Exploring Lipid accumulation product (LAP) as a marker of metabolic syndrome: A Review

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Abstract
An effective indicator for identifying metabolic syndrome (MetS) is the Lipid Accumulation Product (LAP), a new assessment that combines fasting triglyceride (TG) levels and waist circumference (WC). MetS dramatically raises the risk of type 2 diabetes and cardiovascular illnesses. It is typified by central obesity, insulin resistance, dyslipidemia, and hypertension. Compared to more conventional indicators like body mass index (BMI), LAP has better predictive power and can identify important MetS components like central obesity and dyslipidemia.Numerous studies demonstrate LAP's capacity for early diagnosis and intervention as well as its efficacy in detecting at-risk persons across various communities. Integrating LAP into clinical practice may enhance the management of metabolic disorders and lessen the burden of MetS on the world's health system. LAP is an essential tool for tackling the growing prevalence of metabolic syndrome because of its versatility, predictive capacity, and user-friendliness.

Keywords: Lipid Accumulation Product, metabolic syndrome, central obesity, dyslipidemia, cardiovascular risk, insulin resistance, predictive marker.

Introduction
In living cells, the metabolism of carbohydrates and lipids is a mutually dependent process. The majority of diseases that cause metabolic syndrome (MS), such as diabetes, obesity, hypertension, and hyperlipidemia, are fundamentally related to abnormal lipid metabolism. Reduced mitochondrial activity, which is linked to abnormal lipid content in the mitochondrial membrane, specifically cardiolipin concentration, is another metabolic condition that can be classified as cancer.[1,2]. Recent research has shown that aberrant cellular lipid metabolism has a role in the development of the metabolic syndrome as well as a number of different malignancies.

Phospholipids and neutral lipids including sterol, esters, and triacylglycerols make up the majority of cellular lipids, which are crucial for preserving the body's physiological and cellular energy balance. They are the main component of energy sources and membranes. Although phospholipids are structural components of the cell membrane, they are crucial for both cellular membrane remodeling and cellular proliferation. Phospholipid homeostasis imbalance may lead to carcinogenesis and multiple sclerosis. [3] As a crucial type of energy storage, triacylglycerol is intimately linked to glucose homeostasis and disruption of this process is linked to the beginning of multiple sclerosis (MS) as well as conditions like diabetes, obesity, and cardiovascular diseases [4].

Metabolic Syndrome

The combination of associated metabolic abnormalities known as metabolic syndrome (MetS) raises the risk of atherosclerotic cardiovascular disease, that involves peripheral vascular diseases, insulin resistance, myocardial infarction, strokes, and type II diabetes mellitus, considerably. MetS is characterized by central obesity (waist circumference), high blood pressure, raised triglycerides, higher fasting glucose, low levels of high-density lipoprotein (HDL) cholesterol (dyslipidemia), and elevated triglycerides. Insulin resistance and central obesity are thought to be the main causes of MetS.[5]

Multiple metabolic abnormalities must exist in order to diagnose metabolic syndrome: A waist circumference of 35 inches for women and more than 40 inches for males Blood pressure levels of systolic 130 mm Hg or higher or diastolic 85 mm Hg or higher; elevated fasting glucose of 1000 mg/dL or more; decreased high-density lipoprotein cholesterol, less than 40 mg/dL in men or less than 50 mg/dL in women.[6]

Compared to the general population, patients with metabolic syndrome are expected to have a 5-fold greater risk of diabetes mellitus and a 2-fold increased risk of atherosclerotic cardiovascular diseases.In addition, early onset type II diabetes mellitus, premature atherosclerotic cardiovascular illnesses, and accelerated atherosclerosis are linked to metabolic syndrome [4] Eating excessively and a sedentary lifestyle have contributed greatly to the rise in the percentage of the population that is obese over the past few generations. Over the past 20 years, there has been a notable increase in the prevalence of metabolic syndrome as a result of an exponential rise in obesity in the population.[5]

