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Abstract

Purpose:

The aim of this study was to investigate the correlations between areal bone mineral density (aBMD) and body composition measured by two dual-energy X-ray absorptiometers (DXA), the DMS Stratos® **(STR)** and the Hologic Horizon A® **(HRZ)**, and then generate cross-calibration equations between the two scanners.

Methods:

Repeat scans were obtained from 251 adults (85% female), 36 ± 14 years old with mean body mass index (BMI) of 28.7 ± 11.1 kg/m2, using **HRZ** (fan-beam technology) and **STR** (pencil-beam technology). aBMD was measured at whole body [WB], femoral neck [FN], total hip [TH], lumbar spine [LS] and radius, while fat mass [FM] and lean tissue mass [LTM] were determined at whole body and at android and gynoid subregions.

Results:

Compared to **HRZ, STR** underestimated both aBMD at WB and radius and LTM at WB and android and gynoid regions. Conversely, **STR** overestimated aBMD at FN, TH, LS and FM at WB android and gynoid regions. Except for WB bone mineral content ($r=0.87$) and WB aBMD ($r=0.84$), there were strong correlations of aBMD and body composition between the two DXAs ($r>0.91$; $p<0.0001$). Several of the parameters that required the determination of specific cross-calibration equations because of the significant bias between the two DXAs were found to be influenced by BMI.

Conclusions:

Although the data from the **STR** and the **HRZ** were highly correlated for aBMD and body composition parameters, a systematic measurement bias between two DXAs was observed. The development of cross-calibration equations fully corrected these differences and they may thus be useful for multicenter studies when scans are performed with **STR** and **HRZ**.

Introduction

Osteoporosis is defined as a disease characterized by low bone mass and microarchitecture deterioration of bone tissue, leading to enhanced bone fragility and a consequent increase in fracture risk[1]. Areal bone mineral density (aBMD) measurement by dual-energy X-ray absorptiometry (DXA) directly determines a patient's T-score and thus the diagnosis of osteoporosis, as established by the World Health Organization (WHO) in 1994[2]. DXA examinations must therefore meet strict criteria of accuracy and reproducibility to ensure effective care. To achieve high reproducibility, which can range from 0.8 to 1.69% for lumbar spine and total hip3, 4, 5, it is necessary to follow the strict specifications provided by the manufacturer (definition of regions of interest: ROIs, patient positioning, etc…) and by the International Society for Clinical Densitometry (ISCD), which support physicians in aBMD measurement and data interpretation[6, 7]. Nevertheless, although the DXA scans appear to be closely supervised, technical and interpretation errors are extremely common and likely adversely affect patient care8, 9, 10. Another source of errors is related to the cross-calibration bias that can occur when equipment is being replaced, a multicenter study is being performed, or a patient is scanned at two different sites by two devices that are not cross-calibrated[6, 7, 11]. Moreover, numerous studies have reported a difference in the results for aBMD and body composition measured, not only by two densitometers from different manufacturers[5,] 12, 13, 14, but also from the same manufacturer[15, 16]. In this situation, the ISCD[6, 7] has recommended that cross-calibration studies be performed for anatomic sites commonly measured in clinical practice to allow the comparison of data collected on the different systems for the generation of cross-calibration equations[6, 7, 11].

Generally, the concordance between two DXAs has been based on the evaluation on parameters used in clinical routine, such as lumbar spine and total hip aBMD, as well as body composition including whole body fat mass (FM) and lean tissue mass (LTM)[7, 11]. Yet, android (abdominal) and gynoid (femoral-gluteal) FM repartition are of growing interest due to their implication in the development of insulin resistance, cardiometabolic risk and obesity characterization17, 18, 19. Few studies, however, have compared these values measured concomitantly with two different DXAs[20, 21]. In addition, in a recent study with a limited number of participants, our group reported that the concordance for some parameters between two DXAs may have been influenced by body mass index (BMI)[22]. These results need to be confirmed in a larger population.

To our knowledge, Stratos (**STR**) from DMS® has only been cross-calibrated with two older DXAs, QDR 4500A[22] and Discovery A[4], both produced by Hologic®. However, these two devices are no longer on the market and are gradually being replaced. Unfortunately, no data to date have been published on the cross-calibration between the **STR** and more recent DXA systems, such as the Horizon A (**HRZ) from** Hologic Inc.®.

Therefore, the aim of this study was to determine the following: (i) the need for and generation of cross-calibration equations between **STR** (DMS-APELEM; pencil-beam technology) and **HRZ** (Hologic, Inc.; fan-beam technology) for whole body and regional aBMD and whole body composition, (ii) the concordance between the two devices for FM and LTM measured specifically at android and gynoid regions, and (iii) the effect of BMI on the cross-calibration equations.

Materials and Methods

Subjects

Two hundred and fifty-one adults were recruited via an intra-hospital email invitation or from among patients referred to the **Department of Nuclear Medicine, Lapeyronie Hospital (Centre Hospitalier Universitaire de Montpellier, CHU Montpellier, France**) for evaluation of aBMD and body composition. The study protocol was previously described in detail[22]. Briefly, all participants were Caucasian and, to be eligible, they had to be over 18 years old, able to lie supine for 10-15 minutes, and have body weight <2 00kg (table weight limit restriction for the HRZ and STR systems). Participants were excluded from the study if the had a history of lumbar spine or proximal femur fracture, hip replacement or osteosynthesis and cementoplasty at the lumbar spine, or were pregnant or breast feeding. In accordance with the ISCD recommendations, 6 ,7 these participants were representative of our patients and their scans represented the full spectrum of scans performed in our Department. Patients who presented a body mass index (BMI) <1 8kg/m2 were assessed in the context of eating disorders, whereas those with BMI > 30kg/m2 were assessed in the context of medical care for obesity or before bariatric surgery.

