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Correlates of metabolic syndrome in Young adults: A concise review

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Abstract:

Introduction : Metabolic syndrome (MetS), a major health issue of present century, is due to clustering of some metabolic disturbances, including central obesity, hyperglycaemia, dyslipidaemia and hypertension that affects all sections of population including young adults. There are uniform cut-off points across for all these risk factors across different population. Recent findings suggest that apart from these traditional risk factor, the condition is also associated with pulmonary dysfunction, changes in haematological and cardio-respiratory parameters, an increased risk for psychiatric co-morbidity and impaired health related quality of life (HRQL). The present review aims to extract recent knowledge on the underlying mechanisms behind the association of these correlates in pathogenesis of metabolic syndrome with special emphasis on young adults.

Methods : For the purpose, a systematic literature search was conducted at PubMed, Scopus and Google scholar data bases using keywords like MetS, lung function, haematological parameters, cardio-respiratory fitness separately. All papers under different subheadings where clustered separately. The duplicate ideas were deleted. Though no time limit was framed but tried to confine search to last decade only. Mainly meta-analysis, reviews and large population-based studies were considered to establish the relationship.

Result : Studies revealed definite association of metabolic syndrome with cardio respiratory fitness, haematological parameters. There is inadequate data on association of metabolic syndrome with HQRL in young adults.

Conclusion : The findings suggest that these non-invasive correlates of metabolic syndrome can be used to screen subjects specially in field surveys with potential cardio-metabolic risk and intervention can be planned to reduce future risk of progressing to cardio and metabolic disorders.

Keywords: MetS, lung function, haematological parameters, cardio-respiratory fitness.

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Introduction :

The concept of “metabolic syndrome (MetS)” with central pathogenesis of insulin resistance emerged during the last century to identify individuals with risk of future development of diabetes mellitus and cardiovascular diseases (Pandit et. al, 2015). The term “metabolic syndrome”, for association of obesity, diabetes mellitus, hyper-lipoproteinemia, hyperuricaemia and steatosis hepatitis when relating the additive effect of risk factors on atherosclerosis. In 1989, Kaplan coined the term ‘insulin resistance, syndrome’ for clustering of different risk factors in individual (Kaplan, 1989). So far ‘Metabolic syndrome’ remains the most accepted and globally acknowledged terminology for the cluster of metabolically related cardiovascular risk factors.

Metabolic syndrome is currently defined as a constellation of an interconnected physiological, biochemical, clinical and metabolic factors that directly increase the risk of atherosclerotic cardiovascular diseases and type 2 diabetes mellitus (T2DM). The combination of risk factors in individual with metabolic syndrome include atherogenic dyslipidaemia, hypertension, glucose intolerance, pro-inflammatory and thrombotic state.

WHO developed its definition in 1998 to tie together the key components of insulin resistance, obesity, dyslipidaemia and hypertension with insulin resistance to be central to the patho-physiology of metabolic syndrome (Alberti and Zimmet, 1998). In 2001, NCEP, ATP-III derived a definition for metabolic syndrome, which was later updated by American Heart Association and the National Heart Lung and Blood institute in 2005 (Gruady et al., 2006). The NCEP, ATP-III definition is one of the most widely used criteria for metabolic syndrome that incorporates the key feature of hyperglycaemia, insulin resistance (IR), visceral obesity, atherogenic dyslipidaemia, and hypertension. In this, there is no requirement for any specific criteria to be met; only any three of five criteria is required. Thus the definition does not build any preconceived notion for underlying cause of metabolic syndrome, whether it is insulin resistance or obesity. In 2005, IDF published its criteria which necessarily requires obesity not insulin resistance to be present. However, obesity requires to include a population specific cut-off points because of wide range of ethnic differences in obesity cut points across different population.

Pathophysiological Basis of Metabolic Syndrome:

Pathophysiology of metabolic syndrome depends on complex interaction of various genetic and environmental factors. At the centre of pathophysiology of metabolic syndrome is insulin resistance and visceral adiposity.

