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Avaliação da Composição Corporal em Jogadores de Futebol

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DEDICATÓRIA

À minha mulher e à minha filha – razões do meu sorriso e do meu esforço, meu refúgio nas horas difíceis.

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RESUMO

O futebol é praticado por milhões de atletas, estando presente em mais de 200 países. A nível mundial, a sua influência aumentou a atenção dedicada ao jogo. Cada vez mais, existe uma procura pelo conhecimento que se possa refletir na prática diária das equipas, com o objetivo de melhorar a sua performance.

Objetivos

Artigo 1

- Descrever diferenças entre dois métodos de campo, como a BIA e as pregas cutâneas, e um método clínico, como o DXA, entre jovens jogadores de futebol de elite.

Artigo 2

- Descrever o perfil antropométrico de um grupo de jogadores de futebol, de acordo com diferentes idades e as suas posições em campo. Descrever variações na estimação da composição corporal utilizando pregas cutâneas, em jogadores de futebol adultos, de acordo com diferentes equações.

Resultados

Artigo 1

Entre atletas de futebol da elite juvenil, observamos correlações moderadas entre os métodos de campo, BIA e pregas cutâneas, e DXA (0.040 e <0.001, respetivamente) na avaliação da massa gorda. No entanto, a precisão do cálculo da massa gorda entre BIA e DXA apresentou uma diferença entre as medianas de 2,21.

Artigo 2

Em relação à antropometria, os guarda-redes foram quem apresentou a maior diferença em comparação às demais posições, em todas as faixas etárias. Verificamos diferenças estatisticamente significativas para a %MG e para a soma das pregas cutâneas (p = 0,33 e p = 0,023), na faixa etária 12-14, mas não para

peso e altura. Estes resultados contrastam com os encontrados para o grupo 16-18, tendo sido encontradas diferenças no peso e altura (p = 0,001 e p = 0,007), mas não para a %MG e para a soma das pregas cutâneas. Encontramos diferenças estatisticamente significativas para peso, altura, %MG e soma de pregas cutâneas, nos grupos etários 14-16 (p = 0,006; p = 0,052; p = 0,013; p = 0,018) e acima de 18 (p = 0,000; p = 0,000; p = 0,044; p = 0,041). As diferenças entre posições seguiram um padrão de tendência em todas as faixas etárias. Usando a fórmula de Paryzkova, observamos uma variação média (sd) de %MG entre 4,17 (1,91) – 5,18 (1,99) quando comparada com a fórmula de Reilly e 4,87 (1,46) – 5,51 (1,46) quando comparado com Evans.

Conclusões

Artigo 1

- Os métodos de campo, BIA e pregas cutâneas, são métodos válidos para a avaliação da massa gorda por apresentarem correlações moderadas com um método de referência como a DXA.

- As pregas cutâneas, por apresentarem uma maior correlação com a DXA, são uma escolha mais eficaz para avaliar a massa gorda.

Artigo 2

- Com a idade verificaram-se aumentos de peso e altura e diminuição da % MG.

- Observaram-se correlações significativas entre posição e características antropométricas, mostrando que os guarda-redes eram os mais altos, os mais pesados e os que tinham maior %MG.

- A utilização de diferentes equações de estimativa da %MG a partir das pregas cutâneas conduz a valores diferentes, o que invalida a comparação entre avaliações que utilizem equações diferentes.

Palavras chave: Métodos de avaliação, DXA, Bio impedância, Pregas cutâneas, Especificidade posicional

ABSTRACT

Football is played by millions of athletes, being present in more than 200 countries. Worldwide, its influence has increased the attention devoted to the game. More and more, there is a search for knowledge that can be reflected in the daily practice of the teams, in order to improve their performance.

Aims

Paper 1

- To describe the differences between two field methods, such as BIA and skinfolds, and a clinical method, such as DXA, among young elite soccer players.

Paper 2

- To describe the anthropometric profile of a group of soccer players, according to different ages and playing positions.

- To describe variations in the estimation of body composition using skinfolds, in adult soccer players, according to different equations.

Results

Paper 1

Among youth elite soccer athletes, we observed moderate correlations between field methods, BIA and skinfolds, and DXA (0.040 and <0.001, respectively) in the assessment of fat mass. However, accuracy of the calculation of the fat mass between BIA and DXA presented a difference between the medians of 2.21.

Paper 2

In relation to anthropometry, goalkeepers presented the biggest difference compared to other positions, in all age groups. We found statistically significant differences for % BF and for the sum of the skinfolds (p = .33 and p = .023), in the age group 12-14, but not for weight and height. These results contrast with those found for group 16-18, were we see differences in weight and height (p =

.001 and p = .007), but not for %BF and for the sum of the skinfolds. We found statistically significant differences for weight, height, %BF and sum of skinfolds, in the age groups 14-16 (p = .006, p = .052, p = .013, p = .018) and above 18 (p = .000; p = .000; p = .044; p = .041). Differences between positions followed a trend pattern across all age groups. Using Paryzkova formula, we observed a mean change (sd) of %BF between 4.17 (1.91) - 5.18 (1.99) when compared to Reilly formula and 4.87 (1.46) - 5.51 (1.46) when compared to Evans.

Conclusion

Paper 1

- The evaluated field methods, BIA and skinfolds, are valid methods for evaluating fat mass because they present moderate correlations with a reference method such as DXA.

- Skinfolds, because they have a higher correlation with DXA, are a more effective choice to evaluate fat mass.

Paper 2

- With age, there were increases in weight and height and decreases in % BF.

- There were significant correlations between position and anthropometric characteristics, showing that the goalkeepers were the tallest, heaviest, and those with the highest % BF.

- The use of different equations of % BF estimation from the skin folds leads to quite different values, which invalidates the comparison between evaluations using different equations.

- The use of different equations to estimate % BF from the skinfolds leads to quite different values, which invalidates the comparison between evaluations using different equations.

Keywords: Methods of evaluation; DXA; Bio impedance; Skinfolds; positional specificity

LISTA DE ABREVIATURAS

BIA – Bioelectrical Impedance

DXA – Dual-energy X-Ray Absorptiometry

% MG – Percentagem de Massa Gorda

% BF – Percentage Body Fat

IMC – Índice de massa corporal

GV – Gordura visceral

1. REVISÃO DA LITERATURA

1.1 COMPOSIÇÃO CORPORAL

A composição corporal influencia aspetos como a saúde e o rendimento, assim como o risco de lesão nos atletas. Um peso elevado, com uma acumulação de tecido adiposo visceral, refletido num perímetro de cintura mais elevado, está associado a um risco cardiovascular aumentado (Després, 2012).

No mesmo sentido, estes mesmos fatores contribuem para um aumento de lesões músculo-esqueléticas (Jahnke, Poston, Haddock, & Jitnarin, 2013), sendo que o IMC está positivamente associado a maior risco de lesões nos membros inferiores (Nilstad, Andersen, Bahr, Holme, & Steffen, 2014).

Por outro lado, desequilíbrios da massa muscular, que correspondem a diferentes níveis de força entre músculos, podem ser um fator de risco para a ocorrência de lesões (Thompson, Cazier, Bressel, & Dolny, 2017).

O peso elevado não é o único fator a ter em conta, sendo que quanto maior a % MG associada a esse peso, menor a capacidade do atleta em variáveis de performance, como a capacidade de salto (Miller, White, Kinley, Congleton, & Clark, 2002).

Estas ligações encontram-se ilustradas na figura 1, com as diferentes interações que que podem apurar entre as caraterísticas antropométricas, como o índice de massa corporal (IMC) e a saúde, a gordura visceral (GV) e o rendimento ou diferenças de massa muscular e o risco de lesão (Lukaski, 2017).

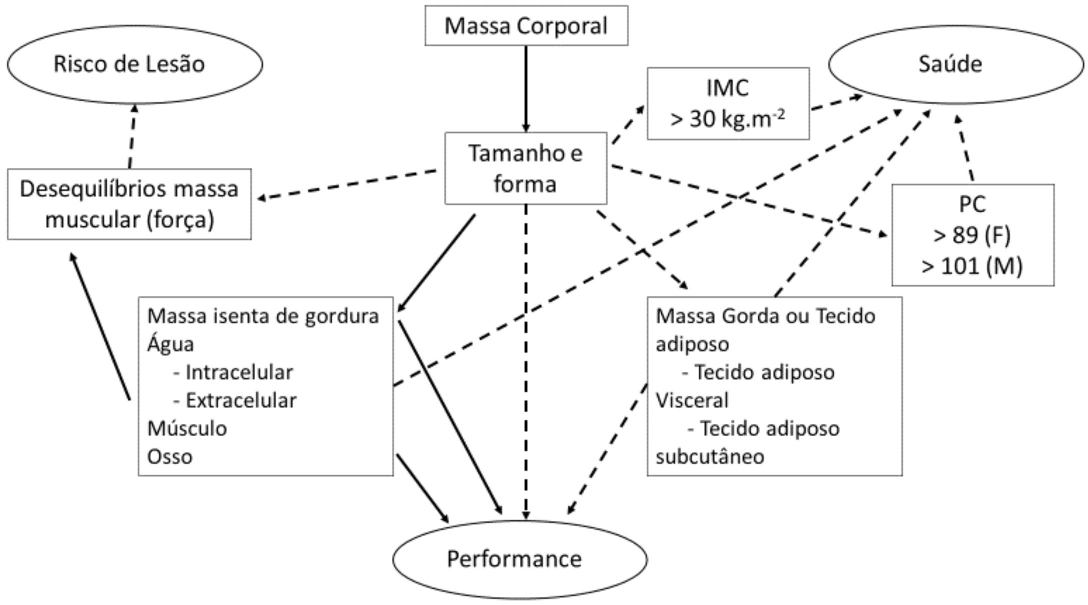

Figura 1 – Modelo integrado das variáveis da composição corporal que afetam a saúde, o risco de lesão e a performance. Linhas sólidas – efeitos benéficos; Linhas tracejadas – efeitos adversos; IMC – Índice Massa Corporal; PC – Perímetro da cinta. *Adaptado de: Lukaski, H.C. (2017). Body Composition: Health and Performance in Exercise and Sport (1st Edition). Taylor & Francis Group*

Analisando a figura, entendemos que a massa corporal vai estar explanada num tipo de corpo, com um determinado tamanho e forma. Se por um lado, a massa isenta de gordura está positivamente associada à performance, também percebemos que o tecido adiposo é um indicador do possível risco para a saúde, assim como de eventuais quebras no rendimento.

