Research Progress on the Relationship Between Body Shape Index and Arteriosclerosis: Post-print

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Abstract

A Body Shape Index (ABSI) is a novel anthropometric indicator derived from measurements such as height, weight, and waist circumference through specific algorithms. With the increasing prevalence of overweight and obese populations, abdominal obesity demonstrates a stronger predictive value for cardiovascular events and mortality. Obesity contributes to the development and even fatal outcomes of cardiovascular diseases including arteriosclerosis, hypertension, and coronary heart disease by generating inflammatory cytokines, triggering chronic inflammatory responses, insulin resistance, metabolic disturbances, and oxidative stress pathways. ABSI exhibits good correlation with abdominal obesity and can predict arteriosclerosis in certain populations, though this relationship is also subject to population characteristics. For example, the association between ABSI and arteriosclerosis differs across populations of various regions, genders, and age groups. Elucidating the relationship between ABSI and arteriosclerosis is of significant importance for early identification of high-risk groups for arteriosclerosis and for rational prevention and management of cardiovascular diseases.

Full Text

Introduction

Atherosclerosis (AS) is a primary manifestation of cardiovascular disease and a crucial predictor of its morbidity and mortality. Early detection of AS can significantly reduce the fatality and disability rates associated with cardiovascular events. However, the global obesity epidemic presents a serious challenge. Changes in lifestyle and dietary patterns have driven a continuous rise in obesity rates. The World Obesity Federation projects that by 2035, more than 4 billion people worldwide will be obese or overweight, representing over half of

the global population [1]. In China, the rates of overweight and obesity are also rising rapidly, with recent studies predicting that by 2030, 65.3% of adults and 31.8% of school-age children and adolescents will be overweight or obese [2]. Furthermore, childhood obesity and adult overweight status are associated with increased cardiovascular disease risk in adulthood [3]. Obesity is a risk factor for numerous chronic non-communicable diseases, and fat distribution plays a critical role in determining cardiovascular disease risk. Current research indicates that abdominal obesity has greater predictive value for cardiovascular events than generalized obesity [4].

1. Overview of ABSI and Its Relationship with Obesity

A Body Shape Index (ABSI) is a novel anthropometric indicator for central obesity that is independent of Body Mass Index (BMI) and height. Compared with traditional BMI, ABSI demonstrates a stronger correlation with abdominal obesity. A deeper understanding of the relationship between ABSI and AS not only contributes to more scientific and effective obesity prevention and treatment but also provides important guidance for the rational prevention and management of cardiovascular disease. Currently, the correlation between ABSI and AS remains controversial, and existing studies lack comprehensive analysis and review of this relationship across different ethnicities and sexes. This review aims to describe the characteristics of ABSI and research progress on its predictive value for AS, thereby providing a scientific basis for early identification of populations at risk for AS.

ABSI was proposed by Krakauer [3-4] as a novel anthropometric index for assessing abdominal obesity, calculated as the ratio of waist circumference (WC) to the product of BMI raised to the 2/3 power and height raised to the 1/2 power [5]. ABSI shows a stronger correlation with mortality risk than BMI and WC [6-7], reflects the degree of body shape change from cylindrical to conical [8], and is currently the only index unaffected by the obesity paradox. In recent years, the validity of BMI as an obesity metric has been questioned, as using BMI alone to assess atherosclerosis may mask the metabolic status of individuals with normal weight [9-10]. Evidence indicates that ABSI is positively associated with higher all-cause mortality risk, and central obesity measures including ABSI can serve as complementary methods for assessing premature mortality risk [11]. ABSI addresses the limitations of BMI in distinguishing between fat and muscle mass and reflecting individual fat distribution [12], while also avoiding the time and economic costs associated with direct visceral fat assessment through computed tomography and magnetic resonance imaging.

2. Pathophysiological Mechanisms of Obesity-Induced Atherosclerosis

Obesity is a major risk factor for atherosclerosis. A recent meta-analysis demonstrated that overweight/obese subjects have increased arterial stiffness even without cardiovascular disease [13]. During obesity, expansion and remodel-

ing of adipose tissue depots lead to vascular dysfunction and cardiovascular disease [14]. The pathophysiological mechanisms through which obesity causes atherosclerosis are highly complex, and current understanding of the origin, molecular composition, and metabolism of perivascular adipocytes remains incomplete. Therefore, additional basic research at the molecular biology level is needed to further elucidate these mechanisms. Known relevant mechanisms are detailed below.

2.1 Obesity Promotes Atherosclerosis Through Inflammatory Responses Obesity can induce chronic low-grade inflammation [15]. Adipose tissue produces various inflammatory factors such as interleukin-6 (IL-6), interleukin-8 (IL-8), and tumor necrosis factor-α (TNF-α) [14]. Increased concentrations of these inflammatory factors in blood not only reduce vascular insulin sensitivity but also enhance recruitment and activation of pro-inflammatory immune cells, such as M1 macrophages [17], leading to impaired vasodilation and arterial wall remodeling that promotes atherosclerosis formation (Figure 1 [Figure 1: see original paper]).