Study procedures

Ethics approval for the study was obtained from the Ethics Review Committee of Nîmes, France (Commission de Protection des Personnes, Sud Méditerranée III on 9 July 2015 reference 201506.02bis), and permission for the clinical trials was granted by the French Medicine and Health Care Products Regulatory Agency (IDRCB :2015-A00596-43, on 21 September 2015). All study participants were volunteers and gave specific signed consent before the scans. All activities performed in this study were in accordance with the Declaration of Helsinki.

Standing height was measured with a stadiometer to the nearest 0.1cm and recorded as the mean of two consecutive measurements. Body weight was measured with a calibrated scale with a precision of 0.1kg Body mass index (BMI) was calculated as weight (kg) divided by the square of height (m).

Dual-energy X-ray absorptiometry measurement procedures

Each day, a quality control was performed according to the respective manufacturer's guidelines by analysis of a vertebral phantom scan. Each patient was scanned first with HRZ (Hologic,Inc.) ,which uses fan-beam technology and was considered as the reference DXA, and immediately after with STR (DMS, Mauguio, France), which uses pencil-beam technology. Positioning and regions of interest (ROIs) were defined according to the procedures described in each densitometer's operating manual. Specifically, a block was placed under the legs for the lumbar spine scan and a positioning triangle was used during the hip scan. For aBMD analysis, the ROIs were defined for the lumbar spine (L1-L4), femoral

neck, total hip, radius and whole body, while for body composition [i.e., LTM, kg and FM, kg and%], the ROIs were defined for legs, arms and whole body. Appendicular lean tissue mass (ALM) was calculated as the sum of LTM of the arms and legs, as described by Heymsfield et al. 23 For body composition analysis, a NHANES calibration was used.

Mirror imaging mode for HRZ, which consists of replacing the partially scanned left extremities (arms and legs) with the right-sided values, was used in the four patients presenting the highest BMI. For the two DXAs, software auto-generated the ROIs of the android and gynoid are as on a total body scan from which total android and gynoid fat were measured. 24 The ROIs could be manually revised if they were deemed in accurate by the analyst. For HRZ, when a patient exceeded a BMI>/=35kg/m2, whole body HP mode for whole body BMD and whole body composition determination was used. Similarly, for lumbar spine and total hip, array mode was used instead of fast mode. Concerning STR, the same mode was used for all the scans.

All scans were performed by the same technician, who analyzed each scan individually. The scan operator had been trained and certified by both Stephanix (the local distributor of Hologic in France) and the DMS manufacturer.

The HRZ scans were analyzed with APEX software version 5.6.0.7 and the STR with version V5.2.1.2.

Table 1
Characteristics of the 251 participants.

Participants	Mean±SD	Range
% Female	213 (85 %)	–
Age (years)	36 ± 14	18 - 73
Weight (kg)	78 ± 30	31 - 170
Height (m)	1.65 ± 0.07	1.48 - 1.89
Body mass index (kg/m^2)	28.7 ± 11.1	12.1 - 64.1

Data are given by mean ± SD. BMI: body mass index.

Statistical analysis

Characteristics are expressed as mean +/-standard deviation (SD) and frequency as percentage. Correlations between the HRZ and STR measurements were calculated using Pearson correlation coefficients (with 95% CI). Inter-scanner differences were evaluated by calculating the systematic difference between the HRZ and STR measurements (systematic bias) and tested against the 0 value using a paired Student's t-test. Agreement was analyzed using a Bland-Altman plot. Cross-calibration equations were estimated using linear regression. Systematic bias and agreement between the STR and HRZ measurements converted using the crosscalibration equations were assessed using paired Student'st-tests and Bland-Altman plots. The BMI effect and effect modification on the crosscalibration model were evaluated by adding an effect and an interaction term with a" Severe-Obesity" variable

to the linear regression model. This dichotomization was chosen because it best fit the data for the interaction effects under consideration. All the analyses were performed using SAS software version 9.4 (SAS Institute Inc, Cary, NC).

Table 2
Repartition of participants according to body mass index class.

BMI Class (kg/m^2)	< 18.5	[18.5 – 25]	[25-30]	[30 – 35]	>35
	59 (23 %)	65 (26 %)	14 (6 %)	17 (7 %)	96 (38 %)

Data are presented as number (percentage).

Results

Two hundred and fifty-one adults (85% female) aged 18-73 years old (mean 36 ± 14 years) were recruited. Their descriptive characteristics are presented in Table 1. To test the hypothesis that BMI might influence the cross-calibration equations, the population studied presented a large range of BMIs from 12.1 to 64.1 kg/m² (mean 28.7 ± 11.1 kg/m²). The repartition of participants according to BMI class is presented in Table 2.

Differences and correlations between DXAs

Mean (SD) a BMD and bone mineral content (BMC) values measured by the HRZ and STRDXAs are given Table 3.

Table 3
Comparison of areal bone mineral density and bone mineral content measured by Horizon A and Stratos at whole body and specific regions.

