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INTERNAL MEDICAL SCIENCES / DAHİLİ TIP BİLİMLERİ

Evaluating the Utility of L1 Level Measurement as an Alternative to L3 in Assessing Myosteatosis on Computed Tomography

Bilgisayarlı Tomografide Miyosteatozun Değerlendirilmesinde L3'e Alternatif Olarak L1 Seviye Ölçümünün Değerlendirilmesi

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Abstract

Objectives: Myosteatosis is a pathology characterized by the accumulation of fat within muscle tissue and serves as a significant indicator for monitoring various medical conditions. Computed tomography (CT) is a useful method for objectively assessing myosteatosis, but exploring alternative anatomical levels for evaluation is necessary. The objective of our study is to investigate the possibility of using the lumbar 1 (L1) level as an alternative to lumbar 3 (L3) level for myosteatosis measurements in CT scans.

Materials and Methods: This retrospective study included 135 participants who underwent abdominopelvic CT scans without contrast. CT scans were performed using a Siemens Somatom Force scanner, and myosteatosis was quantified at the L1 and L3 levels. The abdominal skeletal muscles' cross-sectional area (SMA) and skeletal muscle radiation attenuation (SMRA) values in Hounsfield units (HU) were measured. Statistical analysis included paired t-tests and Pearson correlation coefficients.

Results: SMA at the level of L3 vertebra was statistically significantly higher than that of L1 vertebra (143.5±31.4 cm^2; 128.8 cm^2±27.7 cm^2, respectively, $p<0.001$) We found a significant correlation between SMA of L3 and L1 ($p\leq0.001$, $r=0.93$). The difference in SMRA at L3 and L1 vertebras was small but significant (37.6±6.6 HU; 36.5±6.7 HU, respectively, $p<0.001$) We also found a significant correlation between the SMRA of L3 and L1 ($p\leq0.001$, $r=0.85$).

Conclusion: This study demonstrates a strong correlation between muscle density and area at the L1 and L3 levels. The results of the study support the use of measurements at the L1 level as an alternative to L3 level measurements for evaluating myosteatosis. Future studies could investigate the variations in CT scanners and techniques and explore the reliability and applicability of the results.

Keywords: Myosteatosis, sarcopenia, body composition, computed tomography

Öz

Amaç: Miyosteatoz, kas dokusu içinde yağ birikimi ile karakterize bir patoloji olup, çeşitli tıbbi durumların izlenmesi için önemli bir göstergedir. Bilgisayarlı tomografi (BT), miyosteatozu öznel olarak değerlendirmek için yararlı bir yöntemdir, ancak değerlendirme için alternatif anatomik seviyelerin araştırılması gereklidir. Çalışmamızın amacı, BT taramalarında miyosteatoz ölçümleri için lomber 3 (L3) seviyesine alternatif olarak lomber 1 (L1) seviyesinin kullanılma olasılığını araştırmaktır.

Gereç ve Yöntem: Bu retrospektif çalışma, kontrastsız abdominopelvik BT taramaları yapılan 135 katılımcıyı içermektedir. BT taramaları, Siemens Somatom Force tarayıcısı kullanılarak gerçekleştirilmiştir ve miyosteatoz, L1 ve L3 seviyelerinde değerlendirilmiştir. Abdomen iskelet kaslarının kesitsel alanı (SMA) ve Hounsfield birimleri (HU) cinsinden atenüasyon (SMRA) değerleri ölçülmüştür. İstatistiksel analiz, eşleştirilmiş t-testleri ve Pearson korelasyon katsayılarını içermektedir.

Bulgular: L3 omuru seviyesindeki SMA, L1 omuru seviyesine göre istatistiksel olarak anlamlı şekilde yüksek saptanmıştır (sırasıyla 143,5±31,4 cm^2; 128,8 cm^2±27,7 mm^2, $p<0,001$). L3 ve L1'in SMA'ları arasında önemli bir korelasyon saptanmıştır ($p\leq0,001$, $r=0,93$). L3 ve L1 omurları arasındaki HU

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cinsinden SMRA değerleri farkı küçük ancak anlamlı bulunmuştur (sırasıyla 37,6±6,6 HU; 36,5±6,7 HU, p<0,001). L3 ve L1'in SMRA değerleri arasında da önemli bir korelasyon izlenmiştir (p≤0,001, r=0,85).