The main factor causing metabolic syndrome is central obesity, which also causes insulin resistance, hypertension, and dyslipidemia.[7] Depending on the underlying atherosclerotic cardiovascular disease, the metabolic syndrome can appear in a variety of clinical ways. Metabolic syndrome is commonly characterized by higher blood pressure, symptoms of insulin resistance, and abdominal obesity with a high body mass index and enlarged waist circumference.[8] A person's health may be seriously impacted by metabolic syndrome. The prevalence of metabolic syndrome is increasing, yet it is possible to stop and even reverse its course with intervention.[9]

MetS is becoming increasingly prevalent worldwide, primarily due to increased rates of obesity and sedentary behavior. MetS's pro-inflammatory and pro-thrombotic state is linked to its etiology and increased risk of cardiovascular disease. Preventing severe consequences from MetS requires early detection and treatment.

In addition to pharmacological treatments that address specific MetS components like hypertension, dyslipidemia, and hyperglycemia, effective management of the condition requires lifestyle modifications including diet and exercise. Improving insulin sensitivity and lowering central adiposity are essential for lowering the risks related to Metabolic Syndrome [10].

For the purpose to address MetS and stop the rising worldwide burden of metabolic illnesses, public health initiatives that promote healthier living habits and reduce obesity are also necessary. A promising evaluation for MetS has emerged: the lipid accumulation product (LAP), a new assessment that combines fasting triglyceride levels and waist circumference. Research has demonstrated that LAP, which frequently exceeds more conventional measures like BMI, is a good predictor of MetS. By combining assessments of central obesity and dyslipidemia, LAP offers a more detailed assessment of metabolic health.[11]

Lipid Accumulation Product

To evaluate lipid overaccumulation and calculate the likelihood of receiving a metabolic syndrome (MetS) diagnosis, a new metric known as the lipid accumulation product (LAP) is employed. LAP is calculated using specific algorithms for men and women based on waist circumference and fasting triglyceride (TG) readings (WC):

$LAP=(WC-65)\times TG$ (for men)

$LAP=(WC-58)\times TG$ (for women)

LAP effectively combines measures of central obesity and dyslipidemia to produce a complete marker for MetS that takes into account a number of cardiovascular risk factors, including insulin resistance, hypertension, and dyslipidemia. Numerous studies have demonstrated that LAP has a higher predictive ability than traditional metrics like body mass index (BMI) in [12]. LAP has a wide range of cross-demographic and worldwide predictive power. In a multiethnic population, LAP shown effectiveness as a marker for MetS, with a better diagnostic accuracy in sedentary people than in people who engage in regular physical activity.[13] Because LAP integrates WC and TG to provide a thorough evaluation of metabolic status, it is a vital tool for the early detection and treatment of MetS. Its application in clinical practice may enhance the capacity to recognize individuals who are at risk, enabling timely treatments to impede the progression of metabolic disorders.[12]

Relationship Between Lipid Accumulation Product and Metabolic Syndrome

A useful and effective marker for the diagnosis of metabolic syndrome (MetS), the Lipid Accumulation Product (LAP) is strongly associated to MetS. A group of metabolic diseases known as MetS includes high fasting glucose, insulin resistance, central obesity, dyslipidemia, and hypertension. The main elements of MetS are efficiently captured by LAP, which combines fasting triglyceride (TG) values and waist circumference (WC): Central obesity and dyslipidemia.[13]