	N	Horizon A	range	Stratos	range	Mean relative change [95 % CI]	r ; (p-value)	Bias	p paired t-test
Whole body aBMD (g/cm^2)	247	1.127 ± 0.097	0.852-1.396	0.963 ± 0.131	0.580-1.302	14.7[13.9;15.6]	0.84; <.0001	0.163 ± 0.072	<.0001
Whole body BMC (g)	247	2270.6 ± 375.2	1384.6-3594.9	2327.8 ± 529.6	1227.5-3721.3	-1.9[-3.4;-0.4]	0.87; <.0001	-57.2 ±275.3	0.0012
Femoral neck aBMD (g/cm^2)	249	0.831 ± 0.157	0.391-1.426	0.927 ± 0.158	0.449-1.384	-12.1[-13.0;-11.2]	0.95; <.0001	-0.095 ± 0.049	<.0001
Total hip aBMD (g/cm^2)	249	0.947 ± 0.173	0.463-1.422	1.014 ± 0.16	0.505-1.419	-7.8[-8.6;-7.0]	0.95; <.0001	-0.067 ± 0.055	<.0001
L1-L4 aBMD (g/cm^2)	247	0.997 ± 0.158	0.547-1.48	1.010 ± 0.159	0.575-1.519	-1.4[-1.9;-0.9]	0.97; <.0001	-0.013 ± 0.041	<.0001
Radius aBMD (g/cm^2)	245	0.596 ± 0.063	0.402-0.786	0.582 ± 0.086	0.310-0.829	2.7[1.8;3.5]	0.91; <.0001	0.014 ± 0.038	<.0001

Data are given by mean ± SD. aBMD: areal bone mineral density; BMC: bone mineral content; g: gram; SD: standard deviation; L1-L4: lumbar spine. Bias is defined as the mean difference between Horizon A and Stratos measurements. Mean relative change is calculated as: [(Horizon A-Stratos)/Horizon A]. r is defined as the Pearson coefficient of correlation between the two measurements performed by Horizon A and Stratos.

Values of aBMD on the two DXAs were highly correlated ($p<0.001$ for all), with a coefficient of correlation (r) ranging from 0.84 to 0.97(r=0.84for whole body ;r=0.91 for radius ;r=0.95 for femoral neck; r =0.95 for total hip and r=0.97for L1-L4 aBMD). All these correlations are presented in Table 3 and Fig. 1. Nevertheless, the paired t-test indicated a statistically significant bias ($p=0.0012$ and $p<0.0001$) between the two DXA scanners for all the measurements. Compared to HRZ, STR under estimated whole body and radius aBMD

with respective differences of 0.163g/cm2 and 0.014 g/cm2, corresponding to respective mean relative changes of 14.7% and 2.7%. For all other aBMD and BMC parameters, STR overestimated values at femoral neck (-0.095g/cm2, -12.1%), total hip (-0.067g/cm2; -7.8 %), L1-L4 (-0.013g/cm2; -1.4%) and whole body BMC (-57.2g;-1.9%). The systematic differences for bone parameters are depicted in Fig. 2a with Bland-Altman plots (STR versus HRZ).

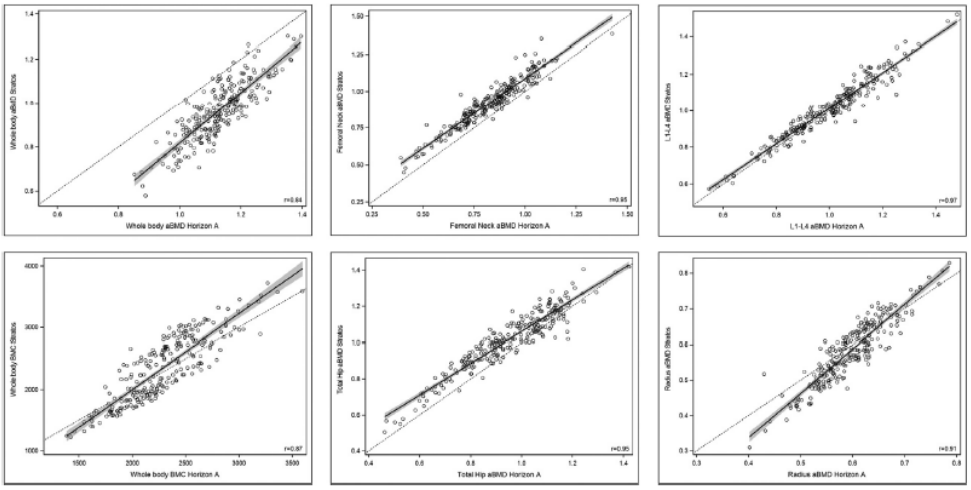

Fig. 1. Correlations between measures obtained on Horizon A and Stratos for areal bone mineral density and bone mineral content. solid line is regression line, gray zone is 95 % CI of regression line, dashed line is line of identity, r is Pearson correlation coefficient. aBMD: areal bone mineral density; L1-L4: lumbar spine; BMC: bone mineral content.

Similar to the bone parameters, despite the highly significant correlations (ranging from 0.95 to 0.99) (Table4 and Fig.3) between the DXA-derived body composition measures for whole body, android and gynoid FM and LTM, the measures differed significantly between the two devices ($p<0.0001$). Briefly, STR overestimated FM (kg and %) and underestimated LTM at whole body and android and gynoid regions. The systematic differences for body composition parameters are depicted in Fig.4a with Bland-Altman plots (STR versus HRZ). This analysis indicated that for most of the body composition parameters, a greater bias was seen at the higher values.