É devido a estas associações, que se tornou hábito avaliar a composição corporal de forma a perceber a resposta antropométrica do indivíduo ao longo do desenvolvimento e relativamente ao tipo treino e ao tipo de alimentação (Driskell & Wolinsky, 2011).

A composição corporal pode ser abordada a partir de 5 níveis (figura 2) (Z.-M. Wang, Pierson, & Heymsfield, 1992), sendo que em termos práticos os métodos de avaliação assentam sobretudo no nível celular e no nível tecidular (Eston & Reilly, 2009).

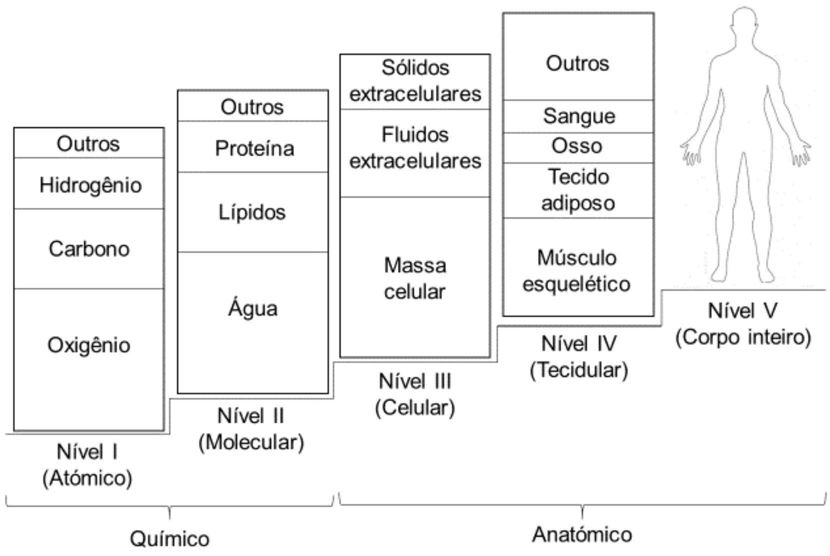

Figura 2 – Os cinco níveis da composição do corpo humano. *Adaptado de: Wang, Z.-M., Pierson, R. N., & Heymsfield, S. (1992). The five-level model : a new approach to organizing. The American Journal of Clinical Nutrition, 56(February), 19–28*

Este modelo fornece uma base estrutural para o estudo da composição do corpo humano, permitindo relacionar os componentes dos diferentes níveis de uma forma reconhecível. Percebe-se, de uma forma clara, que mudanças nos níveis inferiores se vão refletir nos níveis superiores. A perceção dessas ligações permite assunções que vão ser importantes na criação de novos modelos e de novas técnicas de estudo da composição corporal (Z.-M. Wang et al., 1992).

A maioria dos métodos de avaliação divide o corpo em 2 componentes. Com o avanço das tecnologias, foi possível ampliar o estudo da composição a outros compartimentos. Assim, atualmente, podemos estruturar a composição corporal em modelos de compartimentos (figura 3), de acordo com os resultados obtidos a partir do método utilizado (Lukaski, 2017).

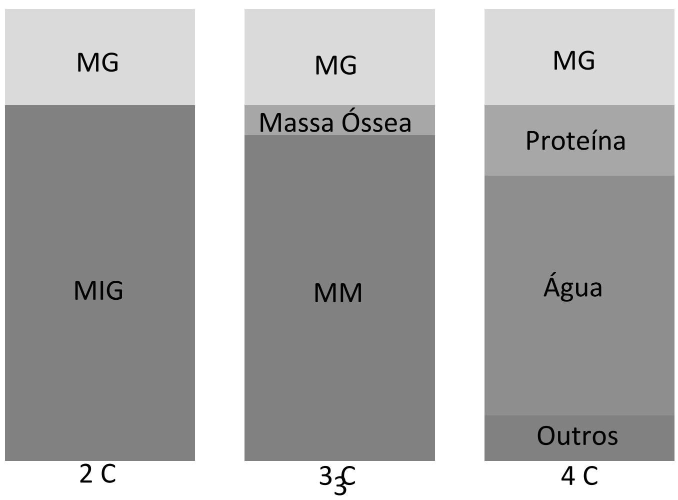

Figura 3 – Principais modelos de composição corporal. MG, massa gorda; MIG, massa isenta de gordura; MM, massa magra; 2 C, dois componentes; 3 C, três componentes; 4 C, quatro componentes. *Adaptado de: Lukaski, H.C. (2017). Body Composition: Health and Performance in Exercise and Sport (1st Edition). Taylor & Francis Group*

Em comum a todos os modelos temos o componente massa gorda, sendo este a caraterística mais valorizada por atletas e por treinadores, pela sua associação ao rendimento e risco de lesões, assim como a sua conexão a determinantes de saúde (Malina, 2007).

1.2 COMPOSIÇÃO CORPORAL NOS JOGADORES DE FUTEBOL

A avaliação da composição corporal em jogadores de futebol pode ajudar a otimizar o seu desempenho e avaliar os resultados dos planos de treino implementados (Sutton, Scott, Wallace, & Reilly, 2009), sendo uma componente importante na individualização e periodização do processo de treino do atleta (Thomas, Erdman, & Burke, 2016)

Encontramos no futebol uma relação entre as caraterísticas antropométricas, nomeadamente a massa gorda, e a ocorrência de lesões (Perroni, Vetrano, Camolese, Guidetti, & Baldari, 2015). Em 321 jogadores de futebol, separados em 2 grupos, sucedidos e não sucedidos, encontraram-se valores mais baixos de % MG nos atletas do grupo sucedido comparativamente ao não sucedido. No mesmo sentido, outras caraterísticas fisiológicas, como a velocidade e a potência, obtiveram também melhores resultados no grupo dos atletas sucedidos, sendo possível relacionar uma maior velocidade e uma maior potência com valores inferiores da % MG (Lago-Peñas, Casais, Dellal, Rey, & Dominguez, 2011).

Num estudo observacional em 189 atletas de futebol, foi possível relacionar a velocidade aos 20 metros, uma variável determinante no rendimento do jogador de futebol, a características antropométricas e fisiológicas. Mais concretamente, neste grupo de jogadores, a um maior tempo para percorrer os 20 metros foi associada uma maior % MG (Nikolaidis et al., 2016).

Por essa razão, juntamente com outros testes fisiológicos, a avaliação da composição corporal é usada para determinar a condição física do atleta, informando e monitorizando todas as intervenções, treino e/ou dietéticas, aplicadas ao atleta (Sutton et al., 2009).

Muitos estudos que incidem sobre o futebol avaliam caraterísticas antropométricas utilizando diferentes métodos de avaliação, e mesmo quando o método utilizado é o mesmo, a utilização de diferentes equações conduz a erros na análise desses resultados (Reilly et al., 2009).

Assumindo o DXA como método de referência para avaliação da massa gorda, podemos encontrar os valores que são assumidos como padrão para jogadores de futebol (tabela 1).

Tabela 1 – Valores relatados de % MG avaliado por DXA para jogadores de futebol (Média ± desvio padrão)

Fonte	**País**	**Amostra (n)**	**Nível competitivo**	**% MG**
Wittich et al (2009)	Argentina	42	Profissional	12,2 ± 3,1%
Reilly et al (2009)	Inglaterra	45	Profissional	11,2 ± 1,8%
Sutton et al (2009)	Inglaterra	64	Profissional	10,6 ± 2,1%
Reinke et al (2009)	Alemanha	10	Profissional	11,9 ± 6,2%
Mero et al (2010)	Finlândia	15	Não referido	14,1 ± 3,9%
Santos et al (2014)	Portugal	28	Não referido *	12,1 ± 1,1%
Milanese et al (2015)	Itália	29	Professional	11,2 ± 2,26%
Devlin et al (2016)	Austrália	18	Professional	12,8 ± 1,9%

* Carga horária de treino de mais de 10 horas.

Na Argentina, numa amostra de 42 jogadores de futebol a competir na liga profissional Argentina, com uma média de idades de 23,2 ± 3,5 anos, foram registados valores de % MG de 12,2 ± 3,1% (Wittich, Oliveri, Rotemberg, & Mautalen, 2001).

Em 64 atletas que disputavam a liga inglesa, com uma idade média de 26,2 ± 4,0 anos, foram encontrados valores médios de % MG de 10,6 ± 2,1% (Sutton et al., 2009).

Num artigo de comparação de equações antropométricas e validação de uma nova fórmula, o valor calculado por DXA em 45 futebolistas ingleses, com uma média de idade de 24,2 ± 5,0 anos, o valor encontrado foi de 11,2 ± 1,8% (Reilly et al., 2009)

Na avaliação a 10 jogadores de futebol, com 25,3 ± 5,1 anos a participar na Bundesliga, a liga profissional alemã, foram encontrados na avaliação por DXA um valor médio de 11,9 ± 6,2% (Reinke et al., 2009).

