

1 **In-vivo precision of the GE Lunar iDXA for the measurement of visceral adipose tissue in**
2 **adults: the influence of body mass index**

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4 Running title: Precision of the iDXA for the measurement of visceral fat

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6 Michelle Grace Mellis¹, Brian Oldroyd², Karen Hind¹

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8 ¹ Carnegie Faculty, Leeds Metropolitan University, Headingley Campus, Leeds, LS6 3QT, UK.

9 ² Division of Medical Physics, University of Leeds, UK.

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11 Corresponding author: Dr Michelle Mellis, Fairfax Hall 112, Leeds Metropolitan University, Headingley

12 Campus, Leeds, LS6 3QS. Tel: 0113 812 4010 Email: m.mellis@leedsmet.ac.uk

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15 **Abstract**

16 CoreScan is a new software for the GE Lunar iDXA, which provides a quantification of visceral
17 adipose tissue (VAT). The objective of this study was to determine the in-vivo precision of CoreScan
18 for the measurement of VAT mass in a heterogeneous group of adults. 45 adults were recruited for
19 this study (age 34.6 (8.6) years), ranging widely in body mass index (BMI 26.0 (5.2) kg.m⁻² (16.7 –
20 42.4 kg.m⁻²). Each participant received two consecutive total body scans with re-positioning. The
21 sample was divided into two sub-groups based on BMI, normal and overweight/obese, for precision
22 analyses. Sub-group analyses revealed precision (RMS-SD:%CV) for VAT mass were 20.9g:17.0% in
23 normal and 43.7g:5.4% in overweight/obese groups. Our findings indicate that the precision error for
24 VAT mass increases with increasing BMI but caution should be used with %CV derived precision
25 error in normal BMI subjects.

26

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28 **KEY WORDS:** DXA; reproducibility; visceral fat; body composition

29 **Introduction**

30 Clinical investigations have demonstrated close relationships between regional fat mass and disease
31 risk, mainly the association of trunk fat with the clustering of cardio-metabolic risk factors associated
32 with metabolic syndrome (1). Abdominal obesity is also an independent predictor of all-cause
33 mortality (2). Computed tomography (CT) is the gold standard assessment of visceral adipose tissue
34 (VAT) but it is expensive and the high radiation exposure suggests the risks would outweigh the
35 benefits if used as a screening tool. Dual-energy X-ray absorptiometry (DXA) provides a precise
36 measurement of three compartment body composition (3). GE have recently introduced CoreScan; a
37 new tool for the quantification of VAT, which has been validated with CT in healthy men and women
38 (4). The advantages of using DXA over CT include the lower radiation exposure and greater time
39 efficiency.

40

41 It is important to determine in-vivo precision of all DXA measurements for interpretation of results
42 and patient monitoring. The purpose of this study was to ascertain the short term in-vivo precision of
43 the GE Lunar iDXA CoreScan software for the measurement of VAT mass in normal, overweight and
44 obese adults.

45

46 **Materials/Subjects and Methods**

47 Forty five men (n=10) and women (n=35) received two consecutive total body DXA scans with re-
48 positioning, after providing signed informed consent to participate in the study approved by the
49 Institution's Research Ethics Committee and in accordance with the Declaration of Helsinki.

50

51 Participants were measured wearing light weight clothing and all jewellery was removed. Height was
52 determined with a stadiometer (SECA, Birmingham, UK) to the nearest 0.1cm, and body weight was
53 recorded by calibrated electronic scales (SECA, Birmingham, UK) to the nearest 0.1kg. BMI was
54 calculated as body mass in kilograms/ height in metres squared. Scans were conducted on a fan-beam
55 GE Lunar iDXA using standard (153mm/sec) or thick (80mm/sec) mode depending on body stature.
56 Participants were placed in the supine position on the scanning table with the body aligned with the

57 central horizontal axis. Arms were positioned parallel to, but not touching the body. Forearms were
58 pronated with hands flat on the bed. Legs were fully extended and feet were secured with a canvas
59 and Velcro support to avoid foot movement during the scan acquisition. Each participant was re-
60 positioned between scans, after dismounting the scanning table. One skilled technologist led and
61 analysed all scans following the manufacturer's guidelines for patient positioning. Identical scanning
62 parameters were used for each scan. The regions of interest for the total body cut-offs were manually
63 adjusted according to the manufacturer's instructions. The ROI over the android region for the
64 assessment of VAT was automated by the software. Scan analyses were performed using the Lunar
65 Encore software (Version 15). The machine's calibration was checked and passed on a daily basis
66 using the GE Lunar calibration hydroxyapatite and epoxy resin phantom. There was no significant
67 drift in calibration for the study period.

68

69 **Statistics**

70 Data analysis was computed using Microsoft Excel 2010 and IBM SPSS Statistics software (Version
71 21). Participant descriptive data are reported as the mean and standard deviation (SD). The precision
72 error is represented as the square root of the mean of the sum of the squares of differences between
73 measurement 1 and measurement 2. The precision parameters, the root-mean-square standard
74 deviation (RMS-SD), %CV (RMS-%CV), intra-class correlation coefficient (ICC) and the resulting
75 least significant changes (LSC) were calculated manually. The %CV is derived from the equation:

$$76 \quad \%CV = (SD/\text{mean value}) * 100.$$

77 Bland Altman analysis was used to compare the paired measurements (5).

78

79 **Results and Discussion**

80 According to the World Health Organisation BMI guidelines, 4% participants were underweight
81 (n=2), 47% were classified as normal weight (n=21), 29% were overweight (n=13) and 20% obese
82 (n=9). For analysis, the underweight and normal weight category were combined to form the 'normal
83 weight group' (BMI = 22.1 (2.2) kg.m⁻²; Age = 33.2 (8.6); n=20 female; n=3 male) with a range of

84 16.7-24.9 kg.m⁻²; and the overweight and obese weight categories were combined to form a group
85 (BMI = 30.0 (4.4) kg.m⁻²; Age = 35.9 (9.0); n=15 female; n=7 male) with a rang of 25.5-42.4 kg.m⁻².

