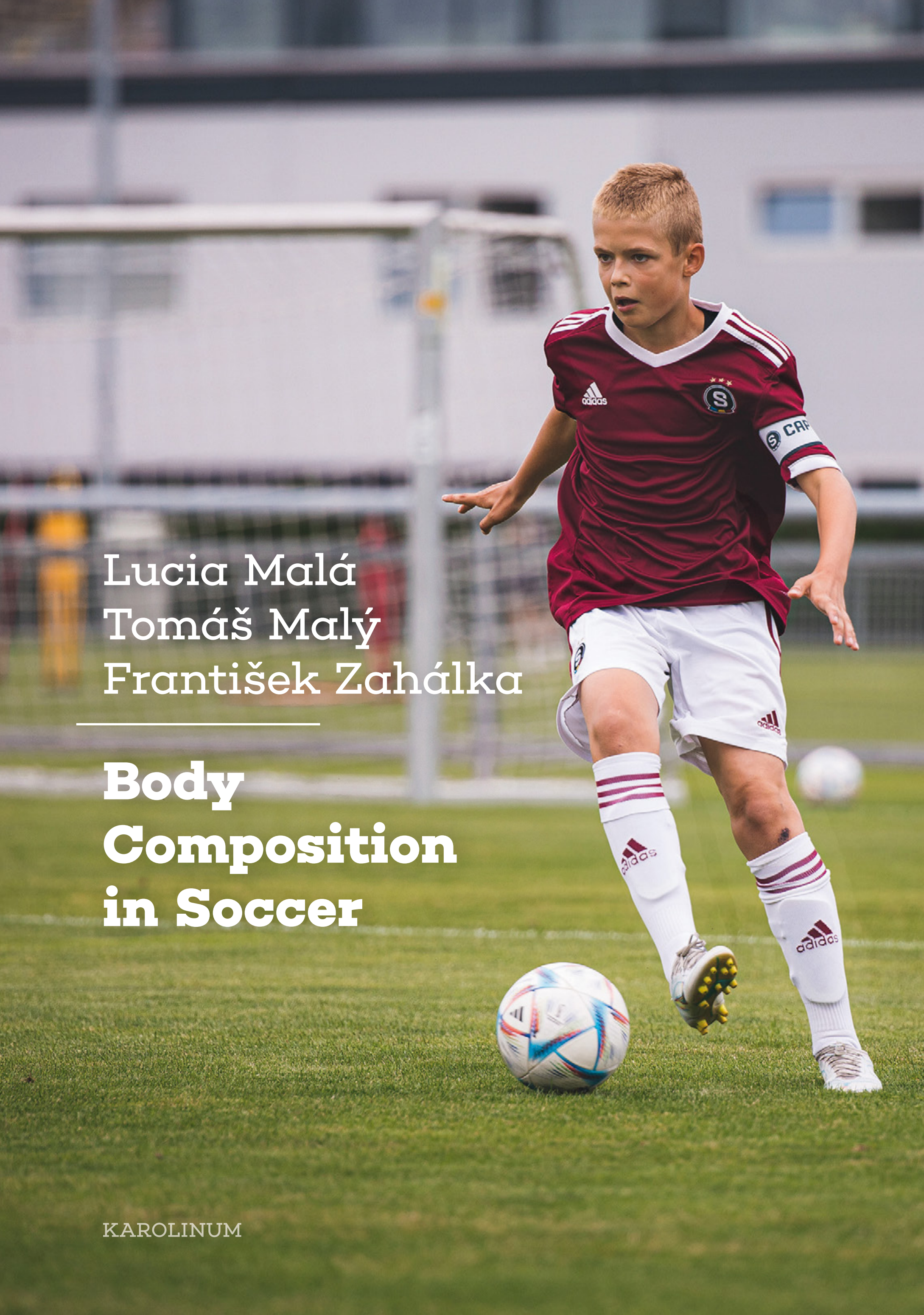

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KAROLINUM

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Preface

The study reflects the opportunity of multi-frequency bioimpedance analysis (BIA) application in soccer environment. It is divided into the subsequent parts: Introduction, Body composition (basic terms, influencing factors, models, methods), Sport as a factor determining the quality of body composition (physical load, energy metabolism in soccer), Methods and values of parameters determining the quality of body composition in soccer (DEXA, hydrodensitometry, air displacement plethysmography, anthropometry and calliper method, bioimpedance method), Body composition in relation to active and inactive mass, Body composition in relation to field positions in soccer, Morphological asymmetries – possible health-preventive key point in soccer, Nutrition as a factor influencing the quality of body composition in soccer.

