

1 **TITLE PAGE**

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

8

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

29

30 **Abstract**

31

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

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

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

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

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

61

## 62 **Key words**

63

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

65

## 66 **Introduction**

67

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

74

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

91

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

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

107

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

114

## 115 **Methods**

116

### 117 ***Participants***

118

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

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

127

### 128 ***Study design***

129

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

150 ***Statistical analysis***

151

152 Data analysis was performed using Microsoft Excel (Microsoft, Redmond, WA,

153 USA). Descriptive data is reported as the mean  $\pm$  standard deviation (SD).

154 Precision is reported as the root-mean-square standard deviation (RMS–SD) and

155 percentage coefficient of variation (%CV), and the resulting LSC with 95%

156 confidence intervals (LSC–95% CI) is calculated following the ISCD protocol [7].

157 The %CV was derived from the equation  $\%CV = (SD/mean)*100$ . Coefficients of

158 determination ( $R^2$ ) were calculated between measurements to establish how

159 well fitted lines of regression approximated the other measure. Paired t-tests

160 were utilised to test for differences based on same-day versus consecutive-day

161 scan results and precision, and independent t-tests were used to test for

162 differences based on gender. Bland Altman plots were created to compare same-

163 day and consecutive-day precision. All statistical significance was set at 0.05.

164

165 **Results**

166

167 Descriptive statistics for the population are given in Table 1. Significant sex-

168 specific differences were observed for the majority of regional body composition

169 measures, and whole body BMC, FM and LM.

170

171 Table 2 displays the mean differences between same-day (technical error only)

172 and consecutive-day (technical error and biological variation) scans, as a whole

173 group and also based on sex. Whole body differences between same-day and

174 consecutive-day scans are also shown in Figures 1-3. Regionally, variations in

175 trunk LM and FM, plus whole body LM and FM were significantly different  
176 between same-day and consecutive-day scans across most groups. Differences  
177 were also observed for variations in leg LM based on gender, with males  
178 exhibiting significantly greater differences across same-day (males  $490 \pm 421$  g  
179 vs females  $153 \pm 99$  g;  $p = 0.024$ ) and consecutive-day measures (males  $629 \pm$   
180  $432$  g vs females  $238 \pm 130$  g;  $p = 0.013$ ).

181

182 Table 3 shows the precision error for each region, represented as the %CV, with  
183 the RMS-SD and LSC-95% CI. There was excellent agreement between same-day  
184 ( $R^2 = 0.99-1.00$ ) and consecutive-day measures ( $R^2 = 0.98-0.99$ ) of whole body  
185 BMC, FM and LM. There was similar agreement for both same-day and  
186 consecutive-day measures of regional BMC and LM ( $R^2 = 0.98-1.00$ ). Agreement  
187 between consecutive-day measures of regional FM ( $R^2 = 0.96-0.97$ ) and VAT ( $R^2$   
188  $= 0.94$ ) was not as strong as same-day measures (FM  $R^2 = 0.99$ ; VAT  $R^2 = 0.96$ ).  
189 Statistically significant differences were found between same-day and  
190 consecutive-day precision in measures of whole body FM and LM, and well as  
191 regional measures of FM (arms, trunk and legs), and LM (arms and trunk). Bland  
192 Altman analysis (Figure 4) shows a relatively small level of bias between same-  
193 day and consecutive-day DXA precision for BMC (1 g), FM (108 g) and LM (347 g),  
194 with relatively wide limits of agreement (BMC -73 to 75 g; FM -902 to 1119 g; LM  
195 -2197 to 1502 g).

196

197 **Discussion**

198

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

206

207 Same-day precision was excellent for whole body BMC (CV 0.6%, LSC 1.7%) and  
208 LM (CV 0.3%, LSC 0.9%), and higher for FM (CV 1.8%, LSC 5.1%). Previously,  
209 studies have investigated either short-term (same-day) precision, which  
210 measures technical error [12, 17, 18], or long-term precision, which takes into  
211 account both technical error and biological variation [15]. Same-day precision  
212 errors were similar to those found on a Lunar iDXA for BMC (CV 0.6%, LSC 1.7%)  
213 and LM (CV 0.5%, LSC 1.4%); however, FM on the iDXA was considerably lower  
214 (CV 0.8%, LSC 2.3%) [12]. In comparison, the short-term precision (same-day  
215 and consecutive-day) identified in this study is better than the long-term  
216 precision errors previously reported when inferred over periods of 3-51 days  
217 [15]. This is unsurprising given significant body composition adaptations can be  
218 achieved in as little as 4-weeks in elite athletes [21], drawing into question the  
219 validity of such long-term precision error estimates.

