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Title

Same-day versus consecutive-day precision error of dual-energy X-ray absorptiometry for interpreting body composition change in resistance trained athletes

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Abstract

Introduction: The application of dual-energy X-ray absorptiometry (DXA) in sport science settings is gaining popularity due to its ability to assess body composition. The International Society for Clinical Densitometry (ISCD) recommends application of the least significant change (LSC) to interpret meaningful and true change. This is calculated from same-day consecutive scans, thus accounting for technical error. However, this approach doesn't capture biological variation which is pertinent when interpreting longitudinal measurements, and could be captured from consecutive-day scans. The aims of this study were to investigate the impact short-term biological variation has on LSC measures, and establish if there is a difference in precision based on gender in a resistance trained population.

Methodology: Twenty-one resistance trained athletes (age 30.6 ± 8.2 years; stature 174.2 ± 7.2cm; mass 74.3 ± 11.6kg) with at least 12 months consistent resistance training experience, underwent two consecutive DXA scans on one day of testing, and a third scan the day before or after. ISCD recommended techniques were used to calculate same-day and consecutive-day precision error and LSC values.

Results: There was high association between whole body (R^2=0.98–1.00) and regional measures (R^2=0.95–0.99) for same-day (R^2=0.98–1.00) and

consecutive-day (R^2=0.95–0.98) measurements. The consecutive-day precision error, in comparison to same-day precision error, was significantly different ($p<0.05$), and almost twice as large for FM (1261g vs 660g), and over three times as large for LM (2083g vs 617g), yet still remained within the ISCD minimum acceptable limits for DXA precision error. No whole body differences in precision error were observed based on gender.

Conclusion: When tracking changes in body composition, the use of precision error and LSC values calculated from consecutive-day analysis is advocated, given this takes into account both technical error and biological variation, thus providing a more accurate indication of true and meaningful change.

Key words

Least significant change, LSC, DXA, lean mass, fat mass

Introduction

Dual-energy X-ray absorptiometry (DXA) has historically been utilised primarily in clinical settings to quantify bone mineral content (BMC) and bone mineral density (BMD) as part of osteoporosis assessment [1]. More recently, DXA has gained popularity in sport science and fitness settings for its ability to assess body composition, incorporating measures of whole body and regional lean mass (LM) and fat mass (FM), including visceral adipose tissue (VAT) [2, 3].

Highly trained athletes are likely to exhibit small body composition adaptations over time [4, 5], however these minor changes can have a significant influence on performance outcomes [6]. The ability to confidently quantify these small but potentially important changes in body composition can enable better refinement of interventions, and thus, potentially enhance athletic performance. The International Society for Clinical Densitometry (ISCD) recommends the application of the least significant change (LSC) in the interpretation of longitudinal body composition measurements, which is calculated using same-day repeat scans [7, 8]. LSC quantifies precision based on two consecutive scans, thus identifying the technical error inbuilt into a specific piece of equipment for a given population [7]. However, in practice, longitudinal measures are taken weeks or months apart, and despite following recommended best practice protocols [9], some level of day-to-day biological variation will be present in variables such as hydration status and muscle solute content, both of which impact results [10, 11]. It is unclear what influence these factors have on body composition LSC calculations.

Excellent precision for DXA body composition measures has been published in non-athletic adults for both whole body and regional measures [12-15]. Varying degrees of precision errors have been reported in athletic populations, with elite male rugby league athletes having established higher precision errors than those reported in other athletes, suggesting size may influence precision error [16-18]. Presently, there is limited information available on female athletes. This is pertinent given that precision errors should be specific to the population studied, and athletes vary greatly in physique depending on their sport [19]. Sex-specific

differences in precision have been recognised in general populations, with precision error in males being higher for FM, and lower in LM [15]. However, it is unclear whether or not these differences exist in athletic populations given the distinctive physique characteristics resistance trained individuals possess. Furthermore, to date, biological variation has not been explored in resistance trained female athletes, and there is little information about LSC values in this sex-specific population.

The aims of this study were to 1) investigate the impact biological variation has on LSC measures using best practice protocols; 2) establish if there is a difference in precision, and day-to-day biological variation based on gender in a resistance trained population; and 3) establish precision errors specific to a population of resistance trained athletes on a given densitometer, the results of which can be used to infer LSC in future longitudinal assessments.

Methods

Participants

Twenty-one resistance trained athletes (11 males and 10 females) participated in the study. All participants had been consistently undertaking resistance training for at least 12 months (averaging three resistance based sessions per week). Resistance training modalities included Olympic lifting, body-weight exercises, and free-weights exercises, with training focused on strength and power related enhancements. All participants provided their signed informed

consent to undertake the scans, and all local radiologic safety regulations were adhered to.

Study design

Participants underwent two consecutive DXA scans on one day of testing (D1S1, D1S2), and a third scan either the day before or after (D2S1), on a Hologic Discovery A (Hologic, Bedford, MA, USA) using the auto whole body fan beam mode. Participants presented and were scanned following the Nana et al. protocol previously described [9]. Specifically, this included being scanned bladder voided in the early morning after an overnight fast in a rested state. Further, prior to both days of testing, participants were instructed to remain well hydrated, consume their normal diet, and refrain from exercise to minimise biological variation over the testing period. The participants were positioned on the densitometer in the position recommended by Nana et al., with foam pads utilised to ensure consistency in positioning [9]. When scans were performed on the same day, participants were re-positioned for the repeat scan after dismounting the scanning table. A single trained technologist, who was an Australian and New Zealand Bone and Mineral Society (ANZBMS) qualified densitometrist with the required radiation use licences, performed all scans. The subsequent analysis was conducted using Hologic software (Version 13.4.2:3) by the same technologist. Regions of interest (ROI) were manually placed according to the manufacture's instructions, including the VAT ROI which has been validated against measures elsewhere [20]. Quality control procedures were undertaken daily using a phantom according to the manufacturer's guidelines.

Statistical analysis

Data analysis was performed using Microsoft Excel (Microsoft, Redmond, WA, USA). Descriptive data is reported as the mean ± standard deviation (SD). Precision is reported as the root-mean-square standard deviation (RMS–SD) and percentage coefficient of variation (%CV), and the resulting LSC with 95% confidence intervals (LSC–95% CI) is calculated following the ISCD protocol [7]. The %CV was derived from the equation %CV = (SD/mean)*100. Coefficients of determination (R^2) were calculated between measurements to establish how well fitted lines of regression approximated the other measure. Paired t-tests were utilised to test for differences based on same-day versus consecutive-day scan results and precision, and independent t-tests were used to test for differences based on gender. Bland Altman plots were created to compare same-day and consecutive-day precision. All statistical significance was set at 0.05.

Results

Descriptive statistics for the population are given in Table 1. Significant sex-specific differences were observed for the majority of regional body composition measures, and whole body BMC, FM and LM.

Table 2 displays the mean differences between same-day (technical error only) and consecutive-day (technical error and biological variation) scans, as a whole group and also based on sex. Whole body differences between same-day and consecutive-day scans are also shown in Figures 1-3. Regionally, variations in

trunk LM and FM, plus whole body LM and FM were significantly different between same-day and consecutive-day scans across most groups. Differences were also observed for variations in leg LM based on gender, with males exhibiting significantly greater differences across same-day (males 490 ± 421 g vs females 153 ± 99 g; p = 0.024) and consecutive-day measures (males 629 ± 432 g vs females 238 ± 130 g; p = 0.013).

