ORIGINAL ARTICLE

# Prevalence of Metabolic Syndrome based on Six Definitions in SouthwesternIran: A Cross-Sectional Study from the Hoveyzeh Cohort Study

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## Abstract

**Background:** Metabolic syndrome (MetS) is identified by an accumulation of signs of a metabolic disorder and has become a growing problem in recent years due to its major public health risks. Therefore, this study aimed to assess the prevalence of MetS and its components based on six definitions.

**Methods:** In this cross-sectional study, 8596 individuals (2966 males and 5630 females) aged 35-70 years were recruited from the Hoveyzeh Cohort Center from May 2016 to August 2018. The diagnostic criteria proposed by the Joint Interim Statement (JIS), the Regional JIS (RJIS), the American Heart Association/ National Heart, Lung, and Blood Institute (AHA/NHLBI), the International Diabetes Federation (IDF), the Regional IDF (RIDF), and Adult Treatment Panel III (ATP III) were used.

**Results:** The prevalence of MetS was 40.7% (ATP III), 47.3% (IDF), 40.8% (RIDF), 44.2% (AHA/NHLBI), 48.9% (JIS), and 44.7% (RJIS). Overall, males and females showed a higher prevalence of MetS based on the JIS criteria. Based on gender, the prevalence of MetS was higher in women than in men according to all six definitions. The most common component for all deinitions was TGs domain. Also, all four MetS components were higher in people living in urban areas than in those living in rural areas.

**Conclusion:** The results of this study suggest that a higher prevalence of MetS is related to the JIS definition; this may also indicate the importance of assessing MetS based on this definition in clinical practice in the southern Iranian population.

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**Keywords:** Metabolic syndrome, Prevalence, Definitions, Cohort, Cross sectional

## Introduction

Metabolic syndrome (MS) refers to simultaneous occurrence of cardiovascular risk factors or type 2 diabetes such as abdominal obesity, high blood pressure and abnormal carbohydrate and lipid metabolism (hypertriglyceridemia, elevated blood glucose), and decrease in high density lipoprotein (HDL) level.[1]

Metabolic syndrome is an accumulation of multiple conditions that together increase a person's risk of developing non-communicable disease such as diabetes mellitus and insulin resistance, cardiovascular and vascular diseases like hypertension (HTN) and neurological complications such as stroke.[1] Many organizations and groups have been trying to give a better definition for MetS. Estimations of the prevalence of MetS vary around the world depending on the definition used, and these variations are clear and significant.[2]

The World Health Organization (WHO) in 1998 and the Adult Treatment Panel III (ATPIII) in 2001 standardized the definitions of MetS.[3] These citeria were later revised in 2005 by the American Heart Association/ National Heart, Lung, and Blood Institute (AHA/ NHLBI),[4] and the International Diabetes Federation (IDF).[5] Recently, a Joint Interim Statement (JIS) issued by numerous scientific societies has attempted to extend a unified description of MetS.[5] According to these expert groups, the main components of MetS include elevated fasting blood glucose (FBS), dyslipidemia, and elevated arterial blood pressure (BP). However, abdominal obesity and/or insulin resistance (IR) have recently received greater attention as central manifestations of the syndrome.[6] Nevertheless, researchers recommend providing a specific definition of MetS that aligns with the criteria of different societies.

Research indicates that the prevalence of MetS is increasing worldwide. Globally, it is estimated that 20-25% of adults experience MetS.[7] Also, reports indicate that the prevalence of MetS in Iran is significantly higher than in other countries.[8] Furthermore, the prevalence rates of MetS were different in different regions of Iran. In the western region, it was 23.7% with 24.4% in males and 23.1% in females. In the northern region, it was 42.3% with 36.5% in men and 47.1% in women. In the southern region, it was 26.8% with 16.6% in males and 36.8% in females.[9] In a systematic review study conducted on the Iranian population over 19 years of age, 43 related studies were reviewed and the prevalence of MetS was reported as 10-60% by gender, age, and region.[10] Accordingly, there is a need to provide a report and comparison of the prevalence of MetS using different criteria that can help researchers gain a more comprehensive understanding of MetS and develop a more precise definition. Therefore, in this study, we used the data from the Hoveyzeh Cohort Center to examine the prevalence and characteristics of MetS according to the ATPIII, IDF, Regional IDF, AHA/NHLBI, JIS, and Regional JIS criteria.

## Materials and Methods

*An Introduction to the Present Study and the Hoveyzeh Cohort Study*

This cross-sectional study extracted the required data from the cohort study conducted in Hoveyzeh County that is located in Khuzestan Province in southern Iran. The Hoveyzeh County Study (HCS) is a prospective population-based cohort study of 10,009 adults (aged 35-70 years) enrolled from May 2016 to August 2018 to assess noncommunicable diseases (NCDs) in southwestern Iran. The Hoveyzeh Cohort Center is one of the sites of the prospective epidemiological research studies in Iran (the PERSIAN Cohort Study). According to the 2016 door-to-door census, 7772 eligible persons resided in Hoveyzeh County. Of these, 4378 people lived in the cities of Hoveyze and Rofayyeh (2187 men and 2191 women). The remaining 3394 people lived in 27 villages and consisted of 1611 men and 1783 women.[11]

*Subjects*

The total population of Hoveyzeh county was 47,032 residents, of whom 12,103 were in the age range of 35- 70. A total of 10,009 of them were included in the study. The method for selecting study participants is shown in Figure 1. The Ahvaz Jundishapur University of the Medical Sciences Ethics Committee approved the study before it was conducted (IR.AJUMS.HGOLESTAN.REC1401.037).

