BODY COMPOSITION ANALYSIS (BCA): APPLICATIONS IN HEALTH AND DISEASE

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Abstract:
Body composition analysis (BCA) provides valuable information about the distribution of fat mass and lean body mass. This data is crucial for assessing an individual's overall health status, identifying obesity or malnutrition, and evaluating the risk of chronic diseases such as diabetes, cardiovascular disease, and osteoporosis. In children, body composition analysis helps track growth and development, identify nutritional deficiencies, and assess overall health and wellness. In elderly, body composition assessment can guide nutritional requirement and prevention of sarcopenia. Athletes can accurately assess their requirement of nutrition depending on various phases of training and workouts as well as preparation of competitions. Clinicians can use body composition to provide appropriate management in cancer patients, patients in critical care setup and overall management of various illness. In the era of precision medicine, body composition data may play a role in tailoring medical treatments based on an individual's unique physiology.

Key Words: Body composition analysis, obesity, athletes, elderly, critical care, nutrition, sarcopenia.

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Introduction:

Body composition, the proportion of different tissue types in the human body, plays a pivotal role in determining overall health and well-being. The quantitative analysis of body composition has emerged as a crucial tool in the field of clinical medicine, providing valuable insights into various physiological and pathological conditions. Traditional anthropometric measurements, such as body mass index (BMI), have long been used to assess body composition (1). However, advancements in technology and the development of sophisticated imaging techniques have revolutionized the way we understand and utilize body composition assessments in clinical settings (2). Body composition analysis (BCA) has emerged a popular tool in both research field and in clinical practice. Though considered more relevant particularly in the field of metabolism and clinical nutrition, but potentially its application is much broader, touching virtually every specialty in medicine. BCA is applicable to the study of physiological conditions—such as aging (3), growth, or adaptations in athlete to physical activity(2). It is also helpful in understanding pathophysiology of many different conditions including obesity, diabetes mellitus, cancer, malnutrition, and sarcopenia. Interventions like physical exercise and nutritional therapy can be assessed for effectiveness by monitoring BCA (4-6).

Body composition analysis provides valuable information about the distribution of fat mass and lean body mass. This data is crucial for assessing an individual's overall health status, identifying obesity or malnutrition, and evaluating the risk of chronic diseases such as diabetes, cardiovascular disease, and osteoporosis (1,5). Understanding body composition helps in distinguishing between fat mass and lean mass. This differentiation is essential for designing effective weight management strategies and monitoring progress during weight loss or gain interventions (1,7). Athletes and fitness enthusiasts can benefit from body composition analysis to assess their muscle mass, body fat percentage, and overall body composition. This information is vital for optimizing

training programs and nutritional plans to enhance athletic performance (8). Body composition analysis aids in developing personalized nutritional plans for individuals based on their body's unique composition. It helps in tailoring macronutrient and caloric intake to meet specific health and fitness goals (1,5). Monitoring Aging and Sarcopenia: With age, there is a natural loss of muscle mass known as sarcopenia. Body composition analysis can help identify sarcopenia early and track its progression, enabling timely interventions to maintain muscle mass and functional independence in older adults (9,10).

Body composition data is valuable in clinical research studies exploring various aspects of health and disease, including treatment outcomes, disease progression, and the impact of interventions (3). Body composition analysis can estimate bone mineral density, aiding in the diagnosis and monitoring of conditions like osteoporosis (4). In children, body composition analysis helps track growth and development, identify nutritional deficiencies, and assess overall health and wellness (11). Body composition analysis can be beneficial for patients undergoing medical treatments, surgeries, or lifestyle changes, as it allows clinicians to monitor changes in lean mass and fat mass and make necessary adjustments to treatment plans (12). Body composition analysis can influence body image perceptions, especially in individuals with eating disorders or body dysmorphia. Clinicians can use this information to provide appropriate counselling and support (5). As precision medicine becomes more prominent, body composition data may play a role in tailoring medical treatments based on an individual's unique physiology (13). Fitness centres and weight management clinics often use body composition analysis to assess their clients' progress and the effectiveness of their programs (13). Thus overall body composition analysis helps in understanding overall health assessment, health promotion, disease prevention, and early identification of subclinical disorders to the management of these disorders. The next part of the review will focus on various key clinical applications in detail.