Sonuç: Bu çalışma, L1 ve L3 seviyelerinde ölçülen SMRA değerlerinde ve SMA sonuçlarında güçlü bir korelasyon olduğunu göstermektedir. Çalışmanın sonuçları, miyosteatoz değerlendirmesi için L3 seviyesi ölçümlerine alternatif olarak L1 seviyesindeki ölçümlerin kullanımını desteklemektedir. Gelecekteki çalışmalar, BT tarayıcıları ve tekniklerindeki varyasyonlarını, sonuçların güvenilirliği ve uygulanabilirliğini araştırabilir.

Anahtar Kelimeler: Miyosteatoz, sarkopeni, vücut kompozisyonu, bilgisayarlı tomografi

Introduction

Myosteatosis, a condition characterized by the accumulation of fat within muscle tissue, serves as an important marker for monitoring disease progression and predicting survival in various pathological conditions. Sarcopenia, a disorder characterized by both muscle mass and quality decline, is intimately linked to it, along with a decrease in physical function (1). Myosteatosis and sarcopenia are strong indicators of disease progression and survival in a variety of medical disorders, including different types of cancer, cardiovascular surgery, rheumatologic diseases, infectious infections like coronavirus disease-2019, and other chronic illnesses (2-6). These disorders are associated with various negative outcomes, such as a higher likelihood of falls, physical disability, major complications after surgery, longer hospital admissions, and greater healthcare costs (7).

Several techniques are used to evaluate muscle mass and quality, such as bioelectrical impedance analysis (BIA), dual-X-ray absorptiometry, ultrasound, magnetic resonance imaging (MRI), and computed tomography (CT). While DEXA is effective for measuring muscle mass in the limbs, it may not yield precise measurements for the muscles in the trunk area (8). BIA can also be used, but several factors can impact analysis, such as hydration status and food intake, potentially making it less accurate than other methods (9). US is a widely used technique for quantifying muscle mass and identifying muscle wasting; however, it is operator-dependent and may be influenced by the experience and skill of the operator, leading to inconsistencies in measurements and affecting reliability (10). Although MRI can provide objective measurements of muscle mass and quality, it is a time-consuming and expensive imaging modality that may not be practical for routine clinical use in measuring sarcopenia (11).

CT is a useful method for objectively assessing myosteatosis. CT has been widely employed as a research instrument to investigate adipose tissue proliferation. CT scans can differentiate between fat and muscle by quantifying tissue attenuation. Within this framework, the observed average decline in muscle tissue indicates the existence of lipids. CT is widely employed as an imaging method to evaluate many acute and chronic medical disorders, including infections, cancer, and rheumatologic diseases. Using CT to measure myosteatosis enhances the significance of the initial diagnosis and provides additional value opportunistically (12,13).

In existing literature, several anatomical regions have been explored for measuring myosteatosis and sarcopenia, with the most commonly used anatomical level being lumber 3 (L3) (14). Typically, L3 measurements are conducted during abdominal tomography examinations, but they are not part of thoracic tomography scans. However, in certain medical conditions like infectious diseases, lung carcinoma, and interstitial lung disease, sarcopenia relevance may extend to thoracic CT scans, making it an essential consideration (6,15-19). Sarcopenia screening at thorax CT may be considerably managed if the lumber 1 (L1) level measurement for sarcopenia is shown to be correlated with the L3 level. The aim of this study is to evaluate the possibility of using the lumbar L1 level as an alternative to the lumbar L3 level for measuring myosteatosis on CT scans when the L3 level is not included in the scan range.

Materials and Methods

The study complied with the Declaration of Helsinki, and was approved by the Ethics Committee and the Institutional Review Board of Gazi University Faculty of Medicine (approval no: 548; date: 04.07.2022).

Since the study was retrospective, the requirement for informed consent was waived.

Patients

This is a retrospective study consisted of a sample of 150 consecutive participants, all of whom were 18 years of age or older and had received abdominopelvic CT scans with non-contrast series as part of CT urography examination for a hematuria workup between January 2018 and June 2022. This examination was chosen because they all had non-contrast series with a standard scanning protocol. To address the potential confounding effect of tissue enhancement on evaluations of muscle attenuation measurements, the study incorporates participants who have received unenhanced CT scans of the abdomen. Injecting intravenous contrast during imaging might impact the accuracy of the results, posing a risk to the dependability of such imaging methods (20). Fifteen subjects were excluded from the study because of metallic hardware artifacts induced by prostheses, as well as motion

artifacts. These variables possess the capacity to influence the precision of the measurements.

