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Prevalence of metabolic syndrome in adolescents of India and the associated risk factors: A systematic review

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ABSTRACT

Background: *The prevalence of metabolic syndrome is increasing in developing countries like India at a very fast pace. The major groups being affected are both adolescents and adults. The age of occurrence of the risk factors for metabolic syndromes is much younger in population of India than that in other countries. Studies related to cardio metabolic factors among children and adolescents are few, and therefore a comprehensive review on this subject would bring about the magnitude of problem in the vital areas of anthropological research.*

Objective: *Purpose of this review is to give an overview on the scientific research done so far in this subject. The prevalence of metabolic risk factors in various communities residing in urban and rural settings has been highlighted. The occurrence of non-modifiable and modifiable risk factors and the probable reasons of their preponderance in Indians have also been accessed thoroughly through the available material on this topic.*

Methods: *The literature from 2006 till March 2016 was collected using electronic databases PUBMED and INDMED to identify relevant studies related to metabolic syndrome in adolescents in India.*

Conclusion: *The prevalence of metabolic syndrome is higher in urban areas but there is a rapid increase in rural areas as well. Traditional communities are adopting habits which were not originally theirs and this change is a growing cause of prevalence of metabolic syndrome and its associated risk factors in rural areas. Risk factors emerging in early age are indicators of occurrence of cardiovascular disease in adulthood. Neglecting this threat will lead to deterioration of health of people in this country. Thus, proper intervention and awareness programmes are required to identify the vulnerable groups prone to such health crisis, so the early detection and management of diseases can be done.*

Keywords: *Metabolic syndrome, anthropometric measures, lipid profile, risk factors, adolescents.*

INTRODUCTION

The prevalence of communicable as well as non-communicable diseases is rapidly increasing in the developing nations. According to World Health Organization estimates, by the year 2020 non‑communicable diseases will account for approximately three quarters of all deaths in the developing world (WHO, 1998). India is experiencing a rapid increase in the prevalence of obesity, type 2-diabetes and deaths from cardiovascular disease (Danaei et al., 2011; Agrawal and Ebrahim, 2012; Ramachandran et al., 2010 and Patel et al., 2011). With nearly 45 million coronary heart disease (CHD) patients and about 50.8 million diabetics in the country, it is being projected that in the near future, India will have the largest number of cardiovascular disease burden in the world. Facts highlight that heart disease in India occurs 10 to 15 years earlier than in the west (http://neocardiabcare.com/what-WHO-says.htm, 2015). Therefore, prevalence of the metabolic syndrome among children and adolescents (6-18 years age group) and its increase with aggravation in obesity is a major cause of concern (Weiss et al., 2004). The disease which was believed to have a late age of onset and was prevalent in the age of 40 years and older, the risk factors are now emerging in even the population aged about 15 years; that too on an alarming rate. Evidence suggests the appearance of metabolic syndrome is as early as in adolescents of age 12 to 16 years (Scott, 2006 and Bacha et al., 2006). Studies across the worldwide population demonstrated that metabolic syndrome has an essential role in the occurrence of cardiovascular factors (Invitti et al., 2006).

Metabolic syndrome, also known as syndrome X, is a combination of risk factors that increase the risks for heart disease, diabetes, and stroke (WHO, 2009 and 2010). The syndrome is characterized by the presence of dyslipidemia, glucose intolerance, hypertension, abdominal obesity, and other abnormalities (Bokyo et al., 2000). The metabolic syndrome is a risk factor for cardiovascular diseases and trends of this syndrome are increasing in adolescents at a startling pace (Weiss et al., 2004 and Ramachandran et al., 2007). People with metabolic syndrome have a bigger risk of development of coronary heart disease and cardiovascular mortality (Isoma et al., 2001). Metabolic syndrome patients are twice as likely to die from heart attack and three times more likely to have a heart attack or stroke in comparison to a fit person who do not suffer from this condition (IDF, 2006). Also, the risk of development of type 2-diabetes increases by five folds in people with metabolic syndrome (Stern et al., 2004).

The metabolic syndrome in adults has been defined as "a cluster of the most dangerous risk factors for cardiovascular disease and type 2-diabetes, which include abdominal obesity, high cholesterol, high blood pressure, diabetes and raised fasting plasma glucose" (Alberti et al., 2005).

