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Review Article

The Assessment of Nutritional Status in Pediatrics: New Tools and Challenges. Review

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Abstract

Nutritional assessment in the pediatric population is a cornerstone of health monitoring, yet it faces unprecedented challenges. This review analyzes the transition from traditional anthropometry to advanced morphofunctional assessment. We evaluate the limitations of the Body Mass Index (BMI) and the emerging superiority of the Tri-ponderal Mass Index (TMI). Furthermore, we discuss the role of body composition models (from two to four compartments), the clinical integration of Bioelectrical Impedance Analysis (BIA), and the diagnostic potential of muscle ultrasound. Finally, we address the evolving therapeutic landscape of GLP-1 receptor agonists and the necessity of expanding nutritional vigilance to oncology and critical care patients.

Introduction

The grand challenges of pediatric endocrinology

The field of pediatric endocrinology and nutrition is currently navigating a period of rapid evolution [1]. The focus has shifted from mere growth monitoring to understanding how early nutritional insults translate into adult morbidity [2,3]. The "Barker Hypothesis" remains a seminal framework, establishing that fetal and infant nutritional status are critical determinants of long-term cardiovascular health and mortality [4,5].

Today, the pediatrician must confront a dual burden: A persistent obesity epidemic and a rising incidence of complex metabolic disorders [2,6]. These challenges require a sophisticated understanding of the endocrine system's role in mediating growth and health throughout the pediatric lifespan.

Clinical Context: Multifactorial Eating Disorders

While the COVID-19 pandemic catalyzed an alarming increase in Eating Disorders (EDs) such as anorexia nervosa, it is imperative to view these conditions through a multifactorial lens [3]. EDs in children and adolescents are not merely environmental reactions but result from a complex interplay of genetic, biological, and psychosocial determinants that pre-date recent global health crises. A comprehensive nutritional assessment must therefore be sensitive to these diverse etiologies to provide effective, individualized care.

Anthropometric Modalities: The BMI *vs.* TMI Debate

Limitations of the Body Mass Index (BMI)

For decades, the BMI (kg/m^2) has been the standard for estimating adiposity [7]. However, its reliability in pediatrics is frequently questioned because the index is not constant; it fluctuates significantly based on age, sex, and pubertal stage [8]. Systematic reviews have shown that BMI often fails to accurately identify obesity when defined by actual body fat percentage, particularly in the "metabolically unhealthy" phenotype [9].

The emergence of the Tri-ponderal Mass Index (TMI)

Current research identifies the TMI (kg/m^3) as a more precise estimator of body fat percentage in children aged 8 to 18 years [10]. Unlike BMI, which requires complex z-score transformations to remain relevant across growth stages, TMI offers a more stable relationship with adiposity. Recent Spanish studies have validated its diagnostic accuracy in identifying unhealthy metabolic phenotypes, suggesting that TMI should be considered for universal adoption in pediatric clinics [11].

Advanced Body Composition and Compartmental Models

The four-compartment (4C) model

Traditional assessment relies on a two-compartment model (fat mass and fat-free mass). However, the 4C model which accounts for water, mineral, protein, and fat content is now the recognized gold standard for research [12,13]. This model integrates multiple techniques, such as DXA and air displacement plethysmography, to provide a definitive picture of the growing human body [14,15].

DXA, MRI, and imaging

Dual-energy X-ray Absorptiometry (DXA) provides a reliable measure of adiposity but is limited by pediatric variability in tissue hydration [16]. While MRI and CT offer high-resolution data, their use is typically reserved for research or critical diagnostic scenarios due to cost and radiation considerations.

Bioelectrical Impedance Analysis (BIA)

BIA has proven to be a more accurate method than simple anthropometry for determining body composition in Spanish populations [17]. By measuring the body's resistance to an electrical current, clinicians can estimate fat-free mass and total body water. In the context of critical illness, the "phase angle" derived from BIA serves as a vital prognostic marker for morbidity and mortality in the Pediatric Intensive Care Unit (PICU) [18].

Muscle Ultrasound and Subjective Global Assessment (SGA)

The transition toward "morphofunctional" nutrition highlights the importance of muscle ultrasound. This non-invasive tool allows for the detection of both quantitative changes (muscle atrophy) and qualitative structural shifts related to systemic inflammation [19]. It complements traditional screening tools like the Subjective Global Assessment (SGA) and the ESPEN guidelines, which emphasize the importance of bedside screening to prevent hospital-acquired malnutrition [18,20].

Pharmacological Landscape: GLP-1 Receptor Agonists

The management of pediatric obesity has been revolutionized by the approval of GLP-1 receptor agonists. Liraglutide and semaglutide are now officially approved by the FDA and EMA for patients aged 12 and older [19,21-23]. Despite this regulatory milestone, clinicians still face significant hurdles in access and supply, complicating the practical implementation of these highly effective treatments [24-28].

Broadening the Clinical Scope: Chronic Disease and Critical Care

Nutritional assessment must be integrated into the management of all pediatric chronic conditions. In oncology, detecting early muscle wasting can alter the course of treatment. In intensive care, where fluid shifts make weight-based assessment unreliable, the use of ultrasound and BIA becomes indispensable. The goal is to move away from a "one-size-fits-all" approach and toward a precision-based nutritional strategy.

Conclusion

The future of pediatric nutrition lies in the integration of simple, cost-effective, and non-invasive tools that provide a qualitative view of health. By universalizing the TMI, standardizing muscle ultrasound, and leveraging new pharmacotherapies, we can better predict and improve the long-term prognosis of our patients.

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