Num estudo de 2010, 15 jogadores de futebol finlandeses com uma média de idades de 22,1 ± 3,9 anos, o valor médio encontrado foi de 14,1 ± 3,9% (Mero et al., 2010). De realçar que neste estudo não é referido o nível dos atletas, sendo que na descrição apenas é indicado que pertenciam ao clube local.

Em Portugal, 28 jogadores de futebol, com idade média de 18,0 ± 0,8 anos, foram avaliados. Apesar de não ser referido o nível competitivo, um dos critérios de inclusão era uma carga horária semanal de treino de mais de 10 horas. Nesses jogadores a % MG média era de 12,1 ± 1,10% (Santos et al., 2014).

Num estudo com 29 jogadores de futebol a participar na liga profissional italiana, com uma média de idades de 27,5 ± 4,38 anos, a avaliação registou valores de % MG na pré-época de 11,2 ± 2,26% (Milanese, Cavedon, Corradini, De Vita, & Zancanaro, 2015).

Na Austrália, 18 jogadores da liga profissional, com 27,2 ± 5,0 anos, apresentaram valores massa gorda, avaliados por DXA de 12,8 ± 1,9% (Devlin, Leveritt, Kingsley, & Belski, 2016).

É expectável encontrar diferenças na composição corporal, tendo em conta o nível competitivo dos jogadores de futebol (Reilly, Williams, Nevill, & Franks, 2000), mas, pelos valores encontrados através do método de referência podemos assumir como modelo, para a % MG entre jogadores de futebol, valores entre 10 e 12%.

A utilização de diferentes equações para predizer a % MG aumenta o erro associado quando comparado com o método da avaliação por pregas cutâneas. A utilização de equações específicas para a população em causa, jogadores de futebol, pode ajudar a reduzir esse erro, mas a comparação entre os valores só será possível se for utilizada a mesma equação (Meyer et al., 2013). Essa é uma das limitações presentes em vários estudos de revisão sobre as características antropométricas no futebol (Slimani & Nikolaidis, 2017).

1.3 MÉTODOS DE AVALIAÇÃO DA COMPOSIÇÃO CORPORAL

Avaliar a composição corporal requer uma compreensão dos princípios e limitações básicos da grande variedade de métodos e técnicas disponíveis, que permitirá escolher um método, e analisar os seus resultados, de acordo com o contexto pretendido (Van Marken Lichtenbelt et al., 2004).

Existem vários métodos para a avaliação da composição corporal, sendo que podem estar validados em 3 níveis: Nível I, em que a totalidade da massa gorda é quantificada diretamente através da dissecação de cadáveres; Nível II, em que se avalia outro parâmetro e se obtém a quantidade de massa gorda a partir de uma relação quantitativa; Nível III, em que é utilizada uma medição indireta e depois se faz uma regressão com um método de Nível II (Eston & Reilly, 2009).

Tendo em conta o nível de validação, podemos classificar os métodos como métodos de referência, métodos laboratoriais e métodos de campo respetivamente (Ackland et al., 2012).

Atualmente, o método reconhecido como método de referência para avaliar adultos saudáveis é a absorptiometria de raios-X de energia dupla (DXA) (Gropper & Smith, 2013). No entanto, uma das limitações deste método relaciona-se com o seu custo, considerado dispendioso ou inacessível para a maioria das situações que envolvem atletas (Shim, Cross, Norman, & Hauer, 2014).

Dentro dos métodos de avaliação duplamente indiretos, a utilização da bioelectrical impedance (BIA) tem-se tornado cada vez mais popular, devido à sua facilidade de utilização, ao seu baixo custo e à sua portabilidade (Driskell & Wolinsky, 2011). Neste método, uma pequena corrente alternada passa entre dois elétrodos, assumindo-se que essa passagem é mais rápida em tecidos corporais sem gordura, mais hidratados e com maior teor de eletrólitos, que através de tecidos adiposo ou ósseos (McArdle, Katch, & Katch, 2010). Por depender do estado de hidratação, existem vários pré-requisitos, como a necessidade de abstenção da ingestão de alimentos e bebidas nas 4 horas prévias ao exame, a ausência de exercício nas 24 horas anteriores, a abstenção de bebidas alcoólicas e de bebidas diuréticas e a necessidade de uma sala a uma temperatura estável de 23 ºC (Pedro Teixeira, Luís Bettencourt Sardinha, & J. L. Themudo Barata, 2008), para que a avaliação seja considerada fiável. Este pressuposto pode tornar impraticável a sua utilização (Ackland et al., 2012).

Outro método duplamente indireto bastante utilizado é a estimação da percentagem da massa gorda (% MG) por pregas cutâneas, através de equações específicas (Meyer et al., 2013). O método das pregas cutâneas baseia-se na ideia de que a avaliação de uma medida representativa da camada de tecido adiposo subcutâneo pode fornecer uma estimativa razoável da massa gorda total (Lee & Nieman, 2003). No fundo, estabelece uma relação entre a medição de uma dupla dobra de pele e tecido adiposo subcutânea por meio de lipocalibradores (figura 4), e a quantidade de gordura total.

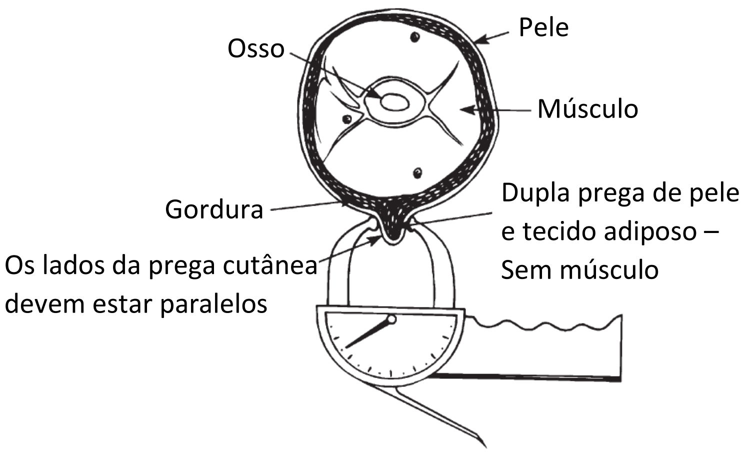

Figura 4 – Representação gráfica da medição de uma prega cutânea. *Adaptado de:* Lee, R. D., & Nieman, D. C. (2003). *Nutritional Assessment* (6th Editio). Boston: McGraw-Hill

Desde que o perito seja experimentado a realizar avaliações de forma regular, baseado num protocolo padrão e certificado, os pressupostos da técnica são reconhecidos e demonstram ampla utilidade na monitorização da composição corporal de atletas (Ackland et al., 2012).

A utilização de modelos matemáticos, recorrendo a equações para determinar valores de percentual de gordura, é um processo comum e amplamente caracterizado na literatura. No entanto, as equações só se deveriam aplicar às populações com características similares aos indivíduos expostos ao processo de validação (Withers, Craig, Bourdon, & Norton, 1987), isto é, deverá haver uma concordância no intervalo de idades, gênero, etnia e nível de condição física

No entanto, e pesquisando na literatura existente, percebemos que, apesar das recomendações irem no sentido de se ajustar a equação utilizada à população que se pretende estudar, não é esta a mais utilizada (figura 2).

Tabela 2 – Métodos de estimativa a partir das pregas cutâneas utilizadas em artigos com atletas de futebol

Fonte	País	Amostra (n)	Método utilizado
Davis et al (1992)	Inglaterra	135	Durnin et Womersley
Arnason et al (2004)	Islândia	297	Média de 4 fórmulas
Vayens et al (2006)	Bélgica	160	Soma de 5 pregas
Gil et al (2007)	Espanha	194	Faulkner
Figueiredo et al (2009)	Portugal	159	Soma de 5 pregas
Canhadas et al (2010)	Brasil	282	Slaughter
Mirkov et al (2010)	Sérvia	89	Soma de 6 pregas
Lago-Peñas et al (2011)	Espanha	321	Faulkner
Nikolaidis et al (2011)	Grécia	297	Paryzkova
Carling et al (2012)	França	158	Durnin et Womersley
Lago-Peñas et al (2014)	Espanha	156	Faulkner
Nikolaidis et al (2014)	Grécia	249	Paryskova
Le Gall et al (2015)	França	161	Durnin et Womersley

A equação de Durnin et Womersley foi validada numa amostra de homens e mulheres normais, representativas da população em geral (Durnin & Womersley, 1974).

Outra equação muito utilizada em vários artigos é a de Faulkner. No seu artigo original, Faulkner utiliza uma fórmula para caracterizar 22 atletas universitários de natação e 158 não atletas. Não é, no entanto, citado o autor da equação, nem a referência que nos reporte para a sua validação, parecendo haver evidência que a equação de Faulkner foi desenvolvida através da combinação de diferentes equações desenvolvidas por Yuhasz (Neto & Glaner, 2007).

A fórmula de Paryzkova utiliza pregas cutâneas que não estão descriminadas no protocolo ISAK (Stewart, Marfell-Jones, & Inernational Society for Advancement of Kinanthopometry, 2011). A sua vantagem parece residir no facto de poder ser aplicada a jovens e a adultos de ambos os sexos, apesar da população onde foi validada não se poder enquadrar num gênero atlético (Pařízková, 1977).

A soma de pregas parece ser outro método utilizado, mas a falta de uniformização das pregas a utilizar, assim como o número de pregas, torna impossível proceder a qualquer comparação entre os resultados.

Além disso, percebe-se que não existe uma uniformidade na escolha para avaliar populações semelhantes. Considerando o exposto, temos neste momento uma equação validada para jogadores de futebol, a fórmula de Reilly (Reilly et al., 2009), que poderá servir para padronizar a forma como se procede à estimação da % MG em futuras pesquisas no futebol.

