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Overview of Body Metric Analysis for Junior Athletes using Ultrasonography and Bioelectrical Impedance Analysis Technology

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Abstract Changes in body composition parameters can be used as a mean of tracking an athlete's health. Athletic performance relative to fat mass should be evaluated as an increase may be detrimental to physical activities by increasing energy demands and decreasing performance. Body composition, is an important indicator of nutritional status, water homeostasis and the specific adaptations to different physical training regimens. Similarly, assessment of the thigh muscles can provide adequate information on functionality and injury vulnerability. Knowledge garnered from biometric analysis using ultrasound and bio-impedance analysis technology, may be used to gauge the health status of future elite athletes. Assessing the body composition and muscle characteristics of young athletes, allow for early detection of weak areas that may negatively affect the performance of these athletes in the future. In addition, knowledge of how these parameters vary with performance provides an athlete with data that may be used to optimize performance.

Keywords: *body composition, ultrasound, bio-impedance analysis, muscle characteristics*

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1. Introduction

Maintaining a body type that enhance performance is necessary for a successful career in athletics. This requires continuous monitoring of the varying body composition parameters. The amount of information one can obtain about specific body measurements (body metrics) is dependent on the extant of the technology at their disposal. In past years, the use of body mass index (BMI) to determine one's health status has been generalized to athletes. Its inability however to distinguish between fat mass and fat free mass, is a limitation because athletes generally possess a higher percentage of muscle mass. It is also further limited in a population of adolescent athletes, whose weight and muscle distribution is heavily influenced by sex, puberty and hormones. Therefore, while BMI is calculated in the same for adolescence and adults, its interpretation varies for children and adolescents between 2 and 20 years old. Therefore BMI must be interpreted relative to a child's age and sex, because the amount of body fat changes with age and varies by sex [1]. With implications such as this, the need for further analysis within these specific cohorts is a necessity. As such, the use of more sophisticated measurements such as those provided by body metric equipment is required. Body metric analysis equipment and tools are able to provide detailed information about size and shape replacing the current reliance on the body mass index system [2].

Advances in technology have made the way for the provision of detailed information about the internal structure of the human body. New technology is inclusive of three-dimensional (3D) body scanners and image processors providing the ability to accurately measure, visualise and interpret an individual's 'body metrics' thus providing detailed body composition information. Body composition refers to the ratio of fat to fat free mass in the body [18]. It functions as a physical measurement, providing more information about the body rather than just weight or mass [3]. Body composition is used as a significant predictor of muscle force efficiency, which directly correlates to athletic performance. Parameters assessed in analysing body composition include: body fat percentage, fat free mass, body mass index and waist to hip ratio.

2. Measures of Body Composition and Muscle Characteristics (Body Metrics)

The body composition of an athlete is of utmost importance, as changes in certain parameters may be indicative of change in health and nutritional state. According to Kavazis & Wadsworth [4], the information garnered from assessment of body composition, can be an important indicator of nutritional status, water homeostasis and the specific adaptations to different physical training regimens [5]. Body metrics, is used in the overall assessment of body composition. In addition, body metric technology has been used to assess muscle characteristics. Body metrics allows for muscle quality assessment by examining thickness relative to fat at a particular site [17]. [6] Used the muscle cross sectional area of the quadriceps, in past studies as a marker of muscle quality in young adults. Similarly, according to [7], within the thigh, there is a linear relationship between muscle thickness and muscle cross sectional area or muscle volume. Particularly for adolescent athletes, assessment of muscle characteristics is beneficial as it indicates the presence and quantity of intra-muscular fat [21]. An increased fat accumulation in the muscle may represent metabolic changes in lipid metabolism including reduced fat oxidation and low basal ATP concentration [8]. In addition, the increase in intramuscular fat has been shown to be related to insulin insensitivity, limitation of functionality, increased risk of injury and decrease in exercise performance [9].

Magnetic Resonance Imaging (MRI), Computerised Tomography (CT) scans and ultrasound, widens the possibilities to explore the anatomy and physiology in vivo [10]. Continued research in body metrics have led to the emergence of new technologies, such as three-dimensional (3D) body scanners and image processors. Such technologies have led to great innovations, thus enhancing the capability to envisage, understand and accurately measure an athlete's body metrics in relation to performance [10]

Body metric analysis can be achieved by indirect and direct methods. Direct methods assess body composition on an atomic and molecular level. To achieve this, methods such as neutron activation and total body counting are used [10]. Indirect methods comprise costly level II assessments such as hydrodensitometry, Dual Energy X-ray Absoptiometry (DEXA), and plethysomography. Level III, assessment methods include indirect methods such as skinfold measurements, ultrasonography and bioelectrical impedance analysis (BIA) [11]. The easy application, safety and simplicity of these level III methods, make good tools for field surveys and clinical research [12].

3. Ultrasound Technology

Ultrasound technology can be used to track lean body mass (LBM), body fat percentage (BF%), BMI and basal metabolic rate (BMR). The new ultrasound machines are modern, small, portable and capable of making fast regional estimates of body composition. The technology behind ultrasound imaging, comes from ultrasound waves being reflected from tissue in the direction of a beam. According to Wagner, [13] the change in acoustic impedance comes from the extent to which sound is reflected between two interfaces, usually tissue interfaces [13]. Acoustic impedance in ultrasound refers a multiplication of the acoustic velocity and tissue density. Tissue has a specific impedance value: fat impedance value is 0.138 $\cdot g m^{-1} \cdot s^{-1}$ while for muscle it is 0.170 $\cdot g m^{-1} \cdot s^{-1}$ [13].

