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MS6 - MEASURING THORACIC MUSCLE BY CHEST CT TO FORESEE SARCOPENIA IN POST-COVID 19 PATIENTS

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Sarcopenia is characterized by progressive and generalized loss of strength and muscle mass, and may be a manifestation of post-COVID-19 syndrome.
The diagnosis of sarcopenia can be obtained on Computed Tomography (CT) images using Cross Sectional Area (CSA) measurement.
Quantify total CSA (CSAt), pectoral muscle (CSAp) and Skeletal Muscle Index (SMI) to predict the development of sarcopenia in post-Covid-19 patients.

In 48 chest CT scans of post-Covid-19 adult patients, a slice at T4 level, was selected, at the level of descending and ascending aorta, as anatomic references. The CSAt of the pectoralis major muscle and total CSA of the pectoral, intercostal, paraspinal, dentate, latissimus dorsi and subscapularis muscles were calculated using ImageJ® software. The Skeletal Muscle Index (SMI) value was also calculated. A scale of 16 pixels/cm was determined and the background of the images was eliminated. Pixels were converted into a grey scale, then using the threshold technique (59 and 168), into binary images. A GE system with 64 rows, were used.

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The average total muscle area was (136.2 cm^2) and the pectoral muscle area was (34.9 cm^2). The maximum calculated value of the total SMI was 74.12 cm^2/m^2 and 26.16 cm^2/m^2 for the pectoral muscle. The correlation between BMI and the variables CSAt and SMIt did not show statistically significant results (R^2=0.036 and R^2=0.049): P>0.05

No values were found for comparison of patients with sarcopenia in populations with similar characteristics.

BMI isn't a good predictor of CSAt and SMIt values, however it was concluded that a decrease in SMIt leads to a decrease in Bone Mass Index (BMI) in post-Covid-19 patients, which may represent an indicator of the development of sarcopenia. Women were more likely to develop sarcopenia.

1. INTRODUCTION

Post-COVID-19 syndrome is defined as the signs and symptoms that develop during or after infection with SARS-CoV-2 and persist for 12 weeks or longer [1, 2]. Sarcopenia is also a syndrome characterized by progressive and generalized loss of muscle mass and strength [3].

Several studies of chest computed tomography (CT) scans show that muscle weakness is one of the symptoms after COVID-19, suggesting that sarcopenia may be a late manifestation of this infection [1, 4- 6].

Sarcopenia can be diagnosed using CT scans by measuring the Cross-Sectional Area (CSA) and calculating the Skeletal Muscle Index (SMI). CSA is usually measured at the L3/L4 level; however, previous studies to determine skeletal muscle mass have shown a correlation between CSA values calculated at the L3 level and the T4 level.

As patients with post-COVID-19 syndrome already have a chest CT scan, CSA can be measured without exposing patients to further radiation by performing an additional abdominal CT scan [3, 4, 7-11].

Currently, increased attention has been paid to sarcopenia in patients with COVID-19 due to its potential effects. However, the associations between sarcopenia and COVID-19 outcomes have not been fully clarified [12].

1.1. OBJECTIVES

This study aims to quantify the total CSA (CSA_t), the pectoral muscle CSA (CSA_p), and the SMI in order to foresee the development of sarcopenia in patients after COVID-19.

2. METHODOLOGY

2.1 Sample

The sample consisted of 48 chest Computed Tomography (CT) scans. For this study 27 male and 21 female exams, in post-COVID-19 follow-up, were selected. The individuals were aged over 18 and underwent chest CT in clinical practice, in an expiratory protocol, for follow-up of SARS-CoV-2.

Patients who did not undergo this protocol and who did not have information on weight and height for subsequent calculation of Body Mass Index (BMI), were excluded.

2.2. Procedure description

The selected scans for this study were carried out on the same equipment model 16-slice CT scanner (GE BrightSpeed; GE Healthcare, Milwaukee, WI, USA).

