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Prevalence of Metabolic Syndrome in India

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Abstract:- Metabolic Syndrome (MS) is increasing in India and other South Asian nations, resulting in increased CVD and T2DM-related mortality and morbidity. About one-third of urban South Asians have evidence of MS. MS has been linked to an elevated risk of chronic diseases, including type 2 diabetes mellitus (T2DM) and cardiovascular disease in adults (CVD), particularly in Asian Indians. The prevalence of the metabolic syndrome is increasing, with urbanization and sedentary lifestyles becoming risk factors. The metabolic syndrome is becoming more common in developed countries, including India. Increasing the prevalence of metabolic syndrome, such as cardiovascular disease, obesity, diabetes, and hypertension, which is contributing to an increase in mortality and sickness in developed nations, is currently a global public health concern. This study aimed to review the prevalence of metabolic syndrome (MS) in India.

Keywords:- *Metabolic Syndrome (MS), Hypertension, Cardiovascular Disease (CVD), Obesity*.

I. INTRODUCTION

Persons with MS are three times more likely to experience a stroke or myocardial infarction (MI) than people without MS, and they are twice as likely to die from these conditions(Isomaa et al., 2001). ATP III defines metabolic syndromes as the presence of at least three of the five risk variables (waist circumference, serum triglycerides, serum high-density lipoprotein (HDL) cholesterol, blood pressure, and fasting glucose level) in an individual (NCEP panel 2001)(Cleeman, Grundy, Becker, & Clark, 2001).

The IDF defines MS as the presence of central adiposity and any two of the four previously identified risk factors. Due to an inaccurate central obesity cutoff that undervalued MS, ATP III was revised for Asians with central obesity as waist circumference >=80 cm in women and >=90 cm in men(Chiu et al., 2020).

Within 20 years of diagnosis, people with metabolic syndrome are 30-40% more likely to develop diabetes and cardiovascular disease(Gupta et al., 2004). MS was identified as the existence of three or more of the following five risk factors, according to Harmonization criteria: (1) waist circumference ≥90 cm for men and ≥80 for women, (2) triglycerides ≥150 mg/dl or on treatment for lipid abnormality, (3) reduced HDL cholesterol (< 40 mg/dl in men and <50 mg/dl in women) or on treatment for lipid abnormality, (4) systolic blood pressure (SBP) ≥130 or diastolic blood pressure (DBP) ≥85 or on medication for hypertension and (5) raised fasting plasma glucose (FPG) ≥100mg/dl) or taking diabetic medicine. They're also five times more likely to have type 2 diabetes (if not already present). MS is now more widely accepted as a risk factor for heart failure (CVD)(Stern, Williams, González-Villalpando, Hunt, & Haffner, 2004). The metabolic syndrome is a set of physiological, biochemical, clinical, and metabolic factors that increase the risk of atherosclerotic cardiovascular disease (ASCVD), Type 2 diabetes mellitus, and all-cause mortality(Grundy, 2005). The metabolic syndrome, which includes abdominal obesity, dyslipidemia, hyperglycemia, and hypertension, has been a significant public health issue around the world. It is a combination of many closely related cardiovascular risk factors that has attracted a lot of attention due to its connection to type 2 diabetes and atherosclerotic cardiovascular disease(Angelico, Baratta, Coronati, Ferro, & Del Ben, 2023).

The prevalence of metabolic syndrome (MS) varies depending on the concepts used and the study population(Marc-Andre et al., 2008). In India, an estimated 62.4 million people have diabetes and 77.2 million have prediabetes (Anjana et al., 2011). The number of people with MS varies according to gender, age, race, and the population's climate(Kassi, Pervanidou, Kaltsas, & Chrousos, 2011).

India is a developed world that is transitioning from undernutrition to obesity as a result of rapid industrialization and urbanization. Obesity has infected more than 135 million people in India. Previously, various findings were published that caused complications in contrast after using different methodologies and cutoff points for determining obesity(Ahirwar & Mondal, 2019).

