Comparison of body fat assessment methods in athletes: Dual-energy X-ray absorptiometry and Ultrasonography

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Aims and objectives

The Body Composition study (BC) dates back to ancient Greece (400 BC) and has since evolved and has recently emerged as an independent area of scientific research (1). The increase in obesity, particularly in the western countries led the World Health Organization to produce a report that highlighted this fact (2), drawing attention to the comorbidities associated with this phenomenon (3,4).

Numerous methodologies for assessment of BC have been developed (5), the clinical applicability of these methods depends largely on the simplicity of procedures and portability (6).

Ultrasonography (US) has been tested as an evaluation technique of BC. Has been considered effective as of the BC evaluation technique, has the advantage of low cost portability and safety (7). The US was used to assess BC in athletes, with an emphasis on its portability (8).

This study aims to assess the effectiveness of the US in the evaluation of Fat Mass (FM) compared with the Dual Energy X-ray Absorptiometry (DEXA), considered the gold standard method of assessing BC.
Methods and materials

Materials and methods

The data acquisition procedure for this project consisted in collecting anthropometric measures, US and DEXA examinations at a Coimbra clinic in February and June of 2014.

Participants

The participants in the study were 61 young males belonging to Academic Association of Coimbra football club, aged between 13 and 14 years old. In order to obtain their cooperation, the whole procedure has been explained to them, as well as the aim of the study and which exams they would have to be submitted to. In the end, a informed consent has been signed by the participants and the adults (parents) who were legal responsible for them.

Anthropometric measures

Collected anthropomorphic measures were height and weight.

Was asked each participant to remove all the objects they had with them, as well as taking of their clothes and wear only a nightgown, proceeding to the determination of their weight and height, while they were barefoot and in the orthostatic position. These measurements were made by using a scale and a stadiometer by SECA, model 220.

DEXA

For the examination of DEXA, in addition to anthropometric measures, we collect data such as ethnicity date of birth, fundamental to carry out this examination.

Each participant was placed in Supine position on the mid-sagittal plane of the DEXA table with their arms in pronation. They were also warned not to move while the examination lasted. After the participant was adequately positioned they went on to the selection criteria in the command console (examination protocol of the whole body and participant data).

The examination lasted for ten minutes in average and the values were presented in percentages and the total kilograms of lean mass (LM), fat mass (FM), bone mineral density (BMD).

Ultrasound
In order to compare the FM values obtained by DEXA we performed US evaluation into two compartments: abdominal and mid-thigh subcutaneous FM.

All the ultrasound images were acquired with B-mode in transverse plane, using a linear probe (7.5MHz) with the subjects in prone and supine position and with the legs in extension. The abdominal and thigh subcutaneous fat thickness from ultrasound examination was measured by Image J software.

The anterior abdominal subcutaneous FM level was evaluated umbilical, on the anterior surface of the abdomen with two ratings, above and below the navel, then we calculate the average of these two FM assessments.

Subcutaneous FM was evaluated in two sites:

The Posterior abdominal subcutaneous FM was obtained, on the lateral back of the participants on the right and left side, half the distance between the spine and the participant's side limit, at an angle of 45 ° from the line of the spine at the umbilical line level.

Subcutaneous mid-thigh FM (SMtFM) was evaluated on both sides right and left. The distance between the greater trochanter and the upper edge of the patella was measured and it was calculated 50% of this measure to find the thigh middle region to obtain the thigh subcutaneous fat.

Statistics strategies

With regard to the first phase of the study we applied the simple descriptive measures (measures of central tendency and dispersion).

Statistical inference:

It initially appealed to the Linear Correlation Coefficient of Pearson and Scatter Diagram with the estimation of the straight simple linear regression.

In a second step we used the Multiple Linear Regression Model (MLRM) by the Method of least Squares (MLS). For the selection of predictor variables and effect on the dependent variable (criterion variable) we used "Enter Method".

To evaluate the Regression Model of Adjustment Quality we used the Regression Analysis of Variance (F#). To estimate the variability fraction of the dependent variable (dependent) would be explained by the model appealed to the Determination Coefficient ($R^2$). The closer to 1 is $R^2$ better the explanatory power of the regression adjusted model.
When applied two or more variables predictors of the dependent variable appealed to the Adjusted Coefficient of Determination ($R^2_{adj}$) and the respective Estimated Standard Error.

As for the evaluation of the effect of each predictor variable in the regression model we used the estimation of non-standard regression coefficients and the respective standard error, (Fig 1), we also used the respective standardized coefficient ($\beta$) using the $t$-Student test.

To evaluate the quality of the magnitude / correlation is assumed to these cut-off points: $r = 1$ Correlation Perfect Positive; $0.8 < r < 1$ Strong Positive Correlation; $0.5 < r < 0.8$ Moderate Positive correlation; $0.1 < r < 0.5$ Correlation Weak Positive; $0 < r < 0.1$ tiny positive correlation; $0 = No$ correlation. These cutoffs are also suitable for negative correlation values.

