Original Article

The agreement of different techniques for muscle measurement in diagnosing sarcopenia: a systematic review and meta-analysis

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Background: The measurement or estimation of muscle mass plays an important role in the diagnosis of sarcopenia. Beside dual-energy X-ray absorptiometry (DXA), several modalities, including bioelectrical impedance analysis (BIA), ultrasound (US), computed tomography (CT), and magnetic resonance imaging (MRI), have helped to provide imaging or electrical biomarkers for muscle mass. This study was aimed at summarizing the diagnostic performance of different techniques on muscle assessment for sarcopenia.

Methods: Studies on the assessment of muscle mass by different techniques (compared with DXA), published from inception to 12 October, 2023 were retrieved from 4 electronic databases: the Cochrane Library, Embase, PubMed, and Web of Science. The quality assessment of included studies was conducted using the Quality Assessment of Diagnostic Accuracy Studies 2 (QUADAS-2). The sensitivity, specificity, Cohen's kappa coefficient (κ), and Pearson correlation coefficient (r) with 95% confidence intervals (CIs) were pooled and presented via forest plots. The area under the curve (AUC) with 95% CI was pooled and presented via summary receiver operating characteristic (sROC) curve.

Results: A total of 28 studies involving 4,926 participants were included. Compared with DXA, the pooled sensitivity and specificity, AUC, and Cohen's κ were 0.79 (95% CI: 0.71–0.86, P<0.001), 0.95 (95% CI: 0.82–0.99, P<0.001), and 0.88 (95% CI: 0.85–0.90), and 0.61 (95% CI: 0.51–0.72) for BIA. The pooled r value between DXA and BIA or US or MRI was 0.94 (95% CI: 0.92–0.96, P<0.001), 0.69 (95% CI: 0.54–0.80, P<0.001), and 0.96 (95% CI: 0.95–0.97, P=0.21), respectively. No qualified original study in relation to CT was included.

Conclusions: BIA, US, and MRI would provide acceptable diagnostic accuracy for sarcopenia by evaluating muscle mass in terms of sensitivity, specificity, accuracy, and their higher correlations with DXA. Further investigation is required to elucidate the value of CT in diagnosing sarcopenia.

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Keywords: Sarcopenia; muscle mass; imaging; meta-analysis; systematic review

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Introduction

Driven by falling fertility rates and remarkable increases in life expectancy, population aging is accelerating globally (1). Sarcopenia progressively results in negative consequences such as falls, fractures, social isolation, hospitalization, and an overall decrease in the quality of life (2). The estimated prevalence of sarcopenia ranged from 8% to 36% in individuals aged <60 years and from 10% to 27% in those ≥60 years when using different classifications and cut-off points (3). Identified as the age-related loss of skeletal muscle mass plus loss of muscle strength and/or reduced physical performance (4,5), sarcopenia is now formally recognized as a muscle disease with an International Classification of Diseases, 10th Revision, Clinical Modification (ICD-10-CM) diagnosis code to support timely prevention and improvement of muscle health worldwide (6).

An expert consensus has been established by European, North American, and Asian working groups on putting forward plans and recommendations for the screening, diagnosis, prevention, and treatment of sarcopenia (7). Currently, the main parameters available for the diagnosis of sarcopenia are muscle mass, muscle strength, and physical function (8). Among these, the identification of muscle mass loss plays a key role. Different kinds of instruments measure the muscle mass in terms of the total body skeletal muscle mass, the appendicular skeletal muscle mass (ASM), or the muscle cross-sectional area of specific muscle groups or body locations (4).

Dual-energy X-ray absorptiometry (DXA) measures fat and bone mineral content and subsequently determines lean tissue quantity (9). Both the European Working Group on Sarcopenia in Older People (EWGSOP) and the Asian Working Group for Sarcopenia (AWGS) recommend the clinical use of DXA for muscle mass measurement due to its ease of operation, non-invasive nature, and relatively low radiation (4,5). However, its relative high cost and non-mobile nature restrict its widespread use in the community (10), especially in those regions with limited medical resources. In addition, the DXA measurements can also be influenced by the hydration and obesity status of those examined. Other imaging or electrical assessments may help to support the measurement of muscle mass. Recently, bioelectrical impedance analysis (BIA), with the advantages of no radiation, cost-effectiveness, and portability, has been recommended to assess muscle mass by the EWGSOP and the AWGS (4,5). Although neither EWGSOP nor AWGS recommends ultrasound (US) as a valid assessment for total body skeletal muscle mass or ASM (4,5), it can measure muscle thickness (MT) and cross-sectional area (11); it shows potential as a convenient and fast method for muscle mass assessment in the community and has clinical application prospects (12). The reliability and validity of US to quantify muscles has been confirmed in older adults, and it has been recommended to be used for muscle assessment in sarcopenia (13,14). Moreover, computed tomography (CT) and magnetic resonance imaging (MRI), which could offer assessments of the structure and morphology of skeletal muscle tissue, are more accurate measurement tools for skeletal muscle quality. In particular, CT is widely used in routine clinical examinations. Retrospective studies of sarcopenia based on previous CT findings have been conducted with increasing interest. The value of CT has also been reported in sarcopenia patients with cancer (15), hip fractures, and refractures (16-18).

Although the performance of these assessments for sarcopenia identification have been studied, the understanding of how they are correlated with the value of DXA and validated evidence for their clinical uses to assess muscle mass in sarcopenia remains limited. Thus, this study was aimed to conduct a systematic review and meta-analysis to evaluate the diagnostic value of the BIA, US, MRI, and CT, comparing with that of DXA, for muscle mass in sarcopenia. We present this article in accordance with the PRISMA-DTA reporting checklist (19) (available at https://qims.amegroups.com/article/view/10.21037/qims-23-1089/rc).

Methods

This study was registered at the International Prospective Register of Systematic Reviews (PROSPERO) (No. CRD42022374959). L.L. and Z.X. independently reviewed and extracted data from the qualified articles, and assessed the risk of bias to evaluate the methodological quality. Any discrepancies were resolved by discussion or further consultation with Y.S.

Search strategy

A systematic search on PubMed, Web of Science, Cochrane Library, and Embase Database was conducted from inception of each database to 12 October, 2023 by using the following search terms with relevant Medical Subject Headings (MeSH) terms: sarcopenia, muscle mass, body composition, DXA, BIA, US, MRI, and CT. Manual retrieval and cross-referencing from reference lists were also conducted. A full description of the search strategy on the 4 databases is provided in Tables S1-S4.

Eligibility criteria

The inclusion criteria were as follows: (I) study design: cohorts, case-control studies; (II) Study subject: patients using BIA, US, MRI, or CT to estimate muscle mass alone or to support the diagnosis of sarcopenia while using DXA as reference, regardless of race, nationality, sex, and so on; (III) diagnostic method: The diagnostic method to be evaluated was BIA, CT, MRI, and US, whereas DXA was the gold standard; (IV) diagnostic parameter: ASM, appendicular skeletal muscle mass/height^2 (ASMI), or other equivalent parameters for DXA and BIA, appendicular lean mass (ALM) or MT for US, and skeletal muscle mass for CT and MRI; (V) outcome: sensitivity, specificity, area under the receiver operating characteristic curve (ROC) curve (AUC), Cohen's kappa coefficient (κ) and Pearson correlation coefficient for all cases; (VI) age of participant: ≥18 years; (VII) publication time of original study: from inception to 12 October 2023. The exclusion criteria were as follows: (I) non-English studies; (II) for repeated publications, the newly published studies with complete data should be selected; (III) studies with incomplete or unretrievable data; (IV) studies focused on "sarcopenia/muscle mass" assessment in specific clinical populations, in which the participants have any specific condition or disease that would impact on muscle mass; (V) abstract, review, comment, lecture, case report, conference paper, and so on; (VI) non-human research.

Data extraction

The extracted data included the following: (I) basic information of the original studies including the first authors, publication year, publication district, population, ethnicity, setting, sample size, age, sex, body mass index (BMI); (II) image omics features for differential diagnosis: the definition of sarcopenia, reference methods, new methods, measured parameters, instrument type, instrument frequency, measurement position; (III) relevant outcome obtained by extracting or calculating: sensitivity, specificity, positive likelihood ratio (PLR), negative likelihood ratio (NLR), positive predictive value (PPV), negative predictive value (NPV), AUC, Cohen's κ, and Pearson correlation coefficient; (IV) statistical findings and overall conclusions.

Quality assessment

Quality assessments were conducted using the Quality Assessment of Diagnostic Accuracy Studies 2 (QUADAS-2) by Review Manager Software version 5.4 (Cochrane Collaboration, Copenhagen, Denmark). The QUADAS-2 tool involves 4 key domains: patient selection, index test, reference standard, and flow and timing. Assessment of the risk of bias and concerns about applicability are regarded as distinct components of quality assessment and classified as "Low", "High", or "Unclear" (20).

Statistical analysis

The representative muscle index derived from DXA and BIA according to AWGS (4) and EWGSOP (5), and the MT and ALM from US according to the published studies (21-23), were selected as the main outcomes for comparison. The diagnostic value was compared based on the estimated sensitivity, specificity, AUC, Cohen's κ, and Pearson correlation coefficient. When multiple outcomes were reported in the same original study due to the different cut-off values, muscular parameters, and predictive equations, the symptomatic 1 or 2 with the largest sensitivity, specificity, or Pearson correlation coefficient and with the most significant level were used in the final analysis. For Cohen's κ scores, the values of 0 to 0.20, 0.21 to 0.40, 0.41 to 0.60, 0.61 to 0.80, and 0.81 to 1.00 were regarded as poor, fair, moderate, good, and excellent agreement, respectively (24). For AUC, the values of 0 to 0.50, 0.51 to 0.70, 0.71 to 0.90, 0.91 to 1.00, and 1.00 were treated as none, low, moderate, high, and perfect predictive power, respectively (25). For the correlation coefficient, the values of 0 to 0.25, 0.26 to 0.49, 0.50 to 0.69, 0.70 to 0.89, and 0.90 to 1.00 were classified as little, low, moderate, high, and very high correlation, respectively (26).

The pooled sensitivity and specificity, Cohen's κ and their 95% confidence intervals (CIs) were computed if there was no heterogeneity according to the Spearman threshold effect analysis. Otherwise, the pooled estimates would be provided for each effect size. The pooled Pearson correlation coefficient and its 95% CI were also computed. An inconsistency index (I^2) was used to evaluate the statistical heterogeneity (27) across the original studies for each outcome. Random effects models were used when heterogeneity was moderate or high ($I^2 \geq 50\%$). A sensitivity analysis was performed by removing each study to test the robustness of the summarized outcomes. Meta-regression analysis and subgroup analysis (by the group of sample size, population source, diagnostic criteria, publication year, publication region, the type of DXA or BIA, the average age of the cases and other information if sufficient) were further performed to explore the sources of heterogeneity for the pooled sensitivity and specificity and pooled Pearson correlation coefficient. A summary receiver operating characteristic (sROC) was also drawn to estimate the pooled AUC and its 95% CI.

Publication bias was evaluated by Deek's funnel plot asymmetry test for the pooled sensitivity and specificity, and Egger's linear regression test (28) and Begg's rank correlation test (29) with funnel plots for the pooled Pearson correlation coefficient. Sensitivity analysis was carried out by removing each study to explore the potential impact of a single study on the summarized estimates. The statistical analyses were conducted by using Stata software version 15.0 (Stata Corp, College Station, Texas, USA), MetaDisc software version 1.4 (Unit of Clinical Biostatistics Team of the Ramony Cajal Hospital, Madrid, Spain), or RStudio Software version 4.2.3 (RStudio, Boston, Massachusetts, USA). A P value <0.05 (2-sides) was considered the level of statistical significance.

Results

Search results and study characteristics

A total of 10,968 records were retrieved (675 from PubMed, 3,922 from Web of Science, 1,816 from Cochrane library, 4,554 from Embase Database, and 1 from manual search). Duplicates (n=4,353) were excluded, and the others (n=6,615) were screened by review of the titles and abstracts. After that, 166 were selected for a full-text review for the eligibility assessment. Of these, 138 studies were removed according to the inclusion and exclusion criteria. Finally, 28 studies were included in this systematic review for narrative synthesis (21-23) and (30-54). The flow chart for the selection process according to the PRISMA guidelines is displayed in *Figure 1*.

In the current meta-analysis, we included 28 articles (16 for BIA, 8 for US, and 4 for MRI), which involved 4,926 participants. Among these, 13 were conducted in Asia, 3 in Europe, 7 in North America, 4 in South America, and 1 in Oceania. The sample size ranged from 18 to 551. The mean age of the cases ranged from 22.1 [standard deviation (SD) =1.4] to 83.3 (SD =3.0) years, and the mean BMI (kg/cm^2) ranged from 21.9 (SD =2.8) to 28.9 (SD =4.7). The characteristics of the 28 studies, including the publication year, publication region, sample size, gender, age, BMI, gold standard, and new method, are shown in *Table 1*.

Quality assessment

Among the selected studies, 6 studies were considered to have a high risk of participant selection bias, 1 study was unclear, 1 study was noted to have high risk of index test bias, and 1 study was noted to have a high risk of flow and timing bias. Beyond the above-mentioned, there were no unclear or high-risk observations for the bias of index test and reference standard. Details about the risk of bias in the included studies are shown in the Figure S1.

