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Correlation of Lean Mass Measurements Between a Novel Whole-body X-ray Bone Densitometer (iNSiGHT C510) and Magnetic Resonance Imaging: A Single-center Comparative study

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Abstract

Background: Sarcopenia, the age-related loss of muscle mass, increases health risks in older adults. Accurate measurement of skeletal muscle mass is critical for diagnosis. While DEXA is widely used, its extended scan time limits clinical utility. This study evaluates the accuracy of lean mass measurements from the newly developed iNSiGHT C510 X-ray bone densitometer compared to MRI, the gold standard.

Methods: This single-center, open-label clinical trial included 20 adult participants (10 males, 10 females) aged 20−70 years. Participants underwent whole-body scans using the iNSiGHT C510 and MRI. Lean and fat mass measurements were obtained from both devices. Statistical analysis included Bland-Altman plots, intraclass correlation coefficients (ICC), and concordance correlation coefficients (CCC) to assess agreement between the two methods. Linear regression analysis was performed to derive conversion formulas between C510 and MRI measurements.

Results: The study found a very strong correlation between lean mass measurements from the iNSiGHT C510 and MRI, with correlation coefficients (r) of 0.961 for the right side, 0.967 for the left, and 0.963 for combined lean mass. ICC and CCC values for lean mass were also high, indicating strong agreement between the two methods. Fat mass measurements, though moderately correlated, showed larger discrepancies compared to lean mass. The iNSiGHT C510 significantly reduced measurement time by 50 % compared to conventional DEXA scans.

Conclusion: The iNSiGHT C510 demonstrated high accuracy in measuring lean mass compared to MRI, with the added benefit of shorter measurement time, making it a practical tool for sarcopenia diagnosis and monitoring in clinical settings. However, further research with larger sample sizes and long-term assessments is needed to validate its broader clinical utility.

Keywords: Body composition; Dual-energy X-ray absorptiometry (DEXA); iNSiGHT C510; Lean mass; Sarcopenia.

Introduction

Sarcopenia, defined as the age-related loss of muscle mass and function, has emerged as a major public health issue, particularly with the global aging population.[1,2] It not only affects physical performance and increases the risk of falls, fractures, and disability but also contributes to elevated healthcare costs due to long-term care needs and increased morbidity.[2,3] In Korea, the prevalence of sarcopenia is significant, with estimates suggesting that around 700,000 to 1 million individuals aged 65 years or older are affected.[4,5] As Korea continues to experience rapid demographic shifts toward an older population, early diagnosis and effective management of sarcopenia have become essential to mitigating its societal impact.[5]

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Accurate assessment of skeletal muscle mass is critical in the diagnosis of sarcopenia. Dual-energy X-ray absorptiometry (DEXA) has been widely adopted as the standard method due to its ability to provide reliable estimates of body composition, particularly fat and lean mass.[6–10] However, conventional DEXA equipment often requires long measurement times (approximately 10 min), which can be impractical in clinical settings where time efficiency and patient comfort are paramount. Furthermore, the need for patients to remain in a fixed posture for extended periods increases the likelihood of motion artifacts, which can compromise measurement accuracy.[11] These limitations underscore the necessity for faster, more accurate diagnostic tools.[12]

The newly developed whole-body X-ray bone densitometer, iNSiGHT C510, offers a potential solution by significantly reducing measurement times while maintaining accuracy comparable to established methods. This study aims to evaluate the accuracy of lean mass measurements obtained from the iNSiGHT C510 by comparing its results to magnetic resonance imaging (MRI), which is considered the gold standard for body composition analysis. Specifically, we seek to determine the correlation between lean mass measurements from iNSiGHT C510 and MRI, with the goal of validating this new device as a practical and efficient tool for sarcopenia diagnosis and monitoring in clinical practice.

Methods

Participants

This study was designed as a single-center, open-label, comparative exploratory clinical trial. Twenty adult volunteers (10 males and 10 females) aged 20–70 years were recruited. The study was approved by the Institutional Review Board of Bumin Hospital, and all participants provided written informed consent.

Measurements

All participants underwent whole-body scans using the iNSiGHT C510 device (Osteosys Co., Ltd., Seoul, Korea) as shown in Fig. 1.[13] The device measured fat mass and lean mass for the entire body. Participants were positioned supine on the examination table with their heads towards the top of the table. The scan was initiated after selecting the "TotalBody" option for the initial position.