2.2 Obesity Promotes Insulin Resistance and Metabolic Abnormalities Insulin metabolic signaling is key to regulating normal endothelial function and inhibiting vascular stiffening. Abdominal obesity more readily leads to insulin resistance and metabolic abnormalities because, under obese conditions, adipose tissue secretes large amounts of inflammatory factors and free fatty acids that interfere with normal insulin signaling pathway regulation, impairing endothelial cell glucose handling capacity and increasing free fatty acids, thereby compromising metabolic function under insulin signaling [16]. The mechanisms through which insulin resistance leads to atherosclerosis are complex. Studies in insulin-resistant Zucker rats have found reduced nitric oxide production and vascular smooth muscle cell damage, suggesting that insulin's effects on vascular smooth muscle are mediated by nitric oxide [18]. Reduced bioavailability of nitric oxide produced by vascular endothelial cells impairs vasodilation [19]. Consequently, obesity and insulin resistance accelerate vascular stiffening progression and increase cardiovascular disease risk.

2.3 Obesity Induces Oxidative Stress Obese individuals often consume high-fat, high-fructose diets that elevate serum uric acid levels [20] and activate hepatic xanthine oxidase (XO), leading to increased oxidative stress [21]. Under obese conditions, increased oxidative stress primarily results from metabolic disorders caused by high caloric intake and poor dietary quality. Uric acid is an important factor in oxidative stress; when dietary purine metabolism produces excessive uric acid, it stimulates XO activity, leading to further free radical generation and triggering oxidative stress responses. These free radicals also bind to intracellular lipids, proteins, and DNA, causing cellular damage and inflammatory responses. These processes accelerate atherosclerosis progression and increase the risk of cardiovascular and kidney diseases.

2.4 Obesity Alters Adipokine Secretion Adipose tissue not only stores fat but also secretes adiponectin, leptin, resistin, visfatin [22], angiotensin, and aldosterone to regulate glucose and lipid metabolism. When adipose tissue metabolism changes, it affects the expression of secreted substances. For example, perivascular adipose tissue (PVAT)-secreted adiponectin has anti-inflammatory effects, maintains insulin sensitivity [23], and provides cardioprotection [24-25]. During obesity, increased oxidative stress causes PVAT to sense oxidative products from the arterial wall and prevent vascular oxidative stress by increasing adiponectin expression [25]. Additionally, Cano et al. [26] confirmed that high-fat diets may disrupt the circadian rhythm of hormone and cytokine secretion through insulin resistance and inflammatory responses, thereby affecting leptin and monocyte chemoattractant protein-1 secretion.

3. Relationship Between ABSI and Atherosclerosis

Increasing evidence suggests an association between ABSI and atherosclerosis. However, due to substantial variations in obese populations across geography, diet, age, and obesity type, research findings on the ABSI-atherosclerosis relationship differ among ethnicities, ages, and sexes. For instance, Gang et al. [27] found that ABSI showed weaker correlation with atherosclerosis compared with traditional anthropometric indices, whereas Natsuho et al. [10] concluded that ABSI could predict atherosclerosis. These discrepancies highlight the need to examine how population characteristics influence this relationship.

3.1 Country and Region Differences in diet, sedentary habits, exercise patterns, and socioeconomic status across countries and regions affect vascular wall collagen metabolism, glucose metabolism, and oxidative stress processes. Research on the ABSI-atherosclerosis association remains controversial. Early studies emphasized ABSI's positive role in predicting atherosclerosis, while recent research has questioned this association. Krakauer et al. [5] found in the U.S. National Health and Nutrition Examination Survey that high ABSI independently predicted premature mortality risk regardless of BMI. A Japanese study on type 2 diabetic populations identified ABSI as an important marker of atherosclerosis in these patients [28]. Subsequently, Natsuho et al. [10] further noted that ABSI and Body Roundness Index (BRI) could identify metabolically healthy/unhealthy individuals and serve as predictive indicators for vascular remodeling or organic vascular dysfunction.

However, a recent cross-sectional study in Hubei, China, found that among overweight and obese populations, BRI showed a closer relationship with atherosclerosis, while ABSI only demonstrated weak correlation. The study suggested that combining ABSI with BMI provided a better index for assessing atherosclerosis [27], though it lacked a normal-weight control group. A recent cohort study on Persian adults found no significant association between ABSI and atherosclerosis in overweight women [29]. Currently, research data on the ABSI-atherosclerosis

correlation are scarce in Africa, Southeast Asia, the Western Pacific, and parts of Asia—regions where obesity rates are rising annually. The atherosclerosis problems resulting from obesity in these areas warrant future attention. Additionally, multi-center studies including multi-regional populations are needed to further clarify geographic differences between ABSI and atherosclerosis, thereby guiding early prevention and treatment of atherosclerosis and obesity in different regional populations.

