were associated with Metabolic Syndrome including gender, age, occupation, region, and marital status. This escalation in Metabolic Syndrome prevalence is assumed to be as a result of life-style changes and epidemiological transition, unhealthy dietary habits, and lack of exercise. Therefore, healthy lifestyle programs encouraging appropriate dietary habits and physical activity are strongly recommended in Jordan. Once the diagnosis is made, the potential treatment should be proactive and persistent in its goal of reducing the risk of CVD and type 2 diabetes.

**Abbreviations**

NCDs
Non-communicable diseases
IDF
International Federation for Diabetes
ATP III
Adult Treatment Panel III
BMI
Body mass index
WC
Waist circumference
WHR
Waist to hip ratio
WHtR

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Declarations

Ethics approval and consent to participate

The study was approved by the Ethical Committee at the National Center for Diabetes, Endocrinology, and Genetics, Amman, Jordan. An informed consent was obtained from each participant. Data were treated with strict confidentiality and used only for scientific purposes.

Consent for publication

Not applicable

Availability of data and material

The data used to support the findings of this study are available from the corresponding author upon request.

Competing interests

The authors declare that they have no competing interests

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Authors' contributions

All authors have read and approved the manuscript
YK, AB, and HJ: Contributed to study design, data collection, analysis, writing the manuscript

MA and MA: Contributed to data analysis and revising the manuscript

KA: Contributed to study design, and writing the manuscript

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**Figures**

![Figure 1](image-url)
Age-specific prevalence of Metabolic Syndrome using the IDF definition in Jordan

Figure 2
Age-specific prevalence of Metabolic Syndrome using the ATP III definition in Jordan

Figure 3
The relative frequencies of the number of metabolic abnormalities according to IDF definition
Figure 4

The relative frequencies of the number of metabolic abnormalities according to ATP III definition