MRI scans were performed using a GE Discovery MR 750w 3.0T scanner (GE Healthcare, United States).[14] The bilateral thigh region (from the lesser trochanter to the femoral condyles) was imaged. The MRI protocol included: Axial IDEAL-IQ (TR 5-10 ms, TE 0-3 ms, slice thickness 6 mm, gap 3 mm, and matrix 152 × 154 interpolated to 512 × 512). Axial T2 mapping with chemical shift selective fat saturation (TR 1,046 ms, TE 7–56 ms, slice thickness 6 mm, gap 3 mm, and matrix 152 × 154 interpolated to 512 × 512). MRI images were analyzed using IDEAL IQ software (GE Healthcare) to quantify fat and lean mass in the thigh region.[15]

Statistical analysis

Statistical analysis was conducted to test the null hypothesis, which posited a correlation coefficient of 0.8 or higher between the two instruments (C510 and MRI) for each measurement site (right, left, and combined fat and lean mass). To evaluate the accuracy between C510

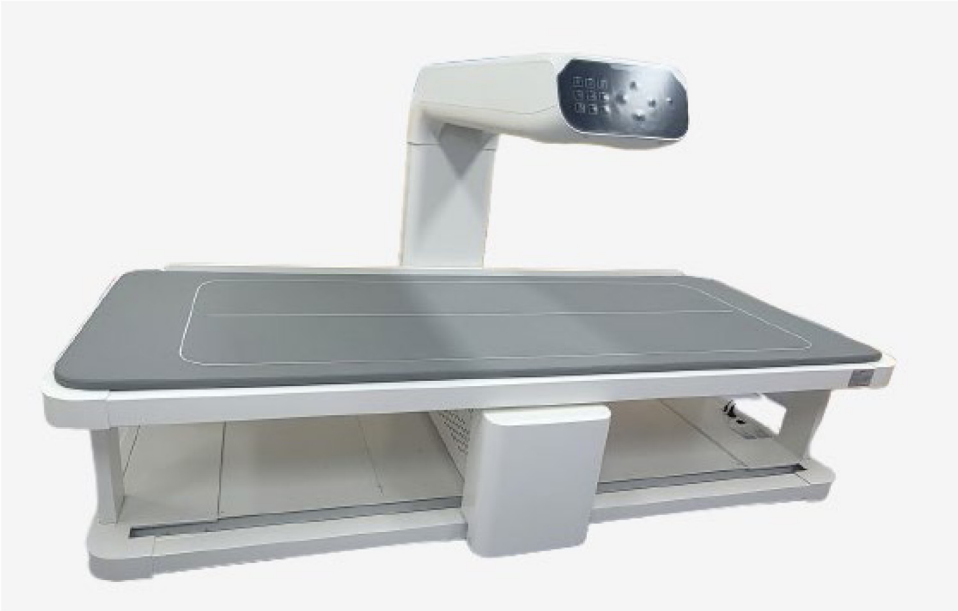

Fig. 1. iNSiGHT C510 device.

and MRI measurements, Bland-Altman analysis was used to plot the differences between the two methods against their average, calculating agreement limits with 95 % confidence intervals.[16,17] The concordance correlation coefficient (CCC) was employed to assess the precision and accuracy of the correlation between C510 and MRI.[18] Correlation coefficients (Pearson's r) were categorized as follows: 0.2 to 0.4 indicated weak correlation, 0.4 to 0.6 indicated moderate correlation, 0.6 to 0.8 indicated strong correlation, and 0.8 to 1.0 indicated very strong correlation.[19] Additionally, the intraclass correlation coefficient (ICC) was computed using a two-way random effects model to measure absolute agreement between the two methods.

A linear regression analysis was performed to derive conversion formulas between the C510 and MRI for fat and lean mass measurements. The slope (β) and intercept of the regression models were reported along with their confidence intervals. Statistical analyses, including Bland-Altman plots, ICC, CCC calculations, and correlation assessments, were conducted using R software (version 4.2.1, R Foundation for Statistical Computing, Vienna, Austria).[20] The ggplot2, irr, DescTools, and Bland-AltmanLeh R packages were used for data handling, analysis, and visualization.

