Original article

The usefulness of densitometry as a method of assessing the nutritional status of athletes. Comparison with body mass index☆

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ABSTRACT

The body mass index (BMI) is used to assess nutritional status. The result in athletes may be overestimated due to increase in muscle mass.

Objective: To assess the usefulness of fat mass index (FMI) and lean mass index (LMI) determination as indicators of nutritional status and to compare the results with BMI.

Material and methods: We studied 28 amateur rugby players, male. After being subjected to whole body densitometry by dual X-ray absorptiometry, we determined fat and lean body mass together with other parameters. FMI (fat in kg/height in m^2), LMI (lean in kg/height in m^2) and appendicular muscle mass index (AMMI, arms and legs musculature in kg/height in m^2) were calculated.

Results: Using BMI, 18 players were overweight and 4 obese type I. Considering FMI, 7 of them had normal values and high LMI and AMMI, one of them changed from overweight to obese and another one from obese to overweight. Of the 6 players with normal BMI, one of them showed fat excess and another one fat defect. The results changed the assessment of nutritional status in 39% of players.

Conclusions: Although BMI is an appropriate parameter in general population for the assessment of nutritional status, in athletes should be taken into account fat and muscle body percentage and their corresponding indices. The whole body densitometry appears to be a simple and reliable technique for this purpose.

Utilidad de la densitometría como método de valoración del estado nutricional del deportista. Comparación con el índice de masa corporal

RESUMEN

El índice de masa corporal (IMC) es utilizado para valorar el estado nutricional. En deportistas su resultado puede estar sobreestimado por aumento de la masa muscular.

Objetivo: Valorar la utilidad de la determinación mediante densitometría de los índices de masa grasa (IMG) y magra (IMM) como indicadores del estado nutricional, comparando los resultados con el IMC.

Material y métodos: Se estudiaron 28 deportistas amateur jugadores de rugby, de sexo masculino. Tras ser sometidos a una densitometría de cuerpo entero mediante absorciometría dual de rayos X, se determinaron entre otros parámetros la masa grasa y magra del cuerpo. Se calcularon los IMG (grasa en kg/talla en m^2), IMM (magro en kg/talla en m^2) e índice de masa muscular apendicular (IMMA, musculatura en brazos y piernas en kg/talla en m^2).

Resultados: Utilizando el IMC, 18 jugadores presentaban sobrepeso y 4 obesidad tipo I. Al considerar el IMG, 7 de estos deportistas presentaban valores normales con IMM e IMMA elevados, uno pasaba de obesidad a sobrepeso y otro de sobrepeso a obesidad. De los 6 jugadores con IMC normal, uno de ellos mostraba exceso de grasa y otro defecto. Los resultados cambiaron la valoración del estado nutricional en el 39% de los jugadores estudiados.

Conclusiones: Aunque para la población general el IMC es un parámetro adecuado para la valoración del estado nutricional, en deportistas debe tenerse en cuenta el porcentaje de grasa y de musculatura determinando sus índices correspondientes. La densitometría de cuerpo entero resulta ser una técnica fiable y sencilla para este propósito.

Introduction

The body mass index (BMI) or Quetelet index is defined as the quotient between the weight of an individual and his/her height squared. This index is used to assess nutritional status, being the method used in epidemiological studies and recommended by health organizations and medical societies because of its easy use and reproducibility.[1] Nonetheless, its value is influenced by muscle mass, bone structure, genre and race. In addition, the relationship between the BMI and fat mass is not lineal, particularly in children, youths and the elderly.[2]

The determination of the nutritional status of the athlete in sports is important since its alteration allows evaluation of the adaptation to different types of training.[3] A high proportion of fat mass is related to an increase in energy expenditure while a decrease reduces performance. A sudden change in the body composition may be a sign of health problems.[4]

Dual-energy X-ray absorptiometry (DXA) determines body composition considering 3 components: lean tissue, fat and bone. The values obtained allow the calculation of the fat mass (FMI) and lean mass (LMI) indices as indicators of nutritional status.[5]

Since the BMI in athletes may be overestimated due to the increase in muscle mass, the objective of our study was to assess the usefulness of DXA in the determination of nutritional status in athletes comparing the results found by the 2 methods.

Material and methods

The study group was made up of 28 Caucasian amateur male athletes all of whom belonged to the rugby team of the city. The mean age was 29 years (range: 19–43 years). Their physical activity corresponded to a training-play program of 5–6 h per week, competing in the regional league.