Table 3 shows the precision error for each region, represented as the %CV, with the RMS–SD and LSC–95% CI. There was excellent agreement between same-day (R^2 = 0.99–1.00) and consecutive-day measures (R^2 = 0.98–0.99) of whole body BMC, FM and LM. There was similar agreement for both same-day and consecutive-day measures of regional BMC and LM (R^2 = 0.98–1.00). Agreement between consecutive-day measures of regional FM (R^2 = 0.96–0.97) and VAT (R^2 = 0.94) was not as strong as same-day measures (FM R^2 = 0.99; VAT R^2 = 0.96). Statistically significant differences were found between same-day and consecutive-day precision in measures of whole body FM and LM, and well as regional measures of FM (arms, trunk and legs), and LM (arms and trunk). Bland Altman analysis (Figure 4) shows a relatively small level of bias between same-day and consecutive-day DXA precision for BMC (1 g), FM (108 g) and LM (347 g), with relatively wide limits of agreement (BMC -73 to 75 g; FM -902 to 1119 g; LM -2197 to 1502 g).

Discussion

The primary finding of this study was that substantial and statistically significant differences were observed between same-day (technical error) and consecutive-day precision error (technical error and biological variation) for FM and LM in a resistance trained population. Consecutive-day precision error was almost twice as large for FM, and over three times as large for LM. Given that longitudinal monitoring of body composition will include both technical error and biological variation, the use of consecutive-day precision error is advocated.

Same-day precision was excellent for whole body BMC (CV 0.6%, LSC 1.7%) and LM (CV 0.3%, LSC 0.9%), and higher for FM (CV 1.8%, LSC 5.1%). Previously, studies have investigated either short-term (same-day) precision, which measures technical error [12, 17, 18], or long-term precision, which takes into account both technical error and biological variation [15]. Same-day precision errors were similar to those found on a Lunar iDXA for BMC (CV 0.6%, LSC 1.7%) and LM (CV 0.5%, LSC 1.4%); however, FM on the iDXA was considerably lower (CV 0.8%, LSC 2.3%) [12]. In comparison, the short-term precision (same-day and consecutive-day) identified in this study is better than the long-term precision errors previously reported when inferred over periods of 3-51 days [15]. This is unsurprising given significant body composition adaptations can be achieved in as little as 4-weeks in elite athletes [21], drawing into question the validity of such long-term precision error estimates.

The ISCD advocates LSC is calculated for body composition indices before any quantitative statement of change can be made for FM and LM measures [7]. To our knowledge this is the first study to explore short-term biological variation as

part of LSC calculations on body composition, to account for possible biological variation observed over 24 hours, in conjunction with technical error. Biological variation can arise from fluctuations in gastrointestinal content, total body water content, and glycogen reserves [10, 18], in particular on the measurement of LM [10, 22]. This is particularly relevant in resistance trained individuals who have the potential for larger fluctuations in hydration status and intramuscular solutes such as creatine and glycogen over a short time frame [11, 23]. Our consecutive-day testing resulted in wider precision errors for FM (CV 1.8% vs 2.9%, LSC 5.1% vs 8.0%) and LM (CV 0.3% vs 1.1%, LSC 0.9% vs 3.2%), indicating small amounts of biological variation despite use of best practice protocols [9], and instructions to the participants to eat normally and not exercise between consecutive-day scans. Further, statistically significant differences were found between the precision of same-day scans in comparison to consecutive-day scans in whole body FM and LM, suggesting short-term biological variation may meaningfully influence the interpretation of results. Nevertheless, it should be noted that the consecutive-day precision errors in the current study were within the acceptable limits for DXA precision as identified by the ISCD which are 3% for FM and 2% for LM [7]. Further, the precision error values were similar to those found in a number of studies as recently reviewed [8].

Accounting for biological variation in addition to technical error significantly widened the LSC for LM and FM, but not for BMC, in this resistance trained population. However, we consider it valid to incorporate the biological variation observed over a single day into LSC values, to ensure that when longitudinal

changes are being interpreted, true changes are able to be identified. Indeed, the consecutive-day LSC values presented here have successfully been used to interpret changes in physique traits in resistance trained individuals over a 12 week period [24]. Furthermore, these findings are similar to those reported for bone mineral density, in that same-day precision underestimated true variability, which could potentially result in an incorrect interpretation of longitudinal change [25].

Same-day regional precision in this study was similar to that observed in previous studies performed in a general population [26], student athletes [19] and elite rugby league athletes [17]. Precision was better for BMC (CV 0.8–1.5%) and LM (CV 0.8–1.2%) in all regions compared to FM (CV 2.1–2.7%). Further, the trunk region exhibited the greatest regional variation, which agrees with reports elsewhere [17, 27]. VAT measures had moderate same-day and consecutive-day precision errors (CV same-day 5.3% vs consecutive-day 7.2%), with a high LSC (same-day 15.3% vs consecutive-day 20.0%). In this study, consecutive-day regional precision was similar to same-day precision for BMC in all areas, however the CV was considerably higher for regional FM (CV 3.4–5.3%) and LM (CV 1.5–1.9%) measures.

It has been advocated that the LSC values applied should be specific to the athletic population being assessed [19]. Given the potential for marked differences in physique between males and females, sex-specific precision should be explored. No whole body differences in same-day or consecutive-day precision error were observed between males and females. Prior to our study

there has only been one investigation of the short-term precision of DXA for body composition assessment in female athletes. The reported precision errors in that study for LM (CV 0.8%) and FM (CV 2.1%) were similar to that found in this present study, although in the previous investigation only 3 athletes were tested using a same-day protocol [28]. In the present study, whole body BMC, FM and LM precision errors were not significantly different to males, with the only sex-specific differences occurring for leg LM and trunk BMC. This is perhaps in part due to similarities in training of the participants. Despite this, the quantification of precision error specific to the athletic population being investigated likely remains warranted, especially in populations with physique extremes [8].

The authors recognise some limitations in the study design which may have had an impact on the findings. Firstly, the sample of participants was relatively small, and slightly smaller than that recommended by the ISCD to calculate LSC. Further, it is recognised that the specialised group of athletes used in the study limits the general applicability of the of the findings. However, it is known precision varies according to body size [16, 17, 29]. Additionally, it is recognised by the ISCD that it is important to understand the precision of DXA within specific groups when interpreting results from others within the same population, making the findings of this study applicable in practice.