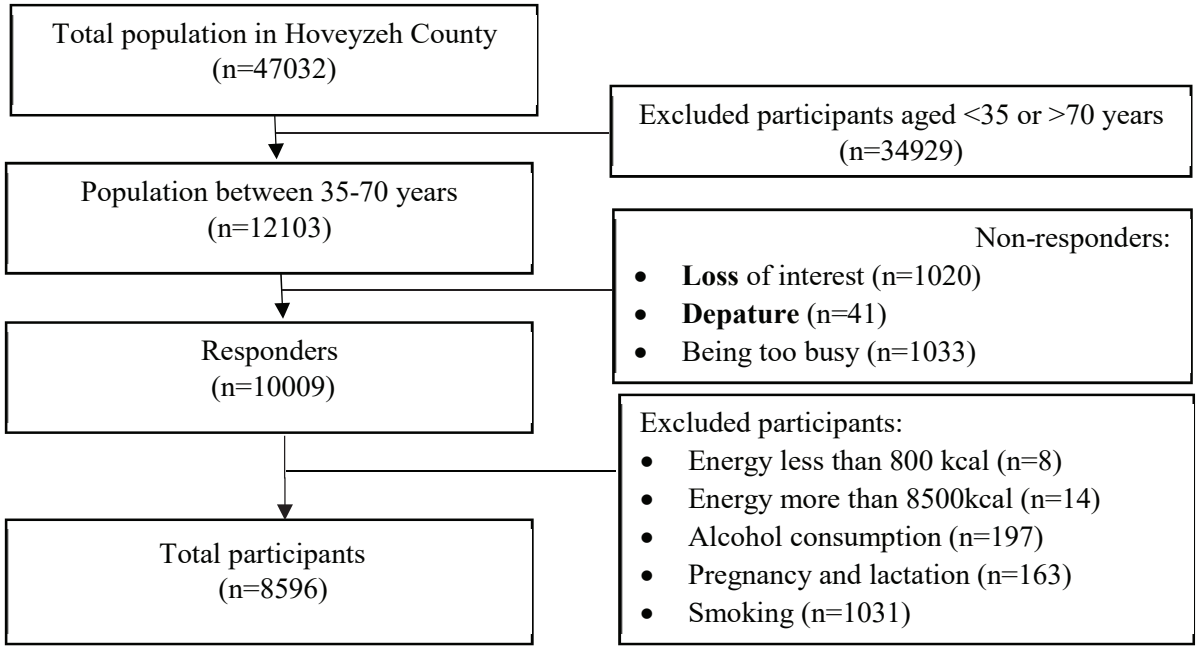


**Figure 1:** Flow chart of participant selection

Written informed consent was obtained from patients after the purpose of the study was explained and patients were assured of the confidentiality of their data. The inclusion criteria were the age of 35 and 70, residency in Hoveyzeh county, and Iranian nationality. The exclusion criteria were participants who were pregnant, breastfeeding mothers, subjects with incomplete demographic or anthropometric data, bariatric surgery in the last year, adherence to special diets, use of certain medications, smoking, energy intake less than 800 and more than 8500 kcal, and physical or mentally handicapped people. A total of 8596 subjects were then included in the study.

*Data Collection*

Demographic data such as age, gender, marital status, type of residence (urban or rural), and level of education were collected through questionnaires administered by the interviewer. The international physical activity questionnaire is based on metabolic equivalents (METs), and it is used to measure physical activity (PA). Before blood pressure measurement, subjects were instructed to rest for 15 minutes. The participant's blood pressure was measured twice, with an interval of 10 minutes between each measurement. The average of these two measurements was then taken as the participant's blood pressure. In addition, the heart rate was measured twice for 60 seconds.

*Anthropometric Measurement*

Weight was measured using a standing scale (Seca 755) while subjects were minimally clothed and barefoot. The height was measured while standing and without shoes using the Seca 206 stadiometer with a relaxed shoulder position. BMI (body mass index) was evaluated by dividing weight (kg) by height squared ($m^2$). The measurement of waist circumference (WC) was taken by using a non-elastic tape at a point in the horizontal plane that is halfway between the iliac crest and the lowest rib. The hip measurement was the greatest circumference at the level of the greater trochanter (the widest part of the hip) on both sides. All measurements were made to the nearest cm.

*Biochemical Measurement*

After 12-14 hours of overnight fasting, a venous blood sample was taken from the subjects and analyzed in the same laboratory on the collection day. Blood samples were centrifuged at 3000 rpm for 10 minutes (Sigma, Germany) to separate the serum. Subsequently, the required serum levels were measured with a BT 1500 autoanalyzer (Biotecnica Instruments, Italy). Blood levels of total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), triglycerides (TGs), and fasting blood sugar (FBS) were measured in all participants.