2. ARTIGOS

ARTIGO 1

Body Composition Evaluation Issue among Young Elite Football Players - DXA Assessment

Leão, C., Simões, M., Silva, B., Clemente, F., Bezerra, P., & Camões, M. (2017). Body Composition Evaluation Issue among Young Elite Football Players: DXA Assessment. *Sports*, *5*(1), 17. https://doi.org/10.3390/sports5010017 sports

MDPI

Article

Body Composition Evaluation Issue among Young Elite Football Players: DXA Assessment

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Abstract: Accurate assessment of body composition is an important issue among athletes. Different methodologies generate controversial results, leading to a deep uncertainty on individual exercise prescriptions. Thus, this study aims to identify the differences between field methods, such as bioelectrical impedance (BIA) and skinfold assessment, with a clinical method, highly accurate, dual-energy X-ray absorptiometry (DXA), among elite young football players. Thirty-eight male football players with a mean (sd) age of 16.7 (0.87) years, involved in the Portuguese national competition of U16 (n = 13) and U19 (n = 25), were evaluated and objective measures of body composition, muscle strength and football skills were collected by trained specialists. Body composition was assessed using BIA (Tanita BC-418, Tanita Corp., Tokyo, Japan), in agreement with all the evaluation premises. Additionally, all athletes were evaluated using the clinical method DXA (Hologic Inc., Waltham, MA, USA). Among the U19 athletes, three skinfold sites (SKF) were assessed: chest, abdomin and thigh. The Spearman correlation coefficients and the mean difference between methods were calculated. The agreement between both methods was analyzed using Bland-Altman plots. Among the evaluated athletes, lower mean values of body fat % were found using BIA as a method of body composition assessment compared with DXA (12.05 vs. 15.58 for U16; 11.97 vs. 14.16 for U19). Despite the moderate correlation between methods (r = 0.33) to estimate the percentage of total fat, the median of the difference (DXA vs. BIA) was relevant in clinical terms, with 2.90% and 1.47% for U16 and U19 athletes, respectively. Stronger correlations were found between the sum of the SKF and DXA fat estimation (r = 0.68). The Bland-Altman plots showed a clear underestimation in the evaluations using the BIA, namely among athletes with better body composition profiles (8%–12% of fat). Using BIA, an underestimation of body fat assessment was observed among 94.5% of the athletes with less than 12% body fat mass. Among the evaluated athletes, fat mass was underestimated at a median value of 2.21% using BIA in comparison with DXA. The sum of the SKF showed a stronger correlation with the reference method (DXA) (r = 0.68) than BIA.

Keywords: body fat evaluation; DXA; BIA; young; football

1. Introduction

There is a significant relationship between competitive success in several sports contexts and certain anthropometric characteristics [1]. In football, we find a heterogeneity in anthropometric and physiological characteristics that makes it impossible to isolate single pre-requisites [2]. However, some physiological characteristics such as aerobic [3] and anaerobic capacity, strength, power [4] and speed [5] are closely related to body composition among elite football athletes [6–8].

The body composition in athletes is a conditioning factor influencing their performance, particularly in jumping ability [9] and in the capacity to execute specific tasks rapidly [10], independently of gender, age and ethnicity. Even small changes in body fat % may have a major impact on the ability to perform anaerobic movements [11]. The assessment of body composition can provide valuable information about the changes observed in athletes during the season [12]. In addition, body composition data may be important in the selection procedures of young athletes, allowing a comparison with reference values, and from there building an athlete development program [13]. Moreover, an incorrect assessment of the body composition may lead to difficulties in prescribing a proper eating plan because of the pressure to achieve a target body fat value [14].

The body composition assessment provides information of particular relevance, with the percentage of body fat being the most valued parameter [14], to either athletes and/or coaches [3,9,15] to determine the optimal body composition. Acknowledging the impact that the manipulation of body composition has on athletic performance, ideally it should take place as soon as possible in the sports season, before the competitive period [16]. Therefore, it is a common practice to assess body composition early in the season and later on in response to training and dietary interventions [8,17], expecting a change in body weight and especially in fat mass [18]. Obtaining a type-specific body composition is directly associated with individual performance, and it is currently recognized as a significant challenge to individualize and periodize the athlete's development process [16].

Despite the importance given to body composition, it remains difficult to obtain an accurate analysis of the percentage of body fat. The available tools for body composition assessment are either inaccurate or supported in data of weak validity, the opposite of what we assume most of the time [19]. The importance of assessing body fat in athletes notwithstanding, there is still no method that offers 100% accuracy [20]. The choice of method should consider several factors, including technical issues, such as security, validity, evaluation of precision and reliability. Additionally, there are other factors to consider, in particular practical factors such as availability, financial implications, portability, invasion of privacy, time availability and technical expertise to conduct the method [17,21]. All available techniques have some inherent advantages and disadvantages, either in methodology, interpretation of data or the assumptions that are made from the same. Hence, the adherence to the prerequisites for each of the techniques is a key requirement [20]. Even methods considered as a reference may have limitations when you change the behaviors before assessment that can impact hydration status [22]. The use of different methods in the evaluation of body composition provides inconsistent results, very often leading to difficulties and doubts in the individual training plan prescription [23].

Currently, the most accepted method for evaluating healthy adults is dual-energy X-ray absorptiometry (DXA) [21], but it is considered costly or inaccessible for most teams, especially young teams [24]. On the other hand, bioelectrical impedance (BIA) has become increasingly popular as an analysis tool of body composition due to its ease of use, portability and low cost [17].

This study describes the differences between field methods, such as BIA and skinfold assessment, and a clinical method, the highly accurate dual-energy X-ray absorptiometry (DXA), among elite young football players.

2. Materials and Methods

2.1. Participants

An observational study was conducted with 38 male football players with mean (sd) age of 16.7 (0.87) years, involved in the Portuguese national competition of under-16 (U16) (n = 13) and under-19 (U19) (n = 25). Study participants were invited to visit the Escola Superior de Desporto e Lazer-Instituto Politécnico de Viana do Castelo to be evaluated on several sports performance determinants. The participants were asked to maintain habitual daily food and water intake during the period of study.

At the time of the evaluations, athletes were on a maintenance phase of the National U16 and U19 championship. These football athletes train a mean of 6 h/week having an average of 6 years of football experience with systematized training. Table 1 describes the characteristics of the athletes, stratified by competitive age (U16 and U19), regarding age, height, weight, body mass index, BIA percentage of fat and DXA percentage of fat.

The research was approved by the technical-scientific council of the Instituto Politécnico de Viana do Castelo and all intervenient signed the Free and Clarified Consent Form according to the Declaration of Helsinki [25].

2.2. Anthropometrics

One week before of the laboratory assessments, it was required to the technical staff of the team that some characteristics on the athletes needed to be preserved in order to reduce the error in the estimation of the different body compartments [26]. All participants were dress light clothing and stood barefoot, with eyes directed straight ahead. Athletes' height was measured to the nearest 0.1 cm with a portable stadiometer (SECA 217, Hamburg, Germany).

2.3. Body Composition

The body composition was analysed with multi-frequency BIA (Tanita® BC-418, Tanita Corp., Tokyo, Japan). This test provides a complete analysis of weight, body mass index, body fat and fat mass percentage, fat free mass and total body water. Before the assessment, the trained specialists manually inserted data on body type profile (athlete format), age, and measured height into the system. The subjects wiped their feet and stood on the weighing platform without bending their knees [26]. All the participants were in agreement with all the evaluation premises, in order to reduce the error in the estimation of the different body compartments: like fasting or stay 4 h without food or drink, absence of exercise in the prior day, the absence of alcohol or diuretic drinks, the need of a stable temperature of 23 °C in the room [26].

In addition, among all the athletes, body composition was evaluated using the clinical method DXA through a General Electric Hologic Discovery scanner (Hologic Inc., Waltham, MA, USA), as stated by the manufacturer specification and with a certified and experienced DXA operator. DXA provides information on three compartments of body composition, according to the terminology: percentage of (%) fat mass, lean mass or the fat-free soft tissue and bone mineral content. Athletes assumed a stationary, supine position on the scanning bed with both arms pronated by their side. The DXA operator manually assisted the young players in order to: (1) straighten the head; (2) position of the shoulders, pelvis and legs; (3) place both arms in pronation by their side; and (4) fix feet together using strapping [27]. Only the data from whole body % of fat mass and subtotal (without head) % of fat mass was considered for the analyses.

2.4. Skinfolds

In a subsample, among the U19 athletes (n = 25), three sites skinfolds (SKF) were collected, two times (to the nearest 0.1 mm), with a Harpenden caliper (British Indicators, Ltd., London, UK), following the recommendations of the International Society for the Advancement of

Kineanthropometry [28]: chest, abdominal and thigh sites. The mean value of the two evaluations was calculated, and the sum of the three SKF was considered.

2.5. Statistical Analysis

A descriptive analysis was performed regarding the anthropometric characteristics, namely fat % among different methods used: BIA, DXA. Non parametric tests were used and the Wilcoxon test was applied to verify the differences in continuous variables between competitive level (U16 and U19). The median values were found to analyse the differences between the reference method—DXA and both field methods, BIA and SKF assessment.

Spearman's correlation coefficients were calculated to describe the relationship between methods. The agreement was illustrated by plotting the differences between the methods against their mean using the Bland-Altman's graphics [29].

All data sets were tested for each statistical technique and corresponding assumptions and performed using SPSS software (IBM Corp. Released 2014. IBM SPSS Statistics for Windows, Version 23.0, Armonk, NY, USA).