The study protocol included written informed consent, the measurement of height and weight using a scale with a stadiometer and whole body densitometry, and was approved by the Ethical Committee of the hospital. The study was performed in the month of October, that is, at the beginning of the regular sports season. Densitometry was carried out using a DXA Norland XR46 equipment performing a whole body scan with a resolution of 2.8 mm × 7.8 mm at a horizontal sweep speed of 200 mm/s. The athletes were requested to take off their clothing, rings, watches, and anything else which may cause artifact.

Among other parameters the study determined fat and lean mass of the whole body and its different parts including the arms and legs. Based on these parameters the FMI (fat in kg/height in m^2) and LMI (lean mass in kg/height in m^2) were calculated as were the appendicular muscle mass index (AMMI, musculature in arms and legs in kg/height in m^2). The processing of the studies which included the definition of the areas of interest in the different parts of the body was carried out by the investigator. Likewise, the BMI was calculated (weight in kg/height in m^2).

The evaluation criteria for BMI recommended by the World Health Organization (WHO) (normal between 18.5 and 24.99 kg/m^2) were considered.[6] According to the reference values of the National Health and Nutrition Examination Survey[7] and those published by Schutz et al.,[8] normal FMI values were considered as below 6 kg/m^2. LMI measurements greater than 20 kg/m^2 and AMMI above 9 kg/m^2 were considered as elevated. The study group was divided into forwards (in general, those who fight for the ball and make up the static phases of the game) and the line of three-quarters (in general, rapid players who are important in the dynamic phases of the game) with the aim of evaluating possible differences.

For the analysis of differences between the mean values of the different variables the Mann-Whitney U test was used. Analysis of the correlations between the variables studied was performing using the calculation of the Spearman coefficient of correlation. Significance was considered above 95% ($p < 0.05$).[9]

Results

The results of the different parameters determined are shown in 3 tables. Table 1 demonstrates the physical characteristics of the study subjects, the densitometry values and the results of the indices calculated.

Table 2 shows the median and ranges of the mentioned parameters considering the group of forwards and the three-quarters together with the statistical significance on comparison between the two groups. Significant differences were observed in weight, lean and fat mass and the 4 indices calculated (BMI, FMI, LMI and AMMI), reflecting the characteristics of the sport.

Table 3 depicts the results of the analysis of the correlations between the 4 indices calculated. The BMI was significantly correlated with the other 3 indices as well as the LMI and AMMI.

According to the classification of the WHO on nutritional status based on the BMI, of the 28 subjects studied, 18 were classified as overweight (BMI between 25 and 29.99 kg/m^2) and 4 as type 1 obese (between 30.00 and 34.99 kg/m^2). Only 6 athletes showed values within normality (between 18.5 and 24.99 kg/m^2).

On applying the criteria based on the FMI the group considered as overweight, 7 presented normal values (>6.9 kg/m^2) with an elevated LMI and AMM (>percentile 90 and >9.9 kg/m^2, respectively), one became classified as type 1 obesity while the classification was not modified in the remaining 10 subjects, with 8 continuing to present an elevated AMMI.

Of the 4 type 1 obese based on the BMI, one thereafter presented an excess of fat on applying the FMI, with an equally elevated LMI and AMMI. Lastly, of the 6 players with a normal BMI (between 18.5 and 24.99 kg/m^2), one presented an excess of fat and another, a moderate deficit.

Thus, the results obtained changed the evaluation of the nutritional status in 11 athletes, representing 39% of the players included in the study group (Fig. 1).

Fig. 2 demonstrates an example of the densitometry study in a subject badly classified as overweight based only on the BMI.

Discussion

Densitometry is considered a basic examination for the study of osteoporosis and other bone diseases. Its main indication is the determination of bone mineral density in the presence of risk factors of fracture such as advanced age, treatment with corticoids or physical inactivity. Likewise, the technique is used for monitoring patients submitted to treatments which may affect the bone marrow and evaluation of periprosthetic bone reabsorption.[10,11]

DXA presents greater photonic flow compared to densitometers based on radioisotope sources, allowing a reduction in the time of acquisition and improvement in resolution and precision.[12] Although the number of DXA equipment used in departments of Nuclear Medicine has diminished in recent years, this study represents a significant percentage of studies performed daily.[13]

Overweight and obesity are characterized by an increase in body fat mass which has been associated with dyslipidemia, diabetes, arterial hypertension and some types of cancer. The distribution of body fat is used as a predictor of metabolic and cardiovascular diseases or early death.[14]

The WHO has proposed the BMI as a parameter for the diagnosis of overweight and obesity. The values of normality have been