*Definition of Metabolic Syndrome*

The diagnostic criteria of MetS according to six definitions, the Joint Interim Statement (JIS), the

**Table 1:** Metabolic syndrome defined by the ATP III, IDF, Regional IDF, AHA/NHLBI, JIS, and Regional JIS

| Components | ATP III | IDF | Regional IDF | AHA/NHLBI | JIS | Regional JIS |
|---|---|---|---|---|---|---|
| Glucose domain | Raised FBS: ≥100 mg/dl (Includes diabetes) | Raised FBS: ≥100 mg/dl (Includes diabetes) | Raised FBS: ≥100 mg/dl (Includes diabetes) | Raised FBS: ≥100 mg/dl (Includes diabetes) | Raised FBS: ≥100 mg/dl (Includes diabetes) | Raised FBS: ≥100 mg/dl (Includes diabetes) |
| Obesity domain | Central obesity defined as WC: ≥102 cm in male ≥88 cm in female | Central obesity defined as WC: ≥94 cm in male ≥80 cm in female | Central obesity defined as WC: ≥95 cm in male ≥95 cm in female | Central obesity defined as WC: ≥102 cm in male ≥88 cm in female | Central obesity defined as WC: ≥94 cm in male ≥80 cm in female | Central obesity defined as WC: ≥95 cm in male ≥95 cm in female |
| Lipid profile | Raised TG level: ≥150 mg/dl Reduced HDL cholesterol: <40 cm in male <50 cm in female | Raised TG level: ≥150 mg/dl or under treatment Reduced HDL cholesterol: <40 cm in male <50 cm in female or under treatment | Raised TG level: ≥150 mg/dl or under treatment Reduced HDL cholesterol: <40 cm in male <50 cm in female or under treatment | Raised TG level: ≥150 mg/dl or under treatment Reduced HDL cholesterol: <40 cm in male <50 cm in female or under treatment | Raised TG level: ≥150 mg/dl or under treatment Reduced HDL cholesterol: <40 cm in male <50 cm in female or under treatment | Raised TG level: ≥150 mg/dl or under treatment Reduced HDL cholesterol: <40 cm in male <50 cm in female or under treatment |
| BP domain | Raised blood pressure: SBP≥130mmHg or DBP≥85 mmHg | Raised blood pressure: SBP≥130mmHg or DBP≥85 mmHg or under treatment | Raised blood pressure: SBP≥130mmHg or DBP≥85 mmHg or under treatment | Raised blood pressure: SBP≥130mmHg or DBP≥85 mmHg or under treatment | Raised blood pressure: SBP≥130mmHg or DBP≥85 mmHg or under treatment | Raised blood pressure: SBP≥130mmHg or DBP≥85 mmHg or under treatment |
| MetS definition | any three components from the above | Obesity domain plus any two components from the above | Obesity domain plus any two components from the above | any three components from the above | any three components from the above | any three components from the above |

ATP III: National Cholesterol Education Program Adult Treatment Panel III; IDF: International Diabetes Federation; AHA/NHLBI: American Heart Association/ National Heart, Lung, and Blood Institute; JIS: Joint Interim Statement; FBS: Fasting Blood Sugar; WC: Waist circumference; TGs: Triglycerides; HDL-C: High Density Lipoprotein Cholesterol; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; MetS: Metabolic Syndrome.

American Heart Association/National Heart, Lung, and Blood Institute (AHA/NHLBI), the International Diabetes Federation (IDF), and the Adult Treatment Panel III ( ATP III) are listed in Table 1. The IDF and JIS definitions were adjusted using the ethnicity-specific values as suggested by the Iranian National Committee of Obesity. In this context, the Iranian cutoffs for WC were introduced as Regional IDF (RIDF) and Regional JIS (RJIS).[12]

*Statistical Analysis*

The data collected were analyzed using SPSS software version 20. The normality of the variables of interest was examined using the Kolmogorov-Smirnov test. The categorical variables were analyzed using the chi-square test. In addition, the t-test was applied to analyze continuous variables, while the Mann-Whitney U-test was used to compare the variables that were not normally distributed. Mean SD (standard deviation) was used to represent quantitative variables, while frequencies and percentages were used for qualitative variables. Values of $P<0.05$ were considered statistically significant.

## Results

In this cross-sectional study, 2966 men and 5630 women were examined, their mean age was 48.64±9.18 years. 5,335 cases (62.1%) lived in urban areas, 7,476 cases (87%) were married, and 5,456 (63.5%) were illiterate. Table 2 shows the basic characteristics of the study participants. Men were older than women and had higher levels of education, physical activity, weight, height, wrist circumference, FBS, TGs, and blood pressure, but their waist circumference, hip circumference, TC, HDL-C, LDL-C, and heart rate were lower than women.

Table 3 shows the prevalence of MetS using different definitions in urban and rural areas. The overall prevalence of MetS, as defined by ATP III, IDF, Regional IDF, AHA/NHLBI, JIS, and Regional JIS, was 40.7% (95% CI: 39.7-41.9), 47.3% (95% CI: 46.2-48.4), 40.8% (95% CI: 39.8-41.9), 44.2% (95% CI: 43.2-45.3), 48.9% (95% CI: 47.8-50.0), and 44.7% (95% CI: 43.7-45.8), respectively, in both urban and rural areas. According to the IDF, Regional JIS, and Regional IDF definitions, MetS prevalence was higher in rural areas, while JIS, AHA/NHLBI, and ATP III were higher in urban areas. Overall, both males and