Conclusion

298 In a population of resistance trained athletes, consecutive-day precision error
299 was almost twice as large for whole body FM, and over three times as large for
300 whole body LM. Despite this, the Hologic Discovery A Densitometer provided
301 acceptable precision error for whole body measures of BMC, LM, and FM, which
302 remained within the ISCD minimum acceptable limits. When tracking changes in
303 body composition, it would seem pertinent to use precision error and LSC values
304 calculated from consecutive-day analysis, given this takes into account both
305 technical error and biological variation, and both contribute to precision when
306 interpreting longitudinal change.
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Table 1: Descriptive statistics of the participants

	All participants (n = 21)		Males (n=11)		Females (n=10)	
	Mean ± SD	**Range**	**Mean ± SD**	**Range**	**Mean ± SD**	**Range**
Age (years)	30.6 ± 8.2	21.3 – 51.1	28.1 ± 6.3	21.3 – 42.2	33.4 ± 9.4	22.6 – 51.1
Stature (cm)	174.2 ± 7.2	160.9 – 183.6	178.9 ± 3.7	173.8 – 183.6	169.1 ± 6.7 [a]	160.9 – 182.8
Mass (kg)	74.3 ± 11.6	57.9 – 98.5	82.9 ± 8.8	69.4 – 98.5	64.8 ± 4.6 [a]	57.9 – 70.9
BMI (kg/m²)	24.4 ± 2.7	19.8 – 29.3	25.9 ± 2.2	22.5 – 29.3	22.8 ± 2.4 [a]	19.8 – 26.4
Arms BMC (g)	421 ± 106	274 – 597	506 ± 61	422 – 597	327 ± 46 [a]	274 – 441
Arms FM (g)	1484 ± 570	943 – 3227	1375 ± 644	943 – 3227	1604 ± 481	1008 – 2528
Arms LM (g)	7379 ± 2453	4555 – 13070	9883 ± 1571	7697 – 13070	5174 ± 564 [a]	4555 – 6153
Trunk BMC (g)	821 ± 180	576 – 1241	934 ± 158	687 – 1241	696 ± 105 [a]	576 – 933
Trunk FM (g)	4911 ± 2109	2876 – 10187	4470 ± 2113	2876 – 10187	5395 ± 2105	3658 – 9760
Trunk LM (g)	29413 ± 5965	22125 – 42985	33748 ± 4800	27461 – 42985	24645 ± 2291 [a]	22125 – 28905
Legs BMC (g)	1023 ± 187	781 – 1370	1175 ± 112	1010 – 1370	854 ± 61 [a]	781 – 966
Legs FM (g)	5565 ± 1974	2316 – 9279	4279 ± 1522	2316 – 7583	6981 ± 1355 [a]	5258 – 9279
Legs LM (g)	19888 ± 4301	13730 – 28072	23414 ± 2496	20352 – 28072	16009 ± 1506 [a]	13730 – 18799
WB BMC (g)	2856 ± 476	2189 – 3804	3216 ± 327	2841 – 3804	2460 ± 227 [a]	2189 – 2803
WB FM (g)	12891 ± 4333	7768 – 22070	11115 ± 4152	7768 – 21988	14846 ± 3804 [a]	11212 – 22070
WB FM (%)	17.6 ± 6.6	9.3 – 31.5	13.2 ± 4.6	9.3 – 24.9	22.4 ± 4.8 [a]	17.0 – 31.5
WB LM (g)	59954 ± 12878	43660 – 87839	70081 ± 8886	59301 – 87839	48814 ± 4191 [a]	43660 – 56101
Android FM (g)	785 ± 410	457 – 1962	771 ± 463	457 – 1962	801 ± 366	485 – 1538
Android FM (%)	16.0 ± 6.9	9.5 – 33.4	13.8 ± 6.5	9.5 – 30.0	18.4 ± 6.9 [a]	13.3 – 33.4
Android FFM (g)	4808 ± 777	3073 – 5529	4642 ± 574	3953 – 5529	3463 ± 407 [a]	3073 – 4253
Gynoid FM (g)	2654 ± 969	1202 – 4789	2033 ± 673	1202 – 3588	3336 ± 772 [a]	2446 – 4789
Gynoid FM (%)	21.4 ± 8.3	9.8 – 36.3	14.9 ± 4.6	9.8 – 24.8	28.6 ± 4.6 [a]	23.2 – 36.3
Gynoid FFM (g)	10053 ± 2081	7109 – 14428	11692 ± 1428	10285 – 14428	8251 ± 684 [a]	7109 – 9664
VAT FM (g)	200 ± 84	89 – 485	252 ± 81	174 – 485	143 ± 37 [a]	89 – 194
VAT Volume (cm³)	216 ± 91	96 – 525	273 ± 88	188 – 525	154 ± 39 [a]	96 – 210
VAT Area (cm²)	42 ± 17	18 - 101	51 ± 17	36 - 101	30 ± 8 [a]	18 – 40

[a] Significant difference (<0.05) between males and females.

BMI = body mass index; BMC = bone mineral content; FM = fat mass; LM = lean mass; WB = whole body; VAT = visceral adipose tissue.

Table 2: Mean difference (± standard deviation) between same-day scans (technical error) and consecutive-day scans (technical error and biological variation).

	Same-day (D1S1 / D1S2) Technical error			Consecutive-day (D1S1 / D2S1) Technical error & biological variation		
	All participants	**Males**	**Females**	**All participants**	**Males**	**Females**
Arms BMC (g)	6 ± 5	6 ± 5	6 ± 6	8 ± 6	8 ± 5	7 ± 7
Arms FM (g)	48 ± 39	55 ± 37	41 ± 41	100 ± 78 [a]	108 ± 96	92 ± 57 [c]
Arms LM (g)	113 ± 90	114 ± 80	111 ± 104	175 ± 133 [a]	167 ± 134	183 ± 139 [c]
Trunk BMC (g)	10 ± 10	14 ± 11	5 ± 5 [d]	11 ± 9	13 ± 10	8 ± 7
Trunk FM (g)	141 ± 106	128 ± 96	154 ± 121	242 ± 204 [a]	236 ± 181	248 ± 236
Trunk LM (g)	324 ± 323	414 ± 405	224 ± 167	782 ± 570 [a]	844 ± 651 [b]	714 ± 491 [c]
Legs BMC (g)	21 ± 20	21 ± 14	22 ± 25	21± 17	17 ± 17	25 ± 17
Legs FM (g)	185 ± 93	199 ± 79	170 ± 109	249 ± 216	212 ± 231	290 ± 201
Legs LM (g)	330 ± 350	490 ± 421	153 ± 99 [d]	443 ± 376	629 ± 432	238 ± 130 [e]
WB BMC (g)	24 ± 18	22 ± 15	27 ± 22	28 ± 22	29 ± 22	27 ± 24
WB FM (g)	295 ± 168	314 ± 137	273 ± 202	522 ± 386 [a]	463 ± 353	588 ± 428 [c]
WB LM (g)	262 ± 179	244 ± 202	281 ± 160	925 ± 538 [a]	905 ± 535 [b]	947 ± 568 [c]
Android FM (g)	27 ± 25	25 ± 24	30 ± 29	34 ± 24	40 ± 27	28 ± 19
Android FFM (g)	44 ± 38	51 ± 41	37 ± 36	97 ± 58 [a]	105 ± 52 [b]	87 ± 65
Gynoid FM (g)	66 ± 49	69 ± 56	63 ± 43	143 ± 95 [a]	109 ± 101	180 ± 76 [c]
Gynoid FFM (g)	64 ± 57	53 ± 43	77 ± 70	92 ± 64	85 ± 69	99 ± 62
VAT FM (g)	14 ± 15	10 ± 11	18 ± 18	25 ± 26	16 ± 13	34 ± 34
VAT Volume (cm^3)	16 ± 16	12 ± 12	20 ± 19	28 ± 29	19 ± 14	38 ± 37
VAT Area (cm^2)	3 ± 3	2 ± 2	4 ± 4	5 ± 5	3 ± 3	7 ± 7

Data presented mean ± standard deviation.