The term "metabolic" refers to the biochemical processes involved in the body's normal functioning. "Risk factors" are traits, conditions, or habits that increase chances of developing a disease. The International Diabetes Federation (2007) defines metabolic syndrome in children and adolescents. The World Health Organization (WHO) defines an "adolescent" as any person between ages 10 and 19 (WHO, 1998).

According to IDF Consensus Report (2007), for children age 10 years or older, metabolic syndrome can be diagnosed with abdominal obesity and the presence of two or more other clinical features (i.e. elevated triglycerides, low HDL-cholesterol, high blood pressure, increased plasma glucose) and for children older than 16 years, the IDF adult criteria can be used.

Identification of the components of phenotype of metabolic syndrome in Asian Indian adolescents is of immense significance as the clusters of risk factors for metabolic syndrome and cardiovascular disease are fairly stable which can be tracked very well from adolescence that is in children above 10 years of age into adulthood (Eisenmann et al., 2004 and Ghosh, 2004).

Identification of the phenotypic components of metabolic syndrome and its expression in different ethnic groups will help in understanding the aetiology of metabolic abnormalities (Scott, 2006). Several studies have been conducted to identify the risk variables associated to metabolic syndrome in adults, however little attention has been given on studies among children and adolescents.

SEARCH METHODOLOGY

Electronic databases such as PUBMED and INDMED were identified for searching articles from 2006 to March 2016 using keywords like "cardiometabolic risk factors" or "cardiovascular disease" or "metabolic risks" or "MetS" and "anthropometric measures" or "body mass index" or "BMI" or "insulin resistance" or "lipid profile" and among "adolescents" or "children" or "young adults" and in "India" or "South Asians". The articles were further selected by going through the abstracts and also, full texts were read for the articles which were majorly related to the area of interest. After the streaming, arrays of

research publications were selected and a thorough reading of the available full texts was done in order to give a review. The cross-references in the research papers were also referred to for the better understanding of the topic.

Cut-off for determining cardiometabolic risk in adolescents and adults

Risk Factor	Defining Level	
	10-16 years	>16 years (IDF, 2007)
Abdominal Obesity (Waist Circumference)	Male >70cm Female >67cm (Misra et al, 2006)	Male >102 cm Female >88 cm
Triglycerides (TG)	>110 mg/dl (Cook et al., 2003)	>150 mg/dl
High density lipoprotein-cholesterol (HDL-c)	<40 mg/dl (Cook et al., 2003)	Male 50 mg/dl Female 40 mg/dl
Blood Pressure	≥130/≥85 mmHg (IDF, 2007)	≥130/≥85 mmHg
Fasting Glucose	>140 mg/dl (IDF, 2007)	110 mg/dl
The metabolic Syndrome (Diagnosis is established when ≥3 risk factors are present).		

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PREVALENCE OF METABOLIC SYNDROME IN INDIA

The prevalence of the metabolic syndrome in Asian Indians varies according to region, extent of urbanization, lifestyle patterns, and socioeconomic/cultural factors (Misra and Khurana, 2009). Prasad et al. (2012) reported that metabolic syndrome had been a serious health problem among the Asian Indians. Research data shows that about one-third of the urban

population in large cities in India have metabolic syndrome (Ramachandran et al., 2003 and Misra et al., 2007). The frequency of occurrence of metabolic syndrome in India ranges 28‑36% in the urban population and 18‑30% in the rural population (Prasad et al., 2012; Vinodh et al., 2013; Deshmukh et al., 2013 and Chow et al., 2003). Recent estimates place the age-adjusted prevalence of the metabolic syndrome among middle class urban Asian Indians at 25.1 % for men and 22% for women (Gupta et al., 2012). Asian countries have similar prevalence of diabetes to West despite lower obesity (Yoon et al., 2006). This supports that diabetes develops at lower levels of body mass index (BMI) among Asians (Huxley et al., 2008 and Lee et al., 2011). Prevalence rates in an Asian Indian population were found to vary from 4.2 to 5.8% (Singh et al., 2007) and rise as high as 36.6% among obese adolescents aged 14 years and above (Kelishadi, 2007). Incidence of metabolic syndrome was about 4.79% among healthy school-going children of age 16-18 years in Jammu and Kashmir (Singh et al., 2013). The occurrence of metabolic syndrome in the Kannavam tribal population of Kerala was 28.3%, which is similar to the incidence rate as seen in the rural population of India (18‑30%) (Deshmukh et al., 2013 and Chow et al., 2008).