The chest CT scans were used and visualized using the RadiAnt® software (DICOM PACS medical image viewer [13]) in order to select the correct sections included in the study, as well as consulting the technical parameters used to obtain the images and their scale.

The patients were positioned in the supine position, head first, with their upper limbs positioned above the head, out from the thoracic area. Images were acquired with the following parameters: 512x512 matrix; slice thickness 1.25 mm; slice interval of 1.25 mm; tube potential of 120 kV and the current of 120 mAs. The images were processed using the smooth body filter.

According to previous studies, the T4 vertebra was selected as the reference point for muscle quantification, therefore, the axial slice referring to the emergence of the descending and ascending aorta artery was selected in each exam (Figure 1).

The level was then confirmed through the vertebra count procedure. The images of the selected slices were recorded in JPEG format, and processed using the ImageJ® software.

In this software, the first step was to set the scale of the images with the "straight line" tool (16 pixels equivalent to 1 cm, previously calculated in RadiAnt® [13]).

Figure 1: Original CT image, at T4 level, selected at RadiAnt®.

The obtained values were entered in the "analyze→set scale" menu. Then, a Region of Interest (ROI) was drawn around the CT images using the "oval selections" tool, to erase the image background ("edit→clear outside") (Figure 2B).

For muscle quantification on ImageJ®, it is necessary to convert the images into binary images, thus the threshold technique was applied [14]. The thresholding technique identifies regions with pixels of similar intensity, turning grey-scale images into binary images. In each image, the pixels' conversion was done creating grayscale images using the "type→8-bit" tool in the "image" menu.

Then, the images were converted to binary with the "threshold→set" tool, located at the "image→adjust" menu. According to previous studies and the quality of the provided images, the threshold range was defined between 59 and 168 [14].

After applying the threshold, the black pixels of the binary images identify soft tissues, and the white pixels indicate the remaining tissues, specifically bone, fat, and air [5-7] (Figure 2C).

Since the spinal cord and heart are also represented by black pixels, ROIs were delineated around them and filled in using the 'fill' tool in the 'edit' menu, so that the pixels inside them became white, preventing them from being quantified as muscle (Figure 2D).

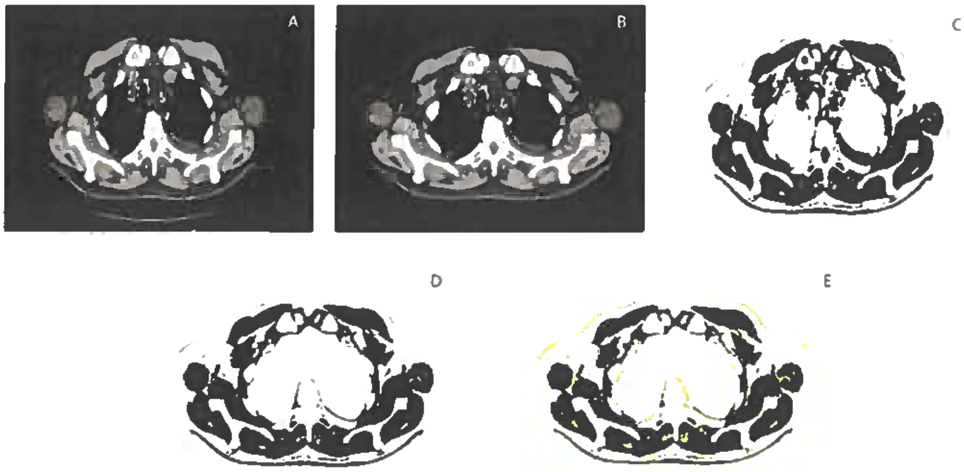

Figure 2 - Total thoracic muscle processing and quantification in ImageJ software.
A) Original axial image. B) Image after background removal. C) Binary image after applying the threshold. D) Binary image after removal of the spinal cord and heart. E) Selection of all pixels corresponding to muscle tissue (black).