**Table 2:** Socio-demographic, lifestyle, and clinical characteristics of the participants

| Variables | Total (n=8596) | Males (n=2966) | Females (n=5630) | P value[a] |
|---|---|---|---|---|
| Age (years) | 48.64±9.18 | 49.20±9.29 | 48.35±9.11 | <0.001 |
| Marital state | | | | |
| Single, n (%) | 322 (3.7) | 22 (0.7) | 300 (5.3) | <0.001 |
| Married, n (%) | 7476 (87.0) | 2922 (98.5) | 4554 (80.9) | |
| Widow, n (%) | 658 (7.7) | 15 (0.5) | 643 (11.4) | |
| Divorced, n (%) | 140 (1.6) | 7 (0.2) | 133 (2.4) | |
| Residence type | | | | |
| Urban, n (%) | 5335 (62.1) | 1875 (63.2) | 3460 (61.5) | 0.057 |
| Rural, n (%) | 3261 (37.9) | 1091 (36.8) | 2170 (38.5) | |
| Education (years) | 3.98±4.96 | 6.82±5.60 | 2.49±3.83 | <0.001 |
| Education levels | | | | <0.001 |
| Illiterate, n (%) | 5456 (63.5) | 1171 (39.5) | 4285 (76.1) | |
| Primary school, n (%) | 1353 (15.7) | 563 (19.0) | 790 (14.0) | |
| Secondary school, n (%) | 526 (6.1) | 326 (11.0) | 200 (3.6) | |
| High school, n (%) | 614 (7.1) | 423 (14.3) | 191 (3.4) | |
| Academic, n (%) | 647 (7.5) | 483 (16.3) | 164 (2.9) | |
| Physical activity, MET | 37.05±5.44 | 38.07±7.25 | 36.51±4.08 | <0.001 |
| Weight (kg) | 78.03±15.42 | 83.13±15.05 | 75.34±14.94 | <0.001 |
| Height (cm) | 163.70±8.86 | 172.77±6.40 | 158.93±5.68 | <0.001 |
| Waist circumference (cm) | 100.17±11.98 | 97.79±11.45 | 101.43±12.07 | <0.001 |
| Hip circumference (cm) | 104.63±9.98 | 101.32±8.53 | 106.38±10.24 | <0.001 |
| Wrist circumference (cm) | 17.44±1.35 | 17.92±1.23 | 17.19±1.34 | <0.001 |
| Fasting blood sugar (mg/dl) | 113.37±50.59 | 114.91±51.62 | 112.55±50.02 | 0.040 |
| Triglycerides (mg/dl) | 162.12±108.04 | 184.12±127.52 | 150.53±94.16 | <0.001 |
| Total Cholesterol (mg/dl) | 189.72±40.49 | 187.51±39.72 | 190.88±40.84 | <0.001 |
| High-density lipoprotein (mg/dl) | 50.76±12.00 | 46.36±10.28 | 53.07±12.20 | <0.001 |
| Low-density lipoprotein (mg/dl) | 106.89±33.02 | 104.96±32.44 | 107.89±33.28 | 0.017 |
| Systolic blood pressure, mmHg | 113.09±18.32 | 117.18±17.27 | 110.93±18.49 | <0.001 |
| Diastolic blood pressure, mmHg | 71.52±11.16 | 74.16±11.12 | 70.13±10.93 | <0.001 |
| Heart rate | 78.72±9.54 | 77.10±9.48 | 79.57±9.47 | <0.001 |

Data are means±SD for quantitative variables and frequency (percent) for qualitative variables. $P\leq0.05$ was considered as statistically significant by the independent samples t test and chi-squared test.

**Table 3:** Prevalence and burden of MetS in Hoveyzeh adults aged 35-70 years based on various MetS definitions

| Gender | Area | ATP III | IDF | Regional IDF | AHA/NHLBI | JIS | Regional JIS |
|---|---|---|---|---|---|---|---|
| Both | Both, n (%) | 3502 (40.7) | 4068 (47.3) | 3507 (40.8) | 3801 (44.2) | 4201 (48.9) | 3845 (44.7) |
| | Rural, n (%) | 1129 (34.6) | 2735 (51.3) | 2376 (44.5) | 1240 (38.0) | 1382 (42.4) | 2603 (48.4) |
| | Urban, n (%) | 2373 (44.5) | 1333 (40.9) | 1131 (34.7) | 2561 (48.0) | 2819 (52.8) | 1242 (38.1) |
| MALE | Both, n (%) | 911 (30.7) | 1174 (39.6) | 1135 (38.3) | 986 (33.2) | 1296 (43.7) | 1268 (42.8) |
| | Rural, n (%) | 296 (27.1) | 382 (35.0) | 372 (34.1) | 326 (29.9) | 425 (39.0) | 417 (38.2) |
| | Urban, n (%) | 615 (32.8) | 792 (42.2) | 763 (40.7) | 660 (35.2) | 871 (46.5) | 851 (45.4) |
| Female | Both, n (%) | 2591 (46.0) | 2894 (51.4) | 2372 (42.1) | 2815 (50.0) | 2905 (51.6) | 2577 (45.8) |
| | Rural, n (%) | 833 (38.4) | 951 (43.8) | 759 (35.0) | 914 (42.1) | 957 (44.1) | 825 (38.0) |
| | Urban, n (%) | 1758 (50.8) | 1943 (56.2) | 1613 (46.6) | 1901 (54.9) | 1948 (56.3) | 1752 (50.6) |

Data presented as number (percent)

females had a higher incidence of MetS according to the JIS criteria.