Results

The demographic characteristics of the study participants are summarized in Table 1. The study included 20 participants, with an equal number of male (n = 10) and female (n = 10) participants. The overall mean height was 167.77 cm, with a standard deviation (SD) of 8.64 cm, and ranged from 150.0 cm to 182.2 cm. Males had a mean height of 174.63 cm (SD = 5.30 cm), while females had a mean height of 160.91 cm (SD = 4.99 cm). The mean weight for all participants was 65.62 kg, with a SD of 12.72 kg, ranging from 43.3 kg to 88.9 kg. Males had a higher mean weight (75.19 kg, SD = 7.19 kg) compared to females (56.05 kg, SD = 9.30 kg). In terms of BMI, the overall mean was 23.10 kg/m^2 (SD = 2.82 kg/m^2), with male participants exhibiting a higher BMI (mean = 24.63 kg/m^2, SD = 1.63 kg/m^2) compared to females (mean = 21.58 kg/m^2, SD = 2.99 kg/m^2).

Table 2 presents the linear regression analysis results used to derive the conversion formulas between the C510 and MRI measurements for fat mass and lean mass. The conversion formula for fat mass on the right side is MRI_Fat_Mass_Right = 0.99 * C510_Fat_Mass_Right + 610.72, and for the left side, it is MRI_Fat_Mass_Left = 1.04 * C510_Fat_Mass_Left + 557.23. The combined fat mass conversion formula, calculated using data from both sides, is MRI_Fat_Mass_Combined = 1.00 * C510_Fat_Mass_Combined + 600.55. For lean mass, the conversion formula on the right side is MRI_Lean_Mass_Right = 1.18 * C510_Lean_Mass_Right - 836.68, and for the left side, it is MRI_Lean_Mass_Left = 1.14 * C510_Lean_Mass_Left - 752.90. The combined lean mass conversion formula is MRI_Lean_Mass_Combined = 1.15 * C510_Lean_Mass_Combined - 770.91.

Table 3 shows the Intraclass Correlation Coefficient (ICC) and Concordance Correlation Coefficient (CCC) values, which were calculated to assess the agreement between C510 and MRI measurements. The ICC values for fat mass measurements were moderate on the right side (ICC = 0.516) and left side (ICC = 0.469), and slightly lower for the combined fat mass (ICC = 0.490). For lean mass, the ICC values were much higher, indicating strong agreement between the two methods, with an ICC of 0.943 on the right side, 0.952 on the left side, and 0.947 for the combined lean mass. Similarly, the CCC values followed the same trend, with moderate agreement for fat mass (CCC = 0.503 on the right, 0.457 on the left, and 0.484 for combined fat mass), and high agreement for lean mass (CCC = 0.941 on the right, 0.950 on the left, and 0.946 for combined lean mass).

The correlation between C510 and MRI measurements for fat mass and lean mass is visualized in Fig. 2, which

Table 1
Demographic characteristics of study participants.

Sex	Height_mean	Height_sd	Height_min	Height_max	Height_range
Total (n=20)	167.77	8.64	150	182.2	32.2
Female (n=10)	160.91	4.99	150	167.7	17.7
Male (n=10)	174.63	5.3	164.4	182.2	17.8
Sex	Weight_mean	Weight_sd	Weight_min	Weight_max	Weight_range
Total (n=20)	65.62	12.72	43.3	88.9	45.6
Female (n=10)	56.05	9.3	43.3	70	26.7
Male (n=10)	75.19	7.19	66	88.9	22.9
Sex	BMI_mean	BMI_sd	BMI_min	BMI_max	BMI_range
Total (n=20)	23.1	2.82	18.39	27.31	8.92
Female (n=10)	21.58	2.99	18.39	27.31	8.92
Male (n=10)	24.63	1.63	22.46	27.18	4.72

Table 2
Conversion formulas for C510 and MRI fat and lean mass measurements.

Measurement	Conversion formula
Fat Mass (Right)	MRI_Fat_Mass_Right = 0.99 * C510_Fat_Mass_Right + 610.72
Fat Mass (Left)	MRI_Fat_Mass_Left = 1.04 * C510_Fat_Mass_Left + 557.23
Lean Mass (Right)	MRI_Lean_Mass_Right = 1.18 * C510_Lean_Mass_Right - 836.68
Lean Mass (Left)	MRI_Lean_Mass_Left = 1.14 * C510_Lean_Mass_Left - 752.90
Fat Mass (Combined)	MRI_Fat_Mass_Combined = 1.00 * C510_Fat_Mass_Combined + 600.55
Lean Mass (Combined)	MRI_Lean_Mass_Combined = 1.15 * C510_Lean_Mass_Combined - 770.91

includes scatter plots with linear regression lines for both individual sides and combined data. The correlation coefficients (r) and confidence intervals (CI) are also displayed on the plots. For fat mass, the correlation was strong on both the right side (r = 0.841, CI = [0.636, 0.936]) and the left side (r = 0.878, CI = [0.712, 0.951]). The combined fat mass measurements showed a similarly strong correlation (r = 0.858, CI = [0.746, 0.923]). For lean mass, the correlation was even stronger, with r = 0.961 (CI = [0.901, 0.985]) on the right side, r = 0.967 (CI = [0.916, 0.987]) on the left side, and r = 0.963 (CI = [0.930, 0.980]) for the combined lean mass.

