Editorial

Beyond the Number: Re-evaluating the History, Limitations, and Future of Body Mass Index

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Body mass index (BMI), with its simple formula of weight divided by height squared, has become a cornerstone tool in global public health for assessing obesity and health risks. However, as populations aging and the demand for precise health evaluation grows, the limitations of this single metric have become increasingly apparent—it fails to distinguish between muscle and adipose tissue and cannot capture the complex relationship between inflammatory status and body composition. A recent study published in *Biomedical and Environmental Sciences* (*BES*) by Zhang et al.[1], which explores the association of white blood cell (WBC) count, platelet (PLT) count, and platelet-to-white blood cell ratio (PWR) with muscle mass among Chinese community-dwelling older adults, provides critical evidence for rethinking the role of BMI. Additionally, several studies published in *BES*, spanning from childhood nutrition to adult metabolism, further illuminate the complexity of health assessment[2–5]. Building on these findings and integrating evidence from multiple Chinese population studies, this commentary revisits the historical context, utility, inherent limitations, and future directions of this classic indicator.

Historical Evolution: From Population Description to Health Assessment

The concept of BMI originated in the 19th century from the "social physics" research of Belgian scholar Adolphe Quetelet. In 1835, Quetelet proposed that "body weight is proportional to the square of height" as a statistical formula to describe the physical characteristics of the "average man", rather than for individual health assessment[6]. This mathematical tool was rediscovered and applied to obesity screening in the mid-20th century, primarily due to its computational simplicity and ease of data collection.

The year 1975 marked a pivotal moment in the application of BMI. Based on population epidemiological data, the United States established BMI ≥ 25 kg/m^2 and BMI ≥ 30 kg/m^2 as the cut-off points for overweight and obesity, respectively[7]. This standardization elevated overweight from an individual health concern to a public health challenge requiring systematic response, providing a unified quantitative tool for monitoring global obesity trends.

Practical Value: A Useful Tool for Population Screening and Related Studies

At the population level, BMI demonstrates unique practical value:

Advantage in Large-scale Monitoring and Studies: It is suitable for macro-level epidemiological surveys and can rapidly reflect population-level obesity trends. For example, Qi et al.[8] used data from six nationwide surveys to clearly outline the long-term trajectory of weight changes among Chinese older adults from 2002 to 2018.

Operational Simplicity: With only height and weight measurements, BMI serves as a standardized indicator for global public health surveillance.

Association with Population Risk: At the group level, BMI shows significant correlations with chronic disease risks. Mi et al.[9] confirmed that elevated BMI is closely associated with an increased risk of type 2 diabetes in Chinese community populations, providing important evidence for formulating group intervention strategies.

Inherent Limitations: Reflections from Superficial to Essential

Inability to Differentiate Body Composition The cross-sectional study by Zhang et al.[1], including 4,033 community-dwelling older adults in China, identified significant negative correlations between WBC, PLT, PWR, and muscle mass (coefficients: −0.0091, −0.0119, −0.0051, respectively) after adjusting for age, sex, smoking, alcohol consumption, and number of chronic diseases,

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profoundly revealing a core flaw of BMI. This highlights BMI's fundamental limitation: it cannot distinguish between "muscle-dominant overweight" and "fat-dominant overweight". Similarly, research by Shen et al.[2] on infant feeding demonstrates complex associations between breastfeeding duration and childhood body composition, further evidence that a single BMI metric struggles to capture body composition differences established early in life. For adult and elderly, the same BMI value may correspond to entirely different health states—a normal BMI may mask muscle loss, while a high BMI may reflect better health outcomes due to preserved muscle mass[10].

Neglect of Population Heterogeneity BMI demonstrates inadequate adaptability across diverse populations:

Regional Variations: A meta-analysis by Sun et al.[11] using a random-effects model (I^2 = 92.4% for children, 96.4% for adults) integrated 21 studies across China, showing that the correlation between BMI and body fat percentage is significantly stronger in northern China than in eastern China (r = 0.74 *vs*. 0.51 in children), with notable urban-rural differences.

Age Specificity: Lv et al.[12] found that among the oldest-old, individuals with BMI ≥ 24 kg/m^2 had a lower 3-year all-cause mortality than those with BMI < 18.5 kg/m^2. This "obesity paradox" is often observed in the very old, those with chronic conditions, or individuals at risk of malnutrition, potentially reflecting the role of body mass in metabolic reserve and disease resilience. It does not negate the overall health risks of obesity in the general population, but cautions against a simplistic interpretation of BMI for prognostic assessment in specific subgroups.