The prevalence of MetS reached its highest in the age group of 65≤ years in the general population based on the JIS criteria (65.2%), while the lowest occurrence was found in participants aged 35 to 44 years according to the ATP III criteria, with a percentage of 29.4%. Related details are listed in Table 4.

Females with a higher level of education had a lower prevalence of MetS, regardless of the definition used. In contrast, MetS prevalence was lower in illiterate males (Table 5). The level of physical activity in the overall population has an inverse relationship with the prevalence of the MetS. Based on residence type, the highest prevalence of MetS was observed in sedentary urban populations and the lowest prevalence in active rural populations (Table 5).

The overall and gender prevalence of each MetS component is presented in Table 6 for all definitions. The most common component for all definitions was the TGs domain, which was highest in urban females. Low serum HDL-C was the most common component in urban males according to the Regional IDF, JIS, and Regional JIS definitions. Furthermore, individuals residing in urban areas exhibited higher levels of all four components of MetS compared to those living in rural areas.

## Discussion

In this cross-sectional study on Iranian adults residing in Hoveyzeh county with a mean age of 48.64±9.18 years, the prevalence of MetS was 40.7–48.9%, depending on different definitions. MetS prevalence is strongly influenced by the different cut-off values and criteria used in different definitions.[6] In the current study, it was found that the JIS criterion was the most common, while ATP III criterion was the least common One. Earlier studies also indicated a similar prevalence in the Iranian population.[8, 12] Estimates of the prevalence of MetS vary widely around the world, depending on the criteria used to define it. Tunisia, another Middle Eastern country, had a prevalence rate of 45.5% according to IDF criteria, but only 24.3% according to ATP III criteria.[13]

In the present study, the increasing prevalence rate of MetS with age was well supported by another study;[12] it was found that due to the aging of the Iranian population and increased life expectancy, there will likely be a rise in MetS prevalence among the elderly. Besides age, gender was another factor contributing to the prevalence of metabolic syndrome. According to all six definitions, the prevalence of MetS was higher in females than in males, which was also found elsewhere.[5, 6]

According to Delavari and colleagues,[14] the prevalence of Metabolic Syndrome was found to be significantly higher among women compared

**Table 4:** Age range of MetS among the Hoveyzeh adults based on gender

| Variable | Participants | Category | ATP III | IDF | Regional IDF | AHA/ NHLBI | JIS | Regional JIS |
|---|---|---|---|---|---|---|---|---|
| Age | Total | 35-44 | 1006 (29.4) | 1265 (37.0) | 1047 (30.6) | 1144 (33.4) | 1308 (38.2) | 1152 (33.7) |
| | | 45-54 | 1239 (44.0) | 1413 (50.1) | 1244 (44.1) | 1333 (47.3) | 1459 (51.8) | 1362 (48.3) |
| | | 55-64 | 912 (52.4) | 1004 (57.6) | 885 (50.8) | 963 (55.3) | 1035 (59.4) | 965 (55.4) |
| | | ≥65 | 345 (56.4) | 386 (63.1) | 331 (54.1) | 361 (59.0) | 399 (65.2) | 366 (59.8) |
| | Male | 35-44 | 276 (24.7) | 384 (34.4) | 364 (32.6) | 300 (26.9) | 425 (38.0) | 406 (36.3) |
| | | 45-54 | 315 (33.0) | 395 (41.4) | 384 (40.3) | 342 (35.8) | 438 (45.9) | 434 (32.4) |
| | | 55-64 | 243 (36.1) | 292 (43.3) | 286 (42.4) | 261 (38.7) | 319 (47.3) | 315 (46.7) |
| | | ≥65 | 77 (34.8) | 103 (46.6) | 101 (45.7) | 83 (37.6) | 114 (51.6) | 113 (51.1) |
| | Female | 35-44 | 730 (31.7) | 881 (38.2) | 683 (29.6) | 844 (36.6) | 883 (38.3) | 746 (32.4) |
| | | 45-54 | 924 (49.5) | 1018 (54.6) | 860 (46.1) | 991 (53.1) | 1021 (54.7) | 928 (49.8) |
| | | 55-64 | 669 (62.6) | 712 (66.7) | 599 (56.1) | 702 (65.7) | 716 (67.0) | 650 (60.9) |
| | | ≥65 | 268 (68.5) | 283 (72.4) | 230 (58.8) | 278 (71.1) | 285 (72.9) | 253 (64.7) |

Data presented as number (percent)