3. Results

The recruited 38 male football athletes had an overall mean (sd) age of 16.8 (0.87) years. The older athletes were heavier (kg) than the younger ones (69.81 vs. 66.25, $p = 0.056$). Supported by the body composition reference method, these athletes were significantly different regarding their body composition. We can see that despite the higher value of absolute weight in U19, there was a significant DXA lower body fat % (14.16 vs. 15.58, $p = 0.041$). Regardless of this, the BIA method did not show significant differences in body fat % among the competitive levels (11.97 vs. 12.05, $p = 0.913$), as shown in Table 1.

Table 1. Sample characteristics.

	U16 ($n = 13$)		U19 ($n = 25$)		p-Value
	Mean	sd	Mean	sd	
Age (years)	15.77	0.44	17.28	0.54	<0.001
Height (cm)	174.62	5.68	175.16	6.40	0.927
Weight (kg)	66.25	5.03	69.81	5.39	0.056
BMI (kg/m^2)	21.65	1.17	22.76	1.52	0.025
BIA fat mass (%)	12.05	2.66	11.97	2.66	0.903
DXA fat mass (%)	15.58	2.03	14.16	1.91	0.041
Sum SKF (mm)	-	-	36.12	8.19	-

Notes: Significance level $p < 0.05$; U16—Under 16; U19—Under 19; BMI—Body Mass Index; kg—kilograms; kg/m^2—kilograms per square meter; %—percentage; mm—millimeters; DXA—dual-energy X-ray Absorptiometry; BIA—bioelectrical impedance; SKF—skinfold.

A moderate correlation (Table 2) was found between the percentage of fat found with BIA and the percentage of fat measured with DXA ($r = 0.335$, $p = 0.040$). Considering the sum of the three skinfolds (SKF) valued in the U19 athletes, we observed a stronger correlation between SKF scores and the percentage of fat measured with DXA ($r = 0.683$, $p < 0.001$).

Table 2. Spearman correlation coefficients between methods.

	DXA Fat Mass (%)	p-Value
BIA fat mass (%)	0.335	0.040 *
Sum of the three skinfolds (mm)	0.683	<0.001 **

Notes: * Significant correlation at the 0.05 level (2-tailed); ** Significant correlation at the 0.05 level (2-tailed); DXA—dual-energy X-ray Absorptiometry; BIA—bioelectrical impedance; %—percentage; mm—millimeters.

Despite the moderate significant correlations found between the field methods and DXA, we observed that the mean difference between the methods was clinically relevant, as shown in Table 3. Fat mass was underestimated by a median value of 2.21% using BIA in comparison with DXA.

Table 3. Descriptive analysis (mean, standard deviation, and median values) on % of body fat estimation among methods and the differences between them.

	Mean	sd	Median
BIA fat (%)	12.0	2.62	12.20
DXA fat (%)	14.06	2.20	13.64
DXA fat-BIA fat (%)	2.06	2.55	2.21

DXA—dual-energy X-ray Absorptiometry; BIA—bioelectrical impedance; %—percentage

Bland-Altman plots (Figure 1) showed a clear tendency regarding the evaluations with BIA. We can see that the smaller the value of fat % measured with BIA, the bigger the difference with the DXA assessment.

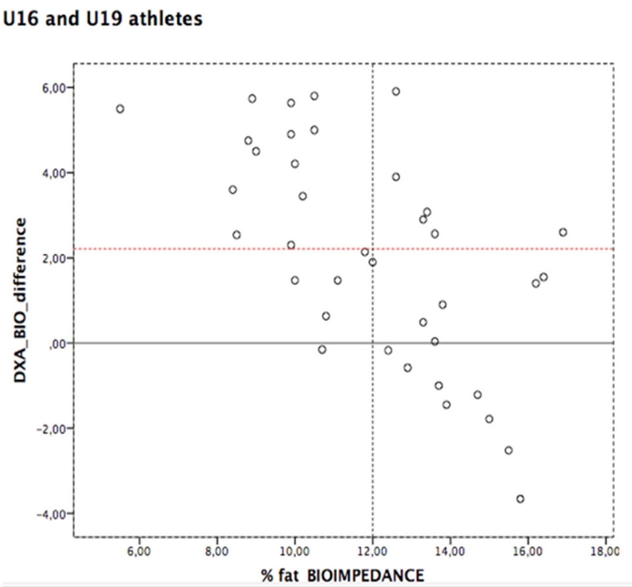

Figure 1. Bland-Altman plots (red line represents the median value of the difference between methods). U16—Under 16; U19—Under 19; DXA—dual-energy X-ray Absorptiometry; BIA—bioelectrical impedance; %—percentage.

4. Discussion

Among elite youth football athletes, we observed moderate correlations between field methods and DXA on body composition assessment. The use of BIA in clinical practice has been validated for various populations [30], but the comparison with a reference method such as DXA, in athletes, has few published studies to date.

BIA is a safe and non-invasive method based on the difference of the electrical conductivity of body fat and fat-free mass [17]. Despite BIA being widely used to estimate body composition, there is still some difficulty in accurately assessing the percentage of body fat from this method [20]. One of the difficulties lies in the need to comply with some assumptions that interfere with the final estimates, such as fasting or spending 4 h without food or drink, the absence of exercise the previous day, the absence of alcohol or diuretic drinks, and the need for a stable temperature of 23 °C in the room [26]. These requirements may interfere with the hydration status, and hence interfere in the correct body composition assessment [20]. Even small changes, such as the fasting period before assessment, can lead to changes in the fat mass estimates by BIA [31]. Another important aspect is that manufacturers do not supply the reference population or the equations in the device used in our study, which makes it difficult to compare with other studies.

In the literature, moderate correlations between BIA and DXA were found [32]. However, these results do not necessarily mean there is a good agreement between methods. In that regard, the present study found a high median value of the difference between the methods (DXA vs. BIA), resulting in fat mass underestimation (2.21%) when using the field method BIA. Other studies, albeit conducted in non-athletes, comparing BIA and DXA reported a systematic underestimation of the body fat percentage by BIA, especially in lean subjects, which is consistent with our results [33–35]. In addition, in non-athletes as well, with different body profiles, we found an overestimation of the body fat percentage, especially in overweight subjects [36–39].

The weight increase, especially in fat-free mass, may be a desired goal, but a body fat increase as large as 2% may lead to decreased performance, for example in vertical jumping [40]. For this reason, evaluation with BIA can lead to misguided training and diet plans in the pursuit of a lower body fat percentage [13,14].

The Bland-Altman plots showed a distinct tendency in the evaluations using BIA, namely among athletes with a better body composition profile (8%–12% of body fat). A clear underestimation of body fat assessment using BIA was observed among 94.5% of the athletes with less than 12% body fat. These results show some agreement with the existing evidence in young athletes. Krzykała (2016) and Sillanpää (2013) have shown that BIA overestimates athletes' body fat percentage, especially in those with lower percentages of body fat in DXA scans. Additionally, BIA underestimated the fat percentage in athletes with more body fat as assessed by DXA [41,42]. For this reason, the use of BIA can lead to deviations from the reference method which may be a limitation to its use in individual evaluation [20].

The use of SKF to evaluate body composition is accepted as valid for athletes [43,44]. It is possible to compare the values we found in U19 athletes with what would be expected in football players [1]. In addition, the use of SKF has been shown to be an alternative that correlates much better with DXA than BIA in athletes [45,46]. Further, although it was not the main goal of this study, we also found that there was a higher correlation between SKF and DXA in these young football players. This can lead to a further discussion about the existing methods to evaluate body composition and their uses in the field.

Despite the small sample size, this observational study provides objective data collected by trained specialists, and the correlations between body composition assessment methods were supported in the DXA comparison, increasing the reliability of the results. Nevertheless, one of the limitations on body composition evaluation and comparison between studies is that there are several brands and types of devices to assess the body fat percentage and fat-free mass [47]. For this reason, in practical terms, it becomes difficult to make comparisons between studies because different devices are used. In addition, the validity of the prediction equations is dependent on how similar the population of interest is to the reference population in which the prediction equations were tested. This assumption could affect the results supported by BIA measurements and could have an impact on the differences found between tested methods. However, having taken into account the different determinants of imprecision that affect the final body composition estimations, this study made the athletes' objective measurements in the same day with trained physicians and under standardized protocols.

5. Conclusions

The main findings of our study suggest that despite being a valid method for use in athletes, there must be caution in the way the results obtained with BIA are interpreted, even taking into account the method's moderate correlation with DXA. Since there is already a validation of the use of skinfolds to estimate body composition in athletes, which is also a very accessible method that is easy to implement, with fewer determinants of imprecision on the final estimates and with a high correlation with DXA [48], it is our suggestion to provide SKF data collection to assess and control body composition among elite athletes.

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ARTIGO 2

Anthropometric profile of soccer players as determinant of position specificity: a cross-sectional study

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Anthropometric profile of soccerplayers as determinant of position specificity: A cross-sectionalstudy

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We aim to describe the anthropometric profile of a large group of football players, relating these characteristics to the different stage of maturation and the position in the field. We also intend to describe the variations on body composition estimation, among adult soccer players, according to different equations . A total of 618 Greek soccer players were evaluated. Later they were grouped in age groups (12-14: n = 97; 14-16; n = 155; 16-18: n = 126; 18-37: n = 240) and in tactical positions (goalkeepers, Defense, Midfield and Forward). For this evaluation, a stadiometer (SECA, UK), a Tanita scale (HD-351, USA) and a skinfold caliper (Harpenden, UK) were used. For the estimation of BF%, the Parizkova formula was used (Parizkova 1978). Additionally we used Reilly and Evans formula (Evans, Rowe, Misic, Prior, & Arngrímsson, 2005; Reilly et al., 2009) to estimate % body fat in players older than 18. In relation to anthropometry, the goalkeepers were the position that presented the most differences relative to the other positions, in all age groups. We see statistically significant differences for % BF and for sum of skinfolds (p=.033 and p=.023), in the age group 12-14, but not for weight and height. These results contrast with the ones found for the group 16-18, were we saw differences for weight and height (p=.001 and p=.007), but not for %BF and for sum of skinfolds. We have statistically significant differences for weight, height, %BF and Sum of SKF, in the age groups 14-16 (p=.006; p=.052; p= .013; p=.018) and over 18 (p=.000; p=.000; p= .044; p=.041). The differences between positions followed a trend pattern across all age groups. Using

Paryzkova formula, we observed a mean (sd) range of variation of % body fat between 4.17 (1.91) – 5.18 (1.99) when compared with the Reilly formula and; 4.87 (1.46) – 5.51 (1.46) when compared with Evans. In conclusion, we observed a position specificity of the anthropometric characteristics, across different stages of maturation. Additionally, among adult athletes, an overestimation of % body fat between 4.40-5.02 was observed, when used Paryskova formula compared with Reilly and Evans.