CT Scanning Parameters and Evaluation of the Measurements

The CT imaging was conducted using a Somatom Force, a third-generation 192-section dual-source CT scanner by Siemens Healthcare. This scanner undergoes daily calibration with phantoms provided by the manufacturer, ensuring consistent and accurate attenuation measurements. During the non-contrast phase, series were taken of the entire abdomen, including the L1 and L3 levels. The acquisition parameters were: tube voltage 90-kVp, current modulation (4D care dose®) with reference 120 mAs, detector configuration 192x0.6 mm, gantry rotation time 0.5 s and a spiral pitch factor of 0.35. An iterative reconstruction algorithm was used with a strength of 3 over 5 (ADMIRE®). Images were reconstructed with a slice thickness of 1 mm and a kernel of Br40. Examinations were transferred on a server (syngo.via; Siemens Healthcare, Erlangen Germany). ImageJ, a public domain Java image processing program (version 1.54h) was utilized to quantify myosteatosis at the L1 and L3 levels in the non-contrast series. An expert radiologist, with a background of twenty years in CT scan analysis selected the areas of interest on axial images. The subcutaneous area above abdominal muscles is first excluded, then rectus abdominis muscles, transverse abdominis muscles, oblique muscles, paraspinal muscles, psoas muscles are drawn manually. In accordance with prior research, we measured the skeletal muscle area (SMA) and skeletal muscle radiation attenuation (SMRA) of the muscles at the L1 and L3 pedicle levels (Figure 1).

The SMRA thresholds are set between -29 Hounsfield units (HU) and 150 HU in the image processing program (21). The ImageJ software enables the identification and distinction of these tissues by utilizing these particular thresholds. In our study, we did not calculate the skeletal muscle index as typically used in sarcopenia studies, which is derived by dividing the limb skeletal muscle mass (SMM) (kg) by the square of the height in meters (m^2). This is because our analysis focuses on comparing the L1 and L3 level measurements within the same individual.

Statistical Analysis

Continuous variables in the study were expressed as mean values along with their associated standard deviations. The assessment of data normality was conducted using the Shapiro-Wilk test. To compare measurement values between the L1 and L3 levels within the same subjects, a paired t-test was employed. To evaluate the strength and direction of linear associations between two variables, we computed the Pearson correlation coefficient, which can range from -1 (indicating a complete negative correlation) to +1 (indicating a complete positive correlation), with 0 signifying no correlation. This statistical analysis was carried out using IBM SPSS software (version 23).

Results

The study included a total of 135 participants, 92 males and 43 females with examinations of unenhanced CT series. The participants ranged in age from 19 to 88 years old, with a mean age of 60.4±13.7 years.

In our study we observed that SMA at the level of L3 vertebra was significantly higher than that of L1 vertebra (143.5±31.4 cm^2; 128.8 cm^2±27.7 mm^2 respectively, $p<0.001$) (Figure 2). We found a significant correlation between SMA of L3 and L1 ($p\leq0.001$, $r=0.93$). The difference in SMRA at L3 and L1 vertebra was small but significant (37.6±6.6 HU; 36.5±6.7 HU respectively, $p<0.001$) (Figure 3). We found a significant the correlation between SMRA of L3 and L1 ($p\leq0.001$, $r=0.85$).

The results are summarized in Table 1.

Discussion

In our study, we found a significant positive correlation between the levels of L1 and L3 in terms of muscle density and muscle area. This suggests that measurements of muscle