During insulin resistance, there is an inefficient insulin action on liver, skeletal muscle and adipose tissue that induces increased gluconeogenesis in liver, decreased glucose disposal in muscle, endothelial

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dysfunction in arteries together with increased release of free fatty acids (FFA) from adipose tissues (Boden and Shulman, 2002). Elevated amount of circulating FFA inhibit cellular insulin signalling and triggers insulin resistance. Elevation of plasma FFA during insulin resistance is merely due to suppression of inhibitory effects of insulin on adipose tissue lipolysis via inhibition of lipase enzyme. This leads to increased lipolysis in adipose tissues releasing increased amount of FFA in circulation. Increased FFA will result in ectopic lipid formation in liver.

It leads to abnormal deposition of fat mainly in the upper body parts. There is a link between positive energy balance and obesity which can be detected by genetic and lifestyle factors such as smoking, physical inactivity etc. The ability to cope with positive energy balance and store fat in different organs determine individual's susceptibility to develop cardio-metabolic risk. When the surplus energy is directed to the metabolically inert SAT (subcutaneous adipose tissue), adipose tissue is elongated via hyperplasia and, up to a specific level 9that can vary among individuals), the subject displays a normal metabolic profile. On the contrary, when SAT is non-functional (hypertrophic), absent or insulin resistant, then surplus energy is deposited in viscera and other non-adipose tissues such as liver, pancreas, heart or skeletal muscles, a phenomenon described as ectopic fat deposition (Indulekha et al., 2011).

Visceral fat deposits contribute to insulin resistance by increasing the amount of FFA. In condition of insulin resistance all the activities of insulin in liver as well as skeletal muscles are compromised. Increased FFA inhibit protein kinase activation in the muscle leading to reduced glucose uptake (Tooke and Hannemann, 2002). FFA enhances hepatic gluconeogenesis and lipogenesis through protein kinase activation leading to increased triglycerides by inhibiting the actions of insulin on hepatic tissues (Tripathi et al., 2003).

FFAs are also lipotoxic to beta cells of pancreas causing decreased insulin secretion (Tooke and Hannemann, 2002). Increase in triglyceride synthesis is associated with production of apolipoprotein B containing triglyceride-rich very low-density lipoprotein (LDL) in the liver (Lewis and Steiner, 1996). Increase in small dense LDL cholesterol and reduction in HDL cholesterol are indirect effects of insulin resistance caused by altered liquid metabolism in the liver.

In addition, IL-6 is reported to increase fibrinogen levels leading to a pro-thrombotic state in metabolic syndrome and also promotes adhesion molecule expressions by endothelial cells and activation of local RAS pathways (Wisse, 2004). Adiponectin on the other hand has anti atherogenic properties and plays a protective role against development of diabetes, hypertension and acute myocardial infarction (Matsuzawa et al., 2004).

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 09, 2023

Prevalence of MetS in Young Adults :

During the present century, metabolic syndrome has emerged as a major public health issue worldwide (Agudelo et al., 2014). Global prevalence of metabolic syndrome varies from 10% to as much as 84 % depending on diagnostic criteria used and also depending on age sex and social economic variability of the individual. Currently for adult population, there is consensus regarding the cut off points used to define metabolic syndrome components. However, it is not the case of adolescents where the diagnostic criterion varies considerably among the different available studies making it difficult to compare among the studies and to predict future clinical consequences (Agudelo et al., 2014). Studies reported in literature indicate syndrome diagnosed during childhood and adolescents persists in the adulthood. Therefore, the diagnosis of the possible presence of metabolic syndrome at early ages, accompanied by control intervention, should have formidable impact on the health of young people and the prevention of adverse outcomes in future.The prevalence of MetS in obese adolescents has been reported to be between 18% and 42% depending on the country of origin suggesting an ethnic based association between obesity and metabolic syndrome (Nasreddine et al., 2012).

A number of studies have been conducted from beginning of present century to identify and cluster the metabolic risk factors in young population. In Young Finns study the prevalence of metabolic syndrome was studied in Finnish young adults.