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II. INDIA

The prevalence of metabolic syndrome was estimated to be 31.6 percent in an Indian urban population (Gupta et al., 2004). Another international survey report says that MS affects roughly 13 percent to 15 percent of India's adult population, with females being more affected (approximately 8 percent to 9 percent among adult males and 18 percent to 19 percent among adult females)(Eckel, Alberti, Grundy, & Zimmet, 2010).

Insulin resistance and MS are widespread in India. According to studies, the age-adjusted prevalence of metabolic syndrome in urban Indian populations is estimated to be about 25%. (Approximately 31 percent in women and 18.5 percent in men). Both men and women are seeing an increase in age-related prevalence(Deedwania & Gupta, 2006). According to statistics, one-fourth to one-third of India's urban population suffers from metabolic syndrome(Aryal & Wasti, 2016).

A study was conducted with 267 metropolitan male and female in the ages between 25 to 70. MS was slightly more common in the urban population than in the rural population. Based on their fasting and 2-hour plasma glucose levels, these participants were grouped into 182 normal glycemic (NGS) and 85 abnormal glycemic subjects (AGS) groups (Mahadik, Deo, & Mehtalia, 2007).

For a total of 2859 urban people (1394 men and 1465 women) and 1185 rural people, complete data on metabolic syndrome was presented (548 men and 637 women). The prevalence of metabolic syndrome, which is characterized as having three of the following five conditions, is a valuable approach for determining metabolic fitness. Obesity, increased blood glucose, high triglycerides, poor amounts of high-density lipoprotein cholesterol, and high blood pressure are also symptoms of central obesity(Gallagher, LeRoith, & Karnieli, 2008).

A community-based, cross-sectional analysis was conducted in 2008 with 495 participants, 304 males and 191 females, ranging in age from 20 to 98. Person MS risk factors were found to be more prevalent in this study. MS is becoming more popular among India's rural population. This may be attributed to the effects of sudden lifestyle and dietary changes. These improvements, in combination with genetic factors in this population, raise the risk of CHD and diabetes in this population at a younger age. Furthermore, the rural community is unaware of the risk factors for CHD and DM and has little access to appropriate healthcare services. Early MS diagnosis may aid in timely intervention (Kempegowda et al., 2011).

According to a survey conducted in eleven major Indian cities from 2006 to 2010, the prevalence of MS was as high as 35%(Kulkarni et al., 2013). With nearly a third of the population living in cities and 40% of the population between the ages of 30 and 70, knowing the current prevalence of MS in India is critical for forecasting the potential burden of type 2 diabetes and cardiovascular disease(Mendis & Chestnov, 2013). As a result, MS prevalence seems to vary considerably from region to region and ethnicity to ethnicity. Even though data on MS is being produced from various parts of the world, there is no nationwide pooled estimation of the burden of MS in the Indian subcontinent that could guide policy action(Upadhyay et al., 2013).

A total of 700 type 2 diabetic participants (Male 504 and Female 196) from Central India's urban areas, ranging in age from 28 to 87 years, were studied in a cross-sectional study. According to NCEP-ATPIII Criteria, IDF, and WHO definitions, the frequency of metabolic syndrome was found to be 45.8%, 57.7%, and 28%, respectively. Women of both ages had a higher prevalence than men, where all three terms were included. The metropolitan population seems to be the most vulnerable demographic for developing MS due to their behavioral patterns(Organization, 2014), (Yadav et al., 2013).

From August 2011 to December 2013, a cross-sectional survey of 397 college students, 235 women and 162 men, aged 18 to 24 years, revealed that the prevalence of MS in the general population was 4.5 percent (Das, Sen, Saha, & Chaudhuri, 2017).

The International Diabetes Federation Criteria were used to do a cross-sectional analysis of postmenopausal participants. A study was conducted to determine the occurrence of metabolic syndrome. The metabolic syndrome was shown to be prevalent in 64% of people. Women with metabolic syndrome had elevated systolic blood pressure and a greater waist circumference, but diabetes and dyslipidemia were not different. Among people with and without metabolic syndrome, there was no substantial variation in the incidence and severity of menopausal symptoms. Metabolic syndrome was shown to be most prevalent in women above the age of ten years postmenopausal. Sugar levels, blood pressure, and lipid levels were all elevated in women with metabolic syndrome (Jeyasheela et al., 2018).