Sensitivity and specificity for BIA

A total of 7 original studies, comprising 1,478 participants, on the diagnostic value of BIA compared to DXA in diagnosing sarcopenia were included. Among these, 4 used the parameter of ASMI as the outcome, and 3 used appendicular lean mass/height^2 (ALMI) (Table S5). The Spearman rank correlation test suggested that there was no threshold effect in the above studies (coefficient =0.36, P=0.43). The heterogeneity was substantial for sensitivity [I^2=75.60% (57.36–93.85%), P<0.001] and specificity [I^2=96.19% (94.49–97.88%), P<0.001]. Thus, the pooled sensitivity, pooled specificity, sROC, and their 95% CI were 0.79 (0.71–0.86), 0.95 (0.82–0.99), and 0.88 (0.85–0.90), respectively (*Figures 2,3*). DXA and BIA had a good agreement with an estimated pooled Cohen's κ statistic of 0.61 (0.51–0.72) (Figure S2). Deeks' funnel plot asymmetry test showed a significant publication bias (P<0.001, Figure S3). Sensitivity analysis revealed that the study conducted by Fang *et al.* (43) may have largely contributed to the publication bias due

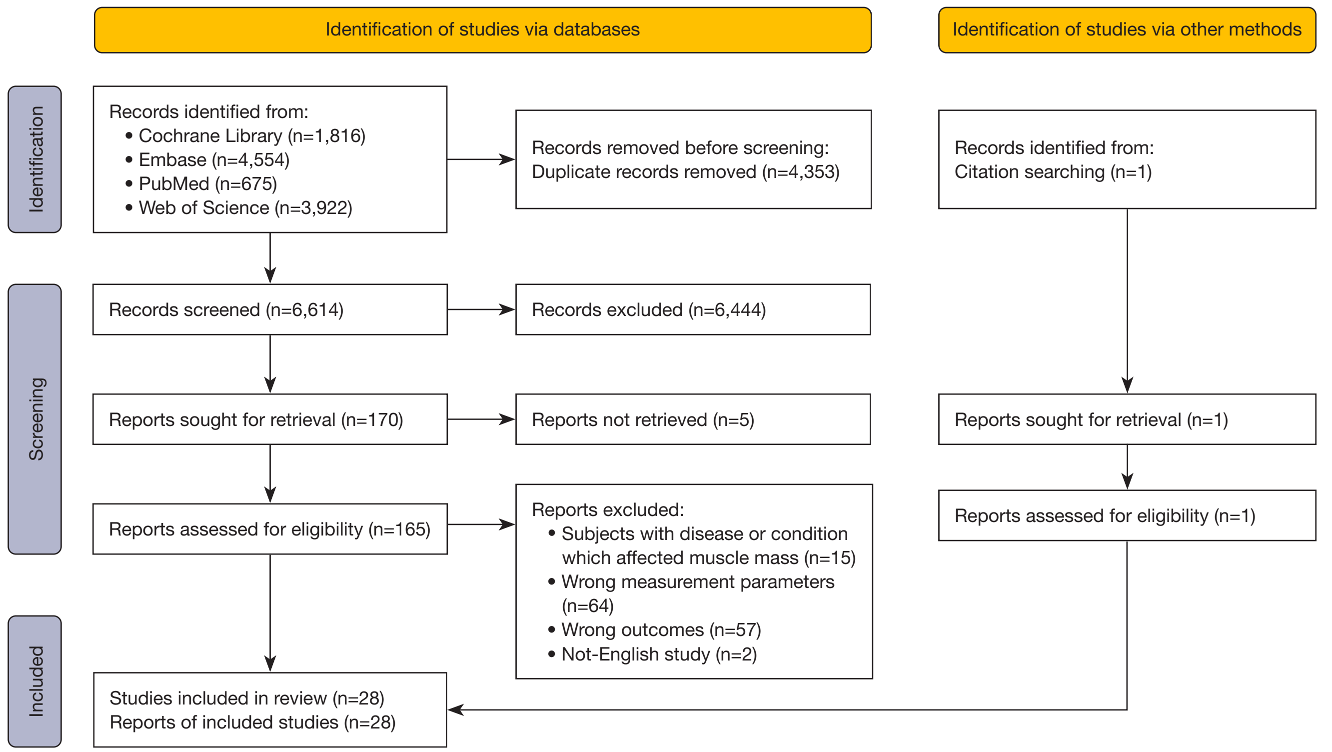

Figure 1 PRISMA flowchart of the studies search. PRISMA, Reporting Items for Systematic Reviews and Meta-Analyses.

to its large sample size compared with the other 6 studies (Figure S4). The results from meta-regression analysis indicated that population source, publication region, and diagnostic criteria were significantly related with the heterogeneity of sensitivity and specificity (*Figure 4*).

Sensitivity and specificity for US, MRI, and CT

There were inadequate studies available to compute the pooled sensitivity and specificity for US (none), MRI (none), and CT (none).

Pearson correlation coefficient for BIA and DXA

A total of 10 studies reported the Pearson correlation coefficient of muscle-related measures between BIA and DXA. Among them, ASM was used in 2 studies, ALM was used in 3 studies, appendicular lean soft tissue (ALST) was used in 4 studies, and ALMI was used in 1 study as the diagnostic parameters for DXA and BIA (Table S6). The correlation coefficient between muscle-related measures between BIA and DXA was very high [pooled r (95% CI) =0.94 (0.92–0.96), I^2=89.00% (P<0.001)] (*Figure 5*). There was no obvious asymmetry for the pooled Pearson correlation coefficient from visual inspection of funnel plot (Figure S5). The Egger linear regression test and Begg's rank correlation test indicated that there was no significant publication bias among the original studies (P>0.05). The results were robust in the leave-one-out sensitivity analysis, and the direction of the estimates were not essentially changed with the removal of each study (Figure S6). The results of subgroup analyses showed that the population source, publication region, sample size, publication year, BIA type, and average age of subjects were not the source of heterogeneity.

Pearson correlation coefficient for US and DXA

A total of 9 studies were included for the Pearson correlation coefficient between US and DXA. Among them, 6 studies used ALM and 3 used ASMI as the outcome for DXA. Regarding the outcome of US, 4 studies used upper limb MT, and the other 5 used lower limb MT (Table S7). The correlation coefficient between muscle-related measures between US and DXA was high [pooled r (95% CI) =0.69 (0.54–0.80), I^2=93.00% (P<0.001)]

Table 1 Characteristics of the included studies

Number	Study	Country	Sample size (total/male/female)	Age (mean ± SD, year)	BMI (mean ± SD, kg/m^2)	Gold standard	New method
1	Ashley A. Herda 2022 (31)	USA	73/19/54	69.4±6.3/66.1±7.2	27.1±4.3	DXA	BIA
2	Hong-Qi Xu 2021 (30)	China	301/129/172	46.7±25.2/52.5±23.5	23.6±3.8/23.1±3.9	DXA	BIA
3	Hyeoijin Kim 2022 (32)	Korea	Development group: 131/63/68	77.5±4.1/76.9±4.4	23.5±2.4/23.6±2.5	DXA	BIA
			Validation group: 64/31/33	76.5±4.4/76.9±3.7	23.7±2.4/23.8±2.1		
4	Jantine van den Helder 2022 (33)	Netherlands	202/58/144	72.0±6.0/72.1±6.6/72.1±6.4	25.2±3.0/25.6±3.8/25.4±3.6	DXA	BIA
5	Kwon Chan Jeon 2020 (34)	Korea	199/94/105	Development group: 76.4±4.2/76.1±4.1	23.7±2.3/23.8±2.2	DXA	BIA
				Validation group: 75.9±4.1/75.6±4.3	23.5±2.3/23.3±2.7		
6	M. Lane Moore 2020 (35)	USA	179/76/103	33.8±14.5/33.4±15.9/33.6±15.3	26.2±4.3/24.2±4.0/25.1±4.2	DXA	BIA
7	Maria Aquimara Zambone 2020 (36)	Brazil	92/92/0	>60	NA	DXA	BIA
8	Purwita W. Laksmi 2019 (37)	Indonesia	120/46/74	71.9±6.1	21.9±3.8/22.9±5.0	DXA	BIA
9	S. Toselli 2021 (38)	Brazil	184/44/140	71.5±7.3	27.9±5.3	DXA	BIA
10	S. Vermeiren 2019 (39)	Belgium	174/91/83	83.3±3.0/83.3±2.9/83.3±3.0	26.8±3.5/27.0±3.2/26.4±3.9	DXA	BIA
11	Shaea A. Alkahtani 2017 (40)	Saudi Arabia	232/232/0	27.1±4.2	28.1±5.5	DXA	BIA
12	Solomon C. Y. Yu 2016 (41)	Australia	195/78/117	48.0±17.0/52.7±14.7	27.4±4.5/26.4±5.7	DXA	BIA
13	Thiago G. Barbosa-Silva, MD, PhD 2020 (42)	Brazil	Single frequency BIA: 181/70/111	≥60	27.0±3.7/28.9±4.7	DXA	BIA
			Multi-frequency BIA: 178/67/111	≥60	26.9±3.6/28.9±4.7		
14	Wen-Hui Fang, MD 2020 (43)	China	438/179/259	73.3±6.8	24.09±3.32	DXA	BIA
15	Ling-Chun Lee 2014 (44)	China	77/42/35	62.5±5.3/62.6±6.0/62.5±5.6	26.4±3.6/25.6±3.8/26.0±3.7	DXA	BIA
16	Miji Kim 2015 (45)	Japan	551/241/310	74.3±5.1/73.0±5.3/73.6±2.4	NA	DXA	BIA
17	Xinyu Zhao 2013 (46)	China	66/52/14	52.0±13.3/46.6±11.8	24.2±3.1/22.7±2.7	DXA	MRI
18	Richard V. Clark 2014 (47)	USA	35/20/15	51.0±23.0	27.0±3.2	DXA	MRI
19	Zhao Chen 2007 (48)	USA	104/0/104	70.7±6.4	27.4±5.1	DXA	MRI
20	Richard V. Clark 2018 (49)	USA	18/14/4	73.3±5.8	NA	DXA	MRI

Table 1 (*continued*)

Table 1 *(continued)*

Number	Study	Country	Sample size (total/male/female)	Age (mean ± SD, year)	BMI (mean ± SD, kg/m^2)	Gold standard	New method
21	M. Neira Álvarez 2021 (50)	Spain	57/24/33	Median (IQR): 78.9 (74.9–81.9)	Median (IQR): 27.1 (25.1–29.2)	DXA	US
22	Takashi Abe, PhD 2018 (51)	USA	311/133/178	Development group: 71.0±5.0	23.5±2.9	DXA	US
				Validation group: 69.0±5.0	23.5±3.1		
23	Takashi Abe 2015 (22)	USA	102/59/43	Development group: 59.3±6.5/58.3±6.4	26.1±3.5/23.9±5.7	DXA	US
				Validation group: 60.6±6.9/57.1±5.4	25.5±2.1/26.0±6.3		
24	Takashi Abe 2016 (23)	Japan	158/72/86	64.0±8.0	24.0±3.4	DXA	US
25	Thiago G. Barbosa-Silva, MD, PhD 2021 (21)	Brazil	190/72/118	69.8±7.5	27.0±3.6/28.9±4.9/28.2±4.5	DXA	US
26	Yen-Lung Chen 2022 (52)	China	91/35/56	76.3±11.3/63.0±6.8/68.3±11.0	24.9±3.5/22.3±3.0/23.3±3.5	DXA	US
27	Akio Morimoto 2017 (53)	Japan	30/30/0	22.1±1.4	NA	DXA	US
28	Satoshi Yuguchi 2022 (54)	Japan	193/72/121	73.2±4.3/71.9±4.2/72.4±4.3	23.2±3.0/21.9±2.8/22.4±2.9	DXA	US

SD, standard deviation; BMI, body mass index; USA, the United States of America; DXA, dual-energy X-ray absorptiometry; BIA, bioelectrical impedance analysis; NA, not applicable; MRI, magnetic resonance imaging; IQR, interquartile range; US, ultrasound.

(*Figure 6*). Obvious asymmetry for the pooled index was not observed from visual inspection of funnel plots (Figure S7). The results of Egger linear regression test and Begg's rank correlation test suggested that there was no significant publication bias among the original studies (P>0.05). In sensitivity analysis, the estimations were robust after removing each of the studies (Figure S8). The results of subgroup analyses showed strong heterogeneities between the groups of different publication region (I^2=95.00%, P<0.001; I^2=0.00%, P=0.42) and MT parameter (I^2=95.00%, P<0.001; I^2=18.00%, P=0.30) (*Figures 7,8*).

There were 3 original studies (659 participants) which used ALM as the outcome, and these were included to compute the pooled estimates for the diagnostic value of US (Table S8). The pooled r (95% CI) was 0.93 (0.91–0.95), with a high heterogeneity (I^2=83.00%, P=0.003) (Figure S9). Sensitivity analysis suggested that the results were robust after removing each of the studies (Figure S10). Publication bias analysis and subgroup analysis were not conducted owing to the insufficient number of the original studies.

Pearson correlation coefficient for MRI and DXA

A total of 4 studies were included for the Pearson correlation coefficient between MRI and DXA. Among them, 3 studies used ALM and 1 used ALST as the outcome for DXA. All 4 studies used total body skeletal muscle mass as the outcome for MRI (Table S9). The correlation coefficient of muscle-related measures between MRI and DXA was very high [pooled r (95% CI) =0.96 (0.95–0.97), I^2=33.00% (P=0.21)] (*Figure 9*). Obvious asymmetry for the pooled index was not detected from visual inspection of funnel plots (Figure S11). The results of Egger linear regression test and Begg's rank correlation test suggested that there was no significant publication bias among the original studies (P>0.05). In sensitivity analysis, the estimations were robust after removing each of the studies (Figure S12). The results of subgroup analyses showed that there was no significant heterogeneity between the groups with different average age of participants (I^2=0.00%, P=0.50; I^2=65.00%, P=0.09) (*Figure 10*). The original or calculated data for the meta-analyses are presented in Tables S10-S14.

Discussion

This study evaluated the diagnostic agreement of BIA, US, CT, and MRI compared with that of DXA in measuring muscle mass to diagnose sarcopenia by meta-analyses.

