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Commentary

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The Importance of Measuring Body Composition in Professional Football Players: A Commentary

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ABSTRACT

Professional football players are not considered to be excessively fat, but there is continuous pressure made by managers, coaches and physiotherapists to monitor player's body composition to help reach optimal performance potential. Consequently, it is not uncommon for sport scientists to assume responsibility for monitoring and managing their players' body composition over the playing season. As body fat is one of the main factors affecting body composition, the knowledge and understanding of whole body density and how it influences the body could be useful to quantify the effectiveness of a prescribed training programme and/or optimal performance potential.

KEY WORDS: Body composition; Body fat; Football; Whole body density; Anthropometry; Optimal performance.

INTRODUCTION

Given the seasonal nature of football, it might be expected that players have to perform consistently at a high level up to 50 matches per season, thereby generating a demand to maintain levels of conditioning to sustain levels of performances. It seems reasonable then to assume that these varying playing roles impose specific physiological demands on a player.[1] These demands will be different dependent upon playing position, but a player will need to be at an optimum status in several aspects of fitness including energy from the aerobic system and the anaerobic system, muscular strength, flexibility and agility.[2]

In a game so variable in its physiological demands, football players must consequently attain a high level of conditioning to cope in the modern game which is played at an even faster pace and intensity than in previous decades. In order to achieve this higher level, Gil et al[3] claim that the relationship between the physiological demands of football and the composition of the player's body is of considerable importance. Although all too often, the judgement concerning optimal playing body fat is made on a trial and error basis with reference to body mass alone, disregarding the players overall body composition characteristics. There is evidence to suggest that optimal body mass could influence the ratio of power to body mass when moved against gravity, hence a low level of body fat is desirable for competitive success in football.[3] Vestberg et al[4] suggest that it is important to recognise that it is possible to lose fat but increase body mass due to increased muscle mass, especially in the pre-season period. A point already substantiated by Egan et al[5] and Wallace[6] where findings suggest that football players accumulated body fat in the off-season, and then reduced fat mass during pre-season. Possible reasons why these fluctuations occur can be a result of injury, habitual activity of players, energy stores, nutritional status and what stage of the competitive season the body composition assessments were executed.[4] Therefore, football players must strive to achieve an optimum sport performance potential with optimal lev-

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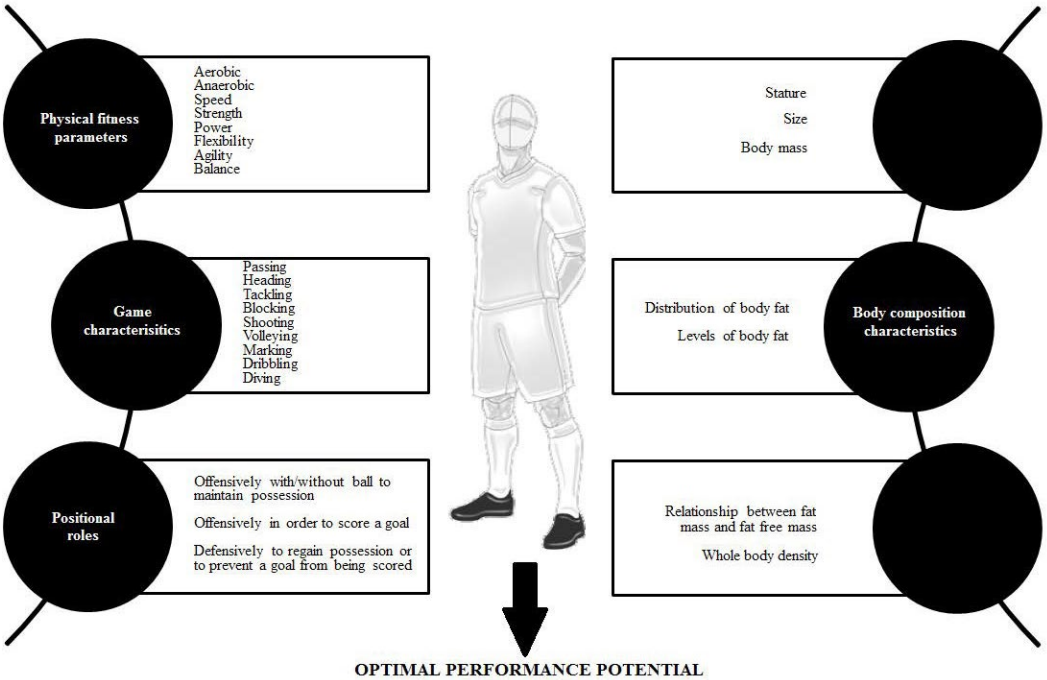
els of body fat taking into account their playing position.[1] By achieving optimal body fat the football player can minimise the negative effects of excess body fat on activity without sacrificing power, assuming of course, that the desired amount and intensity of training is executed.