Evaluation of Body Fat Distribution

Different body fat distribution patterns can be associated with varying health risks. Body composition assessment helps identify individuals with central obesity (excess fat around the abdomen), which is linked to a higher risk of metabolic and cardiovascular diseases (14).

Resting Energy Expenditure (REE) Estimation: Body composition data, along with other factors like age, sex, and physical activity level, is used to estimate resting energy expenditure. This information is crucial for determining an individual's caloric needs for weight maintenance or weight loss (15).

Nutritional assessment:

For healthcare professionals, before advising nutritional changes to the patient, it is important to gain valuable insights into an individual's body composition, fat distribution, and muscle mass. These applications play a critical role in designing personalized dietary plans and optimizing nutritional interventions. By measuring body fat percentage and fat mass, helps identify individuals who are overweight or obese which is essential for evaluating the risk of obesity-related health conditions and tailoring dietary interventions accordingly (1,16). By evaluating lean muscle mass and fat mass, body composition analysis aids in detecting malnutrition and assessing the severity of nutritional deficiencies. This is particularly relevant in clinical settings for identifying individuals at risk of malnutrition (5). By knowing

an individual's body composition provides insights into their unique metabolic needs. This information is crucial for developing personalized nutritional plans that consider factors like muscle mass, metabolic rate, and body fat distribution (13). Regular body composition assessments allow healthcare providers to track changes in fat mass and lean muscle mass during weight loss or gain interventions. This enables them to adjust dietary recommendations and exercise plans as needed to achieve desired outcomes (12,13).

Nutritional Counselling for Athletes

For athletes, body composition analysis provides insights into their body fat percentage and muscle mass, helping optimize their nutrition and training plans to enhance performance and recovery (17). Knowledge of body composition and specifically body fat and lean mass distribution will help to determine the type of fuel mixture which can be used in preparation or during workout or after exercise. Also what proportion of nutrients to use as fuel for practice and also what to use during pre-competition preparation (e.g. athletes with lower body fat typically need more calories and carbohydrates than athletes with higher body fat) this is also a factor in a maintenance program in the off-season, when many athletes are still fuelling for competition (out of habit) but working out significantly less or at lower intensity (3,8).

Body composition in Elderly

The proportion of muscle, bone and fat changes with aging. Several equations have been developed to predict Body composition using anthropometric measurements that determines only fat mass (FM) and fat-free mass (FFM). The correlation between total fat and subcutaneous fat decreases with age. The natural aging process causes progressive bone demineralization and changes in the hydration of the FFM, causing a decrease in its density which also affects the FM estimate. Body composition alterations have a great impact on health, quality of life, and functional capacity in elderly. (18)

Obesity management:

Using body composition assessment in obesity management offers the following benefits:

Incorporating body composition assessment into obesity management allows for a more holistic approach to weight loss, promoting not just a decrease in weight but also an improvement in body composition and overall health. It helps in the differentiation between Fat Mass and Lean Mass which is crucial because weight loss interventions should primarily target fat loss while preserving lean muscle mass (7,11). Understanding an individual's body composition allows for the development of personalized diet and exercise plans, considering their unique metabolic needs and body composition goals (11,19). Regular body composition assessments enable healthcare providers to monitor changes in fat mass and lean mass during the weight loss journey, providing feedback and motivation to patients (16,19). Plateaus are common during weight loss. Body composition analysis helps identify these periods, allowing healthcare providers to adjust the treatment plan and maintain progress (16). By tailoring weight loss interventions based on body composition analysis, patients are more likely to achieve sustainable weight loss, leading to improved overall health and reduced obesity-related comorbidities (13).

Sarcopenia assessment:

It is a medical condition characterized by the progressive loss of skeletal muscle mass, strength, and function, primarily associated with aging (8). The term "sarcopenia" comes from the Greek

words "sarx" (flesh) and "penia" (deficiency), reflecting the reduction in muscle tissue that occurs in this condition. As individuals age, there is a natural decline in muscle mass and function, which can lead to various negative health consequences (11). Sarcopenia is prevalent in older adults and is considered one of the major contributors to age-related frailty, decreased physical performance, and an increased risk of falls and fractures (14). It can significantly impact an individual's quality of life and independence. Several factors contribute to the development of sarcopenia, including hormonal changes, reduced physical activity, poor nutrition, chronic inflammation, and other underlying health conditions (15). However, it is essential to note that not all older adults will experience sarcopenia, and its severity can vary among individuals. Diagnosing sarcopenia involves assessing muscle mass, strength, and physical performance (10). Various methods are used to evaluate muscle mass, such as dual-energy X-ray absorptiometry (DXA) and bioelectrical impedance analysis (BIA) (14).