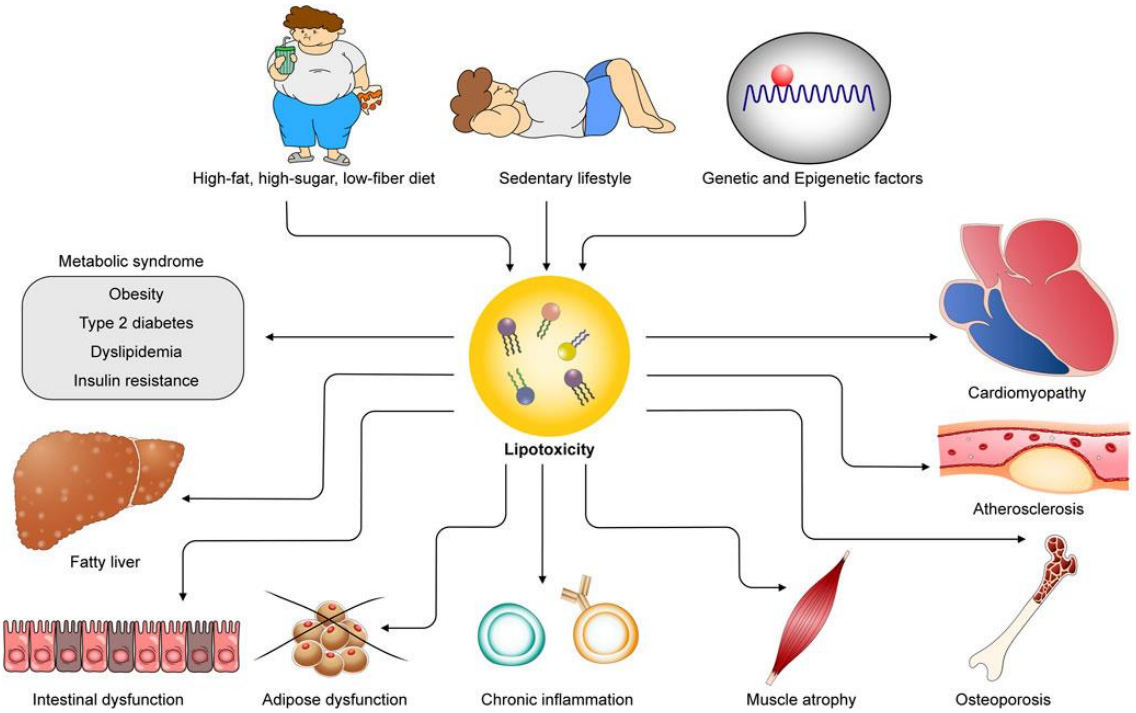

Figure 1. Cardiometabolic disorders are caused by lipotoxicity, which is influenced by hereditary and obesogenic factors. Lipotoxicity is caused by excessive lipid buildup in both adipose and non-adipose tissues, which is brought on by unhealthy diets, sedentary lifestyles, and genetic and epigenetic factors. Numerous cardiometabolic disorders, such as metabolic syndrome, cardiomyopathy, atherosclerosis, fatty liver disease, intestinal dysfunction, adipose dysfunction, chronic inflammation, and osteoporosis, are caused by lipotoxicity. [14]

Central Obesity and Dyslipidemia

A complex and multivariate chronic disease of pandemic proportions, obesity has become much more common and severe in recent decades. It has also continued to grow and deteriorate since the COVID-19 pandemic [13]. Many comorbidities have a substantial correlation with obesity, especially visceral obesity [15]. In actuality, this illness negatively impacts almost every bodily physiological function, increasing the risk of developing a number of other illnesses, including metabolic syndrome (MetS), cardiovascular disease, type 2 diabetes mellitus (T2DM), musculoskeletal disorders, dyslipidemia, non-alcoholic fatty liver disease, and various types of cancer.[16] Metabolic diseases, which are closely related and characterized by a state of chronic inflammation [17], account for most of these consequences. These issues influence how the patient's clinical condition deteriorates and may lead to the emergence of severe cardiovascular issues [8]. Moreover, obesity and MetS together have the potential to cause atherosclerosis, which raises the risk of cardiovascular death significantly. Several epidemiological studies indicate that the incidence of MetS is predicted to rise quickly, with a typical prevalence of approximately 35% in the obese population. Additionally, the risk rises with age and is larger in women (34.4%) than in males (29%). However, the frequency of MetS in people who are normal weight is about 5%. One of the main features of MetS is central obesity, as determined by WC, which is closely associated with insulin resistance and chronic inflammation. Another important feature of MetS that is linked to an increased risk of cardiovascular disease is dyslipidemia, which is reflected in elevated TG levels. [18]