Anthropometric profile of soccer players as determinant of position specificity: A cross-sectional study

Anthropometric of soccer players

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ABSTRACT

We aim to describe the anthropometric profile of a large group of football players, relating these characteristics to the different stage of maturation and the position in the field. We also intend to describe the variations on body composition estimation, among adult soccer players, according to different equations. A total of 618 Greek soccer players were evaluated. Later they were grouped in age groups (12-14: n = 97; 14-16; n = 155; 16-18: n = 126; 18-37: n = 240) and in tactical positions (goalkeepers, Defense, Midfield and Forward). For this evaluation, a stadiometer (SECA, UK), a Tanita scale (HD-351, USA) and a skinfold caliper (Harpenden, UK) were used. For the estimation of BF%, the Parizkova formula was used (Parizkova 1978). Additionally we used Reilly and Evans formula (Evans, Rowe, Misic, Prior, & Arngrímsson, 2005; Reilly et al., 2009) to estimate % body fat in players older than 18. In relation to anthropometry, the goalkeepers were the position that presented the most differences relative to the other positions, in all age groups. We see statistically significant differences for % BF and for sum of skinfolds (p=.033 and p=.023), in the age group 12-14, but not for weight and height. These results contrast with the ones found for the group 16-18, were we saw differences for weight and height (p=.001 and p=.007), but not for %BF and for sum of skinfolds. We have statistically significant differences for weight, height, %BF and Sum of SKF, in the age groups 14-16 (p=.006; p=.052; p= .013; p=.018) and over 18 (p=.000; p=.000; p= .044; p=.041). The differences between positions followed a trend pattern across all age groups.Using Paryzkova formula, we observed a mean (sd) range of variation of % body fat between 4.17 (1.91) – 5.18 (1.99) when compared with the Reilly formula and; 4.87 (1.46) – 5.51 (1.46) when compared with Evans.In conclusion, we observed a position specificity of the anthropometric characteristics, across different stages of maturation. Additionally, among adult athletes, an overestimation of % body fat between 4.40-5.02 was observed, when used Paryskova formula compared with Reilly and Evans.

***Keywords*:** Anthropometry, soccer, position, skinfolds equations

INTRODUCTION

There are many important factors for success in a soccer team, and it is difficult to isolate anthropometric and physiological characteristics as key factors for sports performance (Reilly et al., 2000). There is a relation between the anthropometric characteristics, namely the fat mass, with the susceptibility to the occurrence of injuries (Perroni, Vetrano, Camolese, Guidetti, & Baldari, 2015). It was already described a relationship between some physiological characteristics, such as speed and power, and the anthropometric patterns (Lago-Peñas, Casais, Dellal, Rey, & Dominguez, 2011). As so, assessment of body composition in elite soccer players may help to optimize performance and to keep track the results of the implemented training regimens (Santos et al., 2014)(Sutton et al., 2009).

Youth development follows a normal pattern for age (Canhadas, Silva, Chaves, & Portes, 2010), however differences in weight, height and fat mass relative to the position were already described (Nikolaidis & Karydis, 2011), showing that there are significant differences throughout the maturation process with an impact on position performance. It has been shown that a selection factor for young players is their maturation state, which leads to a higher height and weight of the selected players compared to the unselected ones (Gil, Ruiz, Irazusta, Gil, & Irazusta, 2007), giving emphasis to the discussion of the relative age and the prospective impact on the future of this athletes.

It is possible to find anthropometric differences between positions throughout the development process, which show us that the goalkeepers tend to be the tallest, the heaviest and the players with more % body fat, while the midfielders are at the opposite end (Lago-Peñas, Rey, Casáis, & Gómez-López, 2014) (Towlson et al., 2017). In a study, among professional players, describing the anthropometric differences between playing positions, it was also found significant differences between positions, similar to those found at youth level, with goalkeepers being the highest, heavier and with more fat mass, followed by the defenders, the forwards and finally the midfielders (Sutton et al., 2009). These results seem to suggest that, regardless of the state of maturation of young athletes, there is a selection pattern according to the anthropometric characteristics based on the specificity of the tactical position in the field.

On the other hand, the evaluation of body composition incorporates some difficulties. All techniques have advantages, but they also have limitations (Ackland et al., 2012). We know that there is a wide range of methods used, without uniformity (Meyer et al., 2013), which lead to quite different results (Leão et al., 2017), making it often impossible to make comparisons between samples from different studies. Thus the aims of our study are (1) to describe the anthropometric profile, based on objective measures done in a large group of soccer players, according to different stages of maturation and playing positions in the field and (2) to describe the variations on body composition estimation, among adult soccer players, according to different equations.

METHODS

Participants

A cross-sectional study was carried out among Greek professional, semi-professional and amateur soccer players. A total of 618 Greek soccer players with a mean (SD) age of 18.18 (4.78) years were evaluated during the competitive seasons of 2008-2009, 2009-2010 and 2010-2011. The sample was then distributed by age group (12-14 years old; 14-16 years old; 16-18 years old; >18 years old) and by playing position (Goalkeepers, Defenders, Midfielders, Forwards) (table 1).

The distribution of the athletes by the referred age groups was based on the format of the national and international competitions, which typically use these subgroups. All players of legal age completed consent to participate and those responsible for the education of players under the age of 18 approved the participation of the athletes in the study. The present study followed the recommendations for the study in humans in accordance with the Declaration of Helsinki (Association, 1964).

Table 1 – Distribution of the participants by age group and playing position

Age Group (Years old)	n (%)	Playing Position	n (%)
12 - 14	97 (15.7%)	Goalkeeper (GK)	63 (10.2%)
14 - 16	155 (25.1%)	Defenders	237 (38.3%)

16 - 18	126 (20.4%)	Midfielders	232 (37.5%)
> 18	240 (38.8%)	Forwards	86 (13.9%)

Anthropometric procedures

All the tests were conducted in the laboratory, between 2008 and 2011, on weekdays between 8:00 a.m. and 2:00 p.m. Height (SECA, Leicester, UK) and body weight (HD-351, Tanita, Illinois, USA) were assessed to the nearest 0.1 cm and 0.1 kg, respectively, according to the manufacturer's guidelines. Three measurements of each variable was performed, with the mean value being recorded.

The percentage of body fat (%BF) was calculated using the formula proposed by Parizkova (Pařízková, 1977), with the sum of 10 folds (cheek, wattle, chest I, triceps, sub- scapular, abdominal, chest II, suprailiac, thigh and calf), measured through a skinfold caliper (Harpenden, West Sussex, UK). Three measurements of each fold was performed in a rotating manner, using the mean value in mm for the sum of the 10 skinfolds. All measurements were realized by qualified and experienced tester. In addition, the %BF was calculated using the formula proposed by Reilly (Sutton et al., 2009) and the formula proposed by Evans (Evans et al., 2005) in athletes over 18 years old,

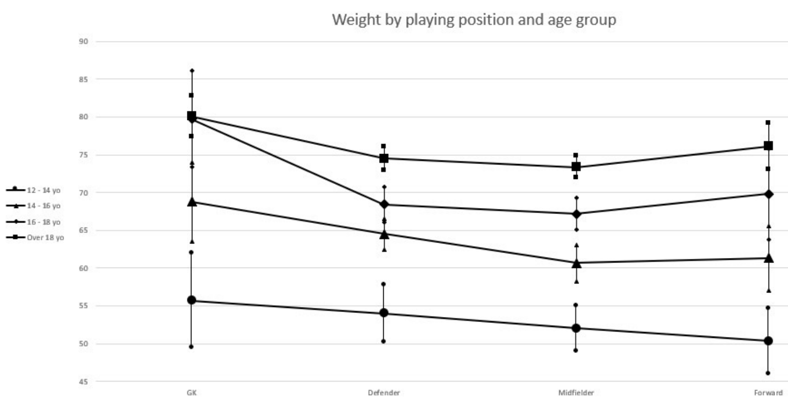
Statistical analysis

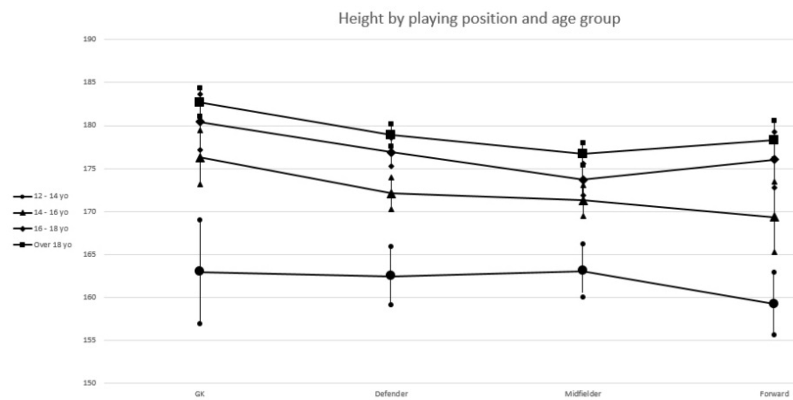
Data on anthropometric characteristics were stratified by age group and playing positions. All results were expressed as mean values and standard deviations (mean ± SD), and the statistical analysis tests were computed at 0.05 level of significance ($p = 0.05$). Statistical analyses were performed using SPSS v.23.0 statistical software (SPSS Inc., Chicago, IL, USA). Shapiro-Wilk test was applied to ascertain the normal distribution of data. ANOVA was used to analyze the anthropometric mean differences between groups. Multivariate regression analysis was conducted to test the associations between anthropometric characteristics, age and tactical positions.