A population-based cohort study conducted in 10 and 15-year-old youth from Estonia, Denmark and Portugal revealed a metabolic syndrome prevalence of 0.2 % and 1.4% in 10 and 15 years old respectively. Cardiorespiratory fitness, physical activity and maternal BMI were all independently associated with metabolic syndrome after adjustment for sex, age group, study location, birth weight and sexual maturity (Ekelund et al., 2009). A community-based and cross-sectional survey through face to face interactions on 606 Korean adolescents aged 12 to 18 years revealed an overall prevalence of metabolic syndrome 13.0% with 15.4% for boys and 10.0% for girls (You and Son, 2012).

A study from Emirates revealed 13 % prevalence of metabolic syndrome with increased weight increase in BMI and boys were having higher prevalence than girls (Mehairi et al., 2013). Indices of metabolic syndrome was 25.5% for young men and 1.8% in young women (Barzin et al. 2012). Using data from China Health and Nutrition Survey (CHNS) to assess the metabolic syndrome based on both NCEP-ATP III guidelines and IDF criteria, an overall prevalence of 3.37 was observed among 831 children of 7- 18 years age group (Song et al., 2017). Study published in 2009 based on the data of National Health and Nutrition Examination Survey (NHANES) 2003-2006 reported the overall prevalence of metabolic syndrome in US adults over 20 years as 34% (Ervin, 2009).Recently a study conducted on 103 healthy

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Caucasian individuals of mean age group of 20 years in University of Ljubljana, Faculty of Health Sciences showed approximately 30% of the individual were at the risk of developing metabolic syndrome (Sostaric et al., 2019).

A cross sectional study conducted on prevalence and correlates of metabolic syndrome among adolescents (10 to 19 years age) from rural Wardha showed a prevalence of 9.9 %. The prevalence of metabolic syndrome was found to be significantly associated with presence of obesity and hypertension among family members (Bhalavi et al., 2015).A school based study on 899 subjects of 10 to 18 years of age from North India revealed 3.5 % prevalence based on ATP III criteria and 1.5 prevalence based on IDF criteria (Bhat et al., 2015).A study conducted amongst medical students of age 17 years and above from central India revealed an overall prevalence of 11.2% among study subjects (Jain et al., 2015).

A cross-sectional study conducted among 18 years and above age group of subjects from Agra, Uttar Pradesh, showed a 37.1% prevalence of metabolic syndrome among the study subjects (Kaushal et al., 2016). A study on prevalence of MetS in youths from both ethnic and non ethnic population from North Eastern part (Tripura) of India revealed that 22.75% of young adult subjects had profound cardio metabolic risk and the most prevalent risk factors identified in both male and female subjects of both the communities were central obesity marked by increased waist circumference and altered lipid profile marked by elevated TG (Nath N and Choudhuri D, 2022).

Cardiorespiratory Fitness and MetS :

Prevalence of obesity and insulin resistance have got wide acceptance over the years. Given that the metabolic syndrome is an important precursor to cardio vascular disease (CVD) and other chronic conditions, it was felt necessary to take a force to reduce the incidence of the condition and its components (Sperling et al., 2015). A growing number of studies over the years have reported an inverse relationship between cardiorespiratory fitness (CRF) and development of metabolic syndrome (Church, 2011). These studies along with recent intervention trial suggest a compelling link between impaired CRF, low physical activity patterns, exercise and metabolic syndrome (Zhang et al., 2017).

Studies on impact of being physically active, whether studied in a cross-sectional cohort or as a result of structured exercise intervention, have been shown to have an important impact on cardio-metabolic risk. Leisure- time physical activity (LTPA) and cardiorespiratory fitness in terms of $\dot{V}O_2$ max was related tofuture problem in sedentary persons. One large prospective study 9007 man (mean age 44±9) and 1491 women (mean age 44±9) free of metabolic syndrome were evaluated for metabolic syndrome according to NCEP ATP III criteria and cardiorespiratory fitness by maximal treadmill test. During a mean follow-up of

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5.7 years 1346 men and 57 women developedmetabolic syndrome. In a sample of 297 apparently healthy men with available computed tomography or magnetic resonance imaging scans of the abdomen, metabolic data and maximal treadmill exercise test results, it was observed that high levels of CRF attenuates cardio-metabolic risk factors independent of abdominal subcutaneous and visceral fat (Lee et al., 2005).