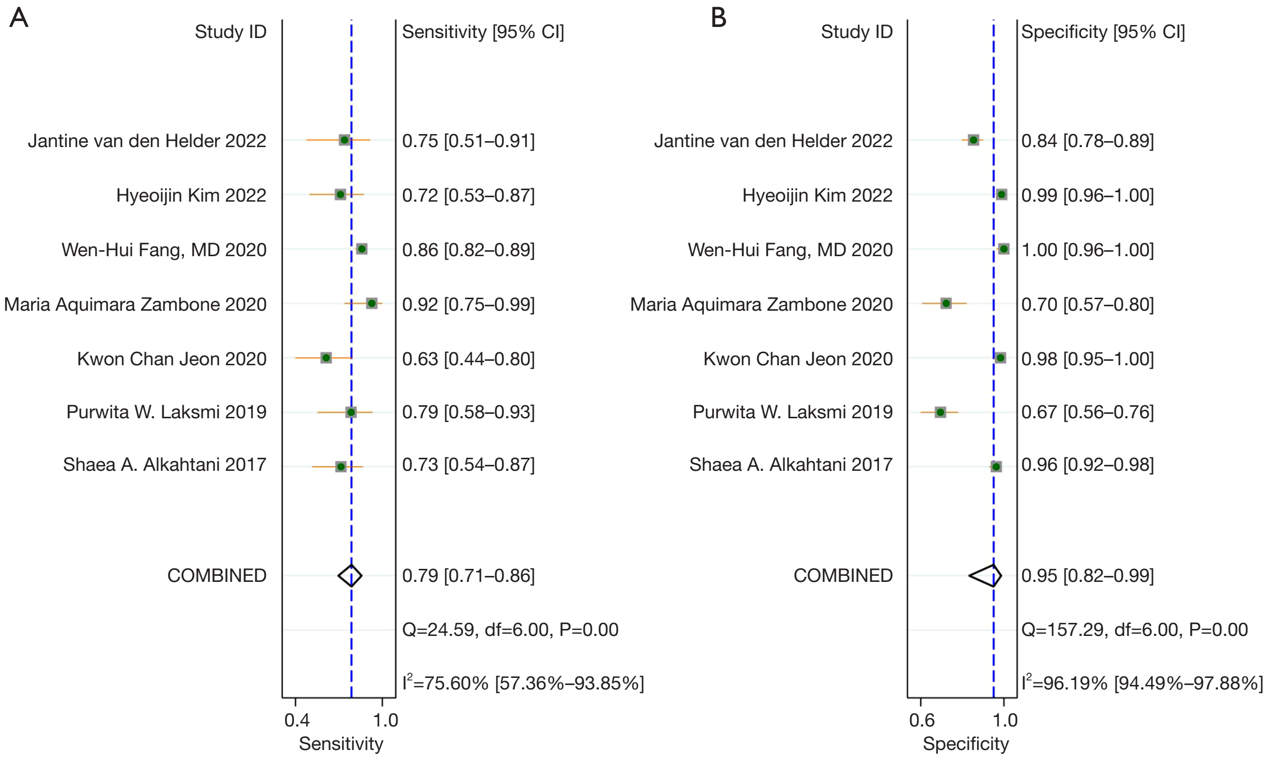

Figure 2 Forest plots of the studies for assessing the diagnostic accuracy between DXA and BIA. (A) Forest plot of sensitivity. (B) Forest plot of specificity. CI, confidence interval; Q, Cochrane Q test; df, degree of freedom; DXA, dual-energy X-ray absorptiometry; BIA, bioelectrical impedance analysis.

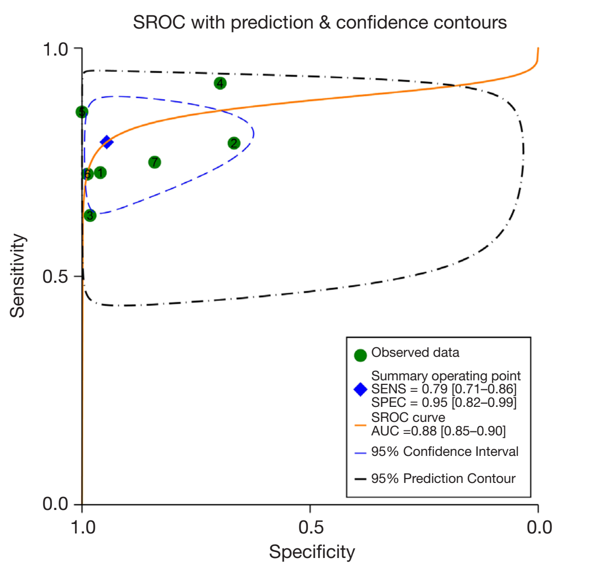

Figure 3 SROC curve of the studies for assessing the diagnostic accuracy between DXA and BIA. sROC, summary receiver operating characteristic; SENS, sensitivity; SPEC, specificity; AUC, area under the curve; DXA, dual-energy X-ray absorptiometry; BIA, bioelectrical impedance analysis.

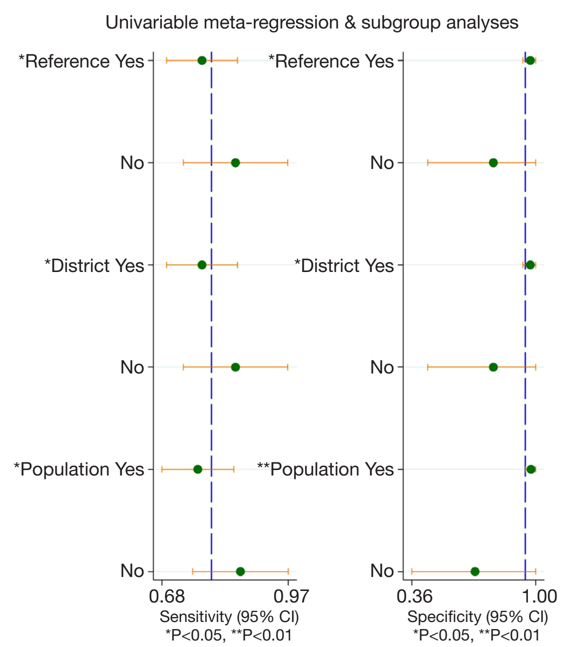

Figure 4 Meta-regression analysis to evaluate factors associated with the accuracy of BIA diagnose sarcopenia. *, P<0.05; **, P<0.01. CI, confidence interval; BIA, bioelectrical impedance analysis.

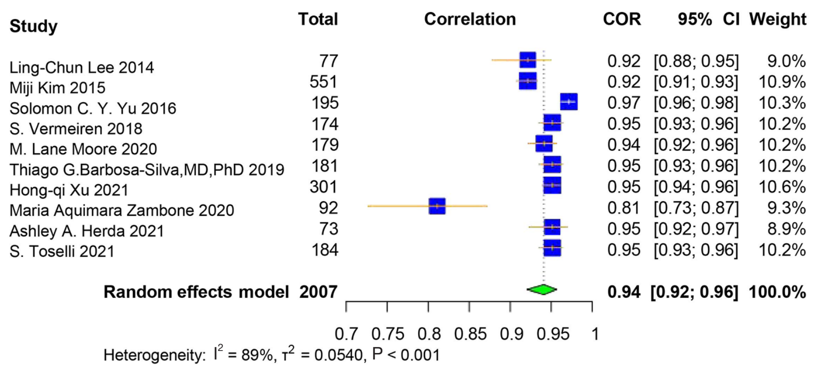

Figure 5 Forest plot of correlation between DXA and BIA. COR, correlation coefficient; CI, confidence interval; DXA, dual-energy X-ray absorptiometry; BIA, bioelectrical impedance analysis.

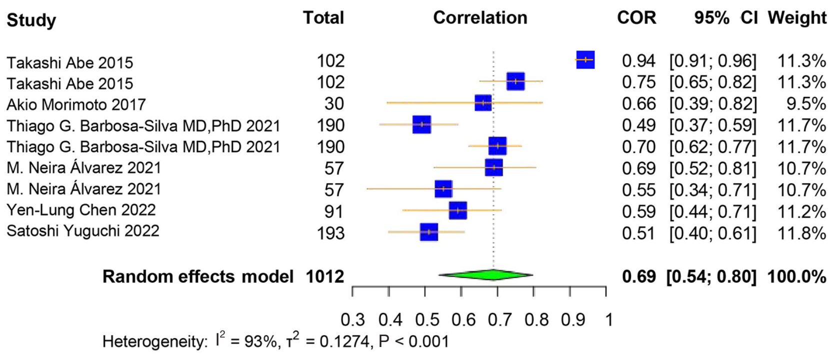

Figure 6 Forest plot of correlation between DXA and US using MT for the diagnostic parameter. COR, correlation coefficient; CI, confidence interval; DXA, dual-energy X-ray absorptiometry; US, ultrasound; MT, muscle thickness.

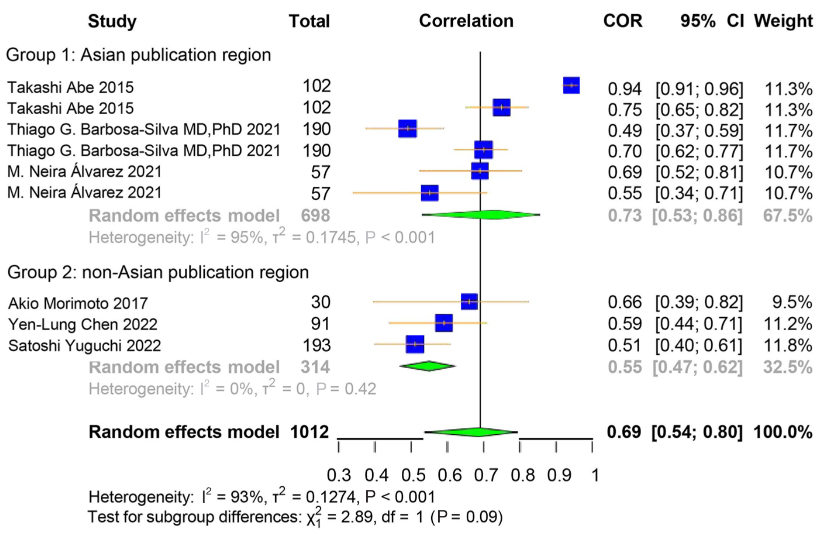

Figure 7 Subgroup analysis based on the publication region of the studies for assessing the correlation between DXA and US using MT for the diagnostic parameter. COR, correlation coefficient; CI, confidence interval; DXA, dual-energy X-ray absorptiometry; US, ultrasound; MT, muscle thickness.

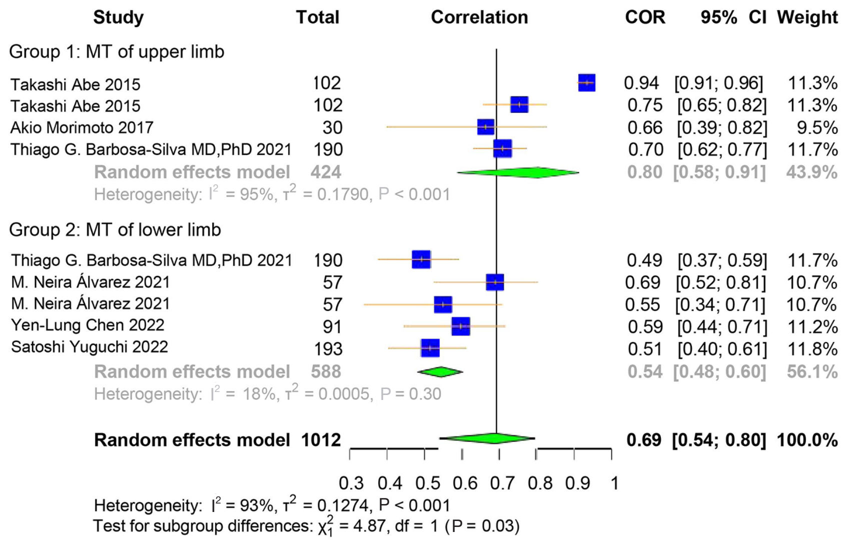

Figure 8 Subgroup analysis based on the MT parameter of the studies for assessing the correlation between DXA and US using MT for the diagnostic parameter. COR, correlation coefficient; CI, confidence interval; MT, muscle thickness; DXA, dual-energy X-ray absorptiometry; US, ultrasound.

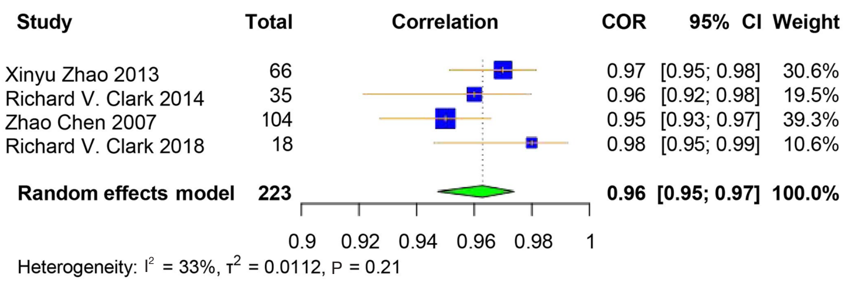

Figure 9 Forest plot of correlation between DXA and MRI. COR, correlation coefficient; CI, confidence interval; DXA, dual-energy X-ray absorptiometry; MRI, magnetic resonance imaging.

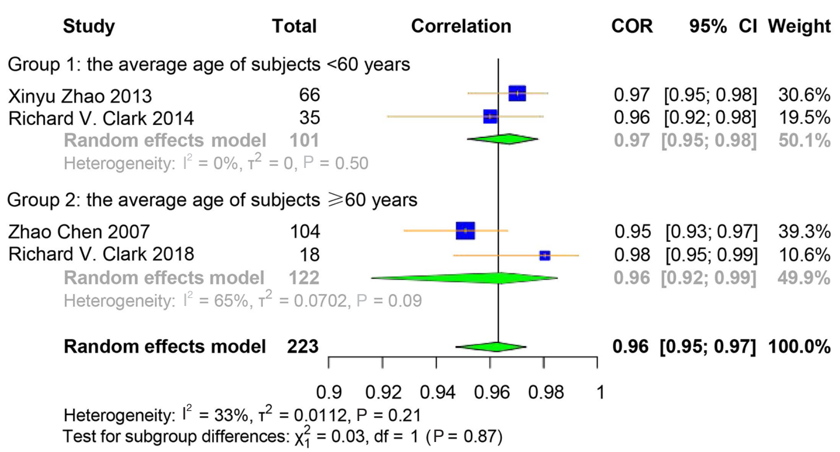

Figure 10 Subgroup analysis based on the average age of the subjects of the studies for assessing the correlation between DXA and MRI. COR, correlation coefficient; CI, confidence interval; DXA, dual-energy X-ray absorptiometry; MRI, magnetic resonance imaging.

Overall, the findings suggested that BIA, US, and MRI may have a good value in quantifying muscle mass to diagnose sarcopenia when compared with DXA. More evidence is needed for the application of CT in helping diagnose sarcopenia.

In the current study, a relative high sensitivity and specificity for using BIA-measured muscle mass in diagnosing sarcopenia were estimated. Especially in specificity, the performance was better than in sensitivity. BIA has been reported as a mathematical method for detecting sarcopenia in adults with cancer prior to treatment, and a viable alternative to DXA, CT, and MRI in oncology clinical practice (55). Furthermore, this meta-analysis confirmed a high positive correlation between muscle mass measured by BIA and DXA. Even so, when compared to DXA, anthropometry and calf circumferences presented better agreements than BIA in 2 studies (36,56). Moreover, following the EWGSOP case finding algorithm, the BIA-based approach resulted in a higher rate of misclassification of sarcopenic/non-sarcopenic cases, when compared to the DXA-based approach (57). Previous studies also reported that BIA significantly overestimated (58,59) or underestimated (45,60) muscle mass in absolute terms. Besides, we found that differences in population source, diagnostic criteria, and publication region among the original studies may introduce substantial heterogeneity for the diagnostic value, which is consistent with the previous studies (61). Similarly, a study reported that when a prediction equation of BIA based on Caucasian data had a good application to Hispanics with minor differences in the muscle mass measured by BIA and DXA, it failed to have a good agreement with Afro-Americans (62). This also suggested that the measurement by BIA, and its agreement with DXA may be influenced by population characteristics (63,64). In addition, a previous study showed that BIA devices with multi-frequency and the ASM estimation equation resulted in poor agreements and significant differences from the reference method of DXA (31).