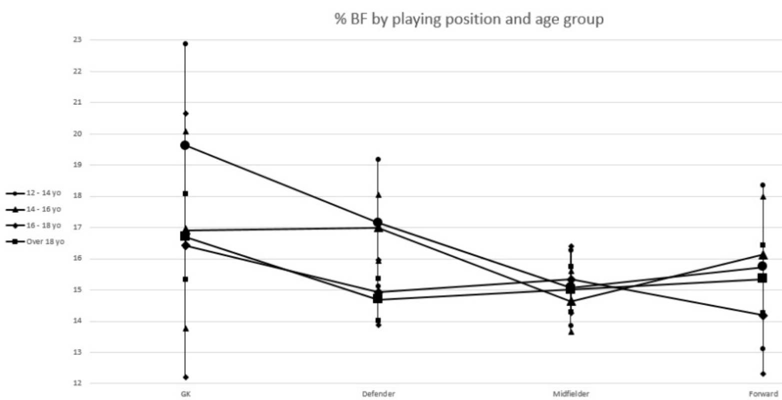
RESULTS

Descriptive values by chronological age group and playing positions are summarized in Table 2. We observed that weight and height increase over all age groups, while the % body fat and the sum of skinfolds decrease with increasing age, in a statistically significant way.

Regarding the playing position, we found a trend in the pattern (figure 1) relative to weight and height across all ages, that show goalkeepers always being the heaviest, the tallest, the ones with the highest % body fat mass and, consequently, with the highest sum of skinfolds.

a. 

b. 

c. 

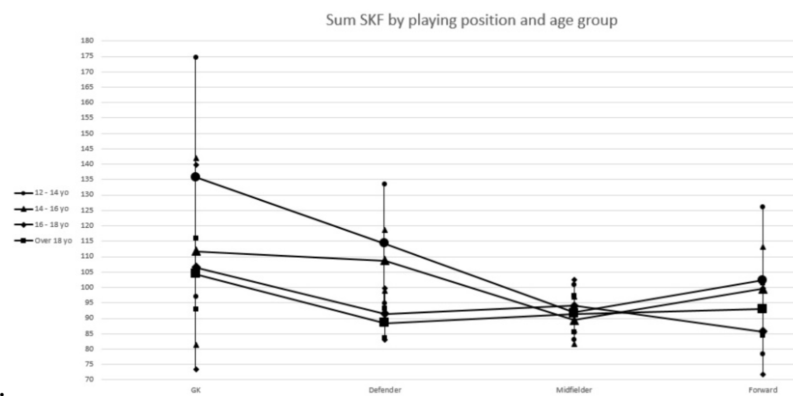
d. 

Figure 1 – Means (CI 95%) of the anthropometric variables (a - weight; b - height; c - % body fat; d – Sum of skinfolds) by age group and playing position

In the age group 12-14 we see statistically significant differences for % BF and for sum of skinfolds (p=.033 and p=.023), between the GK and the midfielders but not for weight and height. These results contrast with the ones found for the group 16-18, were we saw differences for weight and height (p=.001 and p=.007), but not for %BF and sum of skinfolds. In this group, we see differences between the GK and all the other positions regarding weight and between the GK and midfielders regarding height. There are statistically significant differences in weight, height, %BF and Sum of SKF in the 14-16 years old group (p=.006; p=.052; p=.013; p=.018) and in the over 18 years old group (p=.000; p=.000; p=.044; p=.041), . We observed differences between GK and midfielders and GK and forwards in weight and height, respectively, in the 14-16 group. In this group we also noticed differences amidst defenders and midfielders in %BF and sum of SKF. In the group of players over 18, we have differences between GK and defenders and midfielders in weight, and between GK and the other positions regarding height Concerning %BF and sum of SKF we noticed differences among GK and defenders.

From the skinfolds evaluated, 3 formulas were used to calculate the %BF in the group of players older than 18 years. Table 3 shows the calculated values, including the sum of the skinfolds, for the different playing positions.

Table 3 - %BF calculated using different formulas by playing position in players over 18

Position	%BF Paryzkova (%)	%BF Reilly (%)	%BF Evans (%)	*p*
GK	16.69 ± 3.59	11.51 ± 1.80	11.18 ± 2.43	*< 0.001*
Defender	14.69 ± 3.21	10.52 ± 1.46	9.82 ± 1.97	*< 0.001*
Midfielder	15.01 ± 3.44	10.73 ± 1.85	10.09 ± 2.54	*< 0.001*
Forward	15.35 ± 3.06	10.66 ± 1.43	10.12 ± 2.29	*< 0.001*

Taking into account the different formulas used, the pattern of body fat (%), between positions, remains constant, with the GK with the higher values and the defenders with the lower values, independently of the formula used. However, it is possible to observe that the absolute values of %BF is significantly different within position across different formulas used ($p<0.001$). Table 4 showed the mean differences between formulas and we observed the impact on body fat estimation among adult's athletes. The huge differences were observed when the Paryzkova formula was used, with a mean (sd) range of variation of % body fat between 4.17 (1.91) – 5.18 (1.99) when compared with the Reilly formula and; 4.87 (1.46) – 5.51 (1.46) when compared with Evans.

Table 4 – Mean difference between formulas used to calculated %BF by playing position

Position	**Paryzkova - Reilly**	**Paryzkova-Evans**	**Reilly-Evans (%)**
GK	5.18 ± 1.99	5.51 ± 1.46	0.33 ± 0.71
Defender	4.17 ± 1.91	4.87 ± 1.56	0.70 ± 0.58
Midfielder	4.29 ± 1.79	4.92 ± 1.35	0.64 ± 0.74
Forward	4.69 ± 1.84	5.28 ± 1.55	0.59 ± 0.71

DISCUSSION

The primary findings of this cross-sectional study with a large sample of soccer players were a position specificity of the anthropometric characteristics, across different stages of maturation. Additionally, among adult athletes, an overestimation of % body fat between 4.40-5.02 was observed, when used Paryskova formula compared with Reilly and Evans.

Throughout the development process, we saw increases in weight and height and decreases in %BF, in line with what was expected (Nikolaidis & Karydis, 2011) (Malina et al., 2000).. With respect to the values found, in particular in %BF, the values are slightly higher than those already described for other populations (Arnason et al., 2004; Davis, Brewer, & Atkin, 1992; Deprez, Fransen, Lenoir, Philippaerts, & Vaeyens, 2015; Gil et al., 2007; Reilly et al., 2000).

Soccer is a sport characterized by different physiological needs in the various field positions, which consequently leads to different physical characteristics (Bloomfield, Polman, & O'Donoghue, 2007; Di Salvo et al., 2007). In this sense, and from the analysis of our results, we conclude that the goalkeeper position is the one where the athletes have a greater height, greater weight and higher %BF, compared to the other positions. Considering the characteristics described by Ziv (Ziv & Lidor, 2011) for the goalkeeper, we found that the mean for the height of our sample is lower than would be expected. This can be explained by the fact that there are athletes since the age of 12. However, this fact does not explain the difference in %BF, much higher than what was found to be normal.

In line with results from other studies (Milsom et al., 2015; Sutton et al., 2009), we found that for the anthropometric characteristics in the different positions, after the GK, and in descending order of height, weight and %BF, we have the defenders, the forwards and finally the midfield players. At this point, it is interesting to note that this division into positional lines is not used in all studies, which may alter the results of this relationship between different positions. If we think of defense, there are significant anthropometric differences between central and lateral defenders, which may alter the results of this relationship between different positions (Lago-Peñas et al., 2011).

There are some reasons that can be pointed out for the differences found between our sample and previous studies regarding the %BF, namely the level of soccer practiced by the different samples in the different studies. It is presumed that the higher the level of soccer, the lower will be the %BF. In addition, different methods of evaluating the %BF may lead to different results, and it is proven that the difference is not negligible (Leão et al., 2017). The use of formulas to calculate %BF has a good correlation with standard gold methods, like DXA, but different choices can increase the difference between methods (Zemski et al., 2017).

For this reason, we present %BF values calculated using different formulas for a sub-sample of players. Our data show that the formula chosen to calculate the %BF has an impact on the final value found, which may lead to different conclusions regarding them. the use of different formulas to estimate the %BF does not allow to obtain values comparable to each other, regardless of whether they are validated and have a good correlation with reference methods (Rodriguez et al., 2005; Silva, Fields, Quitério, & Sardinha, 2009).

Although more than 100 equations for estimating %BF are validated, the fact that the population used for validation is different may lead to differences between them. In addition, the fact that the different equations use different variables, such as using a total number of different skinfolds besides using skinfolds from different locations, also contributes to this differential between them (Ackland et al., 2012).

Thus, the comparison between values found should always have this concern. One possibility may be to use the sum of the skinfolds, as proposed by ISAK (Stewart et al., 2011), that show a good correlation with all methods of evaluation of %BF, and using it as an indicator of the athlete's adiposity and its changes over time (Zemski et al., 2017). All methods of assessing body composition have their advantages and limitations (Ackland et al., 2012) (Aragon et al., 2017), but standardize the method used to evaluate soccer players in future studies may facilitate the comparison between the methods.