Given the wide dispersion of BMI values (range from 12.1 to 64.1kg/m2), the concordance of measurements between HRZ and STR was analyzed according to BMI class (Supplementary Table 1). For various parameters, including whole body and femoral neck aBMD, whole body FM and LTM android FM, gynoid FM and LTM, significant interactions between the bias measured between the two DXAs and BMI were found (Supplementary Table 1 and Supplementary Fig.1).

Cross-calibration

Due to the observed differences between the two densitometers, linear regression analyses were used to generate crosscalibration equations for all measures of interest for bone mass and body composition parameters. As detailed in Table5, the application of these equations to parameters that differed significantly at the outset canceled the bias and the significant differences between the two DXAs (Table5). The lack of systematic bias after using the

crosscalibration equations was also supported by the repeated Bland-Altman plots (Figs.2b and 4b).

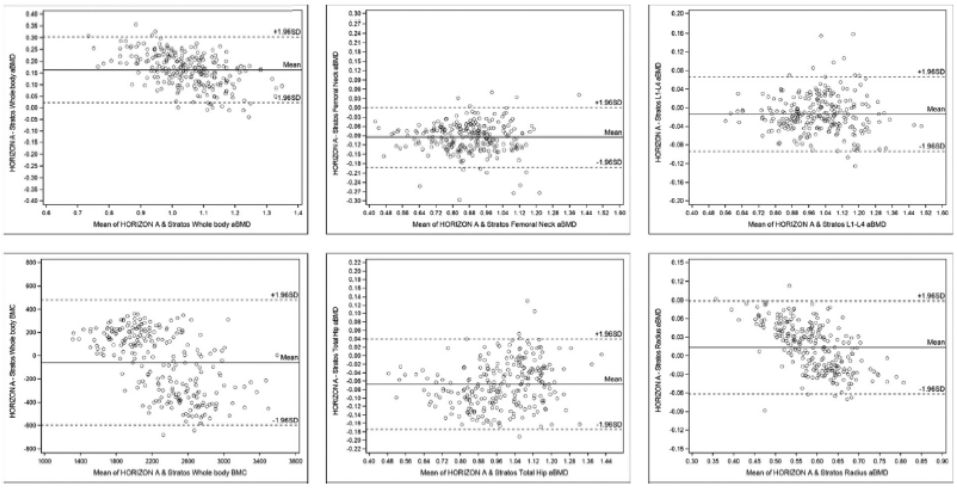

Fig. 2a. Bland-Altman analysis to compare measures obtained on Horizon A and Stratos for bone mass parameters before the cross-calibration equations. plots present means of Horizon A and Stratos measurements (x axis) plotted against the difference between the Horizon A and Stratos measurements (calculated as Horizon A - Stratos). solid line represents the mean difference, dashed lines represent ±1.96 SD of the mean difference. aBMD: areal bone mineral density; L1-L4: lumbar spine; BMC: bone mineral content.

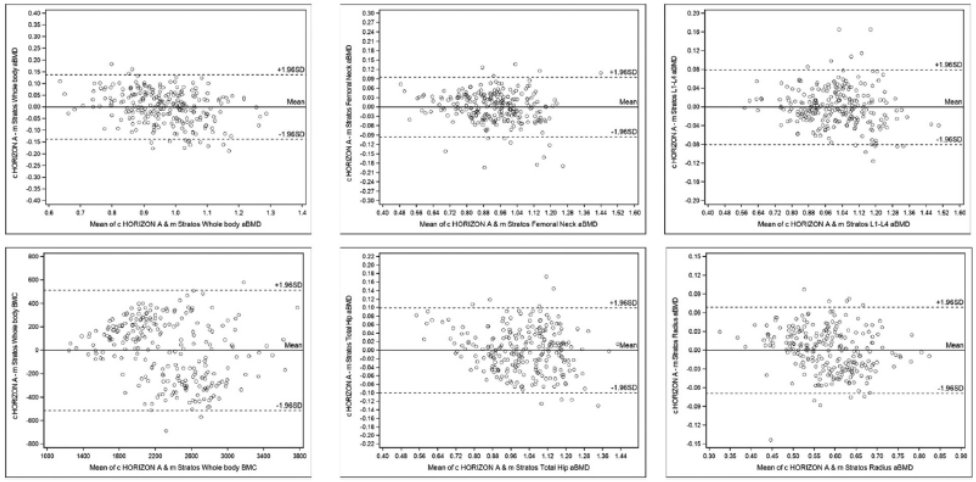

Fig. 2b. Bland-Altman analysis to compare measures converted using the cross−calibration equations for Horizon A and measures obtained with Stratos for bone mass parameters. aBMD: areal bone mineral density; BMC: bone mineral content; L1-L4: lumbar spine. plots present means of Horizon A and Stratos measurements (x axis) plotted against the difference between Horizon A and Stratos measurements (calculated as converted (c) Horizon A − measured (m) Stratos). solid line represents the mean difference, dashed lines represent ±1.96 SD of the mean difference.

Moreover, for various parameters where a significant interaction between the bias measured between the two DXAs and BMI were found, specific cross-calibration equations for the two classes of BMI(>/=35 kg/m2 or >35 kg/ m2) were determined and are presented in Table 6.