The authors present the bioelectrical process in soccer from the point of view of its eventual use in settings for the use of BIA in soccer players, reliability, and validity. The study presents the reactions and relationships between soccer and active bioelectrical factors (fat free mass, body cell mass, muscle mass, intracellular mass, phase angle, intracellular water, resistance, and reactance) and also inactive factors (extracellular water, extracellular mass, and fat mass) (Simini & Bertemes-Filho, 2018). It includes a chapter on morphological asymmetries, which presents the results of the grant project and provides a possible health preventive key point in soccer. The study concludes with a special subchapter discussing nutrition as a factor influencing the quality of body composition in soccer.

Introduction

Sport performance consists of specific physical activities. The content of the activity lies in performing a task under the defined rules of the specific sport discipline while the athlete makes an effort to achieve maximum performance. Maximum performance is a complex coordination of the exercise and integration of the manifestation of many physical and psychological functions of a human in a specific moment associated with maximum motivation to perform. Actual sport performance has its genesis. It means that it has been formed gradually over a long period of time and is the result of ontogenesis, genetic predispositions, abilities (endowments, aptitude, talent) and the influence of environment and sports training. Regarding genetics and interaction with the conditions, we can distinguish morphological, physiological, and psychological predispositions. Due to the influence of various effects (genesis, environment, training), gradually, a set of predispositions for physical activity and performance develops. Sport performance is thus understood as a set of elements that are arranged and interrelated within a network of mutual relationships.

In the context of sport performance, factors are seen as relatively individual components of sport performances based on the fitness level, somatic predispositions, technical skills, tactical skills, and psychological parts of the performance, while their basic common feature is that they can be trained (Dovalil et al., 2002).

Regarding physical conditioning abilities, soccer performance is specific because players have to manage local and whole-body physical fatigue so that it does not lead to an elevated number of errors and lowered quality of technique during a match – especially towards its end (Rampinini et al., 2009). During the match, loading intensity gradually varies – fast sprint bouts alternate with light jogging – therefore, an optimal state of anaerobic or aerobic endurance is important for soccer players (Wisløff et al., 1998). Individual game skills require an above-average level of speed abilities (reaction, action, and maximum speed). Changes of direction and accelerated runs in various directions can only be performed as required thanks to the explosive (dynamic) characteristics of the strength abilities of the lower limbs and agility. The nature of the game indicates which coordination abilities are essential for the optimal solving of specific movement tasks. Movement on the field accompanied with simultaneous perception of the ball and other players requires ability in orientation. The basis of accurate game skills is a high level of kinesthetic differentiation ability. The variability of game situations, in which a player has to react to unexpected actions of both teammates and opponents, puts high demands on the ability to adapt and reconstruct movements.

The anthropometric parameters related to our treatise are presented as non-dominant for sport performance by some authors (Polat et al., 2010; Cossio-Bolanoz et al., 2012; Strauss et al., 2012). Taller players have an advantage in aerial duels, while players with shorter limbs tend to be more successful in duels on the ground or in dribbling the ball thanks to better coordination (Hencken & White, 2006; Gil et al., 2007). Concerning somatotype and the quality of body composition, we can observe certain differences depending on the players' field positions (Sutton et al., 2009; Nikolaidis et al., 2011) which will be discussed in more detail in the treatise. Goalkeepers are usually tall and robust with long limbs. Central defenders (stoppers) are slimmer and, usually, the smallest of all players.