Although the small number of original studies limited the estimation for the diagnostic value of US-measured muscle mass in diagnosing sarcopenia, the relationship between muscle mass measured by DXA and US was explored. We found that US might also be a reliable imaging method to quantify muscle mass for its relatively high correlation with DXA, and it showed a better correlation when using ALM as outcome for DXA and US. There were 2 studies that evaluated the agreement of US with DXA (50,65), 1 of which assessed the agreement between ALM acquired by DXA, and MT of gastrocnemius medialis and longitudinal plane obtained by US (50). MT on gastrocnemius medialis measured by US was not merely correlated well with DXA, but also with calf circumferences values and muscle performance. The sensitivities by MT of the gastrocnemius muscle in transverse and longitudinal plane was 77.80% and 77.10%, respectively, and the specificity was 100.00% and 68.80%, respectively. The other study found that the sensitivity and specificity by MT on gastrocnemius was 70.00% and 76.00%, respectively (65). According to the published studies, the most frequently used parameter for US was MT, following by cross-sectional area, echo intensity, and pennation angle, and the most frequently used positions were muscles in the gastrocnemius and rectus femoris (66). A previous study suggested that gastrocnemius MT and fascicle length values can serve as alternative measurements for predicting/quantifying sarcopenia (67). Besides gastrocnemius medialis, position of forearm-ulna (22) and rectus femoris (52), were also used. A study carried out ultrasonographic examinations for the non-dominant thenar musculature (68), which provided evidence for researchers to perform measurement on such a small muscle. However, US-derived ALM may be overestimated when compared with DXA-derived ALM (22), and the related ultrasonic measurements to anthropometric assessments, such as height (22) and calf circumferences (21), may help improve the accuracy. However, the clinical use of US is narrow due to the lack of a standardized protocol and validated cutoff points. Several new ultrasonic techniques for diagnosing muscle diseases have emerged in recent years, such as elastosonography and artificial intelligence (69).

The forest plot showed that DXA-derived muscle mass had a strong correlation with MRI-derived muscle mass with a pooled r (95% CI) =0.96 (0.95–0.97). Similarly, even if different diagnostic parameters were used, 1 study reported a high correlation between the total body lean mass assessed by DXA and the thigh skeletal muscle size assessed by MRI (r=0.89) (70). The other Chinese study showed significant high correlations between total-body bone-free lean mass measured by DXA and skeletal muscle mass measured by MRI in both women (r=0.78) and men (r=0.83) (71). However, a weak association between ALMI gained by DXA and cross-sectional area measured by MRI (r=0.18), and a modest association between ALMI and muscle volume (r=0.58) were reported in South Korea (72).

A paper reported the correlation between the measurements of muscle mass by CT and DXA (r=0.81–0.98), and provided the prediction equations between lean mass by DXA and lean mass volume by CT (73), which made it possible to convert DXA-derived lean mass to the CT-derived skeletal muscle volume with a higher accuracy in estimation. Another paper reported the correlation between DXA-derived ASMI and CT-derived cross-sectional area for men (r=0.75–0.80) and women (r=0.63–0.71), respectively (74).

Sarcopenia is identified as the gradual loss of skeletal muscle mass and strength (75), therefore, early diagnosis and management are very important. Muscle mass is one of the main parameters in the diagnosis and evaluation of sarcopenia. ASM is a key index to evaluate muscle mass, so a precise quantitative estimate of ASM is fundamental for diagnosing sarcopenia (76). The current meta-analysis showed that BIA is a more attractive method for assessing muscle mass due to its higher correlation with DXA. Although there was also a good correlation between MRI and DXA, MRI is mostly used in the research, especially in populations with a specific condition, for example, patients with cancer (77). BIA would be more available because it provides an affordable, noninvasive test that can be completed within a few minutes during a clinic visit, it does not require highly skilled personnel, and the results are immediately available (55). However, all of the muscle mass parameters such as fat-free mass, skeletal muscle, or ASM measured by BIA depend on an equation, first generated from a validation study against a reference method, usually including MRI or DXA, and the equations or algorithm are device-specific (63). More research should be conducted to standardize the terminology employed to describe muscularity and provide precise cut-off values for specific populations using this method (78).

As far as we know, this is the first meta-analysis to evaluate the diagnostic agreement in sarcopenia of BIA, US, CT, and MRI to assess muscle mass. Eventually, 28 articles met the inclusion and exclusion criteria, and most of the studies in this review have high methodological quality. We selected 2 indicators including diagnostic tests and correlation to examine the validity between DXA and 4 techniques. However, this study had some limitations. Firstly, we did not conduct meta-analysis for CT on account of the limited number of relevant original studies and the discrepancies in measurement parameters. Secondly, the comparison between males and females was not implemented because of inadequate data. Thirdly, there was high heterogeneity in different studies, such as the definition of sarcopenia, publication year, equipment type, and others. Fourthly, the unit disparities within the original studies may be one of the sources of heterogeneity. Additionally, as muscle mass is only one of the parameters in diagnosing sarcopenia, the accuracy of the remaining parameters (muscle strength and/or physical performance) would probably also affect the accuracy of diagnosis. Moreover, the variance in the adopted predictive equations, cut-offs, and their adequacy to the evaluated population may also have compromised the validity of the findings.

Conclusions

BIA, US, and MRI would provide acceptable diagnostic accuracy for sarcopenia by evaluating muscle mass in terms of sensitivity, specificity, accuracy, and their higher correlations with DXA. More studies are needed for the value of evaluating muscle mass by CT in diagnosing sarcopenia.

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Footnote

Reporting Checklist: The authors have completed the PRISMA-DTA reporting checklist. Available at https://qims.amegroups.com/article/view/10.21037/qims-23-1089/rc

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://qims.amegroups.com/article/view/10.21037/qims-23-1089/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Table S1 Search strategy of PubMed (12 October 2023)

No.	Query	Results
#1	"Sarcopenia"[Mesh]	9,622
#2	Sarcopenia[Title/Abstract] OR Sarcopenias[Title/Abstract]	16,700
#3	#1 OR #2	17,703
#4	Skeletal Muscle Mass[Title/Abstract] OR SMM[Title/Abstract] OR Skeletal Muscle[Title/Abstract] OR Muscle Mass[Title/Abstract] OR Muscle[Title/Abstract] OR Mass[Title/Abstract] OR Lean Soft-tissue Mass[Title/Abstract] OR Lean Soft Tissue[Title/Abstract] OR LST[Title/Abstract] OR Lean Body Mass[Title/Abstract] OR Lean Mass[Title/Abstract] OR LM[Title/Abstract]	1,851,320
#5	"Body Composition"[Mesh]	64,130
#6	Body Composition[Title/Abstract] OR Body Compositions[Title/Abstract] OR Composition, Body[Title/Abstract] OR Compositions, Body[Title/Abstract]	47,743
#7	#5 OR #6	84,837
#8	#3 OR #4 OR #7	1,891,398
#9	"Absorptiometry, Photon"[Mesh]	26,031
#10	dual-energy X-ray absorptiometry[Title/Abstract] OR DXA[Title/Abstract] OR Absorptiometry, Photon[Title/Abstract] OR Photon Absorptiometry[Title/Abstract] OR Densitometry, X-Ray[Title/Abstract] OR Densitometry, X Ray[Title/Abstract] OR X-Ray Densitometry[Title/Abstract] OR Photodensitometry, X-Ray[Title/Abstract] OR Photodensitometry, X Ray[Title/Abstract] OR X-Ray Photodensitometry[Title/Abstract] OR X Ray Photodensitometry[Title/Abstract] OR Densitometry, Xray[Title/Abstract] OR Xray Densitometry[Title/Abstract] OR Single-Photon Absorptiometry[Title/Abstract] OR Absorptiometry, Single-Photon[Title/Abstract] OR Single Photon Absorptiometry[Title/Abstract] OR Dual-Energy X-Ray Absorptiometry Scan[Title/Abstract] OR Dual Energy X Ray Absorptiometry Scan[Title/Abstract] OR DXA Scan[Title/Abstract] OR DXA Scans[Title/Abstract] OR Scan, DXA[Title/Abstract] OR Scans, DXA[Title/Abstract] OR DEXA Scan[Title/Abstract] OR DEXA Scans[Title/Abstract] OR Scan, DEXA[Title/Abstract] OR Scans, DEXA[Title/Abstract] OR Dual-Photon Absorptiometry[Title/Abstract] OR Absorptiometry, Dual-Photon[Title/Abstract] OR Dual Photon Absorptiometry[Title/Abstract] OR Radiographic Absorptiometry, Dual-Energy[Title/Abstract] OR Radiographic Absorptiometry, Dual Energy[Title/Abstract] OR Absorptiometry, Dual-Energy Radiographic[Title/Abstract] OR Absorptiometry, Dual Energy Radiographic[Title/Abstract] OR Dual-Energy Radiographic Absorptiometry[Title/Abstract] OR Dual Energy Radiographic Absorptiometry[Title/Abstract] OR Absorptiometry, X-Ray[Title/Abstract] OR Absorptiometry, X Ray[Title/Abstract] OR X-Ray Absorptiometry[Title/Abstract] OR X Ray Absorptiometry[Title/Abstract] OR Dual-Energy X-Ray Absorptiometry[Title/Abstract] OR Dual Energy X Ray Absorptiometry[Title/Abstract] OR X-Ray Absorptiometry, Dual-Energy[Title/Abstract] OR X Ray Absorptiometry, Dual Energy[Title/Abstract] OR DPX Absorptiometry[Title/Abstract] OR Absorptiometries, DPX[Title/Abstract] OR Absorptiometry, DPX[Title/Abstract] OR Absorptiometry, Dual X-Ray[Title/Abstract] OR Absorptiometry, Dual X Ray[Title/Abstract] OR X-Ray Absorptiometry, Dual[Title/Abstract] OR Absorptiometry, Dual-Energy X-Ray[Title/Abstract] OR Absorptiometry, Dual Energy X Ray[Title/Abstract] OR Dual X-Ray Absorptiometry[Title/Abstract] OR Dual X Ray Absorptiometry[Title/Abstract]	35,685
#11	#9 OR #10	43,516
#12	Bioimpedance analysis[Title/Abstract] OR BIA[Title/Abstract] OR Bioimpedance electrical analysis[Title/Abstract] OR Bioelectrical impedance analysis[Title/Abstract] OR bio-electrical impedance analysis[Title/Abstract]	8,240
#13	"Ultrasonography"[Mesh]	489,088
#14	Ultrasound[Title/Abstract] OR US[Title/Abstract] OR Ultrasonography[Title/Abstract] OR Diagnostic Ultrasound[Title/Abstract] OR Diagnostic Ultrasounds[Title/Abstract] OR Ultrasound, Diagnostic[Title/Abstract] OR Ultrasounds, Diagnostic[Title/Abstract] OR Ultrasound Imaging[Title/Abstract] OR Imaging, Ultrasound[Title/Abstract] OR Imagings, Ultrasound[Title/Abstract] OR Echotomography[Title/Abstract] OR Ultrasonic Imaging[Title/Abstract] OR Imaging, Ultrasonic[Title/Abstract] OR Sonography, Medical[Title/Abstract] OR Medical Sonography[Title/Abstract] OR Ultrasonographic Imaging[Title/Abstract] OR Imaging, Ultrasonographic[Title/Abstract] OR Imagings, Ultrasonographic[Title/Abstract] OR Ultrasonographic Imagings[Title/Abstract] OR Echography[Title/Abstract] OR Diagnosis, Ultrasonic[Title/Abstract] OR Diagnoses, Ultrasonic[Title/Abstract] OR Ultrasonic Diagnoses[Title/Abstract] OR Ultrasonic Diagnosis[Title/Abstract] OR Echotomography, Computer[Title/Abstract] OR Computer Echotomography[Title/Abstract] OR Tomography, Ultrasonic[Title/Abstract] OR Ultrasonic Tomography[Title/Abstract]	926,402
#15	#13 OR #14	1,200,745
#16	"Magnetic Resonance Imaging"[Mesh]	536,942
#17	magnetic resonance imaging[Title/Abstract] OR MRI[Title/Abstract] OR Magnetic Resonance Imaging[Title/Abstract] OR Imaging, Magnetic Resonance[Title/Abstract] OR NMR Imaging[Title/Abstract] OR Imaging, NMR[Title/Abstract] OR Tomography, NMR[Title/Abstract] OR Tomography, MR[Title/Abstract] OR MR Tomography[Title/Abstract] OR NMR Tomography[Title/Abstract] OR Steady-State Free Precession MRI[Title/Abstract] OR Steady State Free Precession MRI[Title/Abstract] OR Zeugmatography[Title/Abstract] OR Imaging, Chemical Shift[Title/Abstract] OR Chemical Shift Imagings[Title/Abstract] OR Imagings, Chemical Shift[Title/Abstract] OR Shift Imaging, Chemical[Title/Abstract] OR Shift Imagings, Chemical[Title/Abstract] OR Chemical Shift Imaging[Title/Abstract] OR Magnetic Resonance Image[Title/Abstract] OR Image, Magnetic Resonance[Title/Abstract] OR Magnetic Resonance Images[Title/Abstract] OR Resonance Image, Magnetic[Title/Abstract] OR Magnetization Transfer Contrast Imaging[Title/Abstract] OR MRI Scans[Title/Abstract] OR MRI Scan[Title/Abstract] OR Scan, MRI[Title/Abstract] OR Scans, MRI[Title/Abstract] OR Tomography, Proton Spin[Title/Abstract] OR Proton Spin Tomography[Title/Abstract] OR fMRI[Title/Abstract] OR MRI, Functional[Title/Abstract] OR Functional MRI[Title/Abstract] OR Functional MRIs[Title/Abstract] OR MRIs, Functional[Title/Abstract] OR Functional Magnetic Resonance Imaging[Title/Abstract] OR Magnetic Resonance Imaging, Functional[Title/Abstract] OR Spin Echo Imaging[Title/Abstract] OR Echo Imaging, Spin[Title/Abstract] OR Echo Imagings, Spin[Title/Abstract] OR Imaging, Spin Echo[Title/Abstract] OR Imagings, Spin Echo[Title/Abstract] OR Spin Echo Imagings[Title/Abstract]	526,744
#18	#16 OR #17	739,393
#19	"Tomography, X-Ray Computed"[Mesh]	494,469
#20	computed tomography[Title/Abstract] OR CT[Title/Abstract] OR Tomography, X-Ray Computed[Title/Abstract] OR X-Ray Computed Tomography[Title/Abstract] OR Tomography, X-Ray Computerized[Title/Abstract] OR Tomography, X Ray Computerized[Title/Abstract] OR Computed X Ray Tomography[Title/Abstract] OR X-Ray Computer Assisted Tomography[Title/Abstract] OR X Ray Computer Assisted Tomography[Title/Abstract] OR Tomography, X-Ray Computer Assisted[Title/Abstract] OR Tomography, X Ray Computer Assisted[Title/Abstract] OR Computerized Tomography, X Ray[Title/Abstract] OR Computerized Tomography, X-Ray[Title/Abstract] OR X-Ray Computerized Tomography[Title/Abstract] OR CT X Ray[Title/Abstract] OR CT X Rays[Title/Abstract] OR X Ray, CT[Title/Abstract] OR X Rays, CT[Title/Abstract] OR Tomodensitometry[Title/Abstract] OR Tomography, X Ray Computed[Title/Abstract] OR X Ray Tomography, Computed[Title/Abstract] OR X-Ray Tomography, Computed[Title/Abstract] OR Computed X-Ray Tomography[Title/Abstract] OR Tomographies, Computed X-Ray[Title/Abstract] OR Tomography, Computed X-Ray[Title/Abstract] OR Tomography, Xray Computed[Title/Abstract] OR Computed Tomography, Xray[Title/Abstract] OR Xray Computed Tomography[Title/Abstract] OR CAT Scan, X Ray[Title/Abstract] OR CAT Scan, X-Ray[Title/Abstract] OR CAT Scans, X-Ray[Title/Abstract] OR Scan, X-Ray CAT[Title/Abstract] OR Scans, X-Ray CAT[Title/Abstract] OR X-Ray CAT Scan[Title/Abstract] OR X-Ray CAT Scans[Title/Abstract] OR Tomography, Transmission Computed[Title/Abstract] OR Computed Tomography, Transmission[Title/Abstract] OR Transmission Computed Tomography[Title/Abstract] OR CT Scan, X-Ray[Title/Abstract] OR CT Scan, X Ray[Title/Abstract] OR CT Scans, X-Ray[Title/Abstract] OR Scan, X-Ray CT[Title/Abstract] OR Scans, X-Ray CT[Title/Abstract] OR X-Ray CT Scan[Title/Abstract] OR X-Ray CT Scans[Title/Abstract] OR Computed Tomography, X-Ray[Title/Abstract] OR Computed Tomography, X Ray[Title/Abstract] OR X Ray Computerized Tomography[Title/Abstract] OR Cine-CT[Title/Abstract] OR Cine CT[Title/Abstract] OR Electron Beam Computed Tomography[Title/Abstract] OR Electron Beam Tomography[Title/Abstract] OR Beam Tomography, Electron[Title/Abstract] OR Tomography, Electron Beam[Title/Abstract] OR Tomography, X-Ray Computerized Axial[Title/Abstract] OR Tomography, X Ray Computerized Axial[Title/Abstract] OR X-Ray Computerized Axial Tomography[Title/Abstract] OR X Ray Computerized Axial Tomography[Title/Abstract]	624,990
#21	#19 OR #20	832,985
#22	#12 OR #15 OR #18 OR #21	2,480,020
#23	#8 AND #11 AND #22	5,455
#24	#8 AND #11 AND #22 AND ((clinicaltrial[Filter] OR randomizedcontrolledtrial[Filter]) AND (humans[Filter]))	675