Whether physical fitness is an important marker of health already in childhood and adolescence is still under debate since most of the evidence comes from cross-sectional studies. A population-based longitudinal cohort study of men and women (18 to 30 years) was undertaken in Coronary Artery Risk Development in Young Adults (CARDIA) study. Participants who completed the treadmill examination were followed up from 1985-1986 to 2000- 2001.A subset of participants repeat exercise test in 1992 to 1993. During 15 years study period, the rates of incident diabetes, hypertension, the metabolic syndrome and hypercholesterolemia were 2.8, 13.0, 10.2 and 11.7 per 1000 person- years respectively. The European Youth Heart Study (EYHS) conducted on 589 Danish children revealed physical activity and fitness is inversely associated with metabolic syndrome independent of potential co-founders.

The interaction between physical activity and fitness suggests that the potential beneficial effect of physical activity may be greatest in children with lower cardio respiratory fitness (Brage et al., 2004). Inception cohort study using data from cross-sectional nationally representative National Health and Nutrition Examination Survey 1999- 2002 conducted in USA. Participants were adolescents (age 12 to 19 years) and adult (age 20 to 49 years) free from previously diagnosed CVD underwent submaximal graded exercise treadmill testing to achieve at least 75% to 90% of their age predicted maximal heart rate and it was correlated with CVD risk factors.

Higher levels of physical activity are also positively correlated with insulin sensitivity in adolescents, even in absence of weight loss (Schmitz et al., 2002). A chronically elevated work-related stress have been found to be silent risk factor for metabolic syndrome in all walk of life (Gerber, Schilling, 2018). Regular physical activity and resulting cardiorespiratory fitness have been shown to enhance resistance against stress and stress related cardio metabolic risk (Gerber et al., 2013). Both cardiorespiratory and physical fitness were found to be correlated with various cardio-metabolic risk factors in young adults from India (Nath N and Choudhuri D, 2017).

Haematological parameters and metabolic syndrome :

A complete blood count is an inexpensive, frequently updated taste of haematological status recorded during a routine health examination (NCCLS, 2009). Insulin resistance, an essential core contributing factor for metabolic syndrome has been demonstrated in some studies to be e associated with white blood cell (WBC) and red blood cell (RBC) count. The relationship between WBC or RBC count and various clinical features of metabolic syndrome was evaluated at Taiwan. In a study among Thai professional and office workers it was found that elevated platelet and WBC were significantly associated with metabolic syndrome among men.Nebeck et al. studied relationship between metabolic syndrome and haematological parameters on an occupational cohort in Ethiopia. Haematological parameters like haemoglobin, haematocrit and RBC where positively associated with metabolic syndrome components. Findings from such studies provide evidence in support of using haematological markers in early detection of individuals at the risk for cardiovascular and metabolic disorders.

The relationship between haematological indices and fasting blood glucose level was evaluated in a comparative cross-sectional study conducted at chronic illness clinic of Gender University Hospital. A significant difference in red blood cell distribution width was observed between diabetic patients and controls. Total WBC count, absolute lymphocyte count, absolute neutrophil count, mean platelet volume and platelet distribution width where found to be significantly higher in diabetic subjects (Baidgo et al., 2016).

A significant correlation between IR &MetS was observed among obese adolescents (Manampiring 2016). In a large cross-sectional and longitudinal study followed up until metabolic syndrome developed with a mean duration of 4 years from entry date, it was found that among male subjects both WBC count and haemoglobin level played a predictive role for metabolic syndrome, while in female only WBC count play the predictive role for metabolic syndrome (Chang et al.,2016).In another five-year follow-up and longitudinal study, Tao et al. observed that among various haematological parameters WBC was positively correlated with metabolic syndrome for young adults of 20-30 years irrespective of sex of the subject (Tao et al., 2014).