Technical factors influencing soccer performance especially include coordination with the ball (Halil et al., 2011), shooting, dribbling, passing, heading and receiving the ball, and individual defensive skills without the ball. Based on perfect mastering of these skills, it is possible to lay the tactical foundations for the game. Biomechanical analyses of individual skills help to optimize their technique and show coaches and players how to make specific movements more effectively and economically with regards to energy while participating in the given movement structure (Carling et al., 2008).

Tactical predispositions for soccer performance are determined by several playing situations that the player has to observe, perceive, and respond to using the best approach available; moreover, this often has to be implemented as quickly as possible. The success of the approach is one of the determinants at play in the quality of sport performance. A player has to analyze a specific situation and choose the best option that should be consistent with the intended game strategy of the team (Cordes et al., 2012). This strategy is based on the technical level and physical conditioning of the players (De Costa et al., 2010); furthermore, it is important what the aim of the match is, how the match develops (Lago-Ballesteros et al., 2012) and to what measure the preparedness of individual opponents as well as the tactics of the opposing team have been mapped.

The player's performance is also influenced by his personality traits, character, and temperament (Morris, 2000). The player's unique personality is the basis for his behavior in certain situations and his ability to cope with psychological loading during the match; moreover, based on the player's psychological resilience it is possible to regulate emotions and behavior (Jordet, 2009), the player's motivation (Jordet & Hartman, 2008), mutual communication and relationships in a team. During a match, a player should be able to anticipate, concentrate, decide quickly; the captain should be the leader and should be able to motivate and encourage the team.

Somatic factors include an individual's constitutional features, physical conditioning factors related to physical abilities, technical factors represented by physical skills and technical implementation of movement in sport. Factors of tactics relate to creativity and a player's thinking during a match. Finally, mental factors include an athlete's specific features which enable the soccer player to respond to specific situations and to control and regulate his behavior in the match based on his personality.

Somatic factors directly related to our treatise due to the description of the specific issue of body composition are relatively stable and largely genetically determined. They relate to the musculoskeletal system and soft tissue, i.e., ligaments and tendons. In fact, the fundamental predispositions for soccer performance include height of the body, body mass, length dimensions and proportion, somatotype, and body composition. Concerning the composition of the body, it is possible to consider active body mass and fat mass in relation to the proportion of muscle mass. Muscle mass, a proportion of which is genetically determined, influences the muscle functioning and its ratio is a diagnostic value in talent identification in sports.

1. Body composition (basic terms, influencing factors, models, methods)

Body composition (BC) can be simply defined as the proportions of the individual parts of the human body. Body composition reflects life-long aggregation of various substrates and nutrients, which were externally obtained and stored within the human body. Elements ranging from tissues up to organs constitute the constructing pillars that influence the function, weight, and shape of organisms. Techniques of body composition analysis may help scientists to study the functions of these building blocks and their variations within metabolic condition and age (Heymsfield, Lohman, Wang, & Going, 2005).

The issue of body composition and its relationship to body parameters is a part of sport anthropology (examining morphological and functional conditions of human motion) as well as functional anthropology (describing and assessing body construction and proportionality) (Malá et al., 2014). Body composition assessment and estimation of parameters of individual body segments links functional anthropology to other fields such as nutrition, kinanthropology, sports medicine, biomechanics, and other clinical disciplines (Riegerová, 1998). From the perspective of exercise physiology, body composition parameters are predispositions of sport performance; in other words, some sport disciplines require certain qualities of body composition parameters. BC analysis has roots dating back to antiquity. The first mentions of body composition date as far back as 400 BC to ancient Greece. The Greeks believed that humans are made up of four basic elements of the universe: water, fire, air, and earth. These elements might be hot, cold, wet, or dry. Food and drinks were transferred during digestion into four bodily fluids: blood, phlegm, yellow bile, and black bile (Heymsfield, 2008). A similar composition was also described by Chinese scholars who divided the human body into five elements, namely metal, wood, water, fire, and earth. Good health was achieved when all these elements were in balance. Any imbalance results in a disease (Wang, Wang, & Heymsfield, 1999).