Fig. 3 presents Bland-Altman plots for the same measurements, assessing the agreement between C510 and MRI by plotting the differences against the mean values. For fat mass, the plots show a higher degree of variability in the differences, particularly for larger measurements. The limits of agreement are wider for fat mass, indicating larger discrepancies between C510 and MRI measurements. In contrast, the Bland-Altman plots for lean mass exhibit much narrower limits of agreement, suggesting closer agreement between C510 and MRI measurements for lean mass.

Discussion

This study demonstrated a high correlation between lean mass measurements obtained from the iNSiGHT C510 and MRI, with correlation coefficients for lean mass measurements showing very strong agreement. Specifically, the correlation coefficients were 0.961 for the right side, 0.967 for the left side, and 0.963 for combined lean mass, all indicating excellent agreement between the two devices. These findings suggest that the iNSiGHT C510 can measure lean mass with an accuracy comparable to MRI, which is considered the gold standard for body composition analysis.

A key advantage of the iNSiGHT C510 is its significantly reduced measurement time compared to conventional DEXA equipment. While traditional DEXA scans take approximately 10 min, the iNSiGHT C510 completes measurements in approximately 5 min, offering a 50 % reduction in scan time.[21] This shorter examination time has several benefits: it increases the potential for clinical application, reduces patient discomfort, and minimizes the risk of motion artifacts that can affect measurement accuracy.[22]

In addition to the high correlation values, Bland-Altman plots further demonstrated a strong agreement between the two methods for lean mass measurements, with narrow limits of agreement for lean mass, indicating minimal discrepancies between C510 and MRI measurements. The concordance correlation coefficient for lean mass was 0.941 on the right, 0.950 on the left, and 0.946 for combined lean mass, further validating the precision and accuracy of iNSiGHT C510.

However, for fat mass measurements, the correlation was slightly lower. The correlation coefficients for fat mass were 0.841 on the right, 0.878 on the left, and 0.858 for combined fat mass (Fig. 2). Bland-Altman analysis showed wider limits of agreement for fat mass compared to lean mass, suggesting larger discrepancies between C510 and MRI measurements in fat mass (Fig. 3). This indicates that while iNSiGHT C510 is highly accurate for lean mass, further refinement may be necessary for fat mass measurements.

The slightly lower correlation observed for fat mass measurements compared to lean mass could be attributed to differences in the measurement principles between the iNSiGHT C510 and MRI. MRI provides a detailed spatial resolution that allows it to distinguish between different fat compartments, such as subcutaneous and visceral

Table 3
Agreement between C510 and MRI measurements (ICC and CCC values).

Measurement.Area	ICC	CCC
Fat Mass (Right)	0.516	0.503
Fat Mass (Left)	0.469	0.457
Lean Mass (Right)	0.943	0.941
Lean Mass (Left)	0.952	0.95
Fat Mass (Combined)	0.49	0.484
Lean Mass (Combined)	0.947	0.946

Intraclass Correlation Coefficient (ICC) and Concordance Correlation Coefficient (CCC).