**Table 5:** Prevalence of MetS in Hoveyzeh adults aged 35-70 years based on physical activity and education levels

| Variable | Participants | Category | ATP III | IDF | Regional IDF | AHA/ NHLBI | JIS | Regional JIS |
|---|---|---|---|---|---|---|---|---|
| Level of education | Both | Illiterate | 2421 (44.4) | 2716 (49.8) | 2309 (42.3) | 2589 (47.5) | 2773 (50.8) | 2516 (46.1) |
| | | Primary school | 510 (37.7) | 625 (46.2) | 544 (40.2) | 575 (42.5) | 644 (47.6) | 593 (43.8) |
| | | Secondary school | 180 (34.2) | 220 (41.8) | 200 (38.0) | 198 (37.6) | 232 (44.1) | 215 (40.9) |
| | | High school | 198 (32.2) | 259 (42.2) | 232 (37.8) | 226 (36.8) | 278 (45.3) | 263 (42.8) |
| | | Academic | 193 (29.8) | 248 (38.3) | 222 (34.3) | 213 (32.9) | 274 (42.3) | 258 (39.9) |
| | Urban | Illiterate | 1497 (51.7) | 1638 (56.6) | 1413 (48.8) | 1581 (54.6) | 1666 (57.5) | 1535 (53.0) |
| | | Primary school | 395 (41.7) | 475 (50.2) | 409 (43.2) | 441 (46.6) | 484 (51.1) | 443 (46.8) |
| | | Secondary school | 131 (33.3) | 166 (42.2) | 148 (37.7) | 144 (36.6) | 171 (43.5) | 156 (39.7) |
| | | High school | 169 (33.6) | 224 (44.5) | 200 (39.8) | 194 (38.6) | 240 (47.7) | 227 (45.1) |
| | | Academic | 181 (30.3) | 232 (38.9) | 206 (34.5) | 201 (33.7) | 258 (43.2) | 242 (40.5) |
| | Rural | Illiterate | 924 (36.1) | 1078 (42.1) | 896 (35.0) | 1008 (39.4) | 1107 (43.2) | 981 (38.3) |
| | | Primary school | 115 (28.3) | 150 (36.9) | 135 (33.3) | 134 (33.0) | 160 (39.4) | 150 (36.9) |
| | | Secondary school | 49 (36.8) | 54 (40.6) | 52 (39.1) | 54 (40.6) | 61 (45.9) | 59 (44.4) |
| | | High school | 29 (26.1) | 35 (31.5) | 32 (28.8) | 32 (28.8) | 38 (34.2) | 36 (32.4) |
| | | Academic | 12 (24.0) | 16 (32.0) | 16 (32.0) | 12 (24.0) | 16 (32.0) | 16 (32.0) |
| | Male | Illiterate | 347 (29.6) | 438 (37.4) | 428 (36.5) | 374 (31.9) | 486 (41.5) | 479 (40.9) |
| | | Primary school | 183 (32.5) | 237 (42.1) | 230 (40.9) | 197 (35.0) | 255 (45.3) | 250 (44.4) |
| | | Secondary school | 109 (33.4) | 137 (42.0) | 131 (40.2) | 116 (35.6) | 149 (45.7) | 143(43.9) |
| | | High school | 127 (30.0) | 174 (41.4) | 165 (39.0) | 143 (33.8) | 192 (45.4) | 186 (44.0) |
| | | Academic | 145 (30.0) | 188 (38.9) | 181 (37.5) | 156 (32.3) | 214 (44.3) | 210 (43.5) |
| | Female | Illiterate | 2074 (48.4) | 2278 (53.2) | 1881 (43.9) | 2215 (51.7) | 2287 (53.4) | 2037 (47.5) |
| | | Primary school | 327 (41.4) | 388 (49.1) | 314 (39.7) | 378 (47.8) | 389 (49.2) | 343 (43.4) |
| | | Secondary school | 71 (35.5) | 83 (41.5) | 69 (34.5) | 82 (41.0) | 83 (41.5) | 72 (36.0) |
| | | High school | 71 (37.2) | 85 (44.5) | 67 (35.1) | 83 (43.5) | 86 (45.0) | 77 (40.3) |
| | | Academic | 48 (29.3) | 60 (36.6) | 41 (25.0) | 57 (34.8) | 60 (36.6) | 48 (29.3) |
| Physical activity | Total | Q1 | 1060 (52.0) | 1166 (57.2) | 1063 (52.2) | 1113 (54.6) | 1213 (59.5) | 1152 (56.6) |
| | | Q2 | 949 (42.7) | 1088 (49.0) | 931 (41.9) | 1024 (46.1) | 1113 (50.1) | 1016 (45.7) |
| | | Q3 | 842 (37.5) | 998 (44.4) | 811 (36.1) | 937 (41.7) | 1025 (45.6) | 901 (40.1) |
| | | Q4 | 651 (31.1) | 816 (39.0) | 702 (33.6) | 727 (34.8) | 850 (40.7) | 776 (37.1) |
| | Urban | Q1 | 710 (53.8) | 782 (59.2) | 717 (54.3) | 743 (56.3) | 815 (61.7) | 780 (59.1) |
| | | Q2 | 679 (46.1) | 785 (53.3) | 685 (46.5) | 731 (49.6) | 799 (54.2) | 737 (50.0) |
| | | Q3 | 589 (41.5) | 695 (49.0) | 570 (40.2) | 654 (46.1) | 711 (50.1) | 634 (44.7) |
| | | Q4 | 395 (35.1) | 473 (42.1) | 404 (35.9) | 433 (38.5) | 494 (44.0) | 452 (40.2) |
| | Rural | Q1 | 350 (48.8) | 384 (53.6) | 346 (48.3) | 370 (51.6) | 398 (55.5) | 372 (51.9) |
| | | Q2 | 270 (36.1) | 303 (40.5) | 246 (32.9) | 293 (39.2) | 314 (42.0) | 279 (37.3) |
| | | Q3 | 253 (30.5) | 303 (36.6) | 241 (29.1) | 283 (34.1) | 314 (37.9) | 267 (32.2) |
| | | Q4 | 256 (26.5) | 343 (35.5) | 298 (30.8) | 294 (30.4) | 356 (36.8) | 324 (33.5) |
| | Male | Q1 | 347 (38.7) | 411 (45.8) | 401 (44.7) | 368 (41.0) | 456 (50.8) | 448 (49.9) |
| | | Q2 | 177 (32.4) | 230 (42.1) | 224 (41.0) | 185 (33.9) | 251 (46.0) | 247 (45.2) |
| | | Q3 | 135 (27.7) | 188 (38.6) | 175 (35.9) | 157 (32.2) | 211 (43.3) | 203 (41.7) |
| | | Q4 | 252 (24.3) | 345 (33.3) | 335 (32.3) | 276 (26.6) | 378 (36.5) | 370 (35.7) |
| | Female | Q1 | 713 (62.5) | 755 (66.2) | 662 (58.1) | 745 (65.4) | 757 (66.4) | 704 (61.8) |
| | | Q2 | 772 (46.1) | 858 (51.2) | 707 (42.2) | 839 (50.1) | 862 (51.5) | 769 (45.9) |
| | | Q3 | 707 (40.2) | 810 (46.0) | 636 (36.1) | 780 (44.3) | 814 (46.3) | 698 (39.7) |
| | | Q4 | 392 (37.8) | 471 (44.6) | 367 (34.8) | 451 (42.7) | 472 (44.7) | 406 (38.5) |