At present, body composition assessment is based on biology, medicine, and anthropology, which deals primarily with the parameters of the human body. The basic morphological parameter, which is essential in the assessment of the dynamics of human motion, is body mass. However, due to the complexity of this parameter, it is necessary to examine its components (fractions) that can be referred to as active or passive in terms of movement manifestation (Riegerová, Přidalová, & Ulbrichová, 2006). For simplicity, a preview of the human body as a model consisting of atoms, molecules and tissues is used. The authors of this preview are Wang et al. (1992), and they present a five-level model of body composition in which they distinguish five levels: atomic, molecular, cellular, tissue, and whole body level. Depending on the parameters of body composition we need to examine, we select the appropriate level and method (Table 1).

Table 1 Five body composition levels (Wang et al., 1992)

Model	Principle	Method
Atomic	The body consists of 6 primary elements (C, H, N, O, P, Ca).	Neutron activation analysis
Molecular	The body consists of 6 components (water, proteins, lipids, carbohydrates, bone minerals, soft tissue).	Bioimpedance, DEXA
Cellular	The body consists of cells that create body cell mass. There are several parameters, such as extra- a intracellular water, extracellular organic and inorganic solids, muscle, fat mass cells.	Isotope dilution methods, neutron activation analysis
Tissue – organ	75% of body weight consists of 3 tissues – bone, muscle, fatmass. Human body consists of musculoskeletal, integumentary, nervous, cardiovascular, respiratory, digestive, excretory, reproductive system.	Magnetic resonance
Whole body	Monitoring of body weight, body mass index, body height, skinfolds with calculation of fat mass and FFM.	Calliper method, indices

Note: DEXA – dual-energy X-ray absorptiometry

Many different definitions have been applied over the years by researchers studying molecular-level components (Heymsfield et al., 2005). Simini and Bertemes-Filho (2018) emphasize that in sport environment (competition and training) we experience and recognize terms such as fat mass and lipid mass in inactive components and in the active component terms lean body mass, FFM, and body cell mass. Lipids include all of the biological mass pulled out with lipid solvents such as ether and chloroform (triglycerides, phospholipids, structural lipids). Fats refer to the specific group of lipids consisting of triglycerides (Wang et al., 1992). Approximately 90% of total body lipids in healthy adults are triglycerides and 10% of total body lipids are composed of glyceroposphatides and sphingolipids (Heymsfield et al., 2005). In a three-component model, the term fat mass includes all fats extracted from the adipose tissue and other tissues of the body.

Lean body mass (LBM) is used as an index related to absolute body weight for proper prescription of medication doses and for various assessments of disorders within the metabolic system, as fat mass is less relevant for the metabolic system. Lean body mass (LBM) is an element of body composition. It is calculated by subtracting the weight of body fat mass (BF) from the weight of total body mass (BW): total body weight is lean mass plus fat mass (LBM = BW − BF). Lean body mass plus body fat equals body weight (LBM + BF = BW). The percentage of total body mass that is lean is usually not quoted, it would typically be 60–90%. The body fat percentage, which is the complement, is computed, and typically constitutes 10–40%.

Many authors confuse the terms lean body mass (LBM) and fat free mass (FFM). Lean body mass includes the combined weight of the internal organs, bones, muscles, water, ligaments, and tendons, including the essential fat in the organs, central nervous system, and bone marrow. The weight of the nonessential or storage fat, which is present in the subcutaneous adipose tissue underlying the skin and which surrounds the internal organs, is not a constituent of lean body mass. To obtain FFM, the weight of the essential fat is subtracted from lean body mass. Essential fat cannot be differentiated from storage fat. Estimates vary, but there is about a 2–3% difference between lean body mass and FFM in males and a 5–12% difference in females. In terms of the percentage of cells in FFM, it is an indicator of an athlete's nutrition and fitness levels (Percent Cell Quote). Body cell mass (BCM) is the sum of metabolically active cells of skeletal muscles and cardiac muscle, internal organs, bone tissues, blood cells and central nervous system cells and it is a part of FFM.

BCM is a predictor of muscle efficiency for sport performance (Andreoli et al., 2003). BCM determines an athlete's musculature and it is very important to consider its ratio with extra cellular mass (ECM) and the high-value parameter α, both of which are directly related to the amount of cell mass in intracellular water (BCM = phase angle × ICW × constant) (Malá et al., 2010).