DXA, dual-energy X-ray absorptiometry; BIA, bioelectrical impedance analysis; US, ultrasound; MRI, magnetic resonance imaging; CT, computed tomography.

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Table S2 Search strategy of Embase (12 October 2023)

No.	Query	Results
#1	sarcopenia'/exp	21,033
#2	sarcopenia:ab,ti OR sarcopenias:ab,ti	22,291
#3	#1 OR #2	26,198
#4	'skeletal muscle mass':ab,ti OR smm:ab,ti OR 'skeletal muscle':ab,ti OR 'muscle mass':ab,ti OR muscle:ab,ti OR mass:ab,ti OR 'lean soft-tissue mass':ab,ti OR 'lean soft tissue':ab,ti OR lst:ab,ti OR 'lean body mass':ab,ti OR 'lean mass':ab,ti OR lm:ab,ti	2,352,320
#5	'body composition'/exp	129,536
#6	body composition':ab,ti OR 'body compositions':ab,ti OR 'composition, body':ab,ti OR 'compositions,body':ab,ti	63,981
#7	#5 OR #6	138,108
#8	#3 OR #4 OR #7	2,424,986
#9	absorptiometry, photon'/exp	4,432
#10	dxa:ab,ti OR 'absorptiometry, photon':ab,ti OR 'photon absorptiometry':ab,ti OR 'densitometry, x-ray':ab,ti OR 'densitometry, x ray':ab,ti OR 'x-ray densitometry':ab,ti OR 'photodensitometry,x-ray':ab,ti OR 'photodensitometry, x ray':ab,ti OR 'x-ray photodensitometry':ab,ti OR 'x ray photodensitometry':ab,ti OR 'densitometry,xray':ab,ti OR 'xray densitometry':ab,ti OR 'single-photon absorptiometry':ab,ti OR 'absorptiometry, single-photon':ab,ti OR 'single photon absorptiometry':ab,ti OR 'dual-energy x-ray absorptiometry scan':ab,ti OR 'dual energy x ray absorptiometry scan':ab,ti OR 'dxa scan':ab,ti OR 'dxa scans':ab,ti OR 'scan,dxa':ab,ti OR 'scans, dxa':ab,ti OR 'dexa scan':ab,ti OR 'dexa scans':ab,ti OR 'scan,dexa':ab,ti OR 'scans, dexa':ab,ti OR 'dual-photon absorptiometry':ab,ti OR 'absorptiometry, dual-photon':ab,ti OR 'dual photon absorptiometry':ab,ti OR 'radiographic absorptiometry, dual-energy':ab,ti OR 'radiographic absorptiometry, dual energy':ab,ti OR 'absorptiometry, dual-energy radiographic':ab,ti OR 'absorptiometry, dualenergy radiographic':ab,ti OR 'dual-energy radiographic absorptiometry':ab,ti OR 'dualenergy radiographic absorptiometry':ab,ti OR 'absorptiometry, x-ray':ab,ti OR 'absorptiometry,x ray':ab,ti OR 'x-ray absorptiometry':ab,ti OR 'x ray absorptiometry':ab,ti OR 'dual-energy x-ray absorptiometry':ab,ti OR 'dual energy x ray absorptiometry':ab,ti OR 'x-ray absorptiometry,dual-energy':ab,ti OR 'x ray absorptiometry, dualenergy':ab,ti OR 'dpx absorptiometry':ab,ti OR 'absorptiometries, dpx':ab,ti OR 'absorptiometry,dpx':ab,ti OR 'absorptiometry, dual x-ray':ab,ti OR 'absorptiometry, dual x ray':ab,ti OR 'x-ray absorptiometry, dual':ab,ti OR 'absorptiometry,dual-energy x-ray':ab,ti OR 'absorptiometry, dual energy x ray':ab,ti OR 'dual x-ray absorptiometry':ab,ti OR 'dual x ray absorptiometry':ab,ti	4,990
#11	#9 OR #10	56,608
#12	bioimpedance analysis':ab,ti OR bia:ab,ti OR 'bioimpedance electrical analysis':ab,ti OR 'bioelectrical impedance analysis':ab,ti OR 'bio-electrical impedance analysis':ab,ti	12,973
#13	'ultrasonography'/exp	1,052,218
#14	ultrasound:ab,ti OR us:ab,ti OR ultrasonography:ab,ti OR 'diagnostic ultrasound':ab,ti OR 'diagnostic ultrasounds':ab,ti OR 'ultrasound,diagnostic':ab,ti OR 'ultrasounds,diagnostic':ab,ti OR 'ultrasound imaging':ab,ti OR 'imaging, ultrasound':ab,ti OR 'imagings,ultrasound':ab,ti OR echotomography:ab,ti OR 'ultrasonic imaging':ab,ti OR 'imaging,ultrasonic':ab,ti OR 'sonography, medical':ab,ti OR 'medical sonography':ab,ti OR 'ultrasonographic imaging':ab,ti OR 'imaging, ultrasonographic':ab,ti OR 'imagings,ultrasonograph ic':ab,ti OR 'ultrasonographic imagings':ab,ti OR echography:ab,ti OR 'diagnosis, ultrasonic':ab,ti OR 'diagnoses,ultrasonic':ab,ti OR 'ultrasonic diagnoses':ab,ti OR 'ultrasonic diagnosis':ab,ti OR 'echotomography, computer':ab,ti OR 'computer echotomography':ab,ti OR 'tomography,ultrasonic':ab,ti OR 'ultrasonic tomography':ab,ti	1,320,685
#15	#13 OR #14	2,024,162
#16	'magnetic resonance imaging'/exp	1,246,169
#17	mri:ab,ti OR 'magnetic resonance imaging':ab,ti OR 'imaging, magnetic resonance':ab,ti OR 'nmr imaging':ab,ti OR 'imaging, nmr':ab,ti OR 'tomography, nmr':ab,ti OR 'tomography, mr':ab,ti OR 'mr tomography':ab,ti OR 'nmr tomography':ab,ti OR 'steady-state free precession mri':ab,ti OR 'steady state free precession mri':ab,ti OR zeugmatography:ab,ti OR 'imaging, chemical shift':ab,ti OR 'chemical shift imagings':ab,ti OR 'imagings, chemical shift':ab,ti OR 'shift imaging, chemical':ab,ti OR 'shift imagings, chemical':ab,ti OR 'chemical shift imaging':ab,ti OR 'magnetic resonance image':ab,ti OR 'image, magnetic resonance':ab,ti OR 'magnetic resonance images':ab,ti OR 'resonance image, magnetic':ab,ti OR 'magnetization transfer contrast imaging':ab,ti OR 'mri scans':ab,ti OR 'mri scan':ab,ti OR 'scan, mri':ab,ti OR 'scans, mri':ab,ti OR 'tomography, proton spin':ab,ti OR 'proton spin tomography':ab,ti OR fmri:ab,ti OR 'mri,functional':ab,ti OR 'functional mri':ab,ti OR 'functional mris':ab,ti OR 'mris,functional':ab,ti OR 'functional magnetic resonance imaging':ab,ti OR 'magnetic resonance imaging, functional':ab,ti OR 'spin echo imaging':ab,ti OR 'echo imaging, spin':ab,ti OR 'echo imagings, spin':ab,ti OR 'imaging,spin echo':ab,ti OR 'imagings, spin echo':ab,ti OR 'spin echo imagings':ab,ti	764,141
#18	#16 OR #17	1,314,447
#19	tomography, x-ray computed'/exp	105,902
#20	tomography, x-ray computed'/exp 'tomography, x-ray computed':ab,ti OR 'x-ray computed tomography':ab,ti OR 'tomography, x-ray computerized':ab,ti OR 'tomography, x ray computerized':ab,ti OR 'computed x ray tomography':ab,ti OR 'x-ray computer assisted tomography':ab,ti OR 'x ray computer assisted tomography':ab,ti OR 'tomography, x-ray computer assisted':ab,ti OR 'tomography, x ray computer assisted':ab,ti OR 'computerized tomography, x ray':ab,ti OR 'computerized tomography,x-ray':ab,ti OR 'x-ray computerized tomography':ab,ti OR 'ct x ray':ab,ti OR 'ct x rays':ab,ti OR 'x ray, ct':ab,ti OR 'x rays,ct':ab,ti OR tomodensitometry:ab,ti OR 'tomography, x ray computed':ab,ti OR 'x ray tomography, computed':ab,ti OR 'x-ray tomography,computed':ab,ti OR 'computed x-ray tomography':ab,ti OR 'tomographies,computed x-ray':ab,ti OR 'tomography, computed x-ray':ab,ti OR 'tomography, xray computed':ab,ti OR 'computed tomography, xray':ab,ti OR 'xray computed tomography':ab,ti OR 'cat scan, x ray':ab,ti OR 'cat scan, x-ray':ab,ti OR 'cat scans, x-ray':ab,ti OR 'scan, x-ray cat':ab,ti OR 'scans, x-ray cat':ab,ti OR 'x-ray cat scan':ab,ti OR 'x-ray cat scans':ab,ti OR 'tomography, transmission computed':ab,ti OR 'computed tomography, transmission':ab,ti OR 'transmission computed tomography':ab,ti OR 'ct scan, x-ray':ab,ti OR 'ct scan, x ray':ab,ti OR 'ct scans, x-ray':ab,ti OR 'scan, x-ray ct':ab,ti OR 'scans, x-ray ct':ab,ti OR 'x-ray ct scan':ab,ti OR 'x-ray ct scans':ab,ti OR 'computed tomography, x-ray':ab,ti OR 'computed tomography, x ray':ab,ti OR 'x ray computerized tomography':ab,ti OR 'cine ct':ab,ti OR 'electron beam computed tomography':ab,ti OR 'electron beam tomography':ab,ti OR 'beam tomography,electron':ab,ti OR 'tomography, electron beam':ab,ti OR 'tomography, x-ray computerized axial':ab,ti OR 'tomography, x ray computerized axial':ab,ti OR 'x-ray computerized axial tomography':ab,ti OR 'x ray computerized axial tomography':ab,ti	958,001
#21	#19 OR #20	993,976
#22	#12 OR #15 OR #18 OR #21	3,815,079
#23	#8 AND #11 AND #22	7,439
#24	#23 AND ('case control study'/de OR 'clinical article'/de OR 'clinical trial'/de OR 'cohort analysis'/de OR 'comparative study'/de OR 'compartment model'/de OR 'control group'/de OR 'controlled clinical trial'/de OR 'controlled study'/de OR 'correlational study'/de OR 'cross sectional study'/de OR 'diagnostic test accuracy study'/de OR 'double blind procedure'/de OR 'human'/de OR 'human cell'/de OR 'human experiment'/de OR 'human tissue'/de OR 'in vitro study'/de OR 'in vivo study'/de OR 'intermethod comparison'/de OR 'intervention study'/de OR 'linear regression analysis'/de OR 'longitudinal study'/de OR 'major clinical study'/de OR 'methodology'/de OR 'model'/de OR 'multicenter study'/de OR 'normal human'/de OR 'observational study'/de OR 'pilot study'/de OR 'prospective study'/de OR 'quality control'/de OR 'quantitative study'/de OR 'questionnaire'/de OR 'randomized controlled trial'/de OR 'randomized controlled trial topic'/de OR 'retrospective study'/de OR 'sample size'/de OR 'statistical model'/de OR 'validation process'/de OR 'validation study'/de)	7,225
#25	#24 AND ('Article'/it OR 'Article in Press'/it OR 'Preprint'/it OR 'Short Survey'/it)	4,554

DXA, dual-energy X-ray absorptiometry; BIA, bioelectrical impedance analysis; US, ultrasound; MRI, magnetic resonance imaging; CT, computed tomography.