Patients (n=157) and general population controls (n=263) were recruited from a rural region in South India for a report by (Rawat et al., 2018). The IDF guidelines are used to diagnose MS. Clinical criteria, medication specifics, and nutritional and physical activity habits were also evaluated. Based on subgrouping patients with and without MS, MS predictors were calculated. MS was diagnosed in 50 (31.8%) of the patients and 76 (28.9%) of the test subjects. Female gender and continued antipsychotic exposure were shown to

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be strong predictors of MS, with odds ratios of 2.87 (1.2–6.86) and 4.42 (1.37–14.25), respectively.

A cross-sectional analysis of 1190 participants aged 20 to 79 years between 2015 and 2017. Both participants had their anthropometric measurements, blood pressure, blood glucose, and lipid profile tested. Following Harmonized guidelines, NCEP ATPIII, and IDF criteria, the prevalence of MS was 72.7, 50.2, and 53.9, respectively. The prevalence was highest in centrally obese females aged 51 to 60 who had hyperglycemia and low HDL-C. There were a lot of consensuses between the IDF and the harmonized parameters (k 0.85). The most important statistical risk factors for MS, according to regression analysis, were a high BMI, hypertension, and dyslipidemia (Subramani et al., 2019).

A community-based survey with 500 rural and tribal women between the ages of 30 and 59 years was conducted in the Mysore district. The WHO STEPS methodology was used to gather data on populations and behavioral risk factors for the research. MS was observed in three out of five research participants (47.1 percent, n 14 223). 56.5 percent met three of the five conditions, 32.2 percent met four, and 11.2 percent met all five. Low HDL was the most common criterion in the whole study (88.4%), accompanied by elevated glucose (57.9%), elevated triglycerides (49.3%), elevated blood pressure (41.5%), and raised waist circumference (41.5%). (15.3 percent). The prevalence of MS was found to be high in rural women in this study(Krupp et al., 2020).

The secondary data was collected from the fourth round of India's National Family Health Survey (NFHS-4), which took place between 2015 and 2016. Around 1.1 percent of men in this representative group of Indian men met the International Diabetes Federation (IDF) requirements for metabolic syndrome, although nearly 1.5 percent of women aged 15–49 met this criterion. The findings of multivariate analysis showed that the risk of metabolic syndrome increases with age and that the risk is particularly high among people in the higher wealth quintiles and the postmenopausal era (Meher & Sahoo, 2020).

A. North India

A community-based cross-sectional survey 2007 of 1083 teenagers (ages 12–17 years) in the north Indian city of Chandigarh. Height, weight, BMI, waist circumference, hip circumference, waist-hip ratio, and blood pressure were all measured throughout the anthropometric test. A fasting blood sample was taken for leptin, insulin, and lipid profile measurements. A questionnaire was used to analyze socio-demographic features. The (NCEP ATP III) concept was adjusted for age to assess metabolic syndrome. MS was found to be present in 4.2 percent of teenagers. When the fasting plasma glucose cutoff was reduced to 5.5 mmol/l, the incidence increased to 5.8%. There was no disparity in MS distribution between men and women. The most common component of MS was low high-density lipoprotein, although abdominal obesity was the least common (Singh, Bhansali, Sialy, & Aggarwal, 2007).