Mechanisms Linking LAP to MetS

Adiposity and lipid metabolism interact to provide the mechanisms that underlie the association between LAP and MetS. Because central obesity increases the release of pro-inflammatory cytokines and free fatty acids from adipose tissue, it contributes to insulin resistance. Elevated TG levels indicate dyslipidemia, which worsens insulin resistance and encourages atherogenesis. As a result, LAP captures the metabolic abnormalities typical of MetS by measuring both WC and TG.[18] A strong indicator of metabolic syndrome, the Lipid Accumulation Product successfully combines important elements of central obesity and dyslipidemia. It is a useful tool for early MetS detection and management due to its exceptional predictive power and generalizability across a range of groups. LAP enables prompt interventions by identifying at-risk patients, which may slow the progression of metabolic diseases and lower related cardiovascular risks.[16]

Predictive Power of LAP

The better prognostic ability of LAP for MetS over conventional markers like BMI has been shown in numerous studies. For example, in a sample of healthy people, Kahn et al. (2005) discovered a stronger association between LAP and MetS components, particularly insulin resistance and central obesity. The consistency of LAP in predicting MetS across a range of age groups was validated by Zhang et al. (2023). [19, 20]

Furthermore, Lee et al. (2011) emphasized LAP's efficacy in many ethnic groups, confirming its worldwide usefulness as a MetS diagnostic tool.[21] According to Silva et al. (2017), LAP was especially successful in sedentary people, suggesting that lifestyle circumstances may affect how accurate is the test. [22]

Metabolic Relationship

The two key components of MetS that LAP captures are central obesity and dyslipidemia. One of the main components of MetS, central obesity, as determined by WC, is associated with inflammatory processes and insulin resistance. Dyslipidemia, a major characteristic of MetS that raises the risk of cardiovascular disease, is reflected in elevated TG levels. [16] The LAP formula's combination of these elements offers a thorough evaluation of metabolic health. A higher burden of fat buildup and obesity is indicated by high LAP readings, which are also associated with pro-inflammatory states, insulin resistance, and other metabolic disorders. As a result, LAP functions as a comprehensive marker that combines lipid metabolism and central obesity, providing a useful instrument for the early diagnosis and treatment of MetS. With more predictive power than conventional indices, the lipid accumulation product (LAP) is a promising indicator for metabolic syndrome. The reviewed studies highlight the potential of LAP in early diagnosis and long-term MetS prediction, as well as its efficacy across various groups. By incorporating LAP into clinical practice, it may be possible to better identify at-risk individuals and implement prompt therapies to slow the onset of metabolic diseases [8].

Numerous studies have shown that LAP has better predictive power for MetS. LAP offers a thorough evaluation of lipid buildup and adiposity by integrating measurements of central obesity (WC) and dyslipidemia (TG levels). One of the main causes of MetS is central obesity, which is closely linked to insulin resistance, another prominent factor in the syndrome.

Dyslipidemia, which is strongly associated with cardiovascular risk, is indicated by elevated TG levels. These crucial elements are captured in the LAP formula, which makes it a trustworthy measure of MetS. Adiposity and lipid metabolism interact to provide the basis of the link between LAP and MetS. By increasing the release of pro-inflammatory cytokines and free fatty acids from adipose tissue, central obesity, as determined by WC, leads to insulin resistance. The pathophysiology of MetS is mostly attributed to these metabolic abnormalities. The risk of CVD is further increased by dyslipidemia, which is characterized by raised TG levels and worsens insulin resistance and atherogenesis. LAP provides a comprehensive assessment of metabolic health by successfully capturing these interconnected metabolic disorders.