D1S1 = day 1 scan 1; D1S2 = day 1 scan 2; D2S1 = day 2 scan 1; BMC = bone mineral content; FM = fat mass; LM = lean mass; WB = whole body; VAT = visceral adipose tissue.

[a] Significant difference (<0.05) between same-day and consecutive-day differences in all participants

[b] Significant difference (<0.05) between same-day and consecutive-day differences in males

[c] Significant difference (<0.05) between same-day and consecutive-day differences in females

[d] Significant difference (<0.05) between males and females in the differences in same-day measures

[e] Significant difference (<0.05) between males and females in the difference in consecutive-day measures

Table 3: Precision error for each region, represented as the %CV, with the RMS–SD and LSC–95% CI.

	D1S1 / D1S2 Technical error		D1S1 / D2S1 Technical error & biological variation	
	RMS-SD (LSC–95% CI)	**%CV (LSC–95% CI) %**	**RMS-SD (LSC–95% CI)**	**%CV (LSC–95% CI) %**
Stature*	0.0 (0.0) cm	0.0 (0.0)	0.0 (0.0) cm	0.0 (0.0)
Mass #	0.0 (0.0) kg	0.0 (0.0)	0.4 (1.1) kg	0.4 (1.2)
BMI #	0.0 (0.0)	0.0 (0.0)	0.1 (0.4)	0.4 (1.2)
Arms BMC	5.6 (15.5) g	1.1 (3.0)	6.8 (18.9) g	1.3 (3.7)
Arms FM #	43.5 (120.5) g	2.5 (6.8)	89.1 (246.8) g	5.3 (14.5)
Arms LM #	101.1 (279.9) g	1.2 (3.3)	154.1 (426.7) g	1.9 (5.2)
Trunk BMC	9.7 (27.0) g	0.8 (2.2)	9.8 (27.1) g	0.9 (2.6)
Trunk FM #	123.7 (342.5) g	2.2 (6.0)	221.3 (612.9) g	3.6 (9.9)
Trunk LM #	319.4 (884.7) g	0.8 (2.1)	678.7 (1880.0) g	1.9 (5.3)
Legs BMC	20.2 (56.1) g	1.5 (4.2)	18.6 (51.6) g	1.5 (4.1)
Legs FM #	146.0 (404.4) g	2.7 (7.5)	230.7 (639.1) g	3.4 (9.5)
Legs LM	335.6 (929.6) g	1.1 (3.0)	406.5 (1126.0) g	1.5 (4.1)
WB BMC	21.3 (59.0) g	0.6 (1.7)	25.2 (69.8) g	0.7 (1.9)
WB FM #	238.4 (660.4) g	1.8 (5.1)	455.2 (1261.0) g	2.9 (8.0)
WB LM #	222.7 (616.8) g	0.3 (0.9)	752.0 (2083.0) g	1.1 (3.2)
Android FM	26.1 (72.3) g	2.6 (7.3)	29.0 (80.5) g	3.5 (9.7)
Android FFM #	40.9 (113.4) g	0.8 (2.1)	79.1 (219.2) g	1.7 (4.7)
Gynoid FM #	57.8 (160.1) g	2.1 (5.8)	120.2 (333.0) g	4.0 (10.9)
Gynoid FFM	60.1 (166.5) g	0.5 (1.4)	78.4 (217.3) g	0.7 (1.9)
VAT FM	12.7 (35.0) g	5.3 (15.3)	18.0 (50.0) g	7.2 (20.0)
VAT Volume	13.7 (37.9) cm^3	5.5 (15.4)	19.5 (54.1) cm^3	7.3 (20.2)
VAT Area	2.6 (7.3) cm^2	5.5 (15.3)	3.7 (10.4) cm^2	7.3 (20.2)

BMI = body mass index (kg/m^2); RMS–SD = root-mean-square standard deviation; %CV = percent coefficient of variation; LSC = least significant change; D1S1 = Day 1 Scan 1; D1S2 = Day 1 Scan 2; D2S1 = Day 2 Scan 1; BMC = bone mineral content; FM = fat mass; LM = lean mass; WB = whole body; VAT = visceral adipose tissue.

* Stature was not remeasured on Day 2 of scanning.

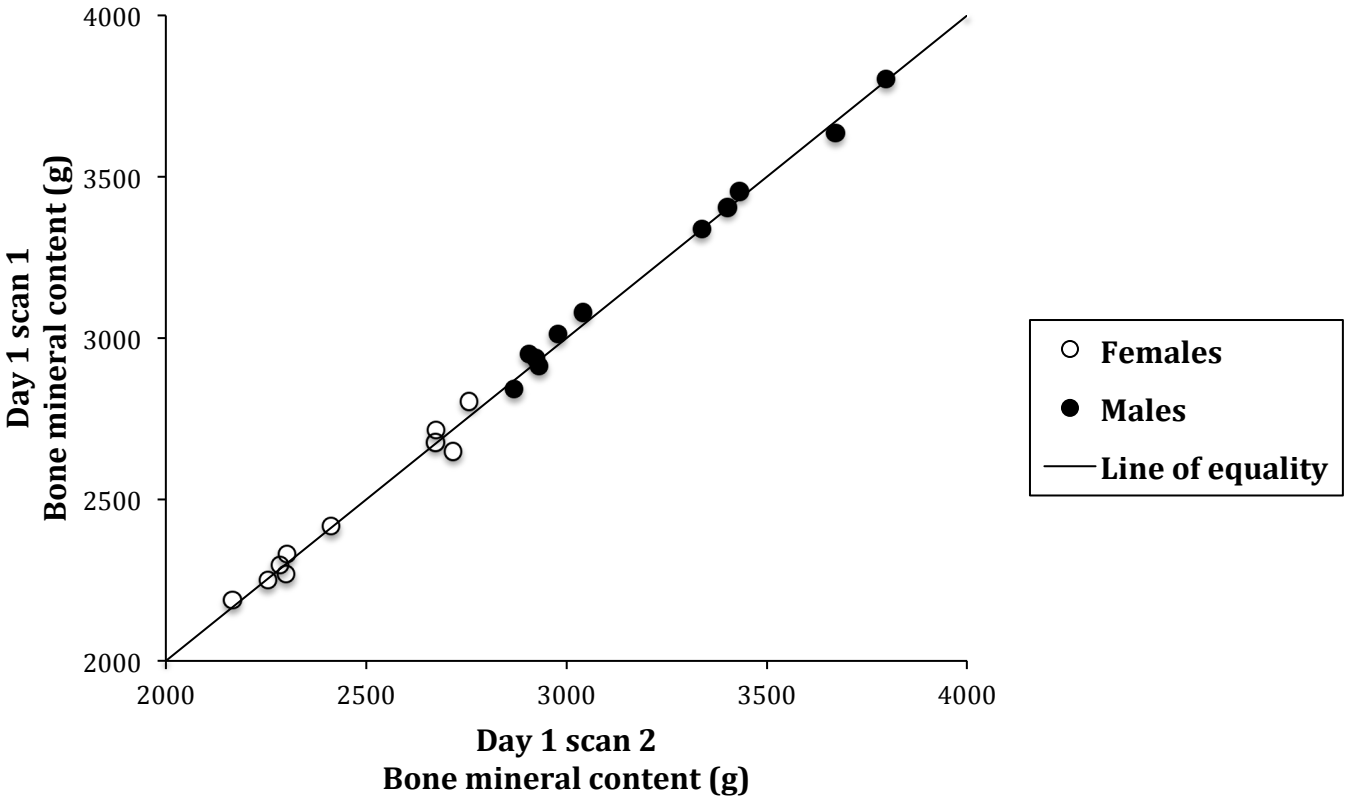
Significant difference (<0.05) between same-day and consecutive-day precision.