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Table S3 Search strategy of Cochrane (12 October 2023)

No.	Query	Results
#1	MeSH descriptor: [Sarcopenia] explode all trees	849
#2	(Sarcopenia or Sarcopenias):ti,ab,kw (Word variations have been searched)	2,249
#3	#1 OR #2	2,249
#4	(Skeletal Muscle Mass or SMM or Skeletal Muscle or Muscle Mass or Muscle or Mass or Lean Soft-tissue Mass or Lean Soft Tissue or LST or Lean Body Mass or Lean Mass or LM):ti,ab,kw (Word variations have been searched)	195,650
#5	MeSH descriptor: [Body Composition] explode all trees	7,141
#6	(Body Composition or Body Compositions or Composition, Body or Compositions, Body):ti,ab,kw (Word variations have been searched)	23,306
#7	#5 OR #6	24,037
#8	#3 OR #4 OR #7	204,567
#9	MeSH descriptor: [Absorptiometry, Photon] explode all trees	2,168
#10	(dual-energy X-ray absorptiometry or DXA or Absorptiometry, Photon or Photon Absorptiometry or Densitometry, X-Ray or Densitometry, X Ray or X-Ray Densitometry or Photodensitometry, X-Ray or Photodensitometry, X Ray or X-Ray Photodensitometry or X Ray Photodensitometry or Densitometry, Xray or Xray Densitometry or Single-Photon Absorptiometry or Absorptiometry, Single-Photon or Single Photon Absorptiometry or Dual-Energy X-Ray Absorptiometry Scan or Dual Energy X Ray Absorptiometry Scan or DXA Scan or DXA Scans or Scan, DXA or Scans, DXA or DEXA Scan or DEXA Scans or Scan, DEXA or Scans, DEXA or Dual-Photon Absorptiometry or Absorptiometry, Dual-Photon or Dual Photon Absorptiometry or Radiographic Absorptiometry, Dual-Energy or Radiographic Absorptiometry, Dual Energy or Absorptiometry, Dual-Energy Radiographic or Absorptiometry, Dual Energy Radiographic or Dual-Energy Radiographic Absorptiometry or Dual Energy Radiographic Absorptiometry or Absorptiometry, X-Ray or Absorptiometry, X Ray or X-Ray Absorptiometry or X Ray Absorptiometry or Dual-Energy X-Ray Absorptiometry or Dual Energy X Ray Absorptiometry or X-Ray Absorptiometry, Dual-Energy or X Ray Absorptiometry, Dual Energy or DPX Absorptiometry or Absorptiometries, DPX or Absorptiometry, DPX or Absorptiometry, Dual X-Ray or Absorptiometry, Dual X Ray or X-Ray Absorptiometry, Dual or Absorptiometry, Dual-Energy X-Ray or Absorptiometry, Dual Energy X Ray or Dual X-Ray Absorptiometry or Dual X Ray Absorptiometry):ti,ab,kw (Word variations have been searched)	9,178
#11	#9 OR #10	9,178
#12	(Bioimpedance analysis or BIA or Bioimpedance electrical analysis or Bioelectrical impedance analysis or bio-electrical impedance analysis):ti,ab,kw (Word variations have been searched)	2,707
#13	MeSH descriptor: [Ultrasonography] explode all trees	17,636
#14	(Ultrasound or US or Ultrasonography or Diagnostic Ultrasound or Diagnostic Ultrasounds or Ultrasound, Diagnostic or Ultrasounds, Diagnostic or Ultrasound Imaging or Imaging, Ultrasound or Imagings, Ultrasound or Echotomography or Ultrasonic Imaging or Imaging, Ultrasonic or Sonography, Medical or Medical Sonography or Ultrasonographic Imaging or Imaging, Ultrasonographic or Imagings, Ultrasonographic or Ultrasonographic Imagings or Echography or Diagnosis, Ultrasonic or Diagnoses, Ultrasonic or Ultrasonic Diagnoses or Ultrasonic Diagnosis or Echotomography, Computer or Computer Echotomography or Tomography, Ultrasonic or Ultrasonic Tomography):ti,ab,kw (Word variations have been searched)	93,397
#15	#13 OR #14	93,397
#16	MeSH descriptor: [Magnetic Resonance Imaging] explode all trees	10,968
#17	(magnetic resonance imaging or MRI or Magnetic Resonance Imaging or Imaging, Magnetic Resonance or NMR Imaging or Imaging, NMR or Tomography, NMR or Tomography, MR or MR Tomography or NMR Tomography or Steady-State Free Precession MRI or Steady State Free Precession MRI or Zeugmatography or Imaging, Chemical Shift or Chemical Shift Imagings or Imagings, Chemical Shift or Shift Imaging, Chemical or Shift Imagings, Chemical or Chemical Shift Imaging or Magnetic Resonance Image or Image, Magnetic Resonance or Magnetic Resonance Images or Resonance Image, Magnetic or Magnetization Transfer Contrast Imaging or MRI Scans or MRI Scan or Scan, MRI or Scans, MRI or Tomography, Proton Spin or Proton Spin Tomography or fMRI or MRI, Functional or Functional MRI or Functional MRIs or MRIs, Functional or Functional Magnetic Resonance Imaging or Magnetic Resonance Imaging, Functional or Spin Echo Imaging or Echo Imaging, Spin or Echo Imagings, Spin or Imaging, Spin Echo or Imagings, Spin Echo or Spin Echo Imagings):ti,ab,kw (Word variations have been searched)	45,575
#18	#16 OR #17	45,781
#19	MeSH descriptor: [Tomography, X-Ray Computed] explode all trees	7,312
#20	(computed tomography or CT or Tomography, X-Ray Computed or X-Ray Computed Tomography or Tomography, X-Ray Computerized or Tomography, X Ray Computerized or Computed X Ray Tomography or X-Ray Computer Assisted Tomography or X Ray Computer Assisted Tomography or Tomography, X-Ray Computer Assisted or Tomography, X Ray Computer Assisted or Computerized Tomography, X Ray or Computerized Tomography, X-Ray or X-Ray Computerized Tomography or CT X Ray or CT X Rays or X Ray, CT or X Rays, CT or Tomodensitometry or Tomography, X Ray Computed or X Ray Tomography, Computed or X-Ray Tomography, Computed or Computed X-Ray Tomography or Tomographies, Computed X-Ray or Tomography, Computed X-Ray or Tomography, Xray Computed or Computed Tomography, Xray or Xray Computed Tomography or CAT Scan, X Ray or CAT Scan, X-Ray or CAT Scans, X-Ray or Scan, X-Ray CAT or Scans, X-Ray CAT or X-Ray CAT Scan or X-Ray CAT Scans or Tomography, Transmission Computed or Computed Tomography, Transmission or Transmission Computed Tomography or CT Scan, X-Ray or CT Scan, X Ray or CT Scans, X-Ray or Scan, X-Ray CT or Scans, X-Ray CT or X-Ray CT Scan or X-Ray CT Scans or Computed Tomography, X-Ray or Computed Tomography, X Ray or X Ray Computerized Tomography or Cine-CT or Cine CT or Electron Beam Computed Tomography or Electron Beam Tomography or Beam Tomography, Electron or Tomography, Electron Beam or Tomography, X-Ray Computerized Axial or Tomography, X Ray Computerized Axial or X-Ray Computerized Axial Tomography or X Ray Computerized Axial Tomography):ti,ab,kw (Word variations have been searched)	97,738
#21	#19 OR #20	97,768
#22	#12 OR #15 OR #18 OR #21	224,854
#23	#8 AND #11 AND #22	1,827
#24	#8 AND #11 AND #22 AND English (language)	1,816

DXA, dual-energy X-ray absorptiometry; BIA, bioelectrical impedance analysis; US, ultrasound; MRI, magnetic resonance imaging; CT, computed tomography.

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Table S4 Search strategy of Web of Science (12 October 2023)

No.	Query	Results
#1	TS=(Sarcopenia)	23,244
#2	AB=(Sarcopenia or Sarcopenias)	12,355
#3	#1 OR #2	23,244
#4	AB=(Skeletal Muscle Mass or SMM or Skeletal Muscle or Muscle Mass or Muscle or Mass or Lean Soft-tissue Mass or Lean Soft Tissue or LST or Lean Body Mass or Lean Mass or LM)	2,697,668
#5	TS=(Body Composition)	151,204
#6	AB=(Body Composition or Body Compositions or Composition, Body or Compositions, Body)	97,186
#7	#5 OR #6	151,204
#8	#3 OR #4 OR #7	2,801,909
#9	TS=(Absorptiometry, Photon)	2,321
#10	AB=(dual-energy X-ray absorptiometry or DXA or Absorptiometry, Photon or Photon Absorptiometry or Densitometry, X-Ray or Densitometry, X Ray or X-Ray Densitometry or Photodensitometry, X-Ray or Photodensitometry, X Ray or X-Ray Photodensitometry or X Ray Photodensitometry or Densitometry, Xray or Xray Densitometry or Single-Photon Absorptiometry or Absorptiometry, Single-Photon or Single Photon Absorptiometry or Dual-Energy X-Ray Absorptiometry Scan or Dual Energy X Ray Absorptiometry Scan or DXA Scan or DXA Scans or Scan, DXA or Scans, DXA or DEXA Scan or DEXA Scans or Scan, DEXA or Scans, DEXA or Dual-Photon Absorptiometry or Absorptiometry, Dual-Photon or Dual Photon Absorptiometry or Radiographic Absorptiometry, Dual-Energy or Radiographic Absorptiometry, Dual Energy or Absorptiometry, Dual-Energy Radiographic or Absorptiometry, Dual Energy Radiographic or Dual-Energy Radiographic Absorptiometry or Dual Energy Radiographic Absorptiometry or Absorptiometry, X-Ray or Absorptiometry, X Ray or X-Ray Absorptiometry or X Ray Absorptiometry or Dual-Energy X-Ray Absorptiometry or Dual Energy X Ray Absorptiometry or X-Ray Absorptiometry, Dual-Energy or X Ray Absorptiometry, Dual Energy or DPX Absorptiometry or Absorptiometries, DPX or Absorptiometry, DPX or Absorptiometry, Dual X-Ray or Absorptiometry, Dual X Ray or X-Ray Absorptiometry, Dual or Absorptiometry, Dual-Energy X-Ray or Absorptiometry, Dual Energy X Ray or Dual X-Ray Absorptiometry or Dual X Ray Absorptiometry)	29,866
#11	#9 OR #10	30720
#12	AB=(Bioimpedance analysis or BIA or Bioimpedance electrical analysis or Bioelectrical impedance analysis or bio-electrical impedance analysis)	9605
#13	TS=(Ultrasonography)	127717
#14	AB=(Ultrasound or US or Ultrasonography or Diagnostic Ultrasound or Diagnostic Ultrasounds or Ultrasound, Diagnostic or Ultrasounds, Diagnostic or Ultrasound Imaging or Imaging, Ultrasound or Imagings, Ultrasound or Echotomography or Ultrasonic Imaging or Imaging, Ultrasonic or Sonography, Medical or Medical Sonography or Ultrasonographic Imaging or Imaging, Ultrasonographic or Imagings, Ultrasonographic or Ultrasonographic Imagings or Echography or Diagnosis, Ultrasonic or Diagnoses, Ultrasonic or Ultrasonic Diagnoses or Ultrasonic Diagnosis or Echotomography, Computer or Computer Echotomography or Tomography, Ultrasonic or Ultrasonic Tomography)	1370347
#15	#13 OR #14	1399906
#16	TS=(Magnetic Resonance Imaging)	390353
#17	AB=(magnetic resonance imaging or MRI or Magnetic Resonance Imaging or Imaging, Magnetic Resonance or NMR Imaging or Imaging, NMR or Tomography, NMR or Tomography, MR or MR Tomography or NMR Tomography or Steady-State Free Precession MRI or Steady State Free Precession MRI or Zeugmatography or Imaging, Chemical Shift or Chemical Shift Imagings or Imagings, Chemical Shift or Shift Imaging, Chemical or Shift Imagings, Chemical or Chemical Shift Imaging or Magnetic Resonance Image or Image, Magnetic Resonance or Magnetic Resonance Images or Resonance Image, Magnetic or Magnetization Transfer Contrast Imaging or MRI Scans or MRI Scan or Scan, MRI or Scans, MRI or Tomography, Proton Spin or Proton Spin Tomography or fMRI or MRI, Functional or Functional MRI or Functional MRIs or MRIs, Functional or Functional Magnetic Resonance Imaging or Magnetic Resonance Imaging, Functional or Spin Echo Imaging or Echo Imaging, Spin or Echo Imagings, Spin or Imaging, Spin Echo or Imagings, Spin Echo or Spin Echo Imagings)	490651
#18	#16 OR #17	550,667
#19	TS=(Tomography, X-Ray Computed)	42,575
#20	AB=(computed tomography or CT or Tomography, X-Ray Computed or X-Ray Computed Tomography or Tomography, X-Ray Computerized or Tomography, X Ray Computerized or Computed X Ray Tomography or X-Ray Computer Assisted Tomography or X Ray Computer Assisted Tomography or Tomography, X-Ray Computer Assisted or Tomography, X Ray Computer Assisted or Computerized Tomography, X Ray or Computerized Tomography, X-Ray or X-Ray Computerized Tomography or CT X Ray or CT X Rays or X Ray, CT or X Rays, CT or Tomodensitometry or Tomography, X Ray Computed or X Ray Tomography, Computed or X-Ray Tomography, Computed or Computed X-Ray Tomography or Tomographies, Computed X-Ray or Tomography, Computed X-Ray or Tomography, Xray Computed or Computed Tomography, Xray or Xray Computed Tomography or CAT Scan, X Ray or CAT Scan, X-Ray or CAT Scans, X-Ray or Scan, X-Ray CAT or Scans, X-Ray CAT or X-Ray CAT Scan or X-Ray CAT Scans or Tomography, Transmission Computed or Computed Tomography, Transmission or Transmission Computed Tomography or CT Scan, X-Ray or CT Scan, X Ray or CT Scans, X-Ray or Scan, X-Ray CT or Scans, X-Ray CT or X-Ray CT Scan or X-Ray CT Scans or Computed Tomography, X-Ray or Computed Tomography, X Ray or X Ray Computerized Tomography or Cine-CT or Cine CT or Electron Beam Computed Tomography or Electron Beam Tomography or Beam Tomography, Electron or Tomography, Electron Beam or Tomography, X-Ray Computerized Axial or Tomography, X Ray Computerized Axial or X-Ray Computerized Axial Tomography or X Ray Computerized Axial Tomography)	523,153
#21	#19 OR #20	529,083
#22	#12 OR #15 OR #18 OR #21	2,330,274
#23	#8 AND #11 AND #22	4,270
#24	#8 AND #11 AND #22 and Review Papers (excluded – document type)	4,018
#25	#8 AND #11 AND #22 and Review Papers (excluded – document type) and paper or Published online or Editorial Material or Data paper or brief report or second edition (document type)	3,976
#26	#8 AND #11 AND #22 and Review Papers (excluded – document type) and paper or Published online or Editorial Material or Data paper or brief report or second edition (document type) and English (language)	3,922

DXA, dual-energy X-ray absorptiometry; BIA, bioelectrical impedance analysis; US, ultrasound; MRI, magnetic resonance imaging; CT, computed tomography.