3.2 Sex Clinical manifestations and incidence of atherosclerosis differ between sexes, with the correlation between atherosclerosis and mortality being twice as strong in women as in men [30]. Women have more subcutaneous adipose tissue, while men are characterized by greater visceral adipose tissue. Atherosclerosis represents an early manifestation of vascular dysfunction in obese individuals [31]. Current evidence suggests that although BMI and WC cannot accurately identify metabolically healthy/unhealthy men and women, ABSI is slightly inferior to BRI and waist-to-hip ratio (WHR) for assessing atherosclerosis in female populations. For male populations, different studies have yielded inconsistent conclusions. For example, some research suggests ABSI can accurately assess fat distribution to predict atherosclerosis in non-obese men, while BRI combined with BMI more accurately evaluates body composition in women [10]. Zhang et al. [32] found that BRI and waist-to-height ratio (WHtR) showed better atherosclerosis prediction ability than ABSI in both sexes. Tang et al. [33] analyzed ABSI, BRI, WHR, and BMI for atherosclerosis prediction and found that WHR showed stronger association with atherosclerosis in women, a phenomenon not observed in men. Currently, sex differences are often adjusted as confounding factors in most studies, with few studies deeply analyzing the ABSI-atherosclerosis relationship from a sex perspective.

3.3 Age Aging is an important and unavoidable risk factor for atherosclerosis, with age directly correlating with increased arterial wall thickness [34-35]. As elastic arteries age, structural changes occur including fracture of elastic lamellae, decreased elastin, and enhanced collagen and its cross-linking, which alter vascular smooth muscle tone and cause atherosclerosis [36]. Atherosclerosis predominantly affects middle-aged and elderly individuals over 40. Bouchi et al. [28] found that patients with high ABSI were older, had longer diabetes duration, and faster brachial-ankle pulse wave velocity compared with low ABSI patients. Beyond lower extremity atherosclerosis, the risk of hypertension-mediated organ damage in elderly individuals increases with elevated ABSI [33]. Due to limited ABSI application in youth and children, no consistent conclusions have been reached regarding age's effect on the ABSI-atherosclerosis relationship.

4. ABSI Applications in Other Fields

ABSI demonstrates considerable potential not only for predicting atherosclerosis but also in cardiovascular disease, metabolic disease, kidney disease, neurological disorders, and mental health. Regarding cardiovascular disease, Otaki et al. [37]

found ABSI associated with mortality from aortic disease. Additionally, ABSI can identify metabolic syndrome [38]. When diagnosing metabolic syndrome, replacing waist circumference with ABSI enhances the predictive ability for renal function decline [39], and ABSI predicts diabetes risk better than BMI [40]. In kidney disease, studies indicate that individuals with higher ABSI levels constitute a high-risk group for elevated urinary albumin-to-creatinine ratio [41]. Similarly, a cross-sectional study of 203 patients with stage 5 chronic kidney disease found ABSI significantly correlated with inflammatory status in these patients [42].

In neurological disorders, Nam et al. [43] found ABSI associated with cerebral small vessel disease. In mental health, Lotfi et al. [44] confirmed that among Iranian adults, ABSI correlates with anxiety, depression, and psychological distress in women. However, some studies suggest ABSI cannot completely replace BMI and WC, and that combining ABSI with BMI provides better predictive ability. A meta-analysis indicated that both original and modified ABSI showed lower predictive ability for pediatric hypertension than BMI and WC [45]. Evidence also suggests that BMI combined with ABSI better identifies obesity-related non-alcoholic fatty liver disease risk, significantly outperforming BMI, WC, or ABSI alone [46].

5. Summary and Outlook

Comprehensive studies demonstrate that obesity contributes to atherosclerosis formation by promoting inflammatory responses, insulin resistance, and altering adipokine secretion. ABSI not only better reflects abdominal obesity but also serves as a novel index for evaluating body morphology related to atherosclerosis, with clinical application value in predicting diabetes and metabolic syndrome. Current research findings on the correlation between ABSI and atherosclerosis show substantial discrepancies. While some studies suggest ABSI correlates with atherosclerosis indicators, an increasing number of scholars have questioned this association in recent years. Moreover, systematic evaluations of their relationship are lacking, necessitating further population studies to clarify the connection between ABSI and atherosclerosis.

As research data accumulate and analytical techniques advance, future ABSI studies could proceed in several directions. First, quantitative research should examine the ABSI-atherosclerosis relationship in different populations. Second, prospective cohort studies comparing outcomes across different ABSI value ranges and initial atherosclerosis severity levels are needed to further confirm ABSI's clinical application value. Additionally, multiple methods including imaging and vascular function testing could explore ABSI's pathophysiological mechanisms in atherosclerosis. Finally, comparing ABSI with other obesity and body morphology assessment indices would help clarify ABSI's advantages and limitations in evaluating body shape. Such research will facilitate more accurate assessment of ABSI's value in atherosclerosis and promote its widespread application in clinical practice.

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Note: Figure translations are in progress. See original paper for figures.