Table 4
Comparison of body composition (fat mass and lean mass) measured by Horizon A and Stratos at whole body and specific regions.

Parameters	N	Horizon A	Range	Stratos	Range	Mean relative change [95 % CI]	r; (p-value)	Bias	p paired t-test
Whole body FM (g)	248	27754.1 ± 16752.0	4534.8-67466.9	32603.5 ± 21907.4	2831.7-78107.5	-10.0[-12.0;-7.9]	0.99;<.0001	-4849.4 ± 5630.1	<.0001
Whole body FM (%)	248	32.2 ± 10.3	11.4-54.1	38.0 ± 15.1	7.5-63.5	-14.9[-16.8;-13.0]	0.98;<.0001	-5.895 ± 5.392	<.0001
Whole body LTM (g)	248	48923.9 ± 13928.1	26330.3-100964.9	43254.0 ± 9753.7	26003.6-85855.3	9.8[8.8;10.9]	0.96;<.0001	5669.9 ± 5399.4	<.0001
Appendicular LTM (g)	248	10365.7 ± 3105.5	5003.7-22172.1	9486.6 ± 2442.1	5096.9-19003.9	7.1[6.3;8.0]	0.97;<.0001	879.1 ± 975.2	<.0001
Android FM (g)	251	2290.9 ± 1841.6	232.3-8889.3	2782.8 ± 2398.4	110.3-9879.2	-8.0[-11.3;-4.7]	0.99;<.0001	-491.9 ± 661.6	<.0001
Android FM (%)	251	31.0 ± 12.1	9.1-53.1	36.2 ± 18.6	3.7-63.8	-9.7[-12.8;-6.6]	0.98;<.0001	-5.2 ± 7.3	<.0001
Android LTM (g)	251	3996.4 ± 1564.0	1624.6-9083.9	3415.7 ± 1050.7	1753.2-7668.0	11.1[9.6;12.5]	0.96;<.0001	580.7 ± 633.7	<.0001
Gynoid FM (g)	251	4931.4 ± 2825.1	573.4-14542.8	5900.7 ± 3863.3	439.3-17733.0	-12.1[-14.5;-9.7]	0.98;<.0001	-969.4 ± 1214.6	<.0001
Gynoid FM (%)	251	34.5 ± 9.2	11.3-53.6	40.6 ± 13.8	8.5-64.6	-15.2[-17.3;-13.0]	0.95;<.0001	-6.1 ± 6.0	<.0001
Gynoid LTM (g)	251	8401.0 ± 2769.8	3618.4-17226.3	6880.5 ± 1824.4	3352.2-14372.8	16.0[14.9;17.1]	0.95;<.0001	1520.5 ± 1181.2	<.0001

Data are given by mean ± SD. SD: standard deviation; FM: fat mass; LTM: lean tissue mass. Bias is defined as the mean difference between Horizon A and Stratos measurements. Mean relative change is calculated as: [(Horizon A-Stratos)/ Horizon A]. r is defined as the Pearson coefficient of correlation between the two measurements performed by Horizon A and Stratos.

Discussion

This study, conducted in a large group of participants (n=251) presenting a wide range of BMIs (12.1-64.1 kg/m²), clearly demonstrated that aBMDs and body composition measurements performed by **STR** and **HRZ** were highly correlated. Nevertheless, the systematic bias indicated a lack of agreement between the two devices, requiring the development of conversion equations to correct these differences. Moreover, for several parameters we found significant interactions between the bias measured between the bias measured between the two DXA sand BMI, further requiring the development of adapted cross-calibration equations.

aBMD

Concerning aBMDs, high correlations between STR and HRZ values were found in this study and the correlation coefficients were close to those generally reported, with a lower value for femoral neck.5 Nevertheless, whole body and radius aBMD values measured with STR were higher than with HRZ, while for whole body BMC, femoral neck, total hip and lumbar spine, values were lower. Although the aBMD difference were in line with those from previous comparisons between two DXAs from different manufacturers, 5 its value exceeded the cutoff (1%) defined by the ISCD. 6, 7, 11 For this reason, crosscalibration equations between the two scanners were needed for each bone site to minimize the difference. Recently, Reitshamer et al. 5 provided a striking example of a hypothetical osteoporotic patient who presented a false bone loss of 20% at the femoral neck after successive measurements by Prodigy followed by HRZ. This difference compromised individual patient management and increased the measurement variability in a multicenter study.5

To our knowledge, no previous study has reported crosscalibrations from STR to HRZ. Interestingly, however, our results are totally stackable, except for radius and lumbar spine, with a recently published study comparing STR with QDR4500A, an older DXAf an beam also manufactured by Hologic. 22