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Table S5 Characteristics of the studies for assessing the diagnostic accuracy between DXA and BIA

Number	Study	Diagnostic parameter of DXA	Diagnostic parameter of BIA
1	Shaea A. Alkahtani 2017	ALMI	ALMI
2	Purwita W. Laksmi 2019	ASMI	ASMI
3	Kwon Chan Jeon 2020	ASMI	ASMI
4	Maria Aquimara Zambone 2020	ALMI	ALMI
5	Wen-Hui Fang, MD 2020	ASMI	ASMI
6	Hyeoijin Kim 2022	ASMI	ASMI
7	Jantine van den Helder 2022	ALMI	ALMI

DXA, dual-energy X-ray absorptiometry; BIA, bioelectrical impedance analysis; ALMI, appendicular lean mass/height2; ASMI, appendicular skeletal muscle mass/height2.

Table S6 Characteristics of the studies for assessing the correlation between DXA and BIA

Number	Study	Diagnostic parameter of DXA	Diagnostic parameter of BIA
1	Ling-Chun Lee 2014	ALST	ALST
2	Miji Kim 2015	ALST	ALST
3	Solomon C. Y. Yu 2016	ASM	ASM
4	S. Vermeiren 2019	ALM	ALM
5	M. Lane Moore 2020	ALST	ALST
6	Thiago G. Barbosa-Silva, MD, PhD 2019	ALM	ALM
7	Hong-Qi Xu 2021	ALM	ALM
8	Maria Aquimara Zambone 2020	ALMI	ALMI
9	Ashley A. Herda 2022	ASM	ASM
10	S. Toselli 2021	ALST	ALST

DXA, dual-energy X-ray absorptiometry; BIA, bioelectrical impedance analysis; ALST, appendicular lean soft tissue; ASM, appendicular skeletal muscle mass; ALM, appendicular lean mass; ALMI, appendicular lean mass/height2.

Table S7 Characteristics of the studies for assessing the correlation between DXA and US using MT for the diagnostic parameter

Number	Study	Diagnostic parameter of DXA	Diagnostic parameter of US
1	Takashi Abe 2015	ALM	MT of forearm-ulna
2	Takashi Abe 2015	ALM	MT of forearm-radius
3	Akio Morimoto 2017	ASMI	MT of forearm ulna
4	Thiago G. Barbosa-Silva, MD, PhD 2021	ALM	MT of dominant thigh
5	Thiago G. Barbosa-Silva, MD, PhD 2021	ALM	MT of dominant arm
6	M. Neira Álvarez 2021	ALM	MT of gastrocnemius longitudinal planes
7	M. Neira Álvarez 2021	ALM	MT of gastrocnemius medialis transverse
8	Yen-Lung Chen 2022	ASMI	MT of rectus femoris
9	Satoshi Yuguchi 2022	ASMI	MT of gastrocnemius

DXA, dual-energy X-ray absorptiometry; US, ultrasound; MT, muscle thickness; ALM, appendicular lean mass; ASMI, appendicular skeletal muscle mass/height2.

Table S8 Characteristics of the studies for assessing the correlation between DXA and US using ALM for the diagnostic parameter

Number	Study	Diagnostic parameter of DXA	Diagnostic parameter of US
1	TAKASHI ABE 2016	ALM	ALM
8	Takashi Abe, PhD 2018	ALM	ALM
9	Thiago G. Barbosa-Silva, MD, PhD 2021	ALM	ALM

DXA, dual-energy X-ray absorptiometry; US, ultrasound; ALM, appendicular lean mass.

Table S9 Characteristics of the studies for assessing the correlation between DXA and MRI

Number	Study	Diagnostic parameter of DXA	Diagnostic parameter of MRI
1	Zhao Chen 2007	ALM	SMM
2	Xinyu Zhao 2013	ALST	SMM
3	Richard V. Clark 2014	ALM	SMM
4	Richard V. Clark 2018	ALM	SMM

DXA, dual-energy X-ray absorptiometry; MRI, magnetic resonance imaging; ALM, appendicular lean mass; ALST, appendicular lean soft tissue; SMM, skeletal muscle mass.

Table S10 Description of studies for assessing the diagnostic accuracy between DXA and BIA

Number	Study	n	TP	FP	FN	TN
1	Shaea A. Alkahtani 2017	232	24	8	9	191
2	Purwita W. Laksmi 2019	120	19	32	5	64
3	Kwon Chan Jeon 2020	199	19	3	11	166
4	Maria Aquimara Zambone 2020	92	24	20	2	46
5	Wen-Hui Fang, MD 2020	438	295	0	48	95
6	Hyeoijin Kim 2022	195	21	2	8	164
7	Jantine van den Helder 2022	202	15	29	5	153

DXA, dual-energy X-ray absorptiometry; BIA, bioelectrical impedance analysis; TP, true positive; FP, false positive; FN, false negative; TN, true negative.

Table S11 Description of studies for assessing the correlation between DXA and BIA

Number	Study	n	r
1	Ling-Chun Lee 2014	77	0.92
2	Miji Kim 2015	551	0.92
3	Solomon C. Y. Yu 2016	195	0.97
4	S. Vermeiren 2019	174	0.95
5	M. Lane Moore 2020	179	0.94
6	Thiago G.Barbosa-Silva,MD,PhD 2019	181	0.95
7	Hong-qi Xu 2021	301	0.95
8	Maria Aquimara Zambone 2020	92	0.81
9	Ashley A. Herda 2022	73	0.95
10	S. Toselli 2021	184	0.95

DXA, dual-energy X-ray absorptiometry; BIA, bioelectrical impedance analysis; r, Pearson correlation coefficient.

Table S12 Description of studies for assessing the correlation between DXA and US using MT for the diagnostic parameter.

Number	Study	n	r
1	Takashi Abe 2015	102	0.94
2	Takashi Abe 2015	102	0.75
3	Akio Morimoto 2017	30	0.66
4	Thiago G. Barbosa-Silva, MD, PhD 2021	190	0.49
5	Thiago G. Barbosa-Silva, MD, PhD 2021	190	0.70
6	M. Neira Álvarez 2021	57	0.69
7	M. Neira Álvarez 2021	57	0.55
8	Yen-Lung Chen 2022	91	0.59
9	Satoshi Yuguchi 2022	193	0.51

DXA, dual-energy X-ray absorptiometry; US, ultrasound; r, Pearson correlation coefficient; MT, muscle thickness.

Table S13 Description of studies for assessing the correlation between DXA and US using ALM for the diagnostic parameter

Number	Study	n	r
1	TAKASHI ABE 2016	158	0.94
2	Takashi Abe, PhD 2018	311	0.91
3	Thiago G. Barbosa-Silva, MD, PhD 2021	190	0.95

DXA, dual-energy X-ray absorptiometry; US, ultrasound; r, Pearson correlation coefficient; ALM, appendicular lean mass.

Table S14 Description of studies for assessing the correlation between DXA and MRI

Number	Study	n	r
1	Zhao Chen 2007	104	0.95
2	Xinyu Zhao 2013	66	0.97
3	Richard V. Clark 2014	35	0.96
4	Richard V. Clark 2018	18	0.98

DXA, dual-energy X-ray absorptiometry; MRI, magnetic resonance imaging; r, Pearson correlation coefficient.

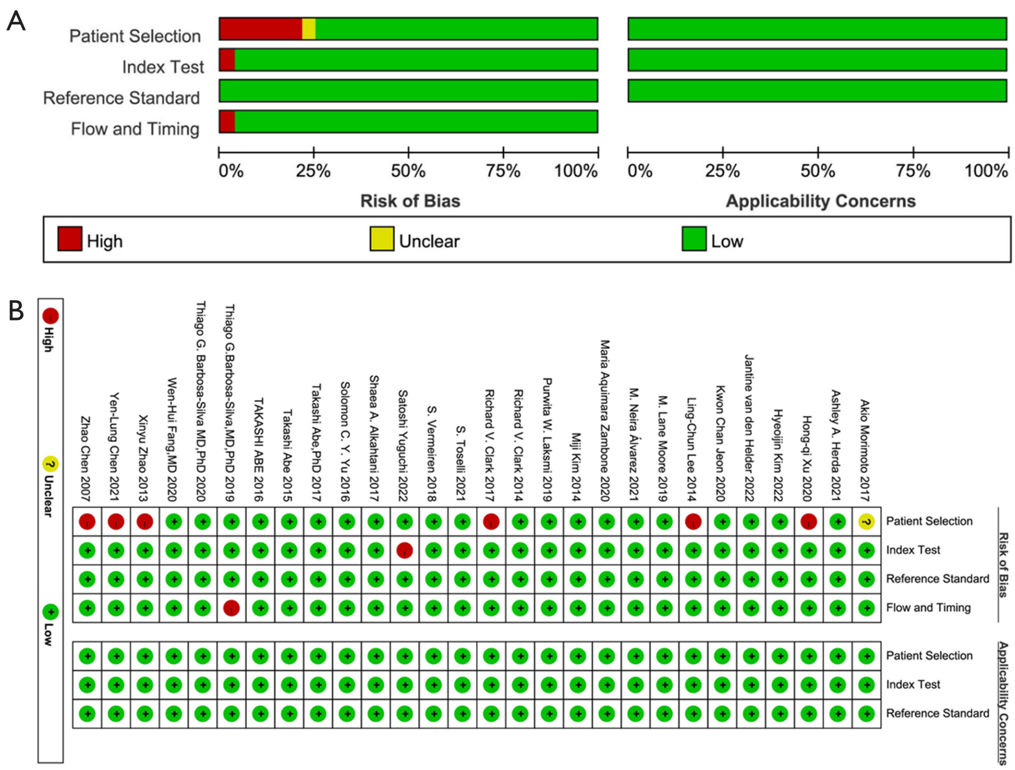

Figure S1 Risk of bias and applicability concerns for the included studies using the QUADAS-2 tool. (A) Risk of bias graph. (B) Risk of bias summary. QUADAS-2, Quality Assessment of Diagnostic Accuracy Studies 2.

 https://dx.doi.org/10.21037/qims-23-1089

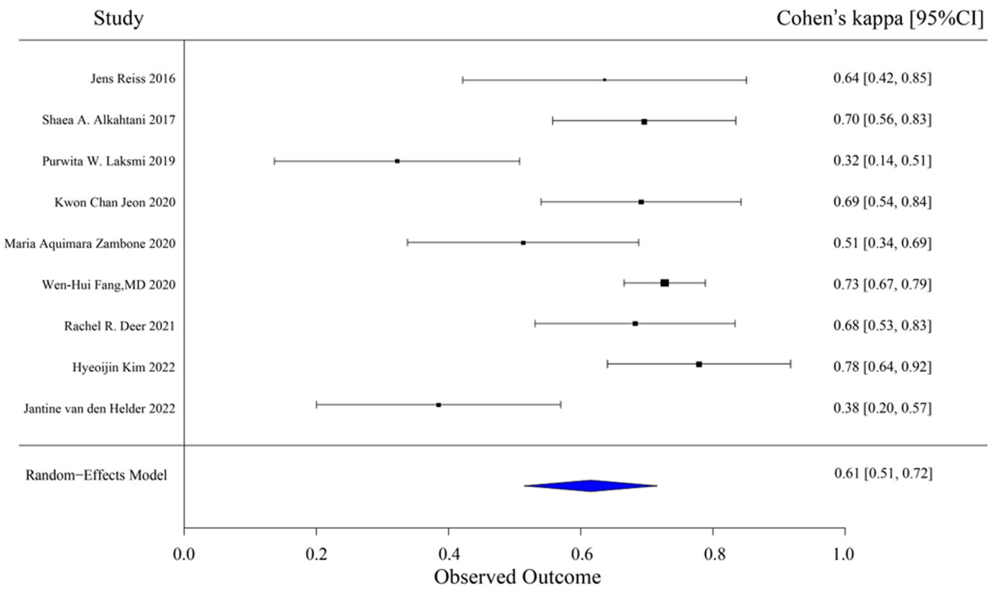

Figure S2 Forest plot of Cohen's kappa estimates of the excluded studies for assessing the diagnostic accuracy between DXA and BIA. CI, confidence interval; DXA, dual-energy X-ray absorptiometry; BIA, bioelectrical impedance analysis.