A study was conducted with 563 recently diagnosed type 2 diabetes patients enrolled in a trial. WHO, NCEP Adult Treatment Panel III (NCEP-ATP III), updated NCEP-ATP-III, and International Diabetes Federation (IDF) guidelines were used to evaluate the MS. The region under the corresponding curves (AUC) was used to determine the predictive utility of each MS parameter. Receiver operating characteristics (ROC) curves of serum triglycerides, HDL, and waist circumference were developed to predict MS. According to the various standards, the prevalence of MS varied from 57 to 68 percent. The updated NCEP-ATP III guidelines had the best predictive performance for MS diagnosis, while the IDF criteria had the worst. The ideal waist circumference cutoff for men and women was 90 cm and 88 cm, respectively. Men's serum triglycerides accurately predicted the existence of MS in newly diagnosed T2DM patients, whereas women's HDL-C was a better predictor of MS (Dhanaraj et al., 2009).

A population-based cross-sectional survey was performed in 2010 with 2225 subjects aged over 20 years, 1068 men (48 percent of total subjects), and 1157 women (52 percent of total). Anthropometric tests and estimations of capillary plasma glucose, HDL cholesterol, and triglycerides were taken. The National Cholesterol Education Program-Adult Treatment Panel III (NCEP ATP III), updated NCEP ATP III, and International Diabetes Federation (IDF) guidelines were used to calculate the prevalence of metabolic syndrome. The prevalence of metabolic syndrome was 35.8% (NCEP ATP III), 45.3 percent (modified NCEP ATP III), and 39.5 percent (modified NCEP ATP III) (IDF criteria). Central obesity was the most common abnormality among females, and high blood pressure was the most common among males, according to updated NCEP ATP III guidelines. Increasing age, female gender, sedentary lifestyle, and diabetes in parents were all risk factors for MS (Ravikiran et al., 2010).

An observational study of 324 newly diagnosed Acute Coronary Syndrome patients with MS was performed at LPS Institute of Cardiology, G.S.V.M. Medical College, Kanpur, India. The prevalence of MS was 37.65 percent(Goel et al., 2015).

- *Delhi*

A study undertook to evaluate and compare the prevalence of metabolic syndrome among Sunni Muslims in Delhi using IDF and Modified NCEP ATPIII criteria, as well as to decide the best cutoff values for various parameters for metabolic syndrome identification. A total of 406 people between the ages of 35 and 65 were hired (125 men and 281 women). Anthropometric, blood pressure and laboratory tests were carried out according to normal procedures. For the determination of the metabolic syndrome, receiver operational

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characteristics (ROC) curves of waist circumference, serum triglycerides, HDL cholesterol, systolic and diastolic blood pressure, and fasting blood glucose were developed, and the region under curve (AUC) was evaluated to determine the predictive utility of each variable of metabolic syndrome. Each parameter's cutoff values were calculated, along with the corresponding sensitivity, precision, Youden index, and probability ratios. The average metabolic syndrome was 75.12 percent using the Modified NCEP ATP III criteria and 75.36 percent using the IDF criterion. Both meanings correctly classified the majority of the participants. Using these criteria, women had a higher rate of metabolic syndrome than men. In updated NCEP ATP III and IDF, the region under the curve (AUC) indicates that serum triglycerides have the best predictive potential for metabolic syndrome (Bansal & Joshi, 2015).

A one-year cross-sectional research was conducted in South Delhi from January to December 2008, with 300 women (>20 years) recruited by multistage systematic random sampling. Anthropometric and blood pressure samples were taken. Blood samples obtained during an overnight fast were subjected to biochemical analyses. The revised National Cholesterol Education Program/Adult Treatment Panel-III (NCEP/ATP-III) recommendations with adjusted waist circumference for Indians and International Diabetes Federation (IDF) requirements were used to describe the metabolic syndrome. Using NCEP/ATP-III and IDF guidelines, the average prevalence of metabolic syndrome was 29.6% (95 percent CI 23.8 to 36.0) and 20.4 percent (95 percent CI 15.3 to 26.1), respectively. The risk of metabolic syndrome rose as people got older and ate more calories. The majority of the research participants (203 (90%)) engaged in physical exercise with a low metabolic equivalent (MET) score, but one-fifth (19.5%) had a calorie intake that was recommended for women engaged in vigorous activity(Sinha et al., 2013).