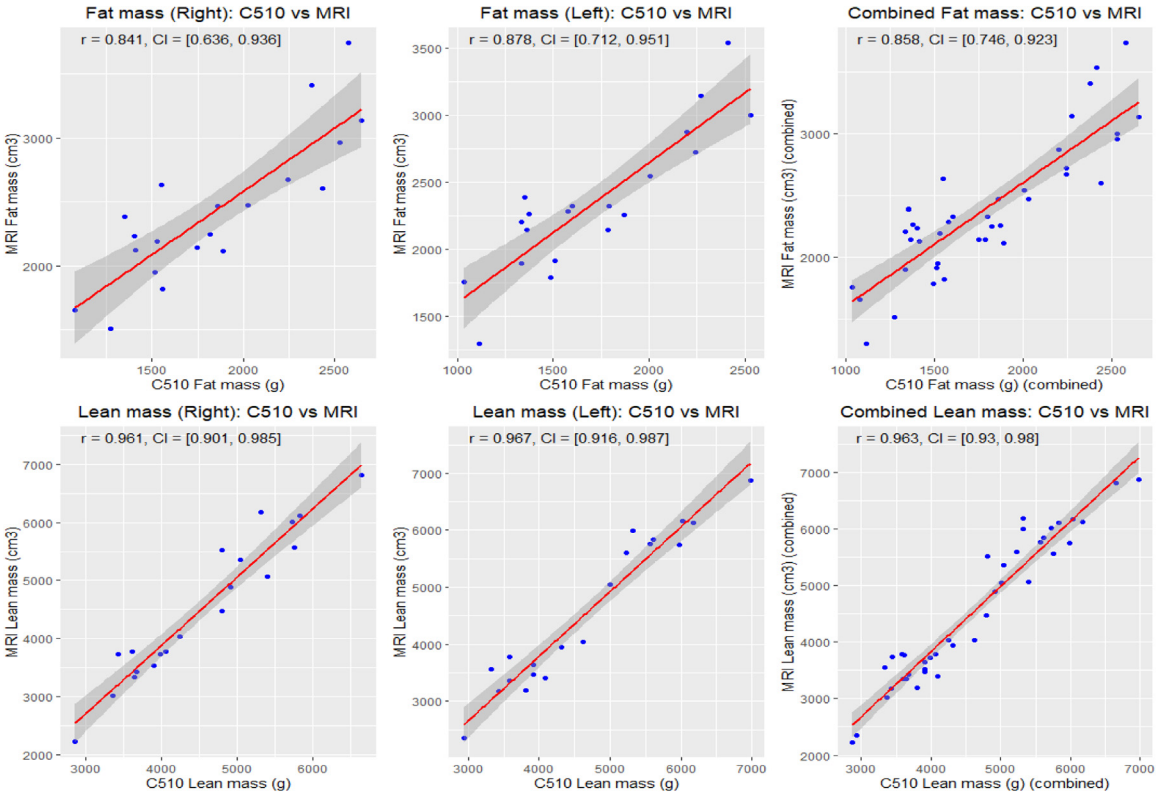

Fig. 2. Correlation plots between C510 and MRI for fat and lean mass measurements.

fat.[23] In contrast, the iNSiGHT C510 relies on X-ray attenuation properties, which may be less sensitive to these distinctions. Additionally, minor variations in patient positioning during scans and the proprietary algorithms used to calculate fat mass might further contribute to discrepancies.

This variability suggests that while the iNSiGHT C510 is highly reliable for lean mass measurements, its use as a comprehensive tool for body composition analysis may require optimization. Enhancing the fat mass estimation algorithms and conducting validation studies focused on specific fat compartments could improve its applicability.[24,25] This consideration is particularly important in clinical contexts where accurate fat mass assessment is integral to diagnosing and managing conditions such as obesity and metabolic syndrome.

The high correlation between iNSiGHT C510 and MRI measurements supports the validity of using this new device for assessing lean mass in the context of sarcopenia diagnosis and monitoring. The ability to quickly and accurately measure lean mass could significantly improve the efficiency of sarcopenia screening and follow-up in clinical settings. Moreover, the reduced cost and greater accessibility of the iNSiGHT C510 make it a practical alternative to MRI, especially in settings where MRI is not available or feasible due to cost or logistical constraints.

However, this study has several limitations that should be addressed in future research. First, the sample size of 20 participants is relatively small, which may limit the generalizability of the results. Larger studies are needed to confirm these findings across a more diverse population. Second, as this was a single-center study, multi-center trials would be beneficial to validate the consistency of results across different settings and operators. Third, the study design did not include long-term follow-up, so the consistency of measurements over time could not be assessed. Future studies should include longitudinal data to evaluate the reliability of iNSiGHT C510 measurements for monitoring changes in lean mass over time.

Additionally, while this study focused on lean mass measurements, future research could explore the accuracy of iNSiGHT C510 in measuring other body composition parameters, such as bone mineral density and fat mass distribution. This would provide a more comprehensive understanding of the device's capabilities in body composition analysis.

It is also worth noting that while MRI is considered the gold standard for body composition analysis, it has limitations in terms of cost and accessibility.[26] The iNSiGHT C510, if proven to be a reliable alternative, could offer a more accessible and cost-effective option for lean mass measurement in both clinical practice and research settings.