Grip strength and gait speed are common measures used to assess muscle strength and physical performance (2). Addressing sarcopenia involves a multifaceted approach that includes lifestyle modifications, exercise, and nutritional interventions (3). Resistance training, such as weight lifting, is particularly beneficial for preserving and building muscle mass and strength (4). Protein intake, along with an overall balanced diet, is essential for supporting muscle health and repair (5). As sarcopenia is a significant public health concern, researchers and healthcare professionals continue to study and develop effective strategies to prevent and manage this condition in older adults (1). Early detection and intervention are crucial for mitigating the impact of sarcopenia and promoting healthy aging and improved functional abilities in older individuals. Regular physical activity, proper nutrition, and medical supervision are essential components of a comprehensive approach to managing sarcopenia (13).

Sarcopenia management:

Though it may not be evident through visual inspection or conventional body weight measurements alone (20). Body composition analysis provides a more precise evaluation of muscle mass, facilitating early and accurate diagnosis by healthcare professionals (21). Regular body composition assessments enable continuous monitoring of muscle mass changes over time, allowing healthcare providers to track the progression of sarcopenia and evaluate the effectiveness of interventions (22). Understanding an individual's body composition helps healthcare professionals design personalized nutritional and exercise interventions tailored to specific needs (23). Customized approaches are more effective in combatting sarcopenia compared to generic methods (20). Sarcopenia can lead to reduced physical performance and difficulties with daily activities (20). Early detection and intervention through body composition analysis enable better management of sarcopenia, potentially leading to improved functional abilities and maintaining independence in older adults (21). Preserving muscle mass and strength is essential for overall health and quality of life in older adults (23). Addressing sarcopenia through targeted nutritional interventions and exercise can enhance mobility, balance, and overall physical function (23-25). Sarcopenia is associated with an increased risk of falls, fractures, and other adverse health outcomes (24). Identifying sarcopenia early and implementing appropriate interventions can help reduce the risk of these complications (25)

Intensive Care management

A correlation has been observed between measured raw impedance parameter, fluid ratios, overhydration and adverse outcomes in critical illness. BIA-derived muscle mass appears a promising biomarker for sarcopenia and it correlates well with CT-analysis. BCM and fat-free mass provide potential use in estimation of metabolic rate, glomerular filtration rate, protein needs and pharmacokinetics. There are several promising areas of BIA research concerning some of the most urgent clinical problems in intensive care. (26).

Cancer management

Body composition analysis can be useful to estimate the fat mass, fat distribution and lean body mass especially sarcopenia. This measurement may provide better prognostic and follow up tools in wide range of cancer patients for prognosis, outcomes and treatment. BMI alone as an indicator of obesity is insufficient considering the complexity and heterogeneity of body composition and nutritional status which might not be reflected accurately by BMI due to difference between body weight and central obesity (27). Also, BMI does not indicate lean body mass, which when reduced is considered an independent prognostic marker for high mortality in some cancer patients. Another interesting area for research is the changing levels of cytokine production in obese and sarcopenic cancer patient categories and their effect on cancer biology and whether supplementary targeting of specific inflammatory or cytokine pathways could augment the response to immunotherapy. (28)

Conclusion

Body composition analysis is crucial not only for assessing overall health status, identifying obesity or malnutrition, but also assessing the risk of chronic diseases. Children may benefit from body composition analysis in terms of specific nutrition requirement for growth and development while elderly may benefit in terms of improvement of quality of life by balancing fat and skeletal muscle mass. Athletes' body composition analysis guide fuel requirements before, during and after workouts. Body composition can guide the management of patients in critical care with respect of fluid requirement and in cancer patients as prognostic marker for overall morbidity and mortality. In the era of precision medicine, body composition data may play a role in tailoring medical treatments based on an individual's unique physiology.

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