The prevalence of metabolic syndrome is increasing rapidly due to sedentary lifestyle, changing dietary patterns, and increased tobacco smoking and alcohol consumption (Singh et al., 2013).

RISK FACTORS ASSOCIATED WITH METABOLIC SYNDROME

“Risk factors” are traits, conditions, or habits that increase chances of developing a disease. Age, race, obesity, history of diabetes, fatty liver, polycystic ovary syndrome, and several other risk factors may increase the chances of developing metabolic syndrome. In case of children, biological as well as lifestyle factors may play their role.

Components of metabolic syndromes are present in children and adolescents as well as in the adults. It is widely accepted that atherosclerotic process which is the anomaly where the plaque starts to build inside the arteries, begins in childhood (10-14years) and advances through adulthood (Strong et al., 1992). The severity of coronary and aortic atherosclerosis in young people (<39 years) increase with an increased occurrence of CVD risk factors (Berenson et al., 1998).

Though the prediction of cardiac events from childhood risk factors is not yet possible, the assessment and modulation of the same is required because the presence of risk factors in

youth (9-24 years) is known to have an association with the thickening and damaging of arterial wall in adulthood (Raitakari et al., 2003).

"Puberty also presents a unique challenge to insulin-glucose homeostasis. Body fat, blood pressure, and lipids are all affected by puberty. The percentage of body fat increases strikingly in females through adolescence, but changes in body fat in males is not consistent" (Irwin, 1991). A rise in systolic blood pressure is also observed with advances in pubertal stage independent of age, especially in girls (Weir et al., 1991 & Bradley et al., 1997). Variation in lipids is seen by pubertal stage in youth (Berenson et al., 1998). In mid-puberty, events of total cholesterol drop occur, however, it begins to rise toward adult levels at the end of puberty (Hill and Trowbridge, 1998). Sexual maturation also influences insulin sensitivity significantly (Misra, 2006).

However, the risk of metabolic syndrome increases with increasing age, an association between childhood metabolic syndrome and adult cardiovascular disease has also been identified (Owens et al., 2009).

Results of study by Kshatriya (2014) show high prevalence of cardiovascular disease and risk factors in tribal communities of Orissa, West Bengal and Gujarat. This study also indicates the co-prevalence of low BMI and raised diastolic blood pressure (DBP) risk among Koras, and highest prevalence of raised systolic blood pressure (SBP) risk among individuals with normal or raised BMI level among Santhals. It also shows a strong correlation between various anthropometric measures and metabolic risk indicators.

Singhal et al., (2010) observed a secular trend of regional adiposity among adolescents of age 9-17 years and concluded that probable explanation for increasing risk of metabolic syndrome at a very early age is a significant increase in abdominal obesity and fasting blood glucose and a decrease in High density lipoprotein cholesterol (HDL-c).

To understand the impact of metabolic syndrome in India, it becomes necessary to access the defining characteristics of body composition among the population vulnerable to this syndrome (Misra, 2014). Asian Indians store more body fat, particularly in the abdomen and in areas where fat is less often found, such as the liver, neck and between the fibres of the muscles. This fat is known as visceral fat. These fat stores are essentially toxic, and increase the risk factors for diabetes and metabolic syndrome. But the reason of the Asian Indian population being at even higher risk of these diseases is that this increased fat storage occurs even at a lower BMI than among Caucasians (Raji et al., 2001; Misra, 2014). Research has shown that sensitivity to blood sugars among Asian Indians without heart disease is similar to

that of British heart attack survivors (Misra, 2014). Also, abdominal obesity leads to elevated blood pressure and insulin resistance (Poirier et al., 2005).

Indian men are less insulin sensitive than whites regardless of their BMI (Raji et al., 2004); with insulin resistance occurring even in lean Indians (Chandalia et al., 1999 and Raji et al., 2001) and Indian adolescents about 14 years of age (Misra et al., 2008). This may be because Indians have percentage body fat for given BMI (Raji et al., 2004 and 2001; Chandalia et al., 1999; Misra et al., 2004; Forouhi et al., 2005 and Bhat et al., 2005) even as newborns (Yajnik et al., 2002) and also there is predisposition towards abdominal adiposity (Raji et al., 2004 and 2001; Chandalia et al., 1999) which is linked to cardiometabolic disease (Janssen et al., 2004; Canoy et al., 2007 and Yusuf et al., 2006).