Numerous previous studies have reported a positive correlation between insulin resistance, components of metabolic syndrome and erythrocyte parameters like RBC count, haematocrit, haemoglobin and red blood cell distribution width (Kawamoto et al., 2013). In a recent study Huang et al. observed a gender differences in this relation. It was observed that in male, RBC count and haemoglobin were identified as risk factors while in female haemoglobin and red blood cell distribution width was found to be most important risk factor (Huang et al., 2017).

RBC count was found to be associated with metabolic syndrome in both male and female subjects but some studies showed a gender difference in change of RBC count associated with metabolic syndrome (Neebek et al, 2012). Similar gender differences in platelet count was also observed in various studies (Park et al., 2012). A study among young adults of Tripura, India, revealed that in subjects with MetS RBC count, PLT count, Hb content showed lower values and WBC showed significantly higher values in subjects with MetS. In both male and female, the haemoglobin content correlated negatively with BMI, waist

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 09, 2023

circumference and triglyceride level whereas only in females it also varied significantly positively with HDL-C level. There was over all impairment of the haematological status in subjects with profound cardio-metabolic risk (Nath N and Choudhuri D, 2022).

Lung Function and Metabolic Syndrome :

There is increasing evidence over the years to show that impaired lung function is more than a simple reflection of airflow limitations in lung; it may also be a marker of premature death (Young et al., 2007). The relationship between metabolic syndrome and lung function was examined in a total of 46,514 subjects recruited from four nationwide MJ Health Screening Centres in Taiwan from 1998 to 2000. The multivariate logistic analysis of the data revealed with adjustment for age, gender, BMI, smoking, alcohol drinking and physical activity; restrictive lung impairment was independently associated with increased risk of having metabolic syndrome (Lin et al., 2006). The relationship between metabolic syndrome and pulmonary function was examined among 1370 subjects as a part of health examination at Eulji General Hospital Health Centre, Seoul Korea. The association between lung function parameters like FEV1, and FVC and FEV1/FVC and metabolic syndrome parameters were analysed. Metabolic syndrome components in man were associated with pulmonary function impairment and the more metabolic syndrome diagnostic criteria factors the patient had, the more severe their pulmonary function tended to decline. In women, waist circumference, triglyceride and high-density lipoprotein cholesterol were associated with pulmonary function change (Bae et al., 2012).

Overweight promotes metabolic and structural changes that make the obese individuals more susceptible to several events, including cardiovascular, pulmonary, renal and biliary diseases, metabolic obstruction and obstructive sleep apnoea. It is known that adequate pulmonary function depends on harmonic operation of structures that compose the respiratory system. The association between impaired lung function and metabolic syndrome was ascertained in a nationally representative sample of US population as a part Third National Health and Nutrition Examination Survey (NHAMES III). After adjusting for potential confounders such as age, body mass index, inflammatory factors medical condition and smoking status, participants with more components of metabolic syndrome had lower predicted values of FVC and FEV1. Impaired pulmonary function was also associated with individual components of metabolic syndrome, such as abdominal obesity, high blood pressure, high triglyceride and low HDL-C (Chen et al., 2014). There is, however, uncertainty as to the relative contribution that each metabolic factor adversely affecting the respiratory system; also, it is unclear how much of the metabolic syndrome related lung effects occur independently of obesity.