Lastly, in the "analyze→set measurements" menu the "area" variable was selected. To quantify CSA_t, the pectoral, intercostal, paraspinal, dentate, latissimus dorsi, and subscapularis muscles were considered (Figure 3). All the black pixel representing these muscles were selected by the "create selection" tool (Figure 2E). CSAt value was given by the "measure" tool. (Figure 3)

To quantify CSAp, only the pectoral muscles were outlined using the 'freehand selection' tool and their background was erased in the 'edit→clear outside' menu (Figure 4).

Figure 3: Image representing the muscles for total CSA quantification, at T4 level, after processing at ImageJ®.

Figure 4: Image representing the pectoral muscle for pectoral CSA quantification, at T4 level, after processing at ImageJ®.

After performing this procedure in the 48 CT images, BMI (Body Mass Index) (BMI = Weight/Height2, kg/m2), SMIt (SMIt = CSAt/Height2, cm2/m2), and SMIp (SMIp = CSAp/Height2, cm2/m2) were calculated for each patient [15-16].

3. RESULTS

Patient data and results are exhibited in Table 1.

Table 1: Patient characteristics variables and results table showing mean values, standard deviation (SD), and minimum and maximum values per variable. Caption: Body Mass Index (BMI), Total Cross-Sectional Area (CSA_t), Pectoral Cross-Sectional Area (CSA_p), Total Skeletal Muscle Index (SMI_t), Pectoral Skeletal Muscle Index (SMI_p).

	Patients		
Average, SD and limits	48 (all patients)	27 (male patients)	21 (female patients)
Age	62,5 ± 12,1 (31-84)	68 ± 11,1 (43-84)	56 ± 9,7 (31-69)
Height	1,66 m ± 0,09 (1,44-1,85)	1,71 m ± 0,06 (1,58-1,85)	1,60 m ± 0.08 (1,44-1,75)
Weight	80 kg ± 13,8 (52-113)	80 kg ± 11,4 (52-98)	80 kg ± 16,7 (58,80-113)
BMI	29,1 kg/m² ± 5,1 (17,58-43,06)	27,2 kg/m² ± 3,5 (17,58-33,25)	31,5 kg/m² ± 5,9 (21,87-43,06)
CSA_t	136,2 cm² ± 26,4 (97,13-216,26)	144 cm² ± 26,5 (104,48-216,26)	126 cm² ± 23 (97,13-171,26)
CSA_p	34,9 cm² ± 10 (22,64-77,38)	37,7 cm² ± 11,3 (25,37-77,38)	31,2 cm² ± 6,8 (22,64-47,32)
SMI_t	49,6 cm²/m² ± 9,6 (32,53-74,12)	49,4 cm²/m² ± 9 (35,36-73,10)	49,8 cm²/m² ± 10,5 (32,53-74,12)
SMI_p	12,7 cm²/m² ± 3.5 (8,52-73,10)	12,9 cm²/m² ± 3,8 (35,36-73,10)	12,3 cm²/m² ± 3 (8,52-20,48)

The mean BMI value of all patients was 29,1 kg/m^2.

CSA_t and CSA_p mean values were, 136.2 cm^2 and 34.9 cm^2, respectively.

SMI_t values varied between 32.53 and 74.12 cm^2/m^2 and SMI_p between 8.52 and 73,10 cm^2/m^2.

The corresponding mean values were 49,6 cm^2/m^2 and 12.7 cm^2/m^2. The correlation between BMI and the variables CSA_t and SMI_t did not show statistically significant results (R^2=0.0036 and R^2=0.049): P>0.05, as shown in Figures 5 and 6.