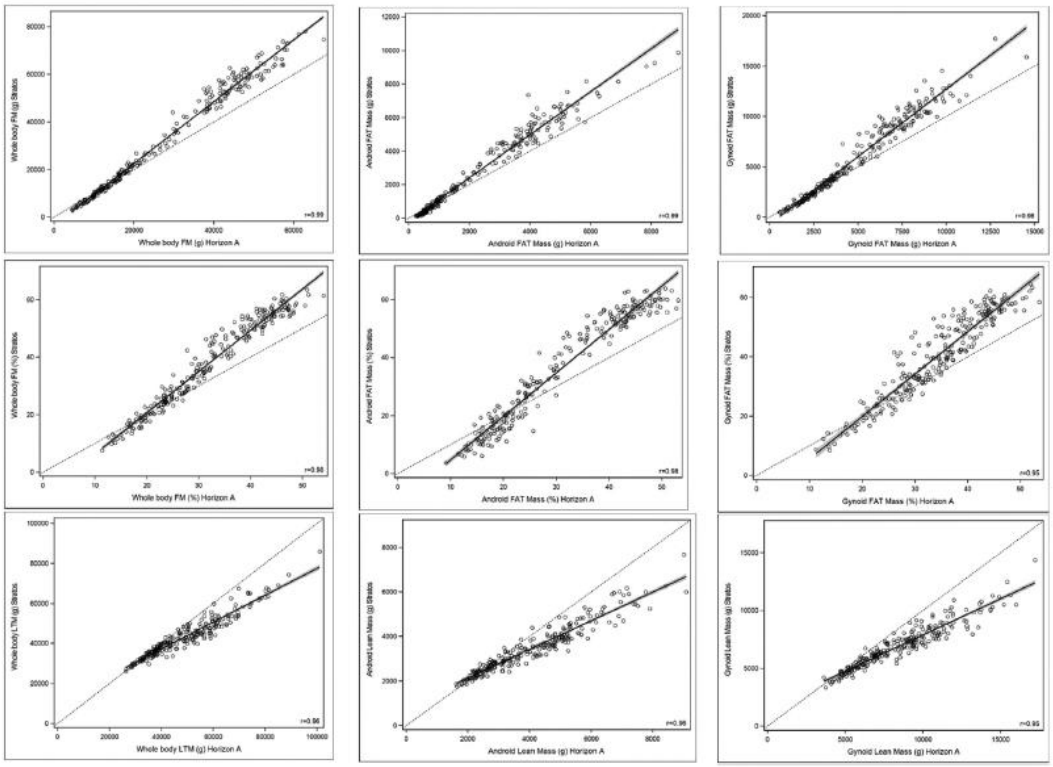

Fig. 3. Correlations between measures obtained on Horizon A and Stratos for body composition parameters. solid line is regression line, gray zone is 95 % CI of regression line, dashed line is line of identity, and r is Pearson correlation coefficient. FM: fat mass; LTM: lean tissue mass.

Body composition

As found for aBMD, the two DXAs were highly correlated for all the conventional parameters of body composition, including whole body LTM and FM (r ranging from 0.96 to 0.99). Nevertheless, compared to **HRZ**, **STR** underestimated FM and underestimated LTM with a mean relative difference of around ±10% for the two components, indicating an approximate absolute mean difference of 4.8-5.5 kg. In this case, cross-calibration equations appear to be essential when upgrading DXA units over the course of long-term follow-up to assess changes in body composition for example, to track the weight loss following bariatric surgery.19 Moreover, the use of DXA to diagnose sarcopenia by assessing indices such as appendicular LTM 25 ,26 also requires that the results given by different scanners be standardized. It is interesting to note the similar trends for FM and LTM when fan-beam Hologic models were compared with different GE Lunar models using similar X-ray technology.5,27,28 Conversely, when a pencil-beam (DPX- NT or DPX from GE) was compared to fan-beam (QDR- 4500C or QDR-2000 from Hologic), inverse results were observed for FM and LTM at appendicular sites 29 or whole body.30 In addition to X-ray technology(fan-beam and pencil-beam),28,31 image acquisition, algorithm sand calibration methods27,31 may also be responsible of the systematic bias found in our study.

Despite growing interest in FM and LTM measured at the android and gynoid regions, few crosscalibration studies have focused on these regions. 14, 21. Yet, our results showed a high correlation for the two body composition components measured at these two regions. Notably, the difference between android (491.9g)and gynoid FM (969.4g) between the two DXAs that

we compared exceeded that reported between iDXA and Prodigy (260g and 500g, respectively). 21 . Nevertheless, the smaller difference between the two DXAs from the same manufacturer (GE) and using similar fan-beam technology seems to be totally expected. Similarly, in a previous study, our group also reported a smaller difference or android and gynoid FM (381.8g and 236g, respectively) when Stratos DR (DMS) was compared to Discovery A (Hologic), two fan-beam DXAs. 14 These findings may suggest that the difference found in the current study may be more related to X-ray technology than to an ROI default.