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 09, 2023

Data obtained from 6684 adults during the 2013- 2015 Korean National Health and Nutrition examination survey showed after adjustment for related variables, metabolic syndrome and metabolic syndrome score were found to be inversely associated with the predicted forced vital capacity and forced expiratory volume in 1s values. The odds ratio of restrictive pulmonary disease significant for higher metabolic syndrome score (≥4). In addition, the odds ratio of restrictive pulmonary disease of the MetS was significantly higher than those of non-metabolic syndrome (Yoon et al., 2018). Relationship between cardio-metabolic risk factors and pulmonary function in young adults of North-east region of Indiarevealed that all the pulmonary function parameters like FVC, FEV1, FEV1/FVC ratio showed lower values in subjects with profound cardio-metabolic risk. In males, FVC, FEV1 and FEV1/FVC ratio significantlycorrelated with BMI, waist circumference and triglyceride level whereas in females all the lung function parameters varied significantly with BMI,waist circumference, triglyceride and HDL-C level. There was over all impairment of the pulmonary function in subjects with profound cardiometabolic risk. Various cardio-metabolic risk factors varied independently with different pulmonary function parameters (Nath N and Choudhuri D, 2020).

A recent report on cross sectional study including 6945 participants attending health examination between 2010 and 2012 in Taiwan showed abdominal obesity was the key component of metabolic syndrome associated with mechanical effect on lung function impairment in a prime age adult population. Although restrictive lung diseasewas not associated with increased probability of having metabolic syndrome, the participants with more metabolic syndrome scores had at a high risk of losing lung function (Lee et al., 2020).

Health Related Quality of Life and Metabolic Syndrome :

Quality of life is a scientifically proven indicator of health experienced by a subject during different diseased conditions, consequently health-related quality of life (HRQL) is emerging as an important outcome in patients (Sato et al., 2012). HRQL isusually determined by using questionnaires in health surveys such as SF 36(Ware et al., 1994). The SF-36 measures 8 concepts: physical functioning (PF), role limitations due to physical health (RP), bodily pain (BP), general health perceptions (GH), vitality(VT), social functioning (SF), role limitation due to emotional problems(RE) and general mental health(MH). Two summary measures of physical (PCS) and mental (MCS) health are constructed from the eight scale.

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 09, 2023

Studies on evaluation of health-related quality of life and components of MetS among young adults revealed that subjects with MetS have lower scores in almost all subscales of quality of life. Gender specific analysis showed significant differences in the mean scores of physical functioning (PF) and general health (GH) between subjects with and without MetS. Female subjects with MetS showed significantly lower values in role emotional (RE) subscale. PF correlated significantly with both systolic and diastolic blood pressure in young males with MetS whereas young females showed no significant correlation with PF. Similarly, GH significantly correlated with BMI and TG level in male subjects but in females it showed no significant correlation (Nath N and Choudhuri D, 2018).

Over recent years, there is a growing interest on the impact of various psychological factors in cardiovascular morbidity and mortality. Several prospective studies suggested that confirmed mental disorders such as depression and anxiety, may be associated with an increased risk of cardiovascular events in otherwise healthy subjects (Grundy et al., 2004). Similarly, diabetes mellitus is found to have a clinically significant impact on HRQL of individuals. Some studies have revealed a positive association between physical activity level and HRQL in diabetic patients (Eckert, 2012).

Although, the aetiology of metabolic syndrome is yet to be understood completely, it is considered as a complex health problem that can trigger physical, emotional and psychological problems. A longitudinal study had proven that expressive disorders were nearly twice as frequent in patients; with metabolic syndrome compared to individuals without metabolic syndrome (Frasure and Lesperance, 2005).

There are a few studies in this area, most of them show association between metabolic syndrome and worsening in HRQL. A study involving 4,480 subjects revealed that the number of components diagnosed with metabolic syndrome was inversely associated with general health, in both genders, although it was positively associated with mental health (Räikkönen et al., 2007).

The relation between HRQL and MetS was analysed among US adults (≥20 yrs.), the results revealed, after adjusting for age, sex, ethnicity, educational status participants with metabolic syndrome were likely to have poor or fair health related quality of life compared to subjects without metabolic syndrome (Ford et al., 2008).The effect of metabolic syndrome on HRQL was studied among community-dwelling adults of ≥20 yrs. in rural Haryana by using SF- 36 questionnaire. Out of metabolic syndrome group 92.7% were having SF- 36 scores between 0 and 50. Physical and mental scores of patients suffering from metabolic syndrome were significantly lower than non- metabolic syndrome group. HRQL was found to be lowered in obese individuals.