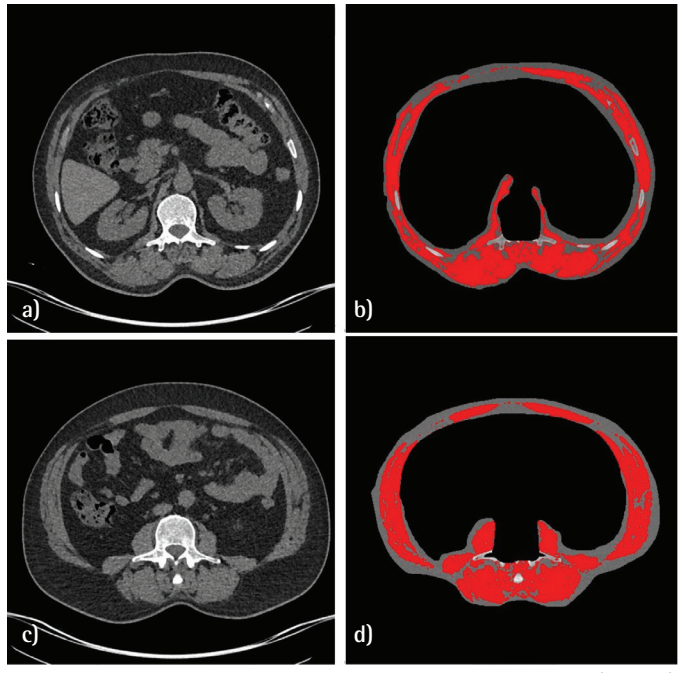

Figure 1: The L1 and L3 pedicle levels are shown in images a) and c), respectively. After excluding the subcutaneous area above the abdominal muscles, the rectus abdominis muscles, paraspinal muscles, oblique muscles, and psoas muscles are manually drawn. The image processing program then identifies and distinguishes muscle attenuation thresholds between -29 and +150 Hounsfield units, which are displayed in red (b) and d)

L1: Lumbar 1, L3: Lumbar 3

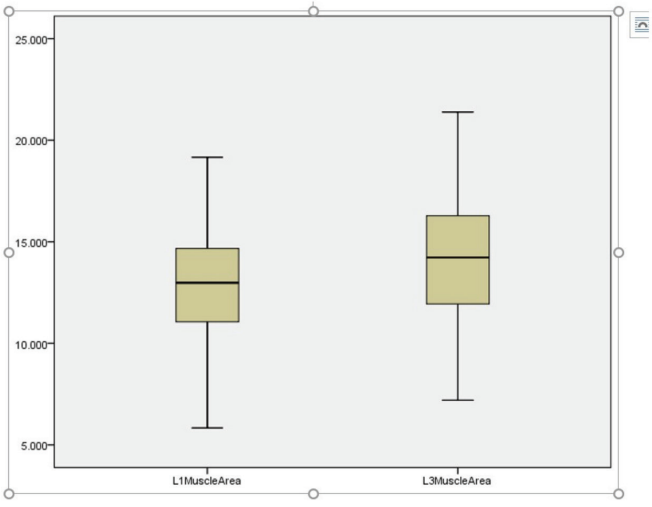

Figure 2: The box plots show skeletal muscle area values at vertebral levels L1 and L3 for the study population, aiding in comparing muscle areas at different spinal levels. This comparison explores the potential of using L1 as an alternative to L3 for detecting sarcopenia

L1: Lumbar 1, L3: Lumbar 3

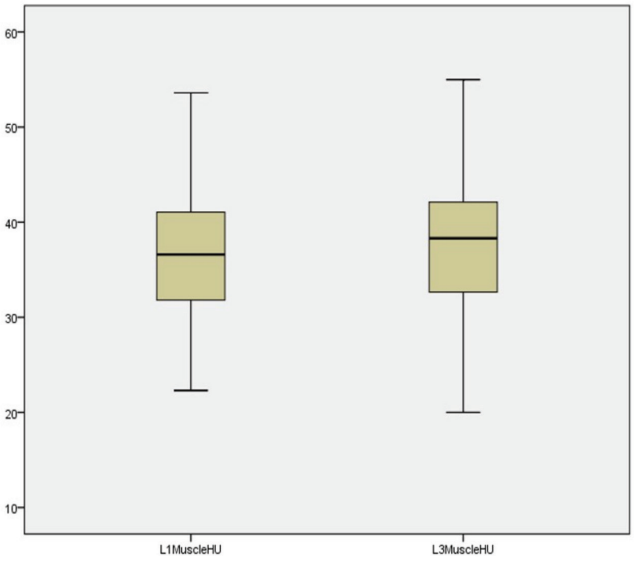

Figure 3: The box plots display skeletal muscle radiation attenuation values at vertebral levels L1 and L3 in the study population, facilitating the comparison of muscle attenuation at different spinal levels

L1: Lumbar 1, L3: Lumbar 3

attenuation and cross-sectional area at L1 could be reliable for detecting sarcopenia, providing comparability to the results from CT scans at L3.

A recent systematic review investigates the potential of using vertebral levels other than the commonly utilized L3 in CT scans for measuring SMM and identifying sarcopenia in individuals with cancer. It notes that not every diagnostic scan covers the L3 level, prompting a search in five databases for studies that measure SMM at higher vertebral slices in cancer patients. However, due to methodological discrepancies, varied sarcopenia thresholds, and a general lack of agreement, the findings do not strongly endorse any vertebral level as a definitive alternative to L3. This underscores the need for further research to provide a standardized technique for evaluating SMM when L3 data is unavailable. This approach aligns with the primary objective of our investigation (14).