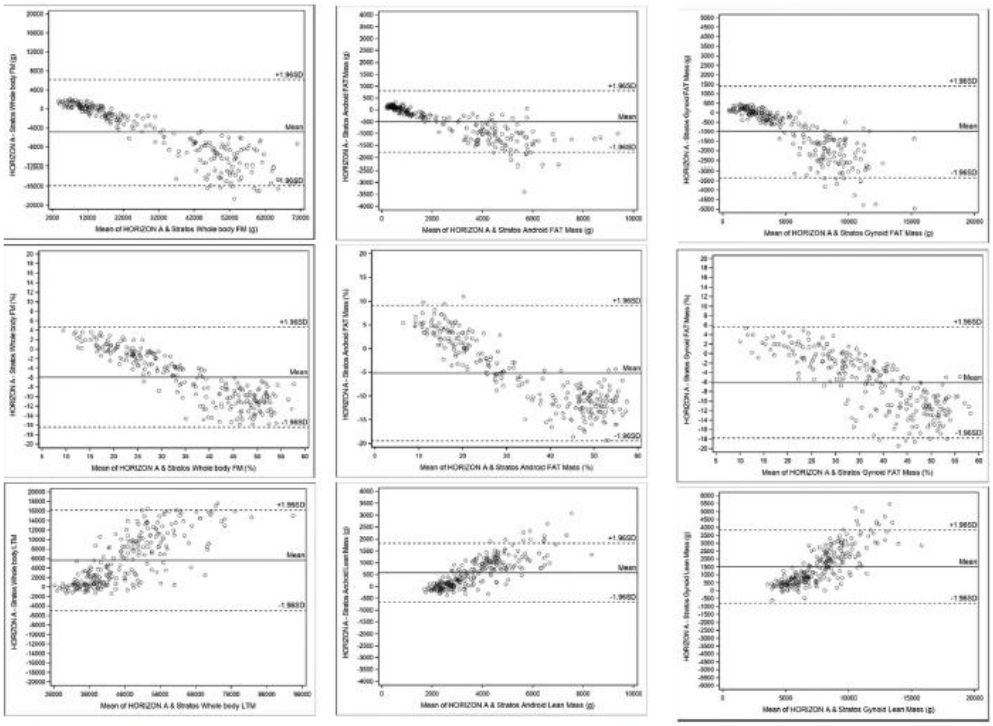

Fig. 4a. Bland-Altman analysis to compare measures obtained on Horizon A and Stratos for body composition parameters before the cross-calibration equations. plots present means of Horizon A and Stratos measurements (x axis) plotted against the difference between Horizon A and Stratos measurements (calculated as Horizon A - Stratos). solid line represents the mean difference, dashed lines represent ±1.96 SD of the mean difference. FM: fat mass; LTM: lean tissue mass.

BMI effect

With the inclusion of participants presenting a wide range of BMIs, we were able to demonstrate that the inter-device differences were greatest in subjects with higher BMIs, equations should be developed for certain parameters when BMIs exceed 35kg/m2. Although at first glance these results appear to be of limited scope given that few people have aBMI>35 kg/m2, the increase in obesity prevalence in the world and the growing importance of DXA for the medical management of patients with obesity19, 32 may justify these adapted crosscalibration equations, particularly for body composition parameters. However, until now, no consensus on the potential impact of BMI or abdominal thickness on cross-calibrations has been reached. Further, both the effects31, 33, 34 and lackof effects5,27,30,35 of BMI have been reported. This discrepancy may potentially be due to the technology used, the parameters analyzed or the characteristics (BMI, numbers, etc. . .) of the population studied. Moreover, our results also suggested that the scan mode used (Array vs Fast) may also be considered as a possible explanation for the different regressions in obese subjects. Nevertheless, Yue tal.36

reported no significant difference between these two modes in 19 different Hologic DXA machines when the European spine phantom (ESP; 1.000 g/cm2) was measured, whereas aBMD differences were found with other modes such as Express. Strengths and limitations

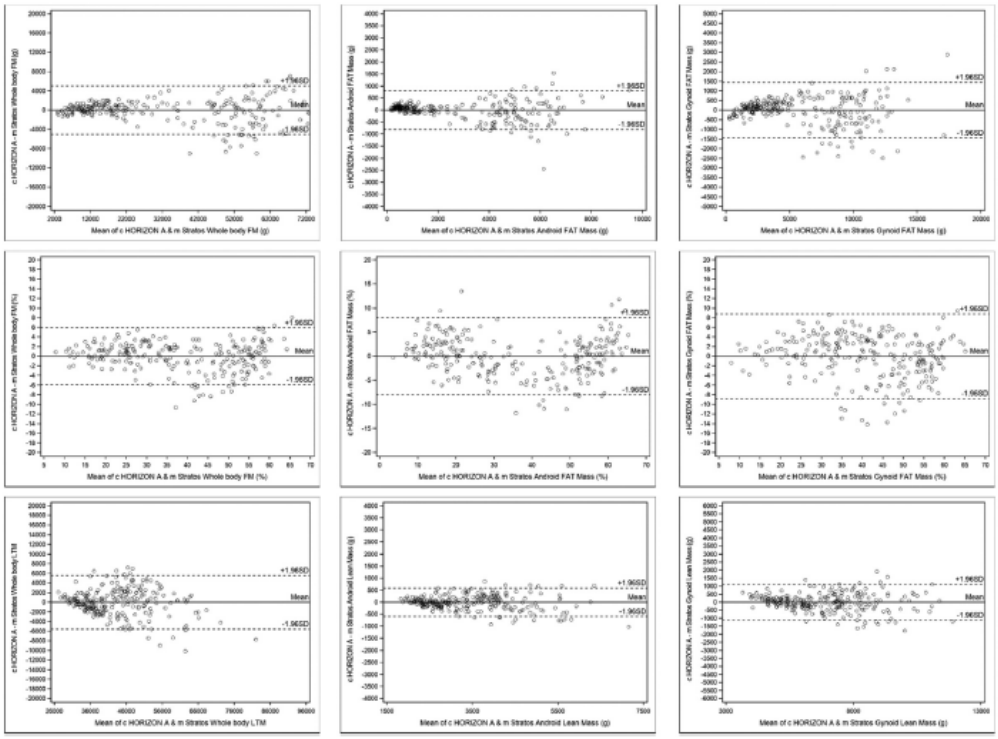

Fig. 4b. Bland-Altman analysis to compare measures converted using the cross−calibration equations for Horizon A and measures obtained with Stratos for body composition parameters. FM: fat mass; LTM: lean tissue mass. plots present mean of Horizon A and Stratos measurements (x axis) plotted against the difference between Horizon A and Stratos measurements (calculated as converted (c) Horizon A − measured (m) Stratos). solid line represents the mean difference, dashed lines represent ±1.96 SD of the mean difference. FM: fat mass; LTM: lean tissue mass.