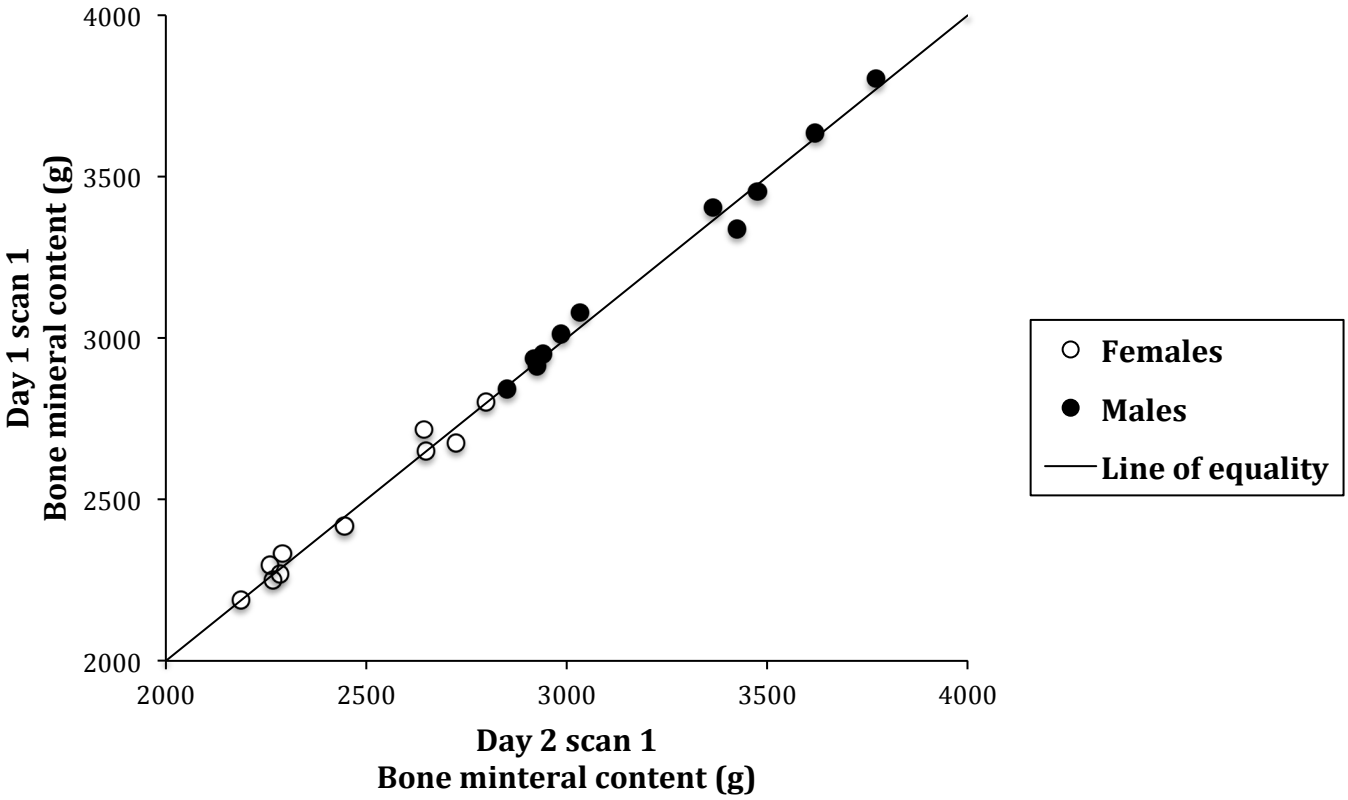
Figure 1: The regressions between measures of bone mineral content for same-day (top; $R^2 = 1.00$) and consecutive-day (bottom; $R^2 = 0.99$) precision.

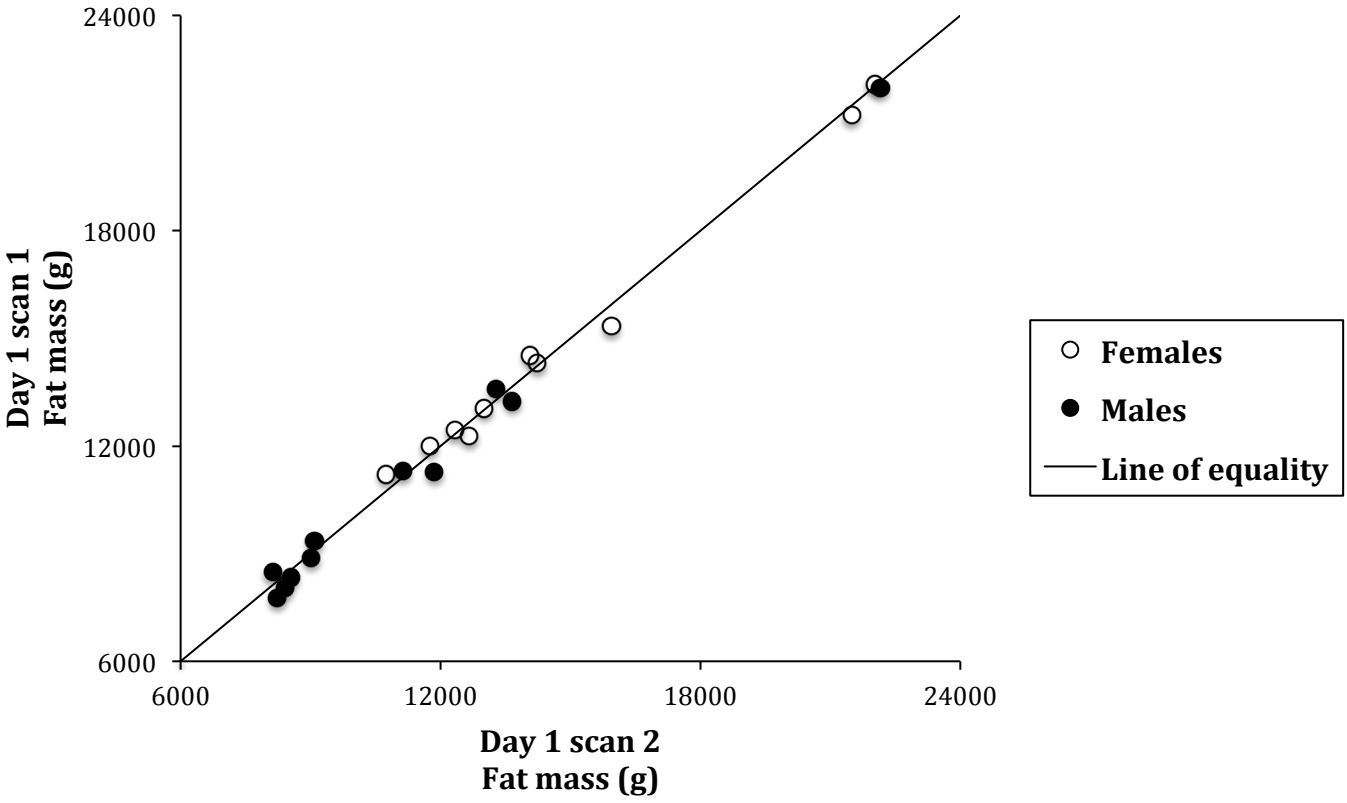
Figure 2: The regressions between measures of fat mass for same-day (top; $R^2 = 0.99$) and consecutive-day (bottom; $R^2 = 0.98$) precision.