86

87 The overweight/obese group had greater VAT mass (mean of two measurements - normal
88 : 123 (104)g; overweight/obese: 806.5 (564)g. Figure 1a and 1b illustrate Bland Altman VAT mass
89 analysis for the two groups. For the normal BMI groups, mean of the differences = -2.3 ± 30.2 with
90 limits of agreement -62.3g to 57.7g. For the overweight/obese group mean of the differences = $15.9 \pm$
91 61.1g with limits of agreement -106g to 138g was observed. Although the mean of the differences
92 were small the range of inter-measurement differences increased with BMI. No magnitude effects
93 were observed from Bland Altman analysis.

94

95 Table 1 shows the VAT mass precision and LSC at 95%CI for both groups and precision values
96 determined from previous studies. For RMS-SD precision values, the normal BMI groups have a
97 lower precision error: 20.9g but increased precision error with %CV: 17.0, compared to the
98 overweight/obese group, 43.7g and 5.4% respectively. This is due to %CV being dependant on its
99 inverse relationship with the mean value and in this study mean values of the two groups are different:
100 123g - 806g, resulting in the observed differences in %CV. Therefore the 95%CI derived from RMS-
101 SD is the more reliable estimate. Our precision estimates for the overweight/obese group are in close
102 agreement with the obese group precision values determined by Rothery et al (6). In the study of
103 severely obese subjects by Carver et al (7) there is an marked increased in the RMS-SD precision
104 error but only a small increase in the %CV precision error compared to the obese subjects due to the
105 higher VAT mass mean value in the severely obese group.

106

107 We investigated precision error of the GE CoreScan VAT software in a heterogeneous sample of
108 adults. This sample was representative of the usual research participants who attend our DXA centre.
109 Using RMS-SD there was a small increase in the imprecision error with BMI in our study groups
110 (20.9g compared to 43.7g). The RMS-SD and %CV precision values for the overweight/obese are
111 similar to those reported by Rothney et al (6) due to the similar mean VAT masses. Our findings

112 differ to those of Carver et al (7) who reported a RMS-SD precision for a severely obese group of
113 294g. A limitation of the study is that the effect of gender could not be investigated due to the low
114 numbers of males. It should therefore provide a valuable avenue for future research.

115

116 We, and others, have previously reported excellent in vivo precision for iDXA measurements of total
117 fat mass and total lean mass, regardless of BMI (3, 8). As suggested elsewhere, the visceral region is
118 relatively small and the mathematical complexities to distinguish VAT from subcutaneous fat may
119 lead to greater precision error (6). In conclusion, iDXA CoreScan provides good precision for VAT
120 measurements for individuals with a BMI between 25.5 – 42.4 kg.m⁻², This study and comparisons
121 with previous studies also highlights that the %CV value for precision should not be used when study
122 population mean values differ as observed in this study.

123

124 **References**

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146

147 **Table Legends**

148 Table 1: Precision comparison between two separate measurements of VAT mass.

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150 **Figure Legends**

151

152 Figure 1: Bland-Altman plot between two measurements of VAT mass in the a) normal BMI group
153 and b) the overweight and obese group

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155

156 **Table 1**

BMI Classification	n	BMI (kg/m ²)	Vat Mass (g)	RMS-SD(g)		%CV	
					LSC(95% CI)		LSC(95% CI)
Normal*	23 (20f/3m)	22.1(2.2)	123	20.9	59.1	17.0	48.1
Overweight/Obese*	22 (15f /7m)	30.0(4.4)	806	43.7	123.6	5.4	15.3
Obese (6)	32f	35.1(3.1)	1110	56.8	160.7	5.1	14.4
Severely Obese (7)	55(36f/19m)	49.0(6.0)	3250	294.0	832.0	8.7	24.9

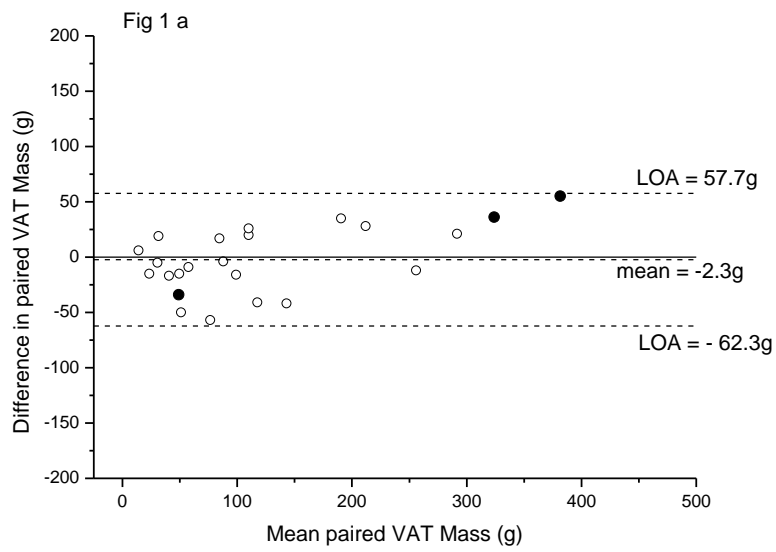
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**Mellis et al (2014) - current study results*

KEY: RMS-SD - Root Mean Square of the Successive Differences; CV - Coefficient of Variation; LSC 95% CI - Least Significant Change at 95% Confidence Intervals