The statistical analysis was performed based on significance level of p-value $\leq 0.05$ with a 95% confidence interval. For the treatment of the data we used the following software: IBM SPSS Statistics.
Fig. 1: Fig 1 -

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Results

We proposed initially understand the variation of different anthropometric variables using Pearson’s correlation test. Fig 2 Table 1:

There was a significant correlation between the pattern of the fat tissue (kg) and the estimated values to the Posterior abdominal subcutaneous FM (PAFM), Anterior Abdominal FM (AAFM) and weight.

These patterns were found to be positive variation between the values of fat tissue (kg) and the estimated values in terms of AAFM and weight. What we can say that people who had higher levels of fat tissue also showed significantly higher values of abdominal fat and weight in general.

But there was a negative correlation between the estimated values of fatty tissue (kg) and the PAFM. We can say that participants with higher levels of fat tissue showed progressively lower amount of fat at the level of the mean posterior fat.

We can see in the scatter plots, the variation pattern whether positive or negative predictive factor with statistical significance in relation to the criterion variable (dependent) FM (kg) (Fig 3 and Fig 4).

The first scatter diagram pattern (Fig 3) is negative between the estimated amount of fat tissue in the abdominal subcutaneous athletes and FM. This pattern of increase was 20.2% of those who participated in the study.

Concerning the AAFM, 12.1% athletes revealed a positive pattern when correlated with the amount of fat tissue (Fig 4). A similar pattern occurred between the weight and the fat tissue in 8.7% of athletes (Fig 5).

After the initial analysis, we propose to study the effect of each independent variable (predictor), to predict the percentage of total fat (Variable Criterion). Was applied at this stage enter the MRLM method. The table 2 (Fig 6) summarizes the key statistics.

We can see that the overall model is frankly adjusted ($R^2>40\%$) and significant. Given the above allowed us to determine the weight, height, PAFM and AAFM showed an average predictor and significant effect on the explained variation of the FM ($p<0.0001$).

In terms of the regression coefficients of each predictor, we can say that 58.8% ($\#_{weight}=0.588$) of the variation in fatty tissue is predicted by the weight of the athlete, i.e. the greater weight of the athlete is predicted that a significant increase in the amount of fatty tissue in kg.
A similar pattern occurs at the level of the AAFM, ie 39.8% ($\#_{AAFM}=0.398$) of the variation is explained by fat tissue AAFM values.

However, we found that 52.3% ($\#_{PAFM}=-0.523$) of the variability of the fat tissue of athletes is predicted by PAFM. This variability revealed a negative direction, that is, the greater amount of fat tissue (kg) Estimated in athletes under study was explained by the lower amount of PAFM. A similar pattern occurred between the predictor variable height with the amount of fat tissue.
**Fig. 2:** Table 1: Correlation between variables Caption: ***p<0,0001; **p<0,01; *p<0,05

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Fig. 3: Fig 3 - Scatter plot Caption - Post Us (PAFM)

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**Fig. 4:** Fig 4 - Scatter plot Caption - Abd US (AAFM)

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Fig. 5: Scatter plot

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Fig. 6: Table 2

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Conclusion

Although the model explains 42.4% of our sample, we still consider valid the equation for our proposal. The predictors that make up the regression equation are AAFM, PAFM, height and weight, we did not consider the SmtFM it has no explanatory power, in our sample of body fat compared with DEXA. Our sample consists of 61 young young males belonging to Academic Association of Coimbra football club, aged between 13 and 14 years old, with an average of 5 weekly workouts and a game.

When we compare our study with Pineau et al, we see that the equation for proposal explains over 97% of the sample used (8). However his study differs from ours or in anthropomorphic reviews chosen for regression equation, waist circumference and thigh for anthropometric measurements addition to the assessments of US PAFM and SmtFM. Also differs in the sample (93 participants) that was composed of athletes, adults, sports fight (boxing, judo) the vast majority (81) and rowing. This sample was recruited at the Institut National des Sports et de l'Education Physique, Paris, between elite athletes who rely on control and stabilization of body weight to remain in the class who want to play.

In 2009 Duz et al found concordance between DEXA and US 93% for men with assessments by US in the chest, abdomen and thigh and 90% for women with assessments by US arm (triceps), supra iliac and thigh. Using a sample of 208 young adults (9)

In a study of 2013 the authors find, in sedentary adults concordance of 97% and 92% for women and men respectively, however this study used as anthropometric measures weight and abdominal circumference at the navel level, in addition to assessments by US PAFM and SmtFM (10).

Leahy et al also found good concordances in the comparison between DEXA and US in young adults, 94.7% for men and 90.9% for women. Used to their regression equations US assessments of abdominal subcutaneous fat and anterior thigh for men and abdominal subcutaneous fat and higher average leg for women (11).

As we can see from the above the studies reviewed did better with regard to the agreement between the evaluations by DEXA and US than ours. However were performed on different samples of our, the po US reviews are also differentesw of our held in different locations. We note that in all studies, ours included, have not yet found local evaluation with ultrasound, that can be considered reliable to the assessment of body fat, since all studies use different areas of evaluation between them, despite the good results shown.

We can conclude from this study that assessment of body fat mass by US is a technique under development, which needs more studies she devoted so that it can be used more extensively. For our work it will continue to be developed, particularly with new reviews.
using different assessments of technical US will, as the assessment of intra-abdominal fat, but also using different anthropometric assessments.