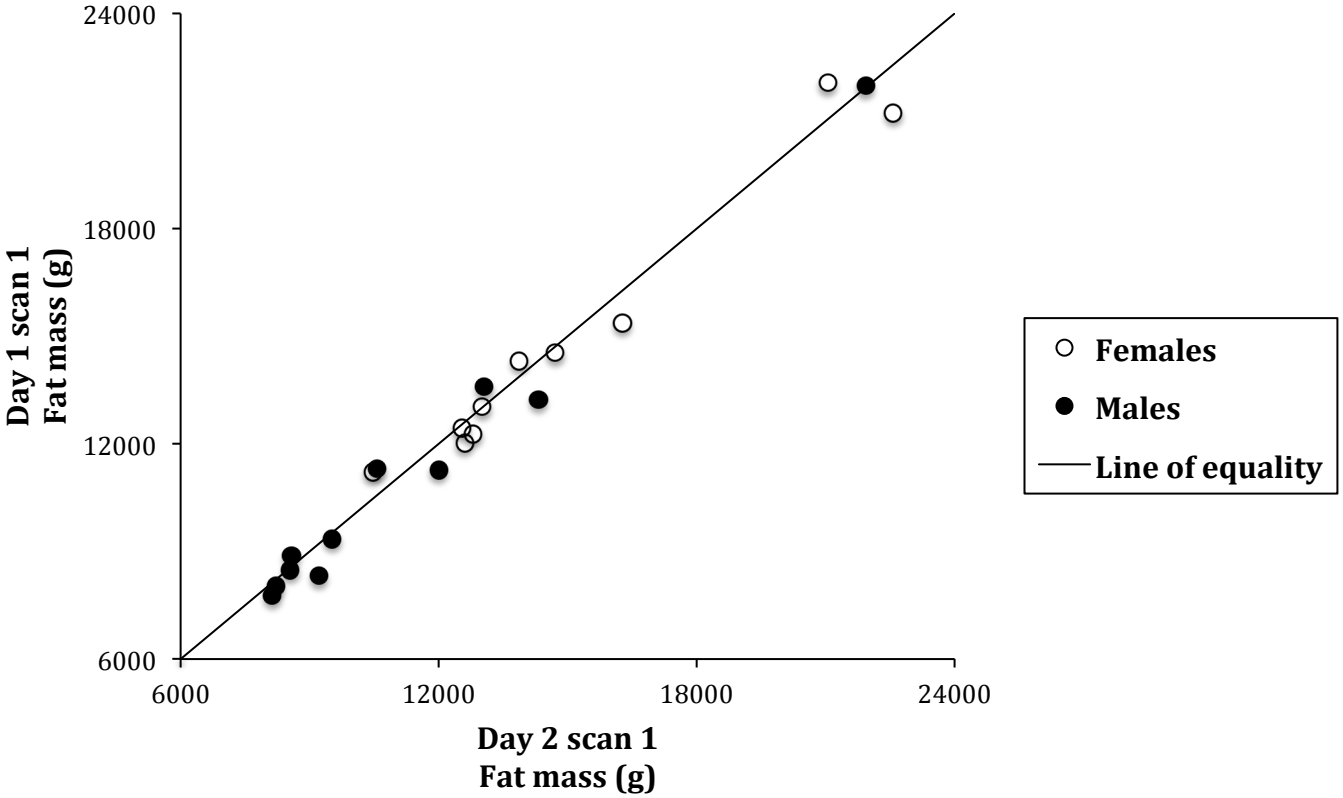
Figure 3: The regressions between measures of lean mass for same-day (top; $R^2 = 1.00$) and consecutive-day (bottom; $R^2 = 0.99$) precision.

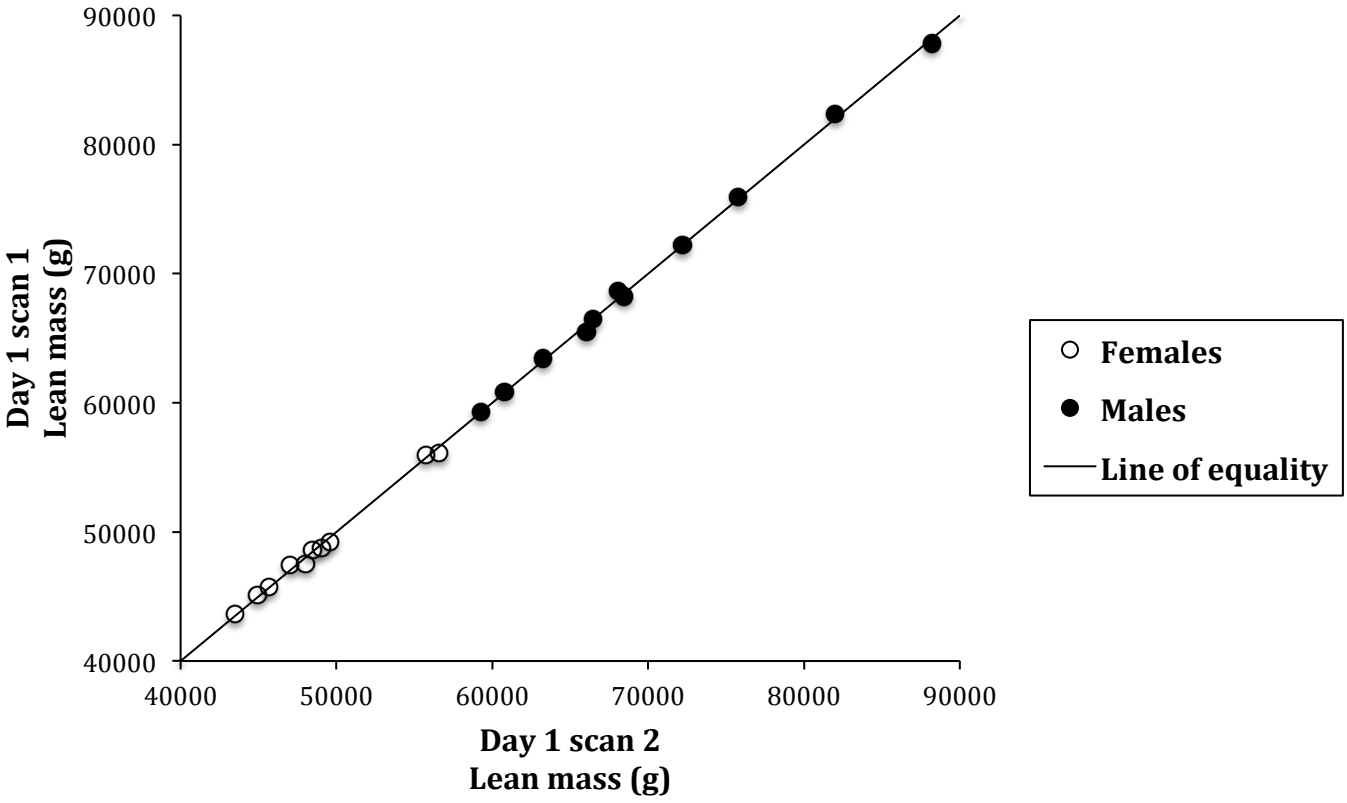
Figure 4: Bland Altman plots for differences in same-day scans versus consecutive-day scans on whole body bone mineral content (top), fat mass (middle) and lean mass (bottom).