Another view, a little different from the five body levels view, is based on the number of body components; in this preview, we can see a human body as a single unit or a two-, three- or four-component model and, thus, we get to the terms defined above. Similarly, an appropriate method is assigned to each model. The human body has to be considered as a model consisting of individual components and can be characterized from several points of view. The most common point of view is chemical and anatomical. Chemically, the human body consists of fat, proteins, carbohydrates, minerals, and water. Anatomically, it consists of fat mass, muscle mass, bones, inner organs, and other tissues (Maud & Foster, 1995; Figure 1).

If we use a method principally based on a multi-component model, we have a chance to get a more accurate estimation of the quality of body composition (Table 2). A multi-component model reduces errors in the two-component model related to individual differences in hydration (Malá et al., 2014). Also, multi-component models have their own

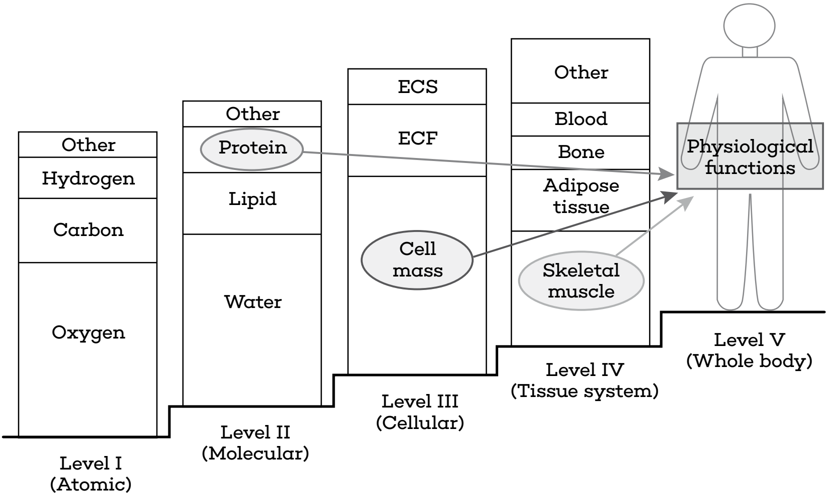

Figure 1 Five-level model of body composition (Wang et al., 1992)

Table 2 Body composition by number of components

Model	Principle	Method
One-component	The human body is a single unit.	Measuring body weight and body height, BMI, WHR, and other indices
Two-component	The body consists of fat mass and lean body mass.	HD
Three-component	It includes body water and its compartments as components of the body.	BIA
Four-component	Calculation of active and inactive mass includes 4 components: body volume, total body water, bone mineral, bone mass.	DEXA

Note: BIA – bioimpedance analysis; BMI – body mass index; DEXA – dual-energy X-ray absorptiometry; HD – hydrodensitometry; WHR – waist to hip ratioindex

estimated constants – the three-component model has a constant ratio of protein and mineral substances (Wang et al., 2005), multi-component models have constant fat mass density (Wang et al., 1992), water (Diem, 1962), bone mineral (Dallemagne & Melon, 1945), protein density (Hulmes & Miller, 1979), density of soft tissue mineral and density of carbohydrates (Wang et al., 2005), and body temperature (Brožek et al., 1963), and they always consist of a calculation of indirectly measurable parameters.

The limitations of these methods, validity, and reliability are discussed in detail in the authors' first publication, *Fitness Assessment Body Composition* (Malá et al., 2014). All the methods used are indirect, i.e., based on quantitative assumptions. Hydrodensitometry (HD) is established based on permanent hydration of FFM and the density of fat mass and lean body mass. Bioimpedance is determined by the assumption of constant hydration of lean body mass and by body model assumption when electrical current flows equally through all segments. The result variability is very dependable according to used formulas and exact regression equations (Malá et al., 2014). All these conditions of maintaining the constant are the limit of the accuracy of the estimated parameter identifying body composition. Taking into account the appropriateness for participants and the required results, the final method is selected.

For soccer players, technical simplicity, availability, and easiness for participants increase the prevalence of the bioimpedance method. Due