- *Gujarat*

The participants in this cross-sectional retrospective sample ranged in age from 20 to 80 years old and attended free health checkup camps. Surendranagar Medical College is located in the Surendranagar district of Gujarat's Saurashtra state. Anthropometric, clinical, and biochemical data, as well as demographics and personal information, were registered. The MS was diagnosed according to the Joint Interim Statement 2009 specification. MS was found to be prevalent in 41.01 percent of the population sampled (females 44.21 percent and males 37.91 percent). The most common components were abdominal obesity (66.38 percent), low high-density lipoprotein-cholesterol (64.69 percent), and high blood pressure (40.59 percent). Age, BMI, overall cholesterol, chewing tobacco use, and a history of hypertension and hyperglycemia were all found to be significant risk factors for MS(Chinawale et al., 2018).

Cross-sectional research was performed on 296 teenagers aged 14 to 19 years (128 boys and 168 girls). Belongs to the Kukana tribe, which lives in Gujarat's Valsad district. The research was conducted from June 2017 to October 2018. The sample population was drawn from two villages, Barumal and Sidhumbar, as well as two urban centers, Udvada and Asura. Purposive random sampling was used to recruit participants. A semi-structured interview schedule was used, which included demographic identifiers such as age, sex, tribe, and native village. Anthropometric measures (height, weight, and waist circumference) were taken, as well as systolic and diastolic blood pressure and biochemical studies. The prevalence of metabolic syndrome was calculated to be 3.8 percent, with a sex-based prevalence of 3.9 percent in boys and 3.6 percent in girls. In this analysis, the most common individual risk factor was low high-density lipoprotein cholesterol(Mahajan & Kshatriya, 2020).

- *Mumbai*

A study was conducted with 5088 type 2 diabetes patients, of whom 2908 men and 2180 women were chosen from Mumbai, India. Anthropometric (waist circumference) and physiological (blood pressure) data were collected, as well as biochemical (serum triglycerides, HDL, fasting and post-prandial blood glucose). Patients undergoing medication for hypertension or dyslipidemia were not included in the study, and even though the criteria were normal, they were used to diagnose MS. MS was found to be prevalent in 77.2 percent of urban Indian diabetic patients, with women (87.71 percent) having a slightly higher prevalence than men (69.33 percent) (p0.0001). In adults, hypertension was the most common risk factor for MS, followed by hypertriglyceridemia, and in women, central obesity was the most common risk factor for MS, followed by hypertension. MS is ubiquitous among diabetics in urban India. According to a survey performed in an urban Indian community, 77.2 percent of T2DM patients have MS (Surana et al., 2008).

A population-based survey was conducted in Mumbai. The respondence fasting lipid profiles, blood glucose, and identified cardiac risk markers were tested in 548 participants (302 males and 246 females). The sample population has a prevalence of MS of 19.52 percent. MS was about twice as common in men as it was in women (P =.008). BMI (>23 kg/m2) was found to be present in 79.01 percent of the population. Males had higher levels of hypertriglyceridemia and lower levels of HDL-C than females (P.0001) (Sawant et al., 2011).

A cross-sectional sample of 313 stable adult males aged 18 to 65 from Mumbai's upper-middle-income neighbourhoods. Using standardized procedures, data on demographic profiles, anthropometric criteria, and biochemical and clinical health markers were collected using a standardized pretested questionnaire. The participants were 46 years old on average. MS was found to be prevalent in 40% of

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the population, with 82 percent of those polled being overweight or obese, and 70.3 percent having a waist circumference of 90 cm. Prehypertension was seen in 36 percent of the participants, and 23.4 percent had systolic and diastolic blood pressures of 140/90 mmHg. Nearly 40% of the participants had dysglycemia, with 34% having elevated triglycerides, 26% having high total cholesterol, 64% having increased serum low-density lipoprotein cholesterol, and almost 66% having low serum high-density lipoprotein cholesterol levels(Madan & Narsaria, 2016).