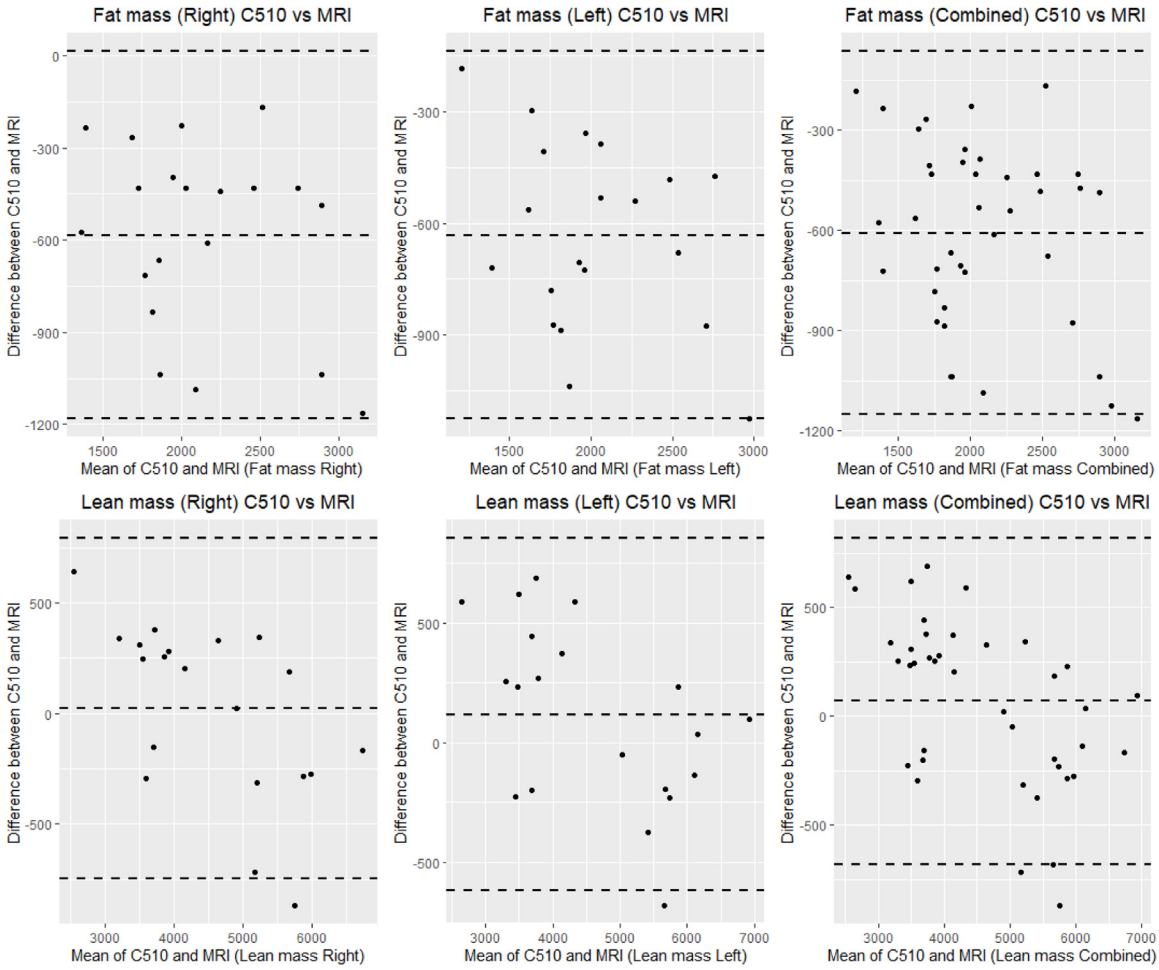

Fig. 3. Bland-Altman plots for agreement between C510 and MRI measurements.

Conclusion

In conclusion, this study provides evidence that the newly developed iNSiGHT C510 whole-body X-ray bone densitometer can measure lean mass with accuracy comparable to MRI. The shorter measurement time of the iNSiGHT C510 compared to conventional DEXA equipment, combined with its high accuracy, suggests that it could be a valuable tool for the diagnosis and monitoring of sarcopenia in clinical settings. However, larger multicenter studies and long-term follow-up assessments are needed to further establish the clinical utility of this device. Future research should also explore the potential of the iNSiGHT C510 in comprehensive body composition analysis, which could expand its applications in both clinical practice and research.

Data availability

The data used in this study were collected at Seoul Bumin Hospital, and inquiries about the data should be directed to the author Y.C.H.

Consent for publication

All individuals included in this study have given their informed consent for the publication of the results.

Declaration of competing interest

The authors declare no competing financial interests.

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