Data presented as number (percent)

to men in all Middle Eastern countries. There are several women-specific factors such as pregnancy, lactation, preeclampsia, menopause, gestational diabetes mellitus, polycystic ovary syndrome (PCOS), and hormonal contraceptives, which can affect the prevalence and characteristics of metabolic syndrome in women.[15] In this study, the gender differences in the prevalence of metabolic syndrome could also be because waist circumference, hip circumference, TC, and LDL-C were higher in females.

In addition, it was found that there was a correlation between MetS prevalence and educational level. Higher levels of education seemed to be associated with lower involvement in unhealthy behaviors like poor eating habits, inactivity, smoking, and limited access to healthcare services, in contrast to lower levels of education.[12] Several previous studies have demonstrated an inverse association between lower levels of education and the likelihood of developing MetS.[16, 17] However, in the present study, it was surprising to find that a higher level of education was

**Table 6:** Prevalence of MetS in Hoveyzeh adults aged 35-70 years based on various MetS definitions

| Variable | Gender | Area | ATP III | IDF | Regional IDF | AHA/ NHLBI | JIS | Regional JIS |
|---|---|---|---|---|---|---|---|---|
| Glucose domain | Both | Both | 2452 (69.1) | 2651 (74.7) | 2334 (65.8) | 2554 (72.0) | 2760 (77.8) | 2590 (73.0) |
| | | Urban | 1716 (71.8) | 1846 (77.2) | 1630 (68.2) | 1784 (74.6) | 1914 (80.1) | 1804 (75.5) |
| | | Rural | 736 (63.6) | 805 (69.6) | 704 (60.8) | 770 (66.6) | 846 (73.1) | 786 (67.9) |
| | Male | Both | 674 (55.1) | 765 (62.5) | 739 (60.4) | 711 (58.1) | 866 (70.8) | 850 (69.4) |
| | | Urban | 464 (57.7) | 529 (65.8) | 510 (63.4) | 488 (60.7) | 592 (73.6) | 581 (72.3) |
| | | Rural | 210 (50.0) | 236 (56.2) | 229 (54.5) | 223 (53.1) | 274 (65.2) | 269 (64.0) |
| | Female | Both | 1778 (76.5) | 1886 (81.2) | 1595 (68.7) | 1843 (79.3) | 1894 (81.5) | 1740 (74.9) |
| | | Urban | 1252 (78.9) | 1317 (83.0) | 1120 (70.6) | 1296 (81.7) | 1322 (83.4) | 1223 (77.1) |
| | | Rural | 526 (71.4) | 569 (77.2) | 475 (64.5) | 547 (74.2) | 572 (77.6) | 517 (70.1) |
| TGs domain | Both | Both | 2561 (69.0) | 2778 (74.8) | 2434 (65.6) | 2633 (70.9) | 2891 (77.9) | 2703 (72.8) |
| | | Urban | 1695 (72.2) | 1836 (78.2) | 1612 (68.7) | 1741 (74.2) | 1905 (81.2) | 1792 (76.4) |
| | | Rural | 866 (63.4) | 942 (69.0) | 822 (60.2) | 892 (65.3) | 986 (72.2) | 911 (66.7) |
| | Male | Both | 760 (49.0) | 914 (59.0) | 882 (56.9) | 795 (51.3) | 1018 (65.7) | 996 (64.3) |
| | | Urban | 497 (51.4) | 602 (62.3) | 578 (59.8) | 520 (53.8) | 667 (69.0) | 651 (74.8) |
| | | Rural | 263 (45.0) | 312 (53.4) | 304 (52.1) | 275 (47.1) | 351 (60.1) | 345 (74.8) |
| | Female | Both | 1801 (83.3) | 1864 (86.2) | 1552 (71.8) | 1838 (85.0) | 1873 (86.6) | 1707 (78.9) |
| | | Urban | 1198 (86.7) | 1234 (89.4) | 1034 (74.9) | 1221 (88.4) | 1238 (89.6) | 1141 (82.6) |
| | | Rural | 603 (77.1) | 630 (80.6) | 518 (66.2) | 617 (78.9) | 635 (81.2) | 566 (72.4) |
| HDL-C domain | Both | Both | 2133 (67.8) | 2307 (73.3) | 1970 (62.6) | 2236 (71.1) | 2385 (75.8) | 2208 (70.2) |
| | | Urban | 1487 (70.1) | 1604 (75.6) | 1389 (65.5) | 1554 (73.2) | 1652 (77.9) | 1547 (72.9) |
| | | Rural | 646 (63.0) | 703 (68.6) | 581 (56.7) | 682 (66.5) | 733 (71.5) | 661 (64.5) |
| | Male | Both | 464 (60.3) | 520 (67.5) | 505 (65.6) | 485 (63.0) | 590 (76.6) | 581 (75.5) |
| | | Urban | 330 (61.9) | 372 (69.8) | 360 (67.5) | 342 (64.2) | 417 (78.2) | 409 (76.7) |
| | | Rural | 134 (56.5) | 148 (62.4) | 145 (61.2) | 143 (60.3) | 173 (73.0) | 172 (72.6) |
| | Female | Both | 1669 (70.2) | 1787 (75.2) | 1465 (61.6) | 1751 (73.7) | 1795 (75.5) | 1627 (68.4) |
| | | Urban | 1157 (72.8) | 1232 (77.5) | 1029 (64.8) | 1212 (76.3) | 1235 (77.7) | 1138 (71.6) |
| | | Rural | 512 (67.0) | 555 (70.4) | 436 (55.3) | 539 (68.4) | 560 (71.1) | 489 (62.1) |
| BP domain | Both | Both | 1988 (65.1) | 2292 (75.0) | 2010 (65.8) | 2241 (73.3) | 2396 (78.4) | 2259 (73.9) |
| | | Urban | 1344 (68.3) | 1542 (78.4) | 1359 (69.1) | 1505 (76.5) | 1609 (81.8) | 1526 (77.5) |
| | | Rural | 644 (59.2) | 750 (68.9) | 651 (59.8) | 736 (67.6) | 787 (72.3) | 733 (67.4) |
| | Male | Both | 567 (52.5) | 663 (61.3) | 649 (60.0) | 638 (59.0) | 758 (70.1) | 750 (69.4) |
| | | Urban | 392 (56.2) | 453 (65.0) | 443 (63.6) | 434 (62.3) | 517 (74.2) | 513 (73.6) |
| | | Rural | 175 (45.6) | 210 (54.7) | 206 (53.6) | 204 (53.1) | 241 (62.8) | 237 (61.7) |
| | Female | Both | 1421 (71.9) | 1629 (62.5) | 1361 (68.9) | 1603 (81.2) | 1638 (82.9) | 1509 (76.4) |
| | | Urban | 952 (74.9) | 1089 (85.7) | 916 (72.1) | 1071 (84.3) | 1092 (85.9) | 1013 (79.7) |
| | | Rural | 469 (66.6) | 540 (76.7) | 445 (63.2) | 532 (75.6) | 546 (77.6) | 493 (70.5) |