B. South India

➢ *Tamil Nadu*

The prevalence of metabolic syndrome was 44.2 percent among women aged 41-50 years, compared to 25.2 percent among women aged 30-40 years. The distinction was made based on a coincidental discovery during the study. The risk of developing metabolic syndrome rises 2.3 times as one ages Ramachandran, Snehalatha, Satyavani, Sivasankari, & Vijay, 2003).

A survey conducted in 2011-12 in Madurai city showed that 13% of the population has diabetes, with another 12% in the pre-diabetic stage. According to the results of these polls, a quarter of Madurai's population has diabetes(Sharmila, Banu, Ann, & Asirvatham, 2018). A cross-sectional population-based study was undertaken by(Thiruvagounder, Khan, & Sheriff, 2010).According to the study, metabolic syndrome was found in 33.17 percent of males and 27.04 percent of females referred to Vinayaka Missions University's High-Tech Hospital in Salem. The metabolic syndrome was diagnosed in 33% of men and 27% of women in this cross-sectional population-based sample. According to the findings, the prevalence of MS rises with age. In Tamil Nadu, the prevalence of diabetes in urban areas (13.7%) is nearly double that of rural areas (7.8%), with an average weighted prevalence of prediabetes of 8.3 percent (Anjana *et al*., 2011).

A survey was conducted with 150 rural women between the ages of 30 and 50 in a primary health center district in Tamil Nadu in 2012. The National Cholesterol Education Program (NCEP), Third Study Adult Treatment Panel ATP III criteria, and Modified NCEP ATP III criteria for Asian Indians were used to determine the prevalence of metabolic syndrome. According to NCEP, ATP-III Criteria, 30.7 percent of people have metabolic syndrome. The prevalence was discovered to be 36%. Increased waist circumference (56.0 percent) was the most frequently found feature of metabolic syndrome in this research, accompanied by low HDL (45.3 percent), elevated triglyceride (37.3 percent), high blood pressure 29.3 percent, and fasting blood sugar 12.7 percent (I. Selvaraj, Gopalakrishnan, & Logaraj, 2012).

A cross-sectional study was conducted among 503 patients. The metabolic syndrome was diagnosed using a modified NCEP ATP 3 standard for Asians. Metabolic syndrome prevalence was 66.20 percent among 503 research participants (95 percent CI - 51.5-60). Males comprised 59% of the study participants, while females comprised 41%. Metabolic syndrome was found in 78.6% of females and 57.5 percent of males. Female diabetics were more likely to have metabolic syndrome. The basic odds ratio is 2.71. (95 percent CI - 1.81- 4.067). Males were 49.13 years old on average, while females were 50.03. Patients with metabolic syndrome had a mean age of 49.76, while those without it had a mean age of 49.16. The prevalence of metabolic syndrome was observed to be most significant in the 46-55-year age range (67.4 percent) (Jacob, George, Jose, Antony, & Sebastain, 2015).

A cross-sectional study was undertaken to identify the prevalence of MS. The prevalence of MS was three-quarters (77.44%) among 1126 adults with type-2 diabetes (663 males, 463 females), higher among women (84.67%) than men (72.40%), and it was greatest among the age group of 60 to 70 years old (81.77 percent). Low HDL and central obesity were more common in women(Sharmila et al., 2018).

A cross-sectional study was undertaken in 2019. According to the survey, 32.4 percent of 360 men aged 20 to 40 years have a higher prevalence than the older age group 31-40 years. MS was found to be present in 16.7% of people. The average age of the participants in this sample was 29.18 (6.738) years (P. Selvaraj & Muthunarayanan, 2019).

A cross-sectional analytical study was undertaken with 668 adult patients aged over 20 years old were included in the study. Around one-fifth (19%) of the patients had a literacy score below that of a primary school graduate. The majority of the research subjects were non-vegetarians (88%) and came from nuclear families (87%). About 65 percent of the patients had less than five family members, and 62 percent had a monthly family income of less than ten thousand rupees. A quarter of the patients (24.2%) reported engaging in moderate physical exercise for at least 30 minutes daily(Meenakshi, Devi, Prabhu, & Shanmugam, 2019).