SBP and DBP are established risk factors in adults. Childhood blood pressure is a strong predictor of adult blood pressure explaining up to one quarter of the adult variance in blood pressure (Bao et al., 1995). BMI is associated with left ventricular hypertrophy, insulin resistance and endothelial dysfunction which are important cardiovascular risk factors in adults as well as children (Reilly et al., 2003).

Sarkar et al. (2006) conducted a cross-sectional survey on Toto and Bhutia tribes of Himalayas (Sikkim), and concluded that even though these tribal communites share a common genetic lineage or ancestry, the prevalence of metabolic syndrome is higher in urban as well as rural Bhutia while lipid profile was adverse in Toto tribe. While BMI was a significant predictor of SBP and biochemical variables such as low density lipoprotein (LDL), very low density lipoprotein (VLDL), fasting blood glucose (FBG) and triglycerides (TG) in Bhutia; waist circumference (WC), hip circumference (HC) and waist-hip ratio (WHR) was a significant predictor for biochemical variables in Totos. Use of anthropometry was made and conclusion was that central obesity was a significant correlate of lipid and blood sugar level in Toto tribe while in Bhutia, overall adiposity and obesity were the significant measures.

High prevalence of abnormal lipid profile was found among the Kannavam tribal population of Kerala, 69% had low HDL cholesterol and 39% had high triglyceride level. BMI, WHR, and VLDL cholesterol were found in significant association with metabolic syndrome. BMI $\geq$25 kg/m^2 was found to be an important factor associated with the development of metabolic syndrome in the studied population (Ismail et al., 2016).

Apart from non-modifiable factors like age, gender, family history; controllable risk factors such as diet, physical inactivity, dietary habits, stress also determine risk of CVD.

Sarkar et al. (2005) found that metabolic syndrome could be a major health problem, also in traditional rural ethnic groups necessarily as a result of modernization and urbanization. People from rural areas may come to urban centres for economic reasons such as work and goods exchange and adopt and are attracted towards the charm of the city life, better standard of living and educational facilities. Rural people are following the material culture of urban people. This can be indicated by recent increase in literacy rates in rural people, change in dressing habits, and use of modern technologies to ward off the burden of doing work manually. These changes are responsible for increase in sedentary life and dependence on machinery rather than manual labour. Advent of television, mobile phones have led to them becoming exposed to good and bad effects of technology. These tools increase their awareness and keep them connected to others; however, television is one way through which people are getting introduced to unhealthy habits such as junk food, smoking, tobacco, etc. These products are advertised with a lot of attractive pomp and show on the television, and the children get attracted to these and may indulge into improper food habits and adopt the lifestyle inappropriate for them.

Food habits also play a role in development of metabolic syndrome. A study on 1875 adults in Chennai city indicated association of cooking oil to the risk of metabolic syndrome in Asian Indians (Lakshmipriya et al., 2012). The results showed that risk of development of metabolic syndrome was higher among sunflower oil users even though stratification was done according to BMI. Higher linoleic acid/alpha-linolenic acid ratio in sunflower oil probably is probably a contributor to increased risk of metabolic syndrome (Lakshmipriya et al., 2012). The recent shift in dietary habits has led to increase in prevalence of dyslipidemia (Misra, 2011). Pan et al. (2008) reported that metabolic syndrome increased the risk of chronic heart disease as well as cardiovascular disease in Asians. Studies have also found that macronutrients composition and the quality of diet were associated with the risk of metabolic syndrome in Asians.

Exercise is known to improve responses to a 2-hour glucose tolerance test and improve insulin sensitivity even without weight loss (Duncan et al., 2003). Physical activity is thought to be inversely proportional to insulin resistance, therefore, increase in physical activity levels

lead to decrease in insulin resistance (Lee et al., 2008). Raitakari (1997) adds that regular physical activity in childhood is associated with a healthy serum lipid profile. Physical exercise may be a strong correlate of metabolic fitness and increasing physical exercise may play a role in preventing metabolic syndrome among young people (McMurray et al., 2009).