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 09, 2023

Conclusion :

A critical analysis of the literature cited revealed that metabolic syndrome (MetS) has emerged as a major public health concern in both developed and underdeveloped countries. Though considered to be a syndrome mostly affecting elderly people, recent trends suggested a high prevalence of the condition in children and adolescents. Prevalence of metabolic syndrome varies according to demography, socio economic condition, race and ethnicity of the population. The cardio-metabolic risk of the subject is influenced mainly by visceral obesity and insulin resistance. The physiological basis of metabolic syndrome is yet to be established fully. Many newer correlates of cardio-metabolic risk has been established in population studies. All these correlates found to have important predictive and clinical significance that can be used to monitor people with metabolic syndrome and for future progression of the condition to either cardio vascular diseases or diabetes mellitus. Most prominent of these correlations are cardiorespiratory fitness, pulmonary function and various haematological indices. Metabolic syndrome has been found to affect the health related quality of life of an individual. Therefore, it is important to have an in-depth study on various correlates of metabolic syndrome in different population, with special emphasis on young adults who are going to be the main future work force of a nation.

CONFLICT OF INTEREST

Authors declare they have no conflict of interest among them.

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ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 09, 2023

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Clinical measure	**World Health Organization 1998**	**European Group for the Study of Insulin resistance 1999**	**Adult Treatment Panel III of the National Cholesterol Education Programme 2001**	**International Diabetes Federation 2005**	**American Heart Association/ National Heart, Lung, and Blood Institute 2005**
Criteria	IR + any other 2	IR + any other 2	Any 3 of 5	Increased WC	Any 3 of 5
Insulin resistance	IGT/IFG IR	Plasma insulin > 75th percentile	–	–	–

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 09, 2023

Blood glucose	IFG/IGT/T2DM	IFG/IGT(excludes diabetes)	⩾110mg/dL (includes diabetes)	⩾ 100 mg/dL	⩾100mg/dL (includes diabetes)
Dyslipidemia	TG⩾1.69 mmol/L & HDL-C: men<0.90 mmol/L women<1.01 mmol/L	TG⩾1.69 mmol/L HDL-C<1.01 mmol/L in men and women	TG⩾1.69 mmol/L HDL-C: men<1.03 mmol/L women<1.29 mmol/L	TG⩾1.69 mmol/L or On TG treatment HDL-C: men<1.03 mmol/L women<1.29 mmol/L Or HDL treatment	TG⩾1.69 mmol/L or On TG treatment HDL-C: men<1.03 mmol/L women<1.29 mmol/L Or HDL treatment
Blood pressure	⩾ 140/90 mmHg	⩾ 140/90 mmHg or on antihypertensive medications	⩾ 130/85 mmHg or on antihypertensive medications	⩾ 130/85 mmHg or on antihypertensive medications	⩾ 130/85 mmHg or on antihypertensive medications
Obesity	Waist: hip ratio: Men>0.9, Women>0.85 and/or BMI> 30 kg/m2	WC Men⩾94 cm Women⩾ 80 cm	WC men ⩾ 102 cm women ⩾ 88 cm	WC ⩾ 94 cm	WC men ⩾ 102 cm women ⩾ 88 cm

Table 1. Various definitions of metabolic syndrome:

BMI, body mass index; HDL-C, high-density lipoprotein cholesterol; IFG, impaired fasting glucose; IGT, impaired glucose tolerance; IR, insulin resistance; T2DM, type 2 diabetes mellitus; TG, triglycerides; WC, waist circumference. (Adapted from the American Heart Association/National Heart, Lung, and Blood Institute report) (Wallace AM et al., 2001)