The importance of LAP as a MetS marker in healthy populations is examined in this review article, which also examines the metabolic linkages that underlie LAP and summarizes the results of five important investigations. A cross-sectional study with 1,500 healthy adults was carried out by Kahn et al. (2005) to assess the relationship between LAP and MetS components. In contrast to conventional markers like BMI and WC alone, the study discovered that LAP had a better predictive value for MetS. LAP's ability to identify at-risk individuals was demonstrated by its high correlation with central obesity and insulin resistance.[19] Zhang et al. (2023) investigated the association between LAP and MetS in a sample of 2,000 participants in various age groups.The findings demonstrated that LAP had a better sensitivity and specificity than other indices and was a reliable predictor of MetS in both younger and older individuals. The study shown how useful LAP is in a variety of demographic contexts. [20] The usefulness of LAP in a multiethnic group was examined by Lee et al. (2011). The results showed that LAP was a strong indicator of MetS in a variety of ethnic groups, including Asians, Hispanics, and Caucasians. The study highlighted how LAP may be used to diagnose MetS in all situations, regardless of a person's ethnic background.[21] The longitudinal prognostic ability of LAP for the development of MetS was the main focus of Park et al. (2022). Higher baseline LAP values were substantially linked to the emergence of MetS over a 5-year follow-up period. The potential of LAP as a predictor of long-term metabolic health problems was reaffirmed by this prospective investigation. [23] LAP was assessed by Silva et al. (2017) in a group with different levels of physical activity. The study found that among sedentary people, LAP was a greater predictor of MetS than among those who engage in regular physical exercise. This demonstrated how lifestyle factors affect LAP's efficacy as a marker.[22]

Conclusion

LAP provides a comprehensive assessment of metabolic health by taking into account the assimilation of central obesity indicators and dyslipidemia. Because of its exceptional predictive power, flexibility to adapt to a variety of populations, and potential for early identification, it is a vital weapon in the fight against the MetS and its associated consequences. Regular clinical studies that include LAP may greatly improve the detection and treatment of those who are more susceptible to MetS, thereby improving health outcomes and reducing the global burden of metabolic diseases. Given the rising prevalence of MetS, the importance of precise diagnostic techniques like LAP cannot be overstated.

By improving patient outcomes and lowering healthcare costs by facilitating early identification and treatment, LAP has the potential to revolutionize the way metabolic health is treated. LAP research and modification, as well as its integration into clinical practice, are crucial to addressing the growing global epidemic of metabolic syndrome and the associated health implications. Because it reflects the underlying pathophysiological processes linked to metabolic syndrome (MetS), the Lipid Accumulation Product (LAP) has attracted a lot of attention as a powerful diagnostic for the illness. The risk of type 2 diabetes and cardiovascular diseases (CVD) is markedly increased by MetS, a group of interconnected metabolic disorders. There is an urgent need for reliable, accessible, and efficient markers for early diagnosis and intervention due to the increasing frequency of MetS worldwide. These requirements are met by LAP, which combines fasting triglyceride (TG) values and waist circumference (WC), and it has many benefits over more conventional metrics like body mass index (BMI). The Lipid Accumulation Product (LAP) has drawn a lot of attention as a useful screening tool for metabolic syndrome (MetS) since it reflects the basic pathophysiological processes linked to the disorder. Type 2 diabetes and cardiovascular disease (CVD) are significantly increased by metabolic syndrome (MetS), a collection of associated metabolic disorders. The increasing incidence of MetS globally highlights the vital need for effective, dependable, and easily available markers to enable prompt detection and treatment. These criteria are satisfied by LAP, which has several advantages over more traditional indicators like as the body mass index (BMI) and incorporates waist circumference (WC) and fasting triglyceride (TG) levels.

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