"Television viewing time has been used as a measure of sedentary behaviour and several studies have shown an association between TV viewing time and cardiovascular risk factors, the metabolic syndrome and type 2 diabetes" (Dunstan et al., 2007, 2004 & 2005; Fung et al., 2000; Hu et al., 2001; Hu et al., 2003). In AusDiab study of Australian adults, higher diastolic blood pressure, triglycerides and fasting insulin in women and fasting plasma glucose, 2 hour glucose and fasting insulin in men were associated with TV viewing time rather than computer screen time or reading (Thorp et al., 2010) Analysis suggests that association between TV screen time and cardio-metabolic biomarkers was mediated by BMI (Nang et al., 2013) and another explanation may be reduced energy expenditure due to increase TV viewing time (Stamatakis et al., 2012).

Ghosh (2007) suggested that while dealing with dyslipidaemic Asian Indians, clinicians should consider obesity measures, metabolic profiles and dietary fatty acids simultaneously to comprehend the condition in a better and thorough manner.

The recent trends indicate that the disease has escalated to younger age groups (25-35years) and exists in a significant number in males and females living in urban as well as rural areas (Gupta et al., 2012).

A cross sectional study to understand the geographical epidemiology of cardio-metabolic factors among the middle class urban residents in India was conducted by Gupta et al., from 2005-2009. From this study, varied observations were made. Among Eastern (Lucknow, Patna and Dibrugarh) regional urban participants; the prevalence of overweight, hypertension, hypercholesterolemia and MetS was low while prevalence of smoking was the highest. Northern (Jammu, Chandigarh and Bikaner) and Southern (Madurai, Belgaum and Nagpur) regions had a high prevalence of hypertension, hypercholesterolemia and low HDL-c. Truncal obesity was observed in Northern region participants. Participants living in cities with lower human social development index (HDI <0.5) have a low prevalence of MetS risk factors (Gupta et al., 2015).

Kshatriya et al. (2016) reported that Tribes from Gujarat exhibited minimal tendency for a low body fat percentage; whereas tribes from Odisha and West Bengal exhibited a high tendency for a low body fat percentage. A high body fat percentage among men and women of the tribes from Gujarat indicated an increasing trend of fat deposition and a predictable risk of obesity. In populations undergoing change in dietary habits, there is an urgent need to observe the association of cardio-metabolic risk factors with anthropometric variables (Garg et al., 2013). Recent evidences indicated that extensive urbanization is strong risk factor for cardiovascular dieases (Riha et al., 2014). Major tribal-dominated states, such as Maharashtra, West Bengal, Andhra Pradesh, Gujarat and Madhya Pradesh have experience a high rate of urbanization leading to more than 20-30% increase during the last census year that is 2001-2011 (Census of India, 2011). Several urban and market centres have developed in and around the tribal regions, which have considerable influence on the socio-cultural lifestyle and habits of the nearby inhabiting tribes. A glimpse of such adaptation and shift from indigenous traditions to an urban lifestyle has been observed in Santhals (Orissa) and Chaudharis (Gujarat) (Kshatriya et al. 2016).

Childhood obesity is widespread in India. The presence of abnormal levels of fat and cholesterol in the blood termed as “dyslipidaemia” is seen in an age as early as 15 years, and increases steeply after 20.Early death from heart disease and other complications associated with metabolic syndrome is common. Thus, early identification of metabolic syndrome is important.India already has some of the world’s largest programmes for intervention in childhood obesity, focusing on lifestyle changes known to help prevent diabetes and heart disease in later life. However, doctors rarely have enough time during clinic visits to provide the advice that patients need on eating healthily, exercising regularly and quitting smoking. Poor training on prevention of disease means that an estimated 70% of the Indian population is deprived of correct lifestyle advice from doctors (Misra, 2014).

CONCLUSION

Risk factors emerging in childhood are evidently a growing cause of cardiovascular disease in adulthood. High prevalence of metabolic syndrome in adolescents as well as adults stress upon the need for effective preventive and therapeutic strategies based on diet, exercise, and life style modification rather than medication to maintain healthy lifestyle habits into and throughout their adulthood (Singh et al., 2013). Investigation is needed to determine which metabolic factors and cut offs should be used to identify children and adolescents at risk of

disease pertaining to cardio-metabolic syndrome. Since India is becoming a country with a triple burden of obesity, under nutrition as well as metabolic syndrome, early prevention and intervention are the need. Neglecting this threat will compromise the future cardio-metabolic health of the population of India and result in serious public health crisis. So, steps to enhance awareness about weight management, healthy diet, and regular health check-ups should be made in rural as well as urban population by public health practitioners in order to estimate the risk factors in people as early as possible.

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