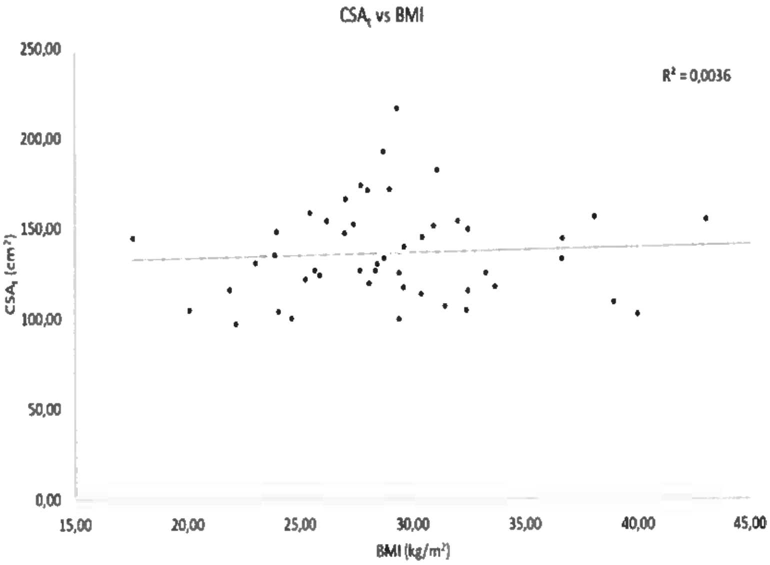

Figure 5: Graph showing correlation between CSA_t and BMI. Caption: Body Mass Index (BMI), Total Cross-Sectional Area (CSA_t).

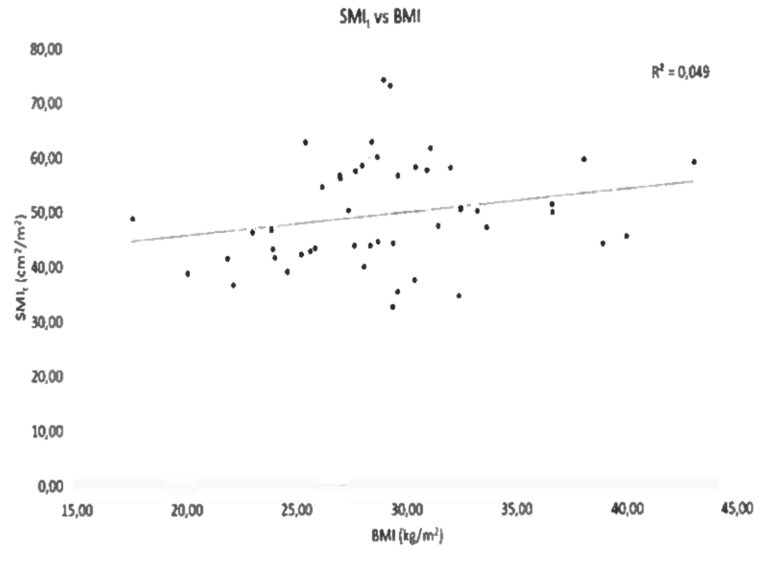

Figure 6: Graph showing correlation between SMI_t and BMI. Caption: Body Mass Index (BMI), Total Skeletal Muscle Index (SMI_t).

4. CONCLUSION

According to the obtained results, we can conclude that BMI is not a good indicator of CSA_t and SMI_t, however, the correlation between BMI and SMI_t shows that a decrease in the values of BMI leads to a decrease in SMI_t values BMI in post-Covid-19 patients, which may represent an indicator of the development of sarcopenia.

CSA_t value discrepancies between male and female patients predict women are more likely to develop sarcopenia. Similar results were obtained in another study, where it was concluded that female patients have a higher tendency to develop this syndrome. The same study was carried out on an Asian population, so we cannot use its values as reference values due to the phenotypic differences [16-17].

Although it was proven that the use of T4 is a valid method to measure skeletal muscle mass [4, 8, 11], there are insufficient reference values. Consequently, a comparison between CSA measurements performed at the T4 level, between general population and patients in post-COVID-19 follow-up and sarcopenia cannot be performed.

Sarcopenia should be routinely screened in clinical practice using available methods; therefore, the prevention and treatment of sarcopenia may prevent the worsening of COVID-19.
The limitations of this study also include a small cohort of patients and no interobserver variability assessed.

STATEMENTS

Nothing to declare

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