➢ *Kerala*

Cohort analysis was conducted with 297 participants aged 15 to 64 years in rural Kerala who were free of hypertension at study enrolment and were followed up from 2003 to 2010. Participants received physical (blood pressure, height, weight, and waist circumference) and biochemical tests at enrolment to assess demographic profiles and behavioural risk factors (fasting plasma glucose and serum lipids). Blood pressure measurements were replicated using the initial instrument and the same technique at the follow-up. Over a mean follow-up time of 7.1 (standard deviation 0.2) years, almost a quarter (23.6%) of the study experienced

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hypertension. 70.1 percent of all recent cases of hypertension were caused by current smoking, elevated average blood pressure, and central obesity combined. Incident hypertension awareness, care, and monitoring ratesere 42.9 percent, 22.9 percent, and 11.4 percent, respectively(Sathish, Kannan, Sarma, Razum, & Thankappan, 2012).

A cross-sectional analysis was conducted among 533 residents of Kulappuram village in Kerala to determine the prevalence of hypercholesterolemia. The residents' fasting blood glucose, overall serum cholesterol, blood pressure, and body mass index were all measured. Hypercholesterolemia was found to be prevalent in 63.8 percent of the population(Karunakaran et al., 2016).

A six-month cross-sectional analysis was conducted with 90 obese people at the Government Medical College Hospital in Trivandrum from July to December 2010. All 90 participants were classified into two groups: those with MS (n = 55; 61.1%) and those without MS (n = 35, 38.9%). The IDF guidelines is used to diagnose MS. The average age of the participants in the sample was 32 years old. Males comprised 56.7 percent (51) and females made up 43.3 percent (39) of the total. In terms of age, the majority of MS participants were between the ages of 30 and 34. MS was found in 58.82 percent of males and 64.1 percent of females. In obese people, biochemical parameters including fasting blood glucose and serum triglycerides (TGs), demonstrated a statistically significant connection to MS(Nair, Nair, & Ponnappan, 2017).

The research included 2535 rural women aged 30 to 60 years old from seven districts in Kerala. A random block from each of these districts was chosen. Anthropometric statistics and information on socio-demographics, physical activity, and dietary preferences were gathered. Blood pressure, fasting blood glucose, and lipid profile were all measured. High BMI and waist circumference were found, as well as diabetes, abnormal cholesterol levels, and hypertension. Type 2 diabetes, hypercholesterolemia, and hypertension were all present in 14.3%, 43.58 percent, and 30.5 percent of the population, respectively. Obesity and overweight were found in 10.69% and 37.94% of the population, respectively(Sreelathakumari, Reveendran, & Sureshkumar, 2017).

According to the NCEP ATP III, IDF, and AHA/NHLBI Harmonization concepts, the prevalence of metabolic syndrome in Kerala was 24 percent, 29 percent, and 33 percent, respectively. The participants were 51 (14) years old on average (SD), with 60 percent of them being female. Women were more likely than men to have MS (28 percent vs 20% for ATP III, p0.001). Similarly, those who lived in cities had a higher prevalence of MS than those who lived in rural areas (26 percent versus 22 percent, p0.001)(Harikrishnan et al., 2018).

Cross-sectional research was conducted among 170 inpatients aged 20 to 80 years in a medical college in central Kerala's rural district. The research took place from March 2013 to April 2014. Personal interviews, physical examinations, and blood tests were used to gather data, and the patients were assessed for common socioeconomic and disease causes that may affect the progression of metabolic syndrome. The prevalence of metabolic syndrome was estimated to be 38.8% of the general population (47.5 percent among females and 31.1 percent in males). The prevalence of metabolic syndrome was 76.4 percent, 83.3 percent, and 89.2 percent for diabetic, hypertensive, and dyslipidemia patients, respectively. Metabolic syndrome was more common in people who had a family history of diabetes, hypertension, or dyslipidemia. The incidence of abdominal obesity was high (42.95 percent), but it was low in people who exercised daily and in patients with higher education levels(Isac, Biju, Mathew, & Francis, s.d.).