220

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

224 part of LSC calculations on body composition, to account for possible biological  
225 variation observed over 24 hours, in conjunction with technical error. Biological  
226 variation can arise from fluctuations in gastrointestinal content, total body water  
227 content, and glycogen reserves [10, 18], in particular on the measurement of LM  
228 [10, 22]. This is particularly relevant in resistance trained individuals who have  
229 the potential for larger fluctuations in hydration status and intramuscular  
230 solutes such as creatine and glycogen over a short time frame [11, 23]. Our  
231 consecutive-day testing resulted in wider precision errors for FM (CV 1.8% vs  
232 2.9%, LSC 5.1% vs 8.0%) and LM (CV 0.3% vs 1.1%, LSC 0.9% vs 3.2%),  
233 indicating small amounts of biological variation despite use of best practice  
234 protocols [9], and instructions to the participants to eat normally and not  
235 exercise between consecutive-day scans. Further, statistically significant  
236 differences were found between the precision of same-day scans in comparison  
237 to consecutive-day scans in whole body FM and LM, suggesting short-term  
238 biological variation may meaningfully influence the interpretation of results.  
239 Nevertheless, it should be noted that the consecutive-day precision errors in the  
240 current study were within the acceptable limits for DXA precision as identified  
241 by the ISCD which are 3% for FM and 2% for LM [7]. Further, the precision error  
242 values were similar to those found in a number of studies as recently reviewed  
243 [8].

244

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

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

256

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

268

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

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

285

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

295

296 **Conclusion**

297

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.