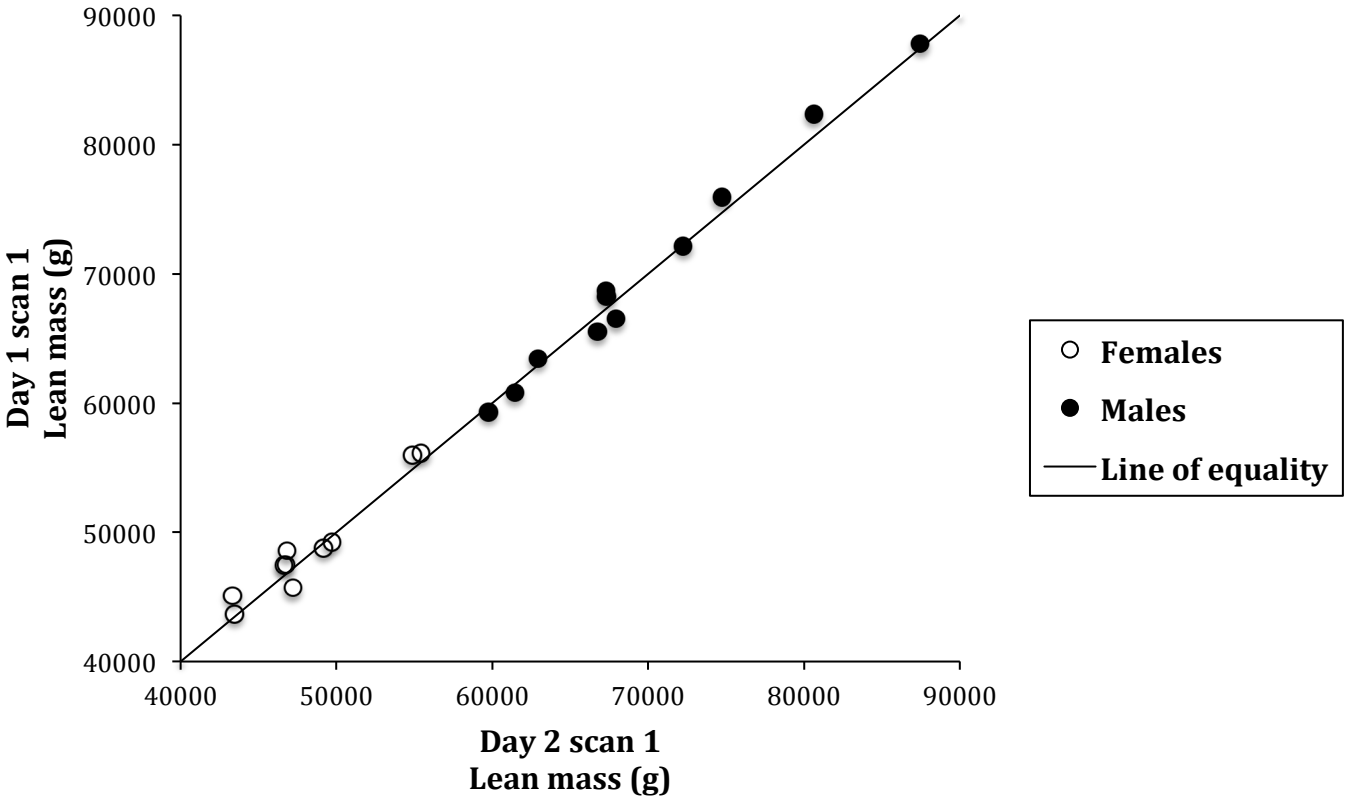

4000
3500
3000
2500
2000
2000
2500
3000
3500
4000
Day 1 scan 1
Bone mineral content (g)
Day 1 scan 2
Bone mineral content (g)
Females
Males
Line of equality

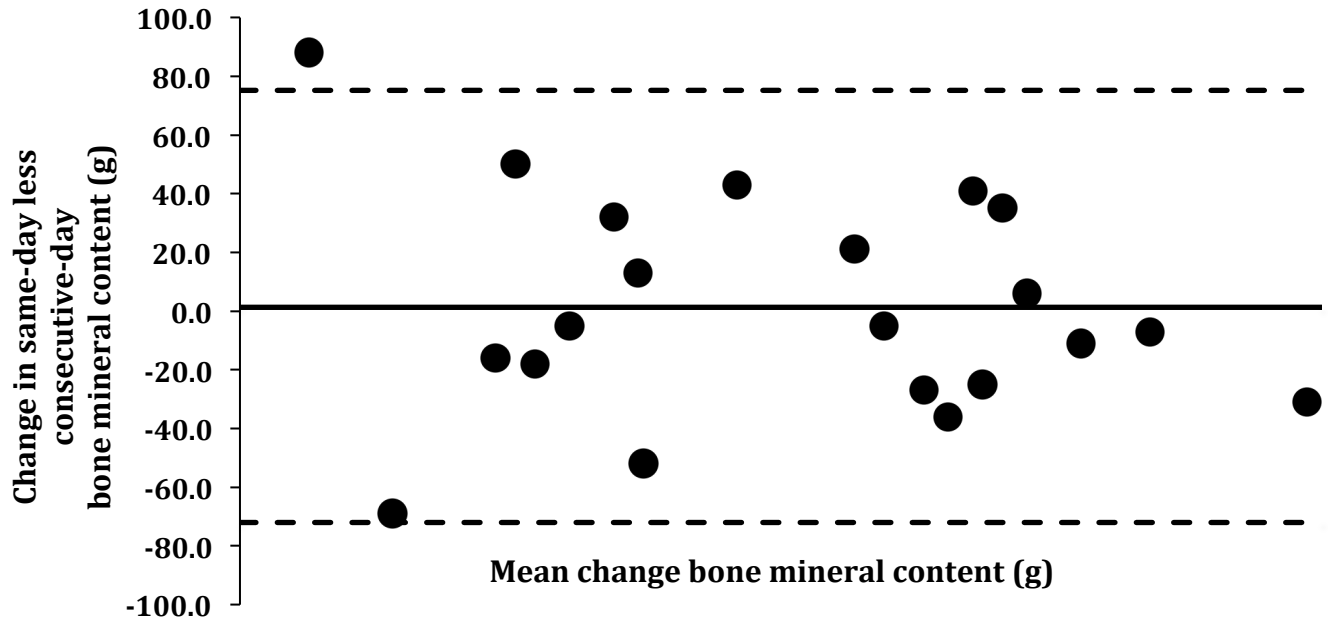

4000
3500
3000
2500
2000
2000
2500
3000
3500
4000
Day 1 scan 1
Bone mineral content (g)
Day 2 scan 1
Bone minteral content (g)
Females
Males
Line of equality