Table 1 Prevalence of Metabolic Syndrome in India

STATES	SAMPLE SIZE	AGE	PREVALENCE (%)	AUTHOR	STUDY DURATION
NORTH					
Delhi	406(Muslim Population)	Above 35	Using NCEP-ATPIII criteria Subjects: (75.12%) Males: (67.6%) Females: (77.88%)	(Kaur & Aeri, 2017)	-
Haryana	1200(Rural area population)	20 and above	Using IDF criteria Subjects:110(9.2%) Males: 37(33.63%) Females:73 (66.36%)	(Pathania, Bunger, Bunger, Mishra, & Arora, 2014)	January 2010 to June 2011
Punjab	300(Rural population)	Age between 25 to 55	Subject:(24.33%) Females: 55(18.3%)	(Randhawa & Sidhu, 2015)	2013 to 2014
Uttarakhand	979(Geriatric subjects)	Above 60	Using IDF criteria Subjects:280(28.6%)	(Kapil et al., 2018)	2015 to 2016

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EAST					
Bihar	380 (T2DM patients)	31 -70	Using IDF criteria Subject: (84%) Males: 65 (34.2%) Females: 83(43.7%)	(Shankar & Agrawal, s.d.)	-
Odisha	170(Doctors)	24 -64	Subject:64(37.65%) Males: (41.9%) Females: (28.3%)	(Manjareeka et al., 2018)	-
West Bengal	388(Urban area population)	18 -49	Subject: (44.6%) Males:(35.4%) Females: (55.6%)	(Banerjee et al., 2019)	2016 to 2018
NORTHEAST					
Assam	502(Urban population)	20 and above	Subject: 165(32.87%) Males: (21.56%) Females: (45.92%)	(Kotokey, Kalita, Agarwala, & Purkayastha, 2013)	Sep2010 to Aug2011
Manipur	608 (Diabetic[327] and non-diabetic[282])	≥50	Subject:(49.5%) Males: (40.2%) Females: (55.9%)	(Behera, Khora, Pathi, & Patro, s.d.)	July 2016 to April 2017.
SOUTH					
Andhra Pradesh	180 (Dolomite mine male workers)	30 and above	Subject: 39(21.66%)	(Madhav, Mallavarapu, & Baer, 2013)	Nov 2011
Karnataka	120 (1st year medical students)	17 to 23	Subject: (10.83%) Males: (9.43%) Females: (11.94%)	(Teli et al., 2019)	January 2018 to July 2018
Kerala	2287(workers)	18-64 years	Using Harmonization criteria Subject: (27%) Males: (30%) Females: (21%)	(Mini, Sarma, & Thankappan, 2019)	-
Puducherry	489 (Rural adults population)	30 years and above	Subject: (39.7%)	(Venugopal, Dongre, & Saravanan, 2019)	January 2016 to August 2017
Tamil Nadu	76 (COPD patient)	Above18	Subject: 54%	(Priyadharshini et al., 2020)	-
WEST					
Goa	325(Rural adult population)	Above 25	Subject: (36.9%) Males: (33.6%) Females: (39.8%)	(Peixoto & Shah, 2014)	January 2012 to June 2012
Gujrat	1500 (Apparently healthy adults)	20-40	Using NCEP-ATPIII criteria Subject: (16) Males: (21.5%) Females: (10.8%)	(Kaur & Aeri, 2017)	-
INDIA	1091 (Urban Indian population)	Above 20	Using NCEP-ATPIII criteria Subject: (31.6) Males: (22.9) Females: (39.9)	(Kaur & Aeri, 2017)	-

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III. CONCLUSION

As a result, the current review paper shows that metabolic syndrome was prevalent among the rural population, higher among women, and in proportions that increased with age across genders. As a result, metabolic syndrome is becoming more common in rural areas. As a result, there is a need to raise awareness among rural residents to minimize metabolic syndrome. Efforts must be undertaken to lower the occurrence of modifiable risk factors associated with metabolic syndrome to decrease the burden of metabolic syndrome.

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