307

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440

**Table 1: Descriptive statistics of the participants**

|                                    | All participants<br>(n = 21) |               | Males<br>(n=11) |               | Females<br>(n=10)         |               |
|------------------------------------|------------------------------|---------------|-----------------|---------------|---------------------------|---------------|
|                                    | Mean ± SD                    | Range         | Mean ± SD       | Range         | Mean ± SD                 | Range         |
| <b>Age (years)</b>                 | 30.6 ± 8.2                   | 21.3 – 51.1   | 28.1 ± 6.3      | 21.3 – 42.2   | 33.4 ± 9.4                | 22.6 – 51.1   |
| <b>Stature (cm)</b>                | 174.2 ± 7.2                  | 160.9 – 183.6 | 178.9 ± 3.7     | 173.8 – 183.6 | 169.1 ± 6.7 <sup>a</sup>  | 160.9 – 182.8 |
| <b>Mass (kg)</b>                   | 74.3 ± 11.6                  | 57.9 – 98.5   | 82.9 ± 8.8      | 69.4 – 98.5   | 64.8 ± 4.6 <sup>a</sup>   | 57.9 – 70.9   |
| <b>BMI (kg/m<sup>2</sup>)</b>      | 24.4 ± 2.7                   | 19.8 – 29.3   | 25.9 ± 2.2      | 22.5 – 29.3   | 22.8 ± 2.4 <sup>a</sup>   | 19.8 – 26.4   |
| <b>Arms BMC (g)</b>                | 421 ± 106                    | 274 – 597     | 506 ± 61        | 422 – 597     | 327 ± 46 <sup>a</sup>     | 274 – 441     |
| <b>Arms FM (g)</b>                 | 1484 ± 570                   | 943 – 3227    | 1375 ± 644      | 943 – 3227    | 1604 ± 481                | 1008 – 2528   |
| <b>Arms LM (g)</b>                 | 7379 ± 2453                  | 4555 – 13070  | 9883 ± 1571     | 7697 – 13070  | 5174 ± 564 <sup>a</sup>   | 4555 – 6153   |
| <b>Trunk BMC (g)</b>               | 821 ± 180                    | 576 – 1241    | 934 ± 158       | 687 – 1241    | 696 ± 105 <sup>a</sup>    | 576 – 933     |
| <b>Trunk FM (g)</b>                | 4911 ± 2109                  | 2876 – 10187  | 4470 ± 2113     | 2876 – 10187  | 5395 ± 2105               | 3658 – 9760   |
| <b>Trunk LM (g)</b>                | 29413 ± 5965                 | 22125 – 42985 | 33748 ± 4800    | 27461 – 42985 | 24645 ± 2291 <sup>a</sup> | 22125 – 28905 |
| <b>Legs BMC (g)</b>                | 1023 ± 187                   | 781 – 1370    | 1175 ± 112      | 1010 – 1370   | 854 ± 61 <sup>a</sup>     | 781 – 966     |
| <b>Legs FM (g)</b>                 | 5565 ± 1974                  | 2316 – 9279   | 4279 ± 1522     | 2316 – 7583   | 6981 ± 1355 <sup>a</sup>  | 5258 – 9279   |
| <b>Legs LM (g)</b>                 | 19888 ± 4301                 | 13730 – 28072 | 23414 ± 2496    | 20352 – 28072 | 16009 ± 1506 <sup>a</sup> | 13730 – 18799 |
| <b>WB BMC (g)</b>                  | 2856 ± 476                   | 2189 – 3804   | 3216 ± 327      | 2841 – 3804   | 2460 ± 227 <sup>a</sup>   | 2189 – 2803   |
| <b>WB FM (g)</b>                   | 12891 ± 4333                 | 7768 – 22070  | 11115 ± 4152    | 7768 – 21988  | 14846 ± 3804 <sup>a</sup> | 11212 – 22070 |
| <b>WB FM (%)</b>                   | 17.6 ± 6.6                   | 9.3 – 31.5    | 13.2 ± 4.6      | 9.3 – 24.9    | 22.4 ± 4.8 <sup>a</sup>   | 17.0 – 31.5   |
| <b>WB LM (g)</b>                   | 59954 ± 12878                | 43660 – 87839 | 70081 ± 8886    | 59301 – 87839 | 48814 ± 4191 <sup>a</sup> | 43660 – 56101 |
| <b>Android FM (g)</b>              | 785 ± 410                    | 457 – 1962    | 771 ± 463       | 457 – 1962    | 801 ± 366                 | 485 – 1538    |
| <b>Android FM (%)</b>              | 16.0 ± 6.9                   | 9.5 – 33.4    | 13.8 ± 6.5      | 9.5 – 30.0    | 18.4 ± 6.9 <sup>a</sup>   | 13.3 – 33.4   |
| <b>Android FFM (g)</b>             | 4808 ± 777                   | 3073 – 5529   | 4642 ± 574      | 3953 – 5529   | 3463 ± 407 <sup>a</sup>   | 3073 – 4253   |
| <b>Gynoid FM (g)</b>               | 2654 ± 969                   | 1202 – 4789   | 2033 ± 673      | 1202 – 3588   | 3336 ± 772 <sup>a</sup>   | 2446 – 4789   |
| <b>Gynoid FM (%)</b>               | 21.4 ± 8.3                   | 9.8 – 36.3    | 14.9 ± 4.6      | 9.8 – 24.8    | 28.6 ± 4.6 <sup>a</sup>   | 23.2 – 36.3   |
| <b>Gynoid FFM (g)</b>              | 10053 ± 2081                 | 7109 – 14428  | 11692 ± 1428    | 10285 – 14428 | 8251 ± 684 <sup>a</sup>   | 7109 – 9664   |
| <b>VAT FM (g)</b>                  | 200 ± 84                     | 89 – 485      | 252 ± 81        | 174 – 485     | 143 ± 37 <sup>a</sup>     | 89 – 194      |
| <b>VAT Volume (cm<sup>3</sup>)</b> | 216 ± 91                     | 96 – 525      | 273 ± 88        | 188 – 525     | 154 ± 39 <sup>a</sup>     | 96 – 210      |
| <b>VAT Area (cm<sup>2</sup>)</b>   | 42 ± 17                      | 18 – 101      | 51 ± 17         | 36 – 101      | 30 ± 8 <sup>a</sup>       | 18 – 40       |

<sup>a</sup> 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 ( $\pm$  standard deviation) between same-day scans (technical error) and consecutive-day scans (technical error and biological variation).**

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

Data presented mean  $\pm$  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.

<sup>a</sup> Significant difference (<0.05) between same-day and consecutive-day differences in all participants

<sup>b</sup> Significant difference (<0.05) between same-day and consecutive-day differences in males

<sup>c</sup> Significant difference (<0.05) between same-day and consecutive-day differences in females

<sup>d</sup> Significant difference (<0.05) between males and females in the differences in same-day measures

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

BMI = body mass index (kg/m<sup>2</sup>); 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).