Body Composition and Football Players

Fortunately, body composition analysis is becoming increasingly widespread in professional football as it helps to further understand the relationships between changes in body fat over time with different fitness parameters. Although not every body composition characteristic is expected to play a role in optimal performance in professional football, it has been recognised by researchers such as Rienzi et al[7] and Gil et al[3] that lower levels of body fat (that is specific to each individual player) is desirable for optimal performance as body mass must be moved against gravity. However, if there are higher levels of body fat (typically found in the visceral area around the waist) then additional metabolic energy is required to displace the excess.[6,7] In other words, body fat does not contribute to force production, so by achieving optimal levels of body fat and fat-free mass, the player can minimise the negative effects of excess body fat without sacrificing skill (Figure 1).

In recent years, sport scientists have made considerable progress in identifying footballers optimum anthropometric characteristics required to cope with football at the highest level.[8] A number of authorities such as Pyke,[9] Hencken and White,[10] Gil et al[11] and Santos et al[12] recommend establishing relationships between anthropometry and aspects of performance to assist management, coaches, national governing bodies, sports science teams and players to reach their full potential. However, it has been considered by Norton and Olds,[8] Reilly et al[13] and Hencken and White[10] that there are many anthropometric pre-dispositions for certain positional roles within football. Not every body composition characteristic is expected to play a role in successful performance, but notably stature and body mass have been considered the most important anthropometric pre-dispositions irrespective of playing position.[8] It is important to recognise that considerable individual differences in low and high levels of body fat occur between players and this might play a bigger role in optimal performance potential than generalisations about body fat itself. Although, today's professional football players are not considered excessively fat, there is continuous pressure by coaches, physiotherapists, managers and sport scientists to reduce players (ranging from professional to academy) body fat to minimum levels in the knowledge that low levels of body fat can enable them to perform more effectively.[14] However, up to a certain point, low levels of body fat are beneficial to performance, as the energy cost of physical activity will be lower and the ability to maintain core temperature during prolonged exercise will be enhanced. Consequently, those responsible for these players who view fat as detrimental to performance might not always recognise its importance for health.[14] When body fat is reduced to dangerously low-levels, there is a risk of encroachment into essential fat reserves that can cause metabolic dysfunction and at worst affect the health status of the football player.[14] Furthermore, it might offset performance benefits of training and compromise fat-

Figure 1. Relationships between Body Composition and Optimal Performance Potential in Professional Football Players.[1,7]



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free mass and energy.[15] As a result, players, coaches and sport scientists need to acknowledge that optimal performance levels may be adversely affected by excessively low levels of body fat, therefore, it is not necessary or desirable that they achieve the lowest levels.[15]

In contrast, high levels of body fat (that is specific to each individual player) have been reported many times by Reilly,[13,16-18] suggesting that high metabolic loading imposed by match play and training is not optimal for performance. Indeed the greater levels of body fat, the greater the detriment to performance, as the fat cells are not contributing toward energy production and the energy costs needed to move the fat is high.[1] A notion supported by Rienzi et al[19] who postulate that excess body fat can lead to an earlier onset of fatigue which not only adversely affects the ability to work, but is also associated with deterioration on skill, increased injury risk and a decreased adherence to training requirements and adaptations. Nevertheless, players cannot afford to reduce their muscle mass, as the power component might be compromised. Football players should therefore concentrate on reducing the quantity of body fat, but within safe limits.[19] As these factors are strongly influenced by age, sex, genetics and training, an argument has been made that football players levels of body fat should be determined when they are healthy and performing at their best. Overall, it is wiser to set individual goals than to expect all players to achieve the same level of body fatness, which illustrates the significance of treating each player as an individual, and not as a member of a team. However, this view challenges Wilmore's[20] theory, whereby all players are actively encouraged to achieve similar levels of body fat. Arguably, football players (with too much body fat) could feel pressured to engage in unsafe fat loss practices such as prolonged physical exercise, semi-starvation, malnutrition and disordered eating behaviours in an attempt to meet unrealistic fat loss.[21]

Reasons for Measuring Body Composition

Sport coaches and sport scientists recognise that the most efficacious way of preparing players for competition is based upon a complex and challenging blend of many component factors necessary for successful sport performance.[22] This places significant professional and academic challenges on the sport scientist. For instance, how the body is categorised its individual compositional characteristics has a profound influence on our health and capacity for exercise.[23] The assessment of body composition is often used as a tool for gauging these various morphological components, therefore this application provides a unique link between the different realms of health and sports performance. The measurement of whole body density is one such method.