Physiological Differences: Zhang et al.[1] also found that the association between inflammatory markers and muscle mass varies by sex and age, a complexity that BMI fails to capture.

Omission of Metabolic and Nutritional Dimensions Research by Zhao et al.[3] indicates that the serum uric acid to HDL-cholesterol ratio (UHR) holds greater value than BMI in assessing the risk of nonalcoholic fatty liver disease, suggesting that reliance on BMI alone may overlook crucial metabolic dysregulation. Similarly, Zhu et al.[5] found independent associations between serum folate and vitamin B12 levels and obesity risk in Chinese children and adolescents, highlighting the importance of nutritional status in obesity assessment. Collectively, these studies demonstrate that BMI, as a purely morphological indicator, fails to reflect the metabolic and nutritional dimensions associated with obesity.

Future Directions: Toward a New Paradigm of Precision Health Assessment

Undoubtedly, BMI remains the first line indicator for both individual and population assessment. But based on current evidence, future health assessment systems must transition from a single metric to a multidimensional integrative approach:

Integration of Body Composition Measurement Technology Adoption: Where resources permit, promote the clinical application of techniques such as bioelectrical impedance analysis (BIA) and dual-energy X-ray absorptiometry (DXA) for accurate assessment of muscle mass and body fat percentage, particularly in high-risk groups such as the elderly and patients with chronic diseases.

Indicator Optimization: Select and adjust indicators based on distinct research or practical purposes. Emphasize the value of central obesity indicators such as waist-to-height ratio (WHtR) in certain circumstances. Research by Mi et al.[9] confirmed that WHtR outperforms BMI in screening for diabetes.

Incorporation of Inflammatory and Metabolic Markers Inflammatory Assessment: Include easily accessible inflammatory markers like WBC, PLT, and PWR in routine evaluations for early identification of risks such as sarcopenia.

Metabolic Profiling: Incorporate novel metabolic ratio indicators like UHR[3] (serum uric acid to HDL-cholesterol ratio) to build a more comprehensive metabolic risk assessment framework, thereby improving risk stratification and avoiding the misclassification of phenotypes such as metabolically healthy obesity.

Development of Population-Specific Standards Age Stratification: Establish differentiated assessment standards for various age groups (e.g., 65–79 years *vs*. ≥ 80 years), with particular attention to the unique characteristics of the oldest-old.

Regional Adaptation: Develop localized reference standards tailored to the characteristics of Chinese populations, accounting for north-south and urban-rural differences, informed by findings on regional disparities such as those reported by Shan et al.[4].

Implementation of Life-Course Management Early Intervention: Studies by Shen et al.[2] on breastfeeding and childhood body composition, alongside the longitudinal follow-up by Liu et al.[13], both indicate that early life factors exert lasting effects on long-term body composition and obesity risk, underscoring the need for early intervention.

Precision Management: Implement differentiated strategies based on population characteristics, such as focusing on malnutrition prevention among rural older women and chronic disease management among urban younger-old adults. Simultaneously, considering the association between nutrient status and obesity revealed by Zhu et al.[5], integrate micronutrient assessment into personalized plans.

Conclusion

As a significant tool in the history of epidemiology, BMI has played an irreplaceable role in population health monitoring. From the establishment of overweight standards in the United States in 1975 to the emergence of the overweight epidemic in China in the late 1990s, BMI has provided important quantitative insights for understanding the epidemiology of obesity. However, in the era of precision medicine, the limitations of BMI have become increasingly evident. Multiple recent studies published in *BES*[1-5] collectively point to one conclusion from different perspectives: health assessment must move beyond the single BMI metric. The study by Zhang et al.[1] reminds us that the focus of health assessment should shift from merely "meeting numerical targets" to a multidimensional integration of "balanced body composition, stable inflammatory status, and optimal metabolic function". The future construction of health assessment systems should retain BMI's irreplaceable value in large-scale population screening, while innovatively developing multidimensional supplementary tools (integrating body composition, inflammation, and metabolism) for individual-level assessments, such as elderly frailty screening, chronic disease management, and childhood growth monitoring. The association between inflammatory status and muscle mass revealed by Zhang et al.[1] epitomizes this necessary shift—health assessment must evolve from "weight divided by height squared" to a multidimensional integration of "composition, metabolism, and inflammation".

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