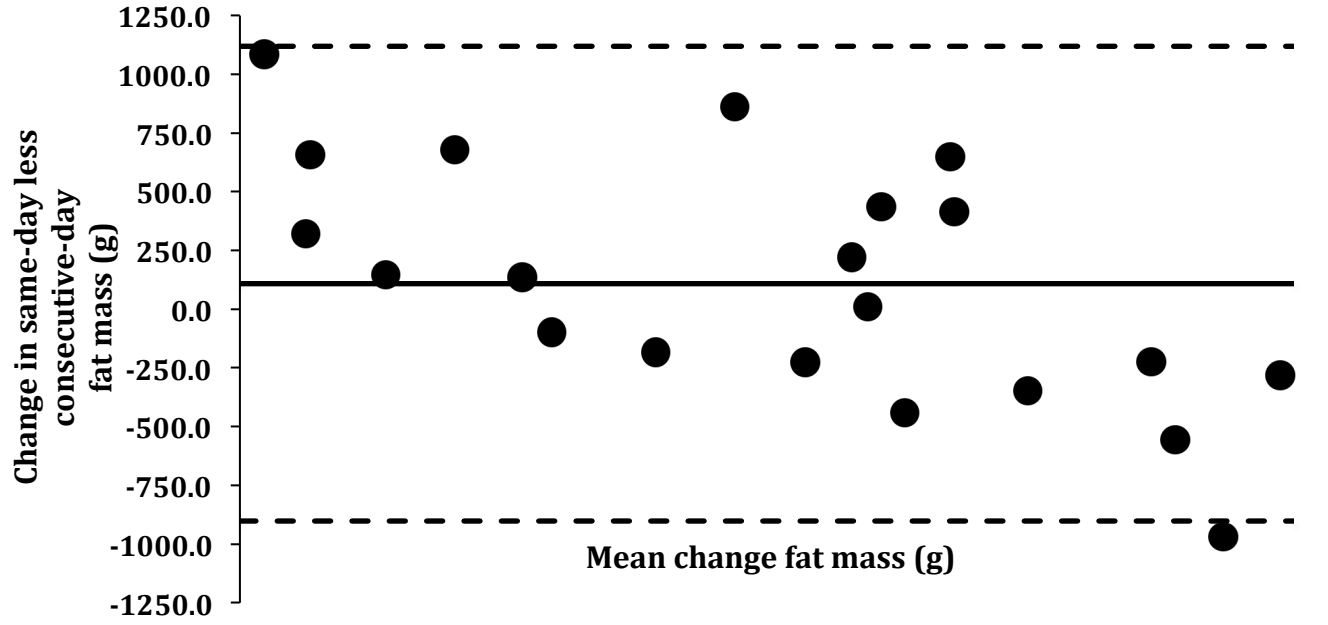

24000
18000
12000
6000
6000
12000
18000
24000
Day 1 scan 1
Fat mass (g)
Day 1 scan 2
Fat mass (g)
Females
Males
Line of equality

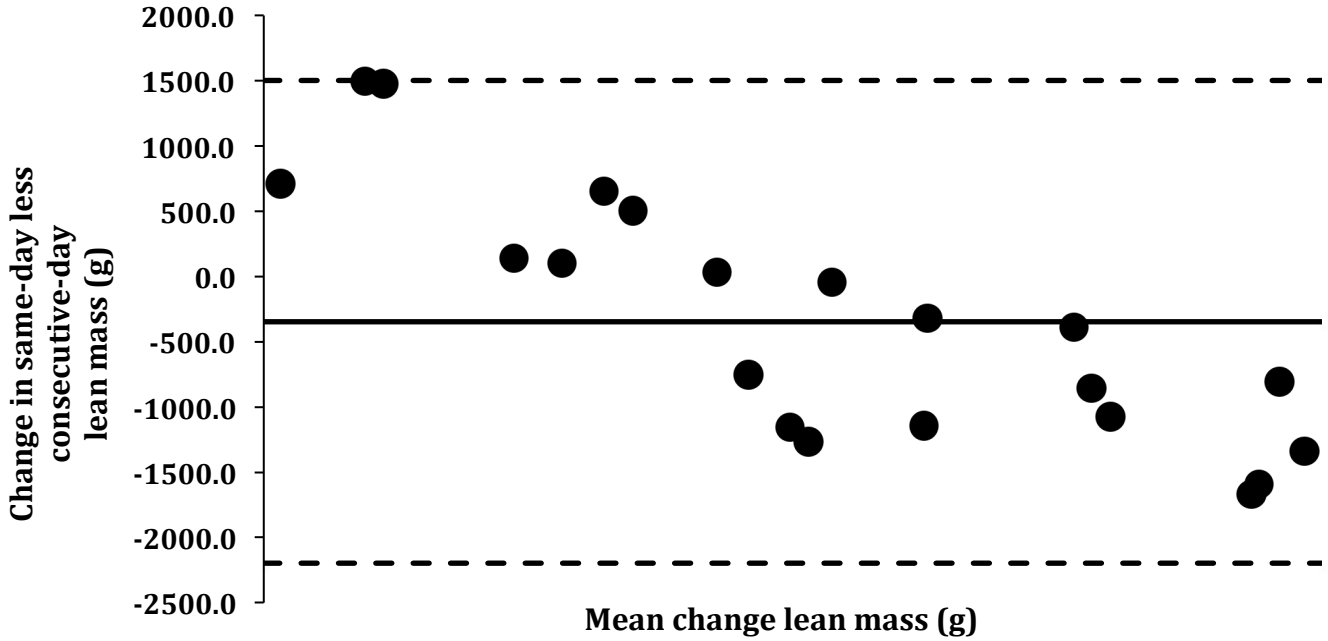

24000
18000
12000
6000
6000
12000
18000
24000
Day 1 scan 1
Fat mass (g)
Day 2 scan 1
Fat mass (g)
Females
Males
Line of equality


90000
80000
70000
60000
50000
40000
40000
50000
60000
70000
80000
90000
Day 1 scan 1
Lean mass (g)
Day 1 scan 2
Lean mass (g)
Females
Males
Line of equality


90000
80000
70000
60000
50000
40000
40000
50000
60000
70000
80000
90000
Day 1 scan 1
Lean mass (g)
Day 2 scan 1
Lean mass (g)
Females
Males
Line of equality


100.0
80.0
60.0
40.0
20.0
0.0
-20.0
-40.0
-60.0
-80.0
-100.0
Change in same-day less consecutive-day bone mineral content (g)
Mean change bone mineral content (g)


1250.0
1000.0
750.0
500.0
250.0
0.0
-250.0
-500.0
-750.0
-1000.0
-1250.0
Change in same-day less consecutive-day fat mass (g)
Mean change fat mass (g)


2000.0
1500.0
1000.0
500.0
0.0
-500.0
-1000.0
-1500.0
-2000.0
-2500.0
Change in same-day less consecutive-day lean mass (g)
Mean change lean mass (g)