Whole body density is the ratio of body mass to volume and can be used to help estimate the proportion of body fat present. The density of the whole body is however dependent upon the relative size of the components of both fat mass and fat-free mass components. Behnke et al[24] quantified both the fat mass and fat-free components to have densities of 1.100 $g.ml^{-1}$ and 0.900 $g.ml^{-1}$ respectively. However, the assumptions that this delimitation is based upon, have been questioned.[23] For instance, the density of fat remains constant over time for individuals, however, this literature suggests that densities vary dependent upon age, sex, ethnicity and levels of physical activity.[23] This has led to the conclusion that fat mass has a lower density than fat-free mass, therefore, an estimate of proportion of fat mass to fat free mass can be established. Direct measures of whole body density can only be made through cadaver analysis which is limited by practical, ethical and legal considerations. Yet such methods are essential for the validation and comparison of indirect methods of estimation for whole body density. However, due to these practical, ethical and legal concerns, it is not surprising that the development of indirect measures of estimating whole body density have increased over the years.

Table 1 summarises a range of available laboratory techniques and their relative accuracy with strengths and limitations. Not all the measures illustrated in Table 1 measure whole body density indirectly. Although it is important to acknowledge that some of these measures such as air displacement plethysmography (BodPod) and dual energy X-ray absorptiometry (DEXA) offer an attractive methodological alternative to hydrostatic weighting due to being faster, and requiring minimal participant cooperation. Despite these alternatives, hydrostatic weighing is still considered by many researchers to be the criterion method against which all other indirect methods should be validated; this is mainly attributable to its reliability.[25]

Some of the measures illustrated in Table 1 have served to promote a renewed interest in the sports science field due to its ability to subdivide the body, however, these methods are not generally accessible for football clubs and sport scientists attached to them due to their clinical application time commitments of participants and testers and expense.[15] Whilst there may be exceptions, such as access to university laboratories, sport scientists require a more accessible and convenient method for obtaining data on players body composition. This accessibility relates to the ease with which the various body sites required for measurement can be located, the time taken to carry out the measurements, minimal financial outlay and the relatively low technical expertise required. The most commonly used method employed by sports scientists via anthropometry, with measures consisting of skinfold thickness, girths, breadths, widths and depths.[4,5]

In turn, these measures can often be transferred to calibration models to estimate whole body density.[22] The calibration models are normally subdivided into regression equations generally developed on anthropometric-based formulae that predict the dependent variable (usually whole body density) from a series of independent variables such as body mass, stretched stature, skinfolds, girths, breadths, depths and widths.[22] As there are

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Table 1. Summary of Some Laboratory Techniques Available for the Estimation of Total Body Composition Characteristics of the General Population.

Method	Measurement	Precision error	Percentage Accuracy	Strengths	Limitations
HW	Density	±2%	96-98%	Criterion method applicable for large participants	Water immersion requires lung volume impractical
BodPod	Density	±4.5%	>95%	Quick, non-invasive immediate results applicable for various populations	Claustrophobia requires lung volume stature and mass restrictions
DEXA	FM/FFM	±1%	97-99%	Quick, non-invasive immediate results applicable for various populations	Radiation loses accuracy with increased fat mass affected by hydration status
MRI	Areas/volumes	<2%	96-98%	Generates accurate total and regional body volumes and dimensions	High levels of training required very expensive
CT	Areas/volumes	<1%	96-98%	Generates accurate total and regional body volumes and dimensions	Radiation high levels of training required very expensive
A	Density	±2.5%	>95%	Portable inexpensive large database	Invasive affected by dehydration and skin thickness technician error
BIA	Total body water [converted to FFM]	±4.5%	<80%	Portable fast non-invasive	Affected by hydration and tmperature status accuracy and precision concerns not recommended for obese/athletic populations