CONCLUSION

Our study adds to the knowledge about the anthropometric characteristics of soccer players and about the evolution of these same characteristics throughout the normal development process. In that sense, and in summary, the age will show increases in weight and height and decreases in %BF, within what would be expected. Moreover, we observed significant correlations between position and anthropometric characteristics. These differences, although already described in previous studies with smaller, more specific samples, seem to remain throughout all age groups, especially between goalkeepers and outfield positions. This seems to suggest that the selection process already takes into account specialization in a position from an early age, and that selection is manifested even in older stages of development. In addition, our work demonstrates that uniformity of criteria, both in the distribution of players by positions and in the method used to calculate% BF, may bring benefits to the study of body composition in athletes.

The authors declare that they have no competing interests

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3. DISCUSSÃO E CONCLUSÃO

A avaliação da composição corporal pode fornecer informações valiosas sobre as mudanças observadas nos atletas no decorrer de toda a periodização do treino (Kyle, Piccoli, & Pichard, 2003). Além disso, os dados de composição corporal podem ser importantes, numa fase inicial, nos procedimentos de seleção em atletas jovens, permitindo uma comparação com valores de referência (le Gall, Carling, Williams, & Reilly, 2010) e, consequentemente, aumentar o potencial no planeamento dos objetivos e expectativas de performance desportiva.

Independentemente da importância que a composição corporal tem, e que por todos é reconhecida, continua a ser difícil obter uma análise precisa da % MG. As ferramentas disponíveis para a avaliação da composição corporal são imprecisas ou suportadas em dados de reduzida validade e precisão, o oposto do que assumimos a maior parte do tempo (Meyer et al., 2013). Não obstante a avaliação da gordura corporal nos atletas ser um aspeto fundamental no planeamento das intervenções, ainda não existe um método que ofereça 100% de precisão (Ackland et al., 2012) e que permita uma monitorização fiável em contexto de treino desportivo.

O uso de diferentes métodos na avaliação da composição corporal fornece resultados inconsistentes, muitas vezes levando a dificuldades e dúvidas na prescrição do plano de treino individual (Bilsborough et al., 2014; Esco et al., 2015). Além disso, uma avaliação incorreta da composição corporal pode levar a dificuldades diversas. Uma delas é a necessidade de prescrever um plano alimentar ajustado às necessidades reais dos atletas, quando as estimativas da composição corporal, tidas como ponto base de prescrição/orientação do treino, se encontram amplamente desajustadas dos valores reais (Fink & Mikesky, 2015).

A escolha do método deve considerar vários fatores, incluindo questões técnicas, como segurança, validade e precisão. Além disso, existem outros fatores a serem considerados, em particular, fatores práticos como disponibilidade, implicações financeiras, portabilidade, invasão de privacidade, disponibilidade de tempo e conhecimentos técnicos para conduzir o método (Driskell & Wolinsky, 2011; Gropper & Smith, 2013).

Todas as técnicas disponíveis possuem algumas vantagens e desvantagens inerentes à mesma, seja na metodologia, na interpretação dos dados ou nas premissas feitas a partir da mesma. Assim, a adesão aos pré-requisitos para cada uma das técnicas é um requisito-chave (Ackland et al., 2012). Mesmo os métodos considerados como referência podem ter limitações quando são alterados os comportamentos antes da avaliação e que conduzem a alterações do estado de hidratação (Rouillier, David-Riel, Brazeau, St-Pierre, & Karelis, 2015).

Na literatura, correlações moderadas entre BIA e DXA foram encontradas (MOUAD et al., 2015). No entanto, esses resultados não significam necessariamente um bom acordo entre os métodos. Vários estudos, embora conduzidos em não atletas, comparando BIA e DXA, relataram subestimação sistemática de gordura corporal por BIA, especialmente em indivíduos magros (Pietrobelli, Rubiano, St-Onge, & Heymsfield, 2004; Völgyi et al., 2008; J.-G. Wang et al., 2013).

Nesse sentido, no nosso estudo, observamos que a BIA, apesar de ser um método válido para ser usado em atletas, deve haver alguma precaução na forma como os resultados obtidos são interpretados, mesmo levando em consideração a sua correlação moderada com DXA. A este respeito, o presente estudo encontrou um valor médio da diferença entre os métodos (DXA vs BIA) de alguma relevância clínico-desportiva, resultando numa subestimativa média da massa gorda em 2,21%, quando se utiliza a BIA como método de campo. Esta situação ganha maior relevo quando estamos a lidar com atletas de alto rendimento, onde pequenas diferenças se traduzem em grandes impactos na performance desportiva e na prevenção de lesões (Piucco & Santos, 2009).

O futebol é um desporto caraterizado por diferentes necessidades fisiológicas nas várias posições de campo, o que, consequentemente, leva a diferentes características antropométricas e físicas (Bloomfield, Polman, & O'Donoghue, 2007; Di Salvo et al., 2007).

Por conseguinte, as diferenças antropométricas, independentemente do método utilizado, encontram-se também associadas à posição ocupada pelo jogador (Slimani & Nikolaidis, 2017), sobretudo entre os guarda-redes e as outras posições (Arnason et al., 2004; Matkovic et al., 2003)

A partir da análise dos nossos resultados, concluímos que a posição do guarda-redes é aquela em que os atletas têm maior altura, maior peso e maior % MG, em comparação com as demais posições.

Em concordância com os resultados de outros estudos (Milsom et al., 2015; Sutton et al., 2009), foi possível perceber que relativamente às caraterísticas antropométricas, nomeadamente a altura, peso e % MG, nas diferentes posições, após o guarda-redes, e em ordem decrescente de altura, peso e % MG, temos os defensores, os avançados e, finalmente, os meio-campistas.

Neste ponto, é interessante notar que esta divisão em linhas posicionais não é utilizada em todos os estudos, o que pode alterar os resultados dessa relação entre diferentes posições. Entre os jogadores tidos como "defesas", muitas das vezes assim caraterizados na literatura, existem diferenças antropométricas significativas entre defensores centrais e laterais, conduzindo a resultados distintos e dificultando múltiplas comparações (Lago-Peñas et al., 2011).

Analisando os valores da % MG, verificamos que os mesmos são ligeiramente superiores aos já descritos para outras populações (Arnason et al., 2004; Davis, Brewer & Atkin, 1992; Deprez, Fransen, Lenoir, Philippaerts, & Vaeyens, 2015; Gil et al., 2007; Reilly et al., 2000). Existem algumas razões que podem ser apontadas para as diferenças encontradas na % MG entre a nossa amostra e estudos anteriores, nomeadamente o nível competitivo dos atletas de futebol avaliados. Presume-se que quanto maior o nível de proficiência, menor será a % MG (Arnason et al., 2004; Vaeyens et al., 2006).

O facto de serem utilizados diferentes métodos de avaliação da % MG pode levar a resultados distintos, sendo esta evidência também descrita por um dos estudos publicados em atletas jovens de elite (Shim et al., 2014), conduzindo a um impacto significativo nas orientações da prescrição alimentar e do exercício físico, condicionando diretamente o planeamento do treino desportivo.

O uso de equações para calcular a % MG, a partir das pregas cutâneas, tem uma boa correlação com os métodos padrão de referência, como o DXA, mas diferentes escolhas de equações podem levar a diferenças significativas no valor final (Zemski, Broad, & Slater, 2017).

Embora estejam validadas mais de 100 equações para estimar a % MG, o facto das populações utilizadas para as validar serem diferentes pode levar a diferenças entre elas. Além disso, o facto de que equações diferentes usem variáveis diferentes, como o uso de um número total de diferentes pregas cutâneas, além da utilização de pregas cutâneas de diferentes locais, também contribui para essa diferença entre elas (Ackland et al., 2012).

Uma possibilidade para diminuir a margem de erro na avaliação pode ser usar a soma das pregas cutâneas, conforme proposto pelo ISAK (Stewart et al., 2011). Esse indicador demonstra uma boa correlação com todos os métodos de avaliação de % MG, e pode ser usado como um indicador da adiposidade do atleta e das suas mudanças ao longo do tempo (Zemski et al., 2017).

Uma vez que já existe uma validação do uso de pregas cutâneas para estimar a composição corporal em atletas que também é muito acessível, fácil de implementar, com menos determinantes de imprecisão nas estimativas finais e com alta correlação com DXA (Oliveira-Junior et al., 2016) , é nossa sugestão que em artigos posteriores sejam disponibilizados os dados das pregas cutâneas, permitindo comparar os valores individuais, assim como para possibilitar a utilização da equação que melhor se adequa ao objetivo da investigação original ou aplicação em contexto de monitorização do treino desportivo.

CONCLUSÕES

- Entre atletas de futebol jovens de elite, observamos correlações moderadas entre métodos de campo e DXA, na avaliação da composição corporal.
- Com a utilização da BIA, observou-se uma subestimação da avaliação da gordura corporal entre 94,5% dos atletas com menos de 12% de massa corporal. Entre os atletas avaliados, a massa gorda foi subestimada em um valor médio de 2,21% usando BIA em comparação com DXA.
- A soma de pregas cutâneas mostrou uma correlação mais forte com o método de referência (DXA) (r = 0,68) do que a BIA.
- Entre atletas de futebol adultos, observou-se uma sobrestimação da % MG entre 4,40-5,02, quando se utilizou a fórmula de Paryskova em comparação com as fórmulas de Reilly e de Evans.
- Foi também observada uma especificidade posicional das características antropométricas, em diferentes estádios de maturação, entre jogadores de futebol. Independentemente da idade, o guarda-redes é a posição na qual os atletas têm maior altura, maior peso e maior % MG.

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