Data presented as number (percent)

associated with a lower prevalence of MetS only in females, while in males, the lower prevalence was observed among those who were illiterate.

Except HDL-C, the frequency of individual MetS components was predominantly higher in females than in males for all criteria. In addition, hypertriglyceridemia was the most common component of MetS in women. It is consistent with the report of previous studies.[6, 18] On the other hand, Nikbakht et al.[10] reported that the most common components of Metabolic Syndrome were abdominal obesity (73.59%), followed by reduced HDL-C levels (44.83%), fasting glucose (35.34%), hypertension (32.64%), and elevated triglyceride (28.33%). In a different study conducted by Osei-Yeboah et al.,[19] it was found that the most prevalent components were high blood pressure (66.67%) and abdominal obesity (69.14%), but our study did not support these findings. Similar to other studies,[9, 20] and as expected, we observed that the risk of MetS decreased with increasing physical activity.

Based on the results of this study , people living in urban areas are more likely to have most of the important MetS components than people living in rural areas. Similar results have been reported in previous studies.[8, 21, 22] A possible explanation for this could be that people living in urban areas tend to have a more inactive lifestyle than those living in rural areas.

The main limitation of this study was the cross-sectional design of the study, as no cause-and-effect relationship could be established. In addition, the examined sample is limited to people between the ages of 35 and 70. It is, therefore, not possible to transfer the results to other age groups, whether younger or older. On the other hand, the greatest strengths of the study are its population-based nature and relatively large

sample size, which was advantageous for comparing the definitions.

## Conclusion

In conclusion, our study indicates that MetS is widespread in southern Iran according to the definitions of JIS, IDF, Regional JIS, AHA/NHLBI, Regional IDF, and ATP III, respectively. While all six definitions can be used to assess MetS prevalence, this may indicate JIS criteria are more appropriate for assessing MetS and showing higher number of non-communicable diseases in the southern Iranian population. However, long-term prospective studies are needed to better understand the underlying mechanisms and identify the specific factors that contribute to the development of MetS.

## Authors' Contribution

Study concept and design: LM, MA, AMA, HSH. Acquisition and data collection of data: SMB and AMA and MA. Analysis, interpretation and statistical analysis of data: SMB And MA. Drafting of the manuscript: SMB and AMA. Administrative, technical, or material support: MA. Study supervision: LM and HSH.

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## Ethical approval

All procedures performed in this study involving human participants were in accordance with the ethical standards of the Ethics committee of Ahvaz Jundishapur University of Medical Sciences with the code of IR.AJUMS.HGOLESTAN.REC.1401.037

**Conflict of Interest:** None declared.

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