KEY: HW: Hydrostatic Weighing; Bod Pod: Air Displacement Plethysmography; DEXA: Dual Energy X-ray Absorptiometry; MRI: Magnetic Resonance Imaging; CT: Computed Tomography; A: Anthropometry (skinfolds, girths, breadths, widths); BIA: Bioelectrical Impedance Analysis. Percentage accuracy is determined as (100 - % error), where the error is the percentage difference from the true value.[23]

many anthropometric pre-dispositions within football, a number of authors have recommended establishing statistical relationships between body composition, health and aspects of sport performance to benefit management, coaches, national governing bodies, sports science team and players to reach their full potential.[25] This might be achieved in the following ways:

Help to determine important characteristics of body composition: This is often the major fundamental reason for testing a player's body composition. In order to achieve this, the sport scientist would have to be able to identify the major components of physical fitness required for successful football performance, although, it might be difficult to isolate each of the requisite components for evaluation in a field-testing setting, due to the complexities of each measurement. In a laboratory environment however, sport scientists are often able to isolate components of physical fitness and assess objectively the players performance on that particular variable. Ultimately they should be able to identify which players, playing in a particular playing position might have a functional advantage. For instance, findings from the soccer of kinanthropometry international project (SOKIP)[26] revealed that goalkeepers and defenders were the tallest and heaviest players compared to the midfield and strikers. Furthermore, goalkeepers showed systematically higher proportional girths and skinfolds than other players. These findings might help to quantify the important characteristics required for key positional roles, where body composition, rather than playing skills, provides an advantage to assist with optimisation in football. Although it is important to note that stature is not in itself a bar to success in football, it might be a functional advantage and may be exploited for tactical purposes, and therefore could determine the choice of playing position and success in performance.[5]

Help to customise training for specific positions and roles within the team: To provide baseline data for the development of a players individual training programme, measurement results, objectively gathered and analysed, can form the basis for training pre-scriptions that are specific to a particular player's position and then can be aimed at optimising that player's performance within the team.[8]

Help to track changes in a player's body composition: If the sport scientist repeats body composition measurements at regular intervals, comparisons of a player's results can help assess the effectiveness of their pre-scribed training programme or dietary regimen.[6] This however, is based on the assumption that individuals will respond comparably to similar training programmes. Indeed the sport scientist might well find that training prescribed to one player proves to be effective, but when prescribed to another may be less effective or not effective at all.[27] Additionally, evidence of the Hawthorne effect has been suggested by Falk and Heckman[28] where players are somewhat liable to modify their performance if they know that a test variable will be repeated at a later date.

Help to provide information about the health and wellbeing of players: Training for high level competition is a demanding and stressful process that can, in certain players, induce a negative ealth status. Certain tests can be adapted to screen and moni-

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tor players to help detect disease and disorders associated with excessively low levels of body fat that might not otherwise be identified by a standard medical examination.[6] The measurement of body composition is frequently used as a tool for monitoring and gauging levels of body fat and could prove useful if players engage in unsafe fat loss practices. Indeed, there is an ethical expectation that the sport scientist should be aware of the consequences of low levels of body fat which might influence the morbidity of a player. In other words, how the health of the player could impede their ability to perform at an optimal level.[29]

Help to educate players in the area of optimising their body composition: Sport scientists have an opportunity to provide an educational process where players learn to better understand their own body composition attributes and those required for success in football. This requires systematic planning of a player's development programmes, where sport scientists interpret test results directly to the player. In turn, this helps the player increase their appreciation of the components of football as well as an awareness of their own strengths and limitations.

Help in the development of a whole body density calibration model: The generation of different body composition variables among elite football players might help to provide valuable data in the future development of calibration models aimed at estimating whole body density in this sport.[23]

CONCLUSION

Our quest for knowledge and understanding regarding body composition and how it can affect performance potential has indeed intensified in recent years. This quest has been driven in part by the desire to gain an advantage within the sports science arena. Yet for the non-expert, such as the football coach, understanding why body composition measures are important and useful can often be confusing. With the primary goal of assessing whole body density to help determine the proportion of fat mass relative to fat-free mass, understanding these proportions can influence the effectiveness of a prescribed training programme and/or athletic performance potential.

Irrespective of the number of body composition parameters that are available, body composition assessment should be conducted on a regular basis to establish relationships between body composition, health and aspects of football performance. Recommendations should therefore ensure that a football player firstly maintains overall health by reducing the quantity of body fat, but within safe limits and secondly reaches optimal physical requirements needed for football performance in their specific playing position.[4,27] The recognition of treating each player as an individual and not as a team is equally important, especially with the setting of body composition goals. These recommendations could benefit management, coaches, national governing bodies and the sports science team to enable players to reach their full potential.[19]

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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