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 09, 2023

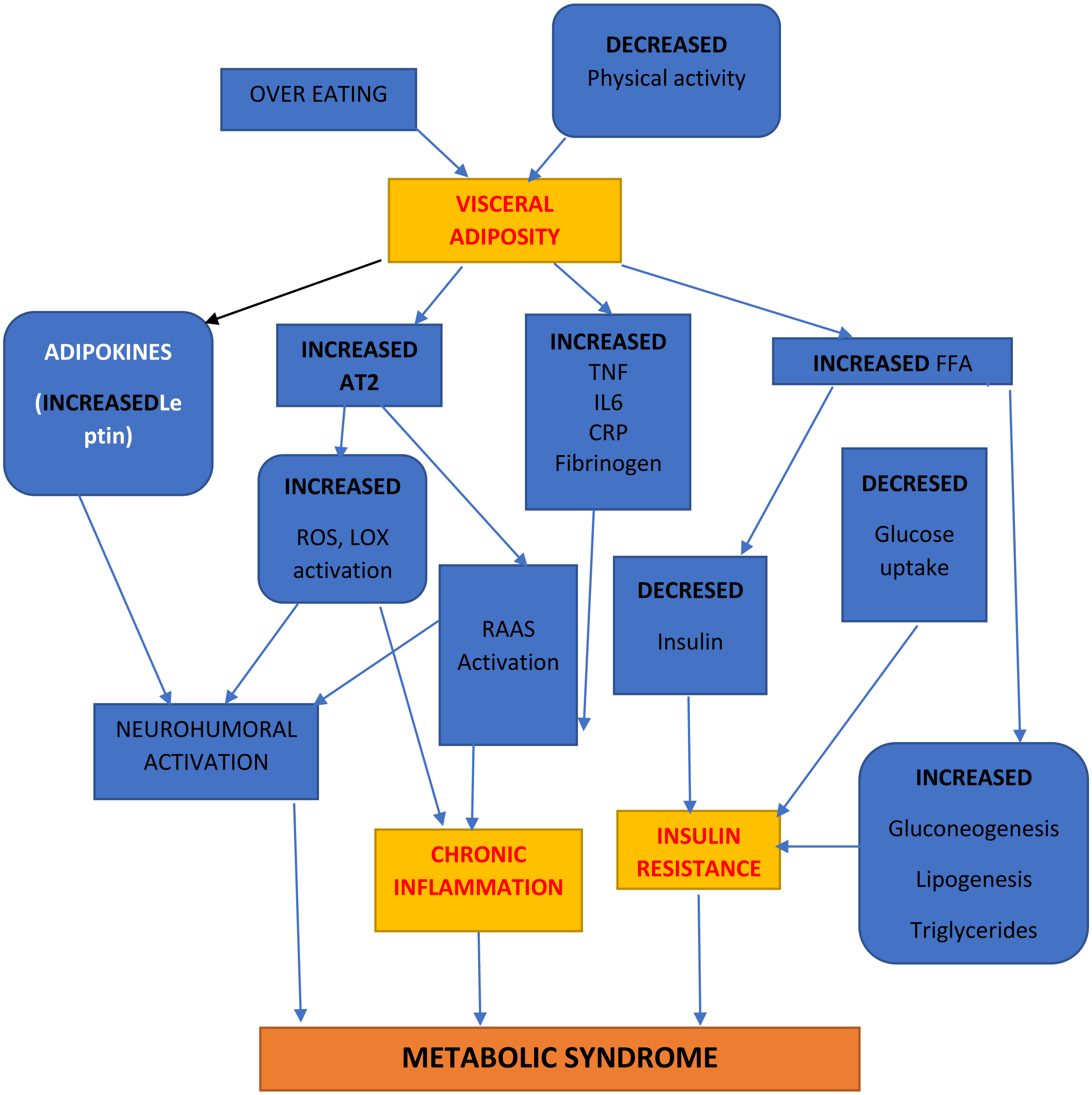

Fig I: Pathophysiological basis of metabolic syndrome. AT2- angiotensin II type 2 receptor, CRP- C-reactive protein, IL-6- interleukin 6, LOX- lectin-like oxidized low- density lipoprotein, RAAS- renin angiotensin- aldosterone system, ROS- reactive oxygen species, TNF- tumour necrosis factor.