This study is the first to compare STR with a DXA of the latest generation, namely HRZ. The main strengths of our study are the determination of the in-vivo cross-calibration equations based on a large population (n=251) presenting a wide range of aBMD and body composition parameters. Moreover, the characteristics of our population were highly representative of the patients seen in our Department, making these cross-calibration equations appropriate for our clinical context. This study also reported not only the commonly assessed parameters for aBMD and body composition ,but also at android and gynoid regions, which until now has been poorly evaluated but whose clinical utility continues to grow. In addition, the inclusion of a population with a wide range of BMIs allowed us to show that several cross-calibration equations are influenced by BMI. This finding suggests that in the future, the analysis of the concordance between two DXAs needs to include BMI adjustment. Finally, to limit the potential impact of biological changes—such as hydration status—on the results, the two scans were performed consecutively and immediately one after the other. Nevertheless, our study did not include subjects under the age of 18 years, which limits our cross-calibration equations to adult and not pediatric patients. Similarly, only Caucasian participants were included in this study and consequently our results cannot be generalized to other ethnic groups. Moreover, neither the precision error for each region on the two devices (RMS-SD) nor the least significant changes (LSC) were determined, and no phantom, such as ESP, was used to check the cross-calibration equations. These may be considered as major weaknesses of this study.

Table 5
Cross-calibration equations.

	N	Cross-calibration equations	R-square	RMSE	Intercept p-value	After conversion	
						Bias	P paired t-test
STR Whole body aBMD	247	-0.3312 + (1.1489* HRZ Whole body aBMD)	0.7123	0.07	<.0001	0 ± 0.07	0.9959
STR Whole body BMC	247	-458.6446 + (1.2272*HRZ Whole body BMC)	0.7557	262.31	<.0001	-0.01 ± 261.78	0.9994
STR Femoral Neck aBMD	249	0.1344 + (0.9531*HRZ Femoral Neck aBMD)	0.9044	0.05	<.0001	0 ± 0.05	0.9885
STR Total Hip aBMD	249	0.1789 + (0.8822*HRZ Total Hip aBMD)	0.8996	0.05	<.0001	0 ± 0.05	0.9993
STR L1-L4 aBMD	247	0.0413 + (0.9718*HRZ L1-L4 aBMD)	0.9345	0.04	0.0134	0 ± 0.04	0.9809
STR Radius aBMD	245	-0.1631 + (1.2503*HRZ Radius aBMD)	0.8348	0.04	<.0001	0 ± 0.04	0.9912
STR Whole body FM (g)	248	-3438.8826 + (1.2986*HRZ Whole body FM (g))	0.9861	2588.11	<.0001	-0.86 ± 2582.87	0.9958
STR Whole body FM (%)	248	-8.0209 + (1.4328*HRZ Whole body FM (%))	0.9606	3.01	<.0001	-0.01 ± 3.00	0.9943
STR Whole body LTM (g)	248	10471.9782 + (0.6701*HRZ Whole body LTM (g))	0.9155	2840.45	<.0001	1.88 ± 2834.69	0.9917
STR Appendicular LTM (g)	248	1610.0219 + (0.7599*HRZ Appendicular LTM (g))	0.9338	629.73	<.0001	0.30 ± 628.46	0.9939
STR Android FM (g)	251	-157.6588 + (1.2835*HRZ Android FM (g))	0.9713	407.15	0.0002	-0.09 ± 406.34	0.9971
STR Android FM (%)	251	-10.2541 + (1.4986*HRZ Android FM (%))	0.9522	4.08	<.0001	-0.01 ± 4.07	0.9973
STR Android LTM (g)	251	843.7206 + (0.6436*HRZ Android LTM (g))	0.9177	301.96	<.0001	0.11 ± 301.35	0.9954
STR Gynoid FM (g)	251	-720.002 + (1.3426*HRZ Gynoid FM (g))	0.9639	735.37	<.0001	0.12 ± 733.90	0.9979
STR Gynoid FM (%)	251	-8.7528 + (1.43*HRZ Gynoid FM (%))	0.8946	4.50	<.0001	-0.01 ± 4.50	0.9980
STR Gynoid LTM (g)	251	1621.4932 + (0.626*HRZ Gynoid LTM (g))	0.9032	568.71	<.0001	-0.01 ± 567.57	0.9998

RMSE: root mean square error; aBMD: areal bone mineral density; BMC: bone mineral content; L1-L4: lumbar spine; g: gram; FM: fat mass; LTM: lean tissue mass; STR: Stratos®; HRZ: Horizon A®.

Conclusions

This study clearly identifies a systematic measurement bias between STR and HRZ despite the high correlations of the aBMD and body composition parameters from the two DXAs. The application of the in-vivo cross-calibration equations we developed fully corrected these differences and their use may be beneficial for multicenter studies when scans are performed with STR and HRZ. The wide range of the participants'anthropometric characteristics helped us to clearly show that extreme BMI (>35kg/m2) may affect the concordance between the two DXAs.

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