In most ultrasound technology, a special gel is used before applying the ultrasound probe to the skin, in order to alleviate friction on the skin. When the probe is applied, the transducer radios high frequency sound waves through the tissue. The waves produce an echo, when in contact with tissues such as the bones or other tissues [14]. This technology provides images of the tissue of interest, which is then analysed by probe movement over the skin of the tissue. Movement of the probe over the skin is dependent on the purpose of the test. In comparison to skinfold measurements, only about ±5 mm, is usually scanned, however, if necessary an entire area such as the thigh can be scanned [13].

In many studies, the muscle thickness was obtained using ultrasound technology. One such study included the use of B-Mode ultrasound (Philips-VMI, Ultra Vision Flip, model BF). In using this technology, the muscle thickness (MT) of the rectus femoris muscle (RF) and of the biceps brachii (BIC) were measured [15]. In assessing the muscle thickness of athletes, [10] defined muscle thickness as the distance from the subcutaneous adipose tissue-muscle interface to muscle-bone interface. In another study [4], tissue thickness and hardness were measured in the subcutaneous fat and the muscle group of the right anterior thigh by using the ultrasound muscle hardness meter. Additionally, MRI technology has been used to obtain scanned images of the right thigh, abdomen, and right lower leg and was able to determine the muscle cross sectional area of major muscles such as the quadriceps femoris (QF) and the hip adductors (ADD) [13]. Several researchers reported that ultrasound is often incorporated I clinical use as it acts as an alternate to radiography for measuring tissue thicknesses [2,10]. Reliability was also reported as excellent, however, it has been reported that the intraobserver reliability of skinfolds was better for radiography than ultrasound at almost every 1 of 15 measured sites [13]. Ultrasound provides the advantage of evaluating site-specific points on the body, of either the muscles or adipose layer quickly and at a faster rate than other imaging software. Wagner stated that the ultrasound probe is limited, for the purpose of assessing body composition as body composition measures gained from this device are not as clearly defined or standardized as they are with other body composition methods [13]. In spite of the limitations, using ultrasound technology on developing muscle in young potential elite athletes will give valuable data on both muscle characteristics and body composition.

4. Bioelectric Impedance Analysis

Bioelectric impedance analysis measures impedance of the body to a small electric current. BIA incorporates the use of electrodes, which are place on the body to facilitate the adjustment of bioelectrical data for height [16]. Bioelectrical impedance analysis, can be dubbed one of the most practical clinical techniques for measuring body composition. The technique incorporates low-frequency electrodes placed on the hands and feet or either, to measure body composition parameters such as body water and body fat [17]. The age and height of the individual being measured heavily influence the relationship between bioelectrical data and total body water (TBW). Limitations however affect the accuracy of this type of technology. It has been found that within a healthy population, BIA equations are limiting, with errors in individuals typically of about ±8% fat [16]. Provided that electrode placement is consistent such as where an individual stands on the fitness scales, high precision is possible. This is however for conventional single frequency electrodes. Such precision makes the technology suitable for monitoring short term changes in total body water in individuals. Built is relatively consistent over short time periods even in growing children, such measurements could indicate the direction of changes in FFM, but are less likely to measure accuracy [16].

In a study comparing the bioelectrical impedance with dual energy X-RAY absorptiometry. [10] Concluded that results obtained from the bio impedance analysis method should be interpreted with caution, specifically in younger individuals. The data produced by BIA, often shows significant variance to that obtained by DEXA, for fat mass in spite of the amount of fat. However, according to [8]. BIA provides the advantage of easy operation and speed and efficiency of measurements.

5. Conclusion

Of greater importance to an athlete than their weight, is their body composition, i.e. the ratio of distribution of their fat and muscles. Body Metric analyses serves to provide detailed measurements about the ratio of fat to lean muscle tissue, the percentage of water in the body, the metabolic rate (BMR) and BMI. An athlete cognitive of his/her reference values within these parameters, has the advantage of reaching their optimum physical self-using body metric techniques to assess changes in their body composition and muscle characteristics. In fact according to Armstrong, (2010) studies of elite young athletes in their sporting environment are limited and, where appropriate, the extant sport literature is complemented with data from untrained young people [15]. Unfortunate, such values aren't available for all cohorts of athletes, specifically junior athletes. Using traditional techniques and newer technology such as BIA and ultrasound technology on future Olympians, provides them with the opportunity also to obtain their best physical self. Furthermore, using body metrics over a period of time will provide evidence of change in important parameters such as lean body mass and body fat percentage. Actively seeing such changes as training progresses will influence diet changes and manipulation of exercise program, all of which will contribute to better athletic performance.

Abbreviations

ADD	Hip Adductors
BIA	Bioelectrical Impedance analysis.
BMI	Body Mass Index
BF%	Body Fat Percentage,
BMR	Basal Metabolic Rate
CT	Computed Tomography
DEXA	Dual Energy X-ray Absorptiometry
LBM	Lean Body Mass
MRI	Magnetic Resonance Imaging
TBW	Total Body water
QF	Quadriceps Femoris

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