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Title:

Assessing Adult Obesity: A Comprehensive Review of Diagnostic Tools and Measurement Indicators

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Abstract

Obesity is a complex, chronic metabolic disorder characterized by excess adiposity and associated with numerous comorbidities, including cardiovascular, endocrine, and immune dysfunctions. As global prevalence and incidence of obesity continue to rise, early and accurate assessment of body composition is critical for effective disease prevention, management, and intervention. This review synthesizes current knowledge regarding adult obesity diagnostic approaches, focusing on commonly used measurement tools and indices. We examine anthropometric indices (body mass index, waist circumference, waist-to-hip ratio, waist-to-height ratio, neck circumference, skinfold thickness, and body adiposity index), density-based methods (air displacement plethysmography, underwater weighing), advanced imaging techniques (dual-energy X-ray absorptiometry, computed tomography, magnetic resonance imaging), and bioelectrical impedance analysis. Each approach's advantages, limitations, and practical applicability are discussed. Emphasis is placed on the importance of selecting appropriate methods according to individual, ethnic, and population-level contexts. This comprehensive overview aims to inform improved clinical decision-making and guide future research toward more accurate and accessible obesity assessment technologies.

1. Introduction

Obesity has reached epidemic proportions globally, imposing tremendous burdens on healthcare systems and affecting individuals' health and life quality. Characterized by abnormal or excessive fat accumulation, obesity predisposes individuals to a spectrum of metabolic, cardiovascular, and musculoskeletal disorders, as well as psychological issues [1,2]. According to the World Health Organization (WHO), worldwide obesity rates have nearly tripled since 1975, with an estimated 650 million obese adults in 2016 [3]. Effective diagnosis, assessment, and monitoring of obesity are therefore essential for early intervention and health promotion.

Traditional measures, notably body mass index (BMI), have historically served as convenient screening tools due to simplicity and cost-effectiveness. However, BMI alone is insufficient for accurately characterizing adiposity distribution and body composition, prompting the development and validation of complementary measurement techniques [4,5]. Advances in imaging, bioelectrical impedance, and anthropometric indices have refined obesity diagnostics. This review consolidates existing literature on adult obesity diagnostic tools, their underlying principles, limitations, and practical applications, providing a roadmap for clinicians and researchers in selecting and implementing appropriate assessment strategies.

2. Density Measurement Methods

2.1. Air Displacement Plethysmography (ADP)

ADP estimates body density by measuring changes in air volume displaced within a sealed chamber. Devices like the BOD POD offer rapid, noninvasive assessment, demonstrating errors around 1–2% in body fat percentage estimation [6,7]. While

ADP correlates well with reference methods, expenses, technical complexity, and the need for specialized equipment limit widespread use.

2.2. Underwater Weighing (Hydrodensitometry)

Long considered a “gold standard,” underwater weighing determines body density based on weight differences in air versus submerged in water [8]. Correcting for residual lung volume yields body fat percentage estimates with a standard error of approximately 1.3–1.5% [9]. However, the method’s inconvenience, discomfort, and high resource requirements curtail routine clinical use.

3. Anthropometric Indices

3.1. Body Mass Index (BMI)

BMI, calculated as weight (kg)/height2 (m2), has been widely adopted for obesity screening due to its simplicity and low cost. Although BMI correlates with body fat, it fails to distinguish between fat and lean mass or account for fat distribution [10]. Despite limitations, BMI remains integral in large-scale epidemiological studies and initial clinical screening.

3.2. Waist Circumference (WC)

WC serves as a surrogate measure of abdominal (visceral) fat, strongly linked to metabolic and cardiovascular risks [11,12]. Different international cutoffs exist, reflecting population-specific differences. WC is simple, low-cost, and clinically relevant, making it valuable in identifying central obesity.

3.3. Waist-to-Hip Ratio (WHR)

WHR, the ratio of WC to hip circumference, indicates fat distribution and central adiposity. It correlates with metabolic disturbances and cardiovascular risk more closely than BMI, though variability in measurement and interpretative complexity limit its routine application [13,14].

3.4. Waist-to-Height Ratio (WHtR)

WHtR (WC/height) effectively identifies central obesity and predicts hypertension, dyslipidemia, and type 2 diabetes risks. WHtR's independence from gender and relatively uniform cutoff (≥0.5) streamline comparisons across populations [15,16].

3.5. Neck Circumference (NC)

NC indirectly reflects upper-body subcutaneous fat and correlates with metabolic syndrome, obstructive sleep apnea, and cardiovascular risk [17,18]. While simple to measure, NC cutoffs vary by ethnicity and require further standardization.

3.6. Skinfold Thickness

Measuring skinfold thickness at various body sites (e.g., triceps, subscapular) estimates subcutaneous fat and, by extension, total body fat. Although low-cost and widely accessible, results depend heavily on operator skill, skinfold site selection, and caliper precision [19,20].

3.7. Body Adiposity Index (BAI)

BAI employs HC and height to estimate fat percentage without measuring weight. While simpler than density-based methods, BAI's accuracy remains debated, and it may underperform compared to WC and BMI [21,22].

3.8. A Body Shape Index (ABSI)

ABSI combines WC, BMI, and height to reflect central obesity and associated health risks. While potentially superior to BMI alone, ABSI's complexity and lack of universal standardization limit its clinical uptake [23].

4. Bioelectrical Impedance Analysis (BIA)

BIA estimates body composition by measuring electrical impedance differences between fat and lean tissues. BIA devices range from simple hand-held units to sophisticated multi-frequency systems. Although convenient and relatively accurate, BIA is influenced by hydration status, recent exercise, and device-specific algorithms [24,25]. Thus, BIA is suitable for clinical and research settings but requires careful protocol adherence.

5. Dual-Energy X-ray Absorptiometry (DEXA)

DEXA quantifies bone mineral density and partitions body mass into fat and lean compartments with high precision and moderate radiation exposure. DEXA provides regional fat distribution data and correlates strongly with reference methods like CT and MRI [26,27]. Equipment cost, technical complexity, and limited portability restrict DEXA's widespread use in routine practice.

6. Advanced Imaging Techniques: CT and MRI

CT and MRI offer unparalleled detail on adipose tissue distribution and organ-specific fat infiltration, considered reference standards for body composition analysis [28,29]. However, these methods are expensive, less accessible, and may involve radiation (CT) or lengthy scanning times (MRI), limiting their feasibility for large-scale screening.

7. Limitations and Considerations

Each diagnostic tool presents unique advantages and drawbacks. Genetic, ethnic, and sex differences influence body composition and necessitate population-specific criteria. Age-related changes in muscle mass and bone density further complicate obesity assessment [30]. Multiple-marker approaches, combining BMI with WC, WHtR, or BIA, improve accuracy. Standardization and validation studies are essential for new indices like ABSI or BAI. Cost, complexity, and patient comfort also guide method selection.

8. Conclusion

A range of diagnostic tools and indicators enables comprehensive obesity assessment, each with differing accuracy, cost, feasibility, and clinical utility. Anthropometric indices (e.g., BMI, WC, WHtR) remain indispensable for large-scale screening due to simplicity and affordability. BIA, DEXA, and imaging modalities offer refined body composition insights, beneficial for targeted interventions. Future research should pursue harmonized reference standards, integrate multi-indicator approaches, and develop innovative, accessible tools that enhance early detection, personalized management, and prevention of obesity-related comorbidities.

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