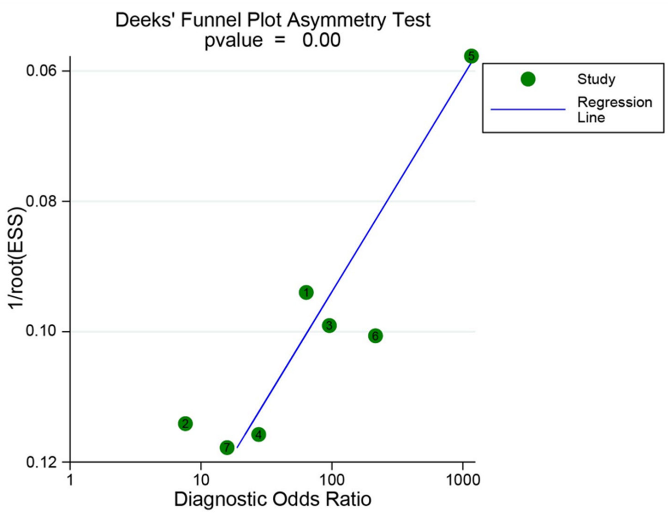

Figure S3 Deeks' funnel plot of the studies for assessing the diagnostic accuracy between DXA and BIA. DXA, dual-energy X-ray absorptiometry; BIA, bioelectrical impedance analysis.

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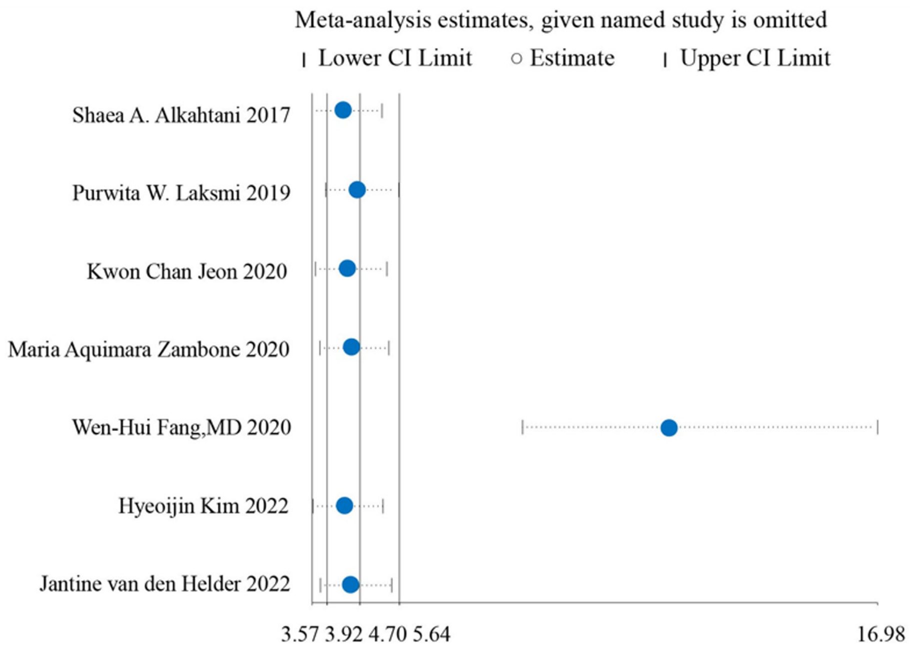

Figure S4 Sensitivity analysis of the excluded studies for assessing the diagnostic accuracy between DXA and BIA. CI, confidence interval; DXA, dual-energy X-ray absorptiometry; BIA, bioelectrical impedance analysis.

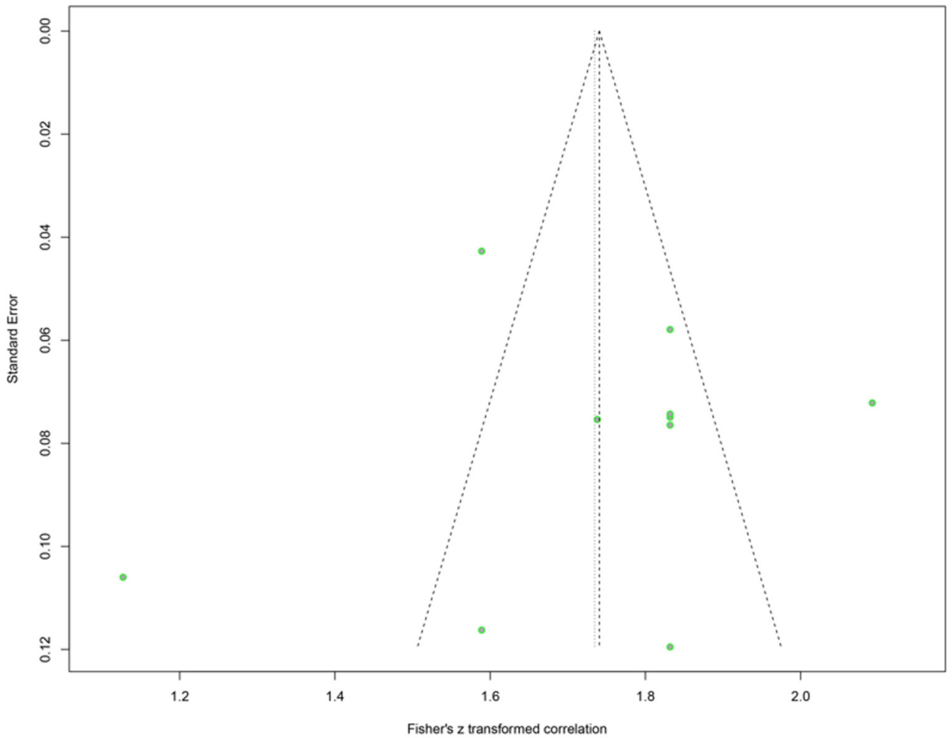

Figure S5 Publication bias of the studies for assessing the correlation between DXA and BIA. DXA, dual-energy X-ray absorptiometry; BIA, bioelectrical impedance analysis.

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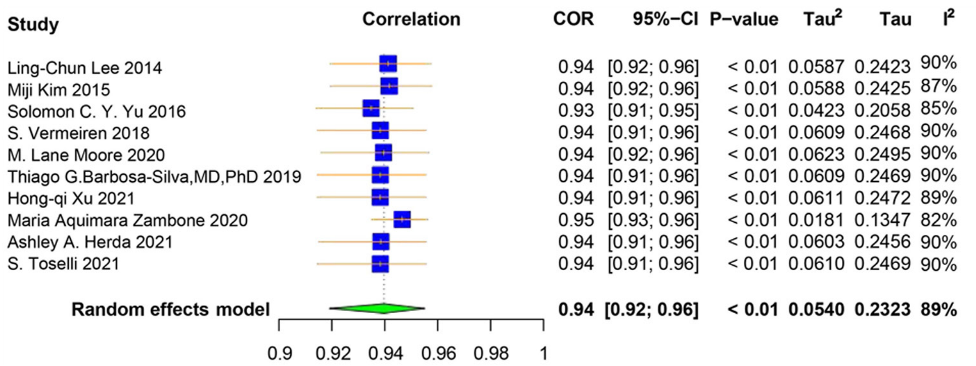

Figure S6 Sensitivity analysis of the excluded studies for assessing the correlation between DXA and BIA. CI, confidence interval; DXA, dual-energy X-ray absorptiometry; BIA, bioelectrical impedance analysis; COR, correlation coefficient.

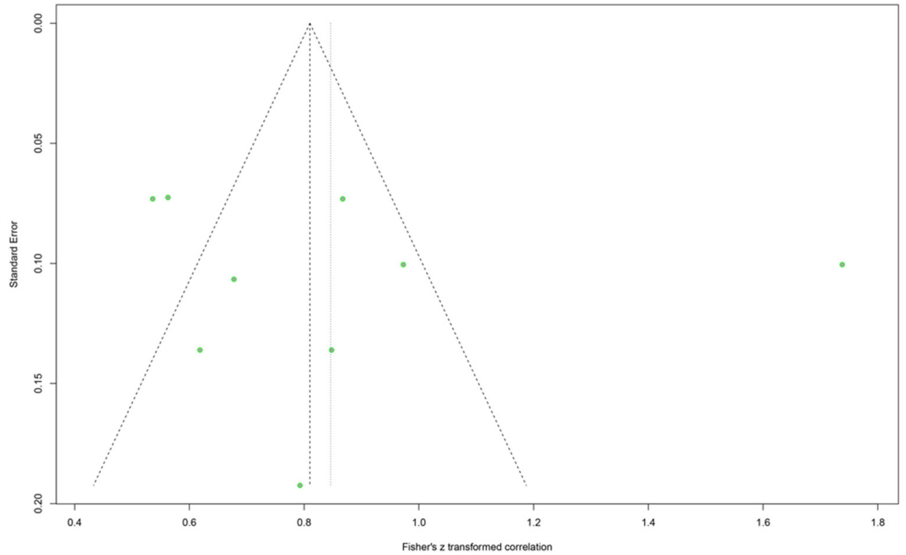

Figure S7 Publication bias of the studies for assessing the correlation between DXA and US. DXA, dual-energy X-ray absorptiometry; US, ultrasound.

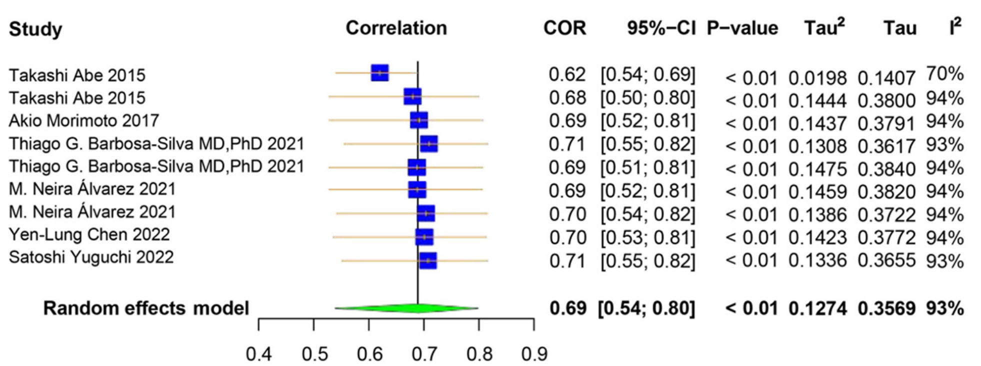

Figure S8 Sensitivity analyses of the excluded studies for assessing the correlation between DXA and US using MT for the diagnostic parameter. COR, correlation coefficient; CI, confidence interval; DXA, dual-energy X-ray absorptiometry; US, ultrasound; MT, muscle thickness.

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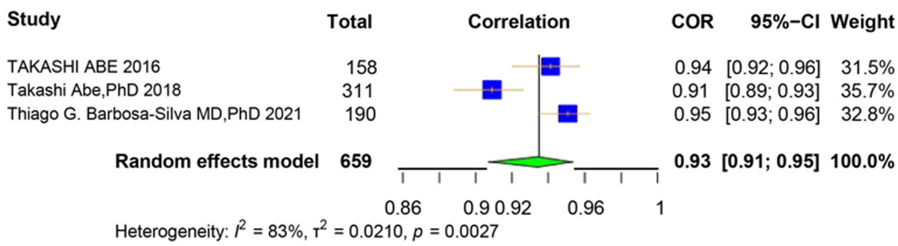

Figure S9 Forest plot of correlation between DXA and US using ALM for the diagnostic parameter. COR, correlation coefficient; CI, confidence interval; DXA, dual-energy X-ray absorptiometry; US, ultrasound; ALM, appendicular lean mass.

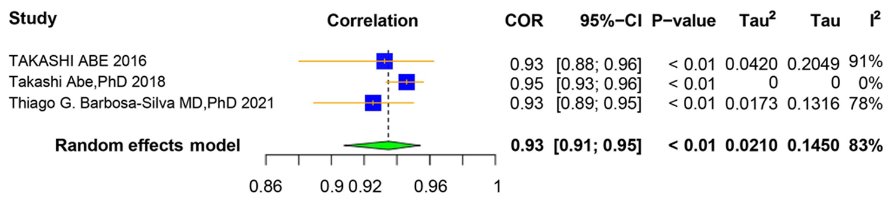

Figure S10 Sensitivity analyses of the excluded studies for assessing the correlation between DXA and US using ALM for the diagnostic parameter. COR, correlation coefficient; CI, confidence interval; DXA, dual-energy X-ray absorptiometry; US, ultrasound; ALM, appendicular lean mass.

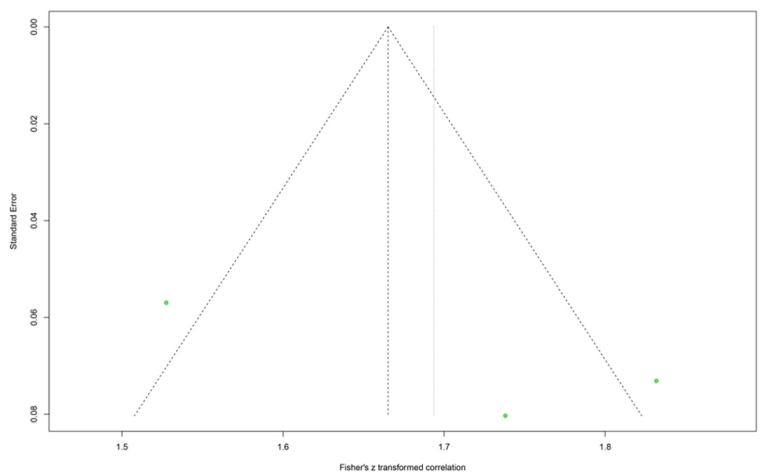

Figure S11 Publication bias of the studies for assessing the correlation between DXA and MRI. DXA, dual-energy X-ray absorptiometry; MRI, magnetic resonance imaging.

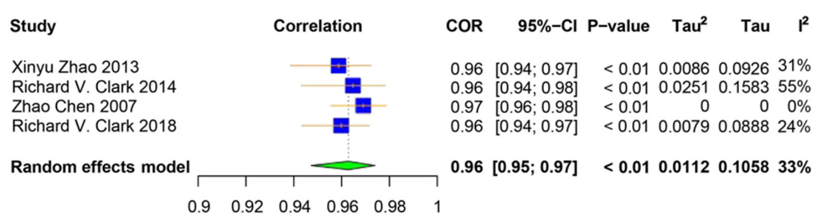

Figure S12 Sensitivity analysis of the excluded studies for assessing the correlation between DXA and MRI. COR, correlation coefficient; CI, confidence interval; DXA, dual-energy X-ray absorptiometry; MRI, magnetic resonance imaging.

https://dx.doi.org/10.21037/qims-23-1089