Liu et al. (22) investigated the possibility of utilizing L1 level chest CT images to evaluate SMM in a Chinese population. The study shows a significant association between L1 and L3 measurements, similar to our research. This suggests that chest CT scans may have the potential to replace abdomen CT scans for assessing muscle mass, particularly when the L3 level is not included in the scan field (22).

Patients undergo only thorax CT scans in various scenarios, systemic sclerosis is one of these conditions. A study was conducted to analyze muscle mass in patients with systemic sclerosis (16). The researchers used chest CT scans at the L1 level to examine myopenia and myosteatosis. The findings indicate that measurements taken at the L1 level can effectively detect myopenia and show a strong correlation with clinical outcomes. The study's results have important implications for the diagnosis and treatment of sarcopenia in systemic sclerosis. They show that using chest CT scans to measure skeletal muscle at the L1 level is an effective method as we hypothesize in our study.

The work conducted by Pickhardt (13) examines the efficacy of a completely automated deep learning algorithm in evaluating sarcopenia through the analysis of CT scans. The method involves comparing muscle measurements taken at the L1 and L3 vertebral levels to make predictions about the likelihood of future hip fractures and mortality. The results indicate that measurements taken at the L1 level are similar to those taken at the L3 level, which is widely employed for assessing sarcopenia.

Table 1: The results of statistical analysis exploring the relationship between skeletal muscle area and skeletal muscle radiation attenuation at two different vertebral levels: L1 and L3

	L1 vertebra level	L3 vertebra level	*p value	Ωr
Skeletal muscle area ± SD (cm^2)	128.8±27.7	143.5±31.4	0.001	0.93
Skeletal muscle radiation attenuation ± SD (HU)	36.5±6.7	37.6±6.6	0.001	0.85

*Significance level is set at <0.05, ΩPearson correlation coefficient
SD: Standard deviation L1: Lumbar 1, L3: Lumbar 3, HU: Hounsfield units

The study's findings suggest that incorporating L1-level assessments can enhance the effectiveness of opportunistic CT screening for sarcopenia by enabling the utilization of both chest and abdomen CT scans. The study emphasizes the usefulness of automated CT-based muscle attenuation assessments in predicting important health outcomes. Although we could not automatically measure muscle attenuation using CT in our study, it is still feasible to utilize thorax CT to assess myosteatosis and provide additional information to the main objective of the examination in situations where automated measurement is not available (13).

Study Limitations

The study possesses certain limitations, including a rather modest sample size and the inclusion of patients who underwent unenhanced series of abdominal CT scans for a limited diagnosis of hematuria as part of CT urography examination. We chose this examination to examine a non-contrast series with a standard protocol and dose. Nevertheless, a correlation analysis within the same patient was conducted, hence enhancing the reliability of the obtained data. Although numerous studies have previously affirmed the effectiveness of the measurement style, the selection of locations for evaluating SMA and attenuation values was performed manually, potentially resulting in decreased measurement precision. And measurements are made by a single observer in a single institution. Additionally, it should be noted that the study did not incorporate thoracic CT scan data, a crucial component for demonstrating the applicability of the findings to a broader population. If we had chosen non contrast thorax CT examination, it would not be possible to compare levels L1 and L3 measurements, since L3 level is not included in thorax CT examinations. Therefore, additional research must be conducted to validate the findings of this study across various practice contexts, thereby establishing their generalizability.

Conclusion

In conclusion, there exists a correlation between the measures of mass and quality of psoas muscles at the L1 level and those conducted at the L3 level. These measurements have the potential to be utilized in future research to assess the correlation between sarcopenia and can serve as an additional benefit to CT scans without the need for supplementary imaging techniques. Nevertheless, it is imperative to acknowledge the limits of the study, which indicate the necessity for additional research to ascertain the dependability and applicability of the results. Future research fields can study the examination of variations in CT scanners and techniques, as well as the inclusion of more diverse patient populations and examination types.

Ethics

Ethics Committee Approval: The study complied with the Declaration of Helsinki, and was approved by the Ethics Committee and the Institutional Review Board of Gazi University Faculty of Medicine (approval no: 548; date: 04.07.2022).

Informed Consent: Since the study was retrospective, the requirement for informed consent was waived.

Authorship Contributions

Concept A.C.K.K, H.K.K., G.E., Design A.C.K.K., S.K.Ö., Data Collection or Processing: A.C.K.K, S.Ç., Analysis or Interpretation: A.C.K.K, M.K., H.K.K., Literature Search: A.C.K.K., Writing: A.C.K.K.

Conflict of Interest: The authors declared that there was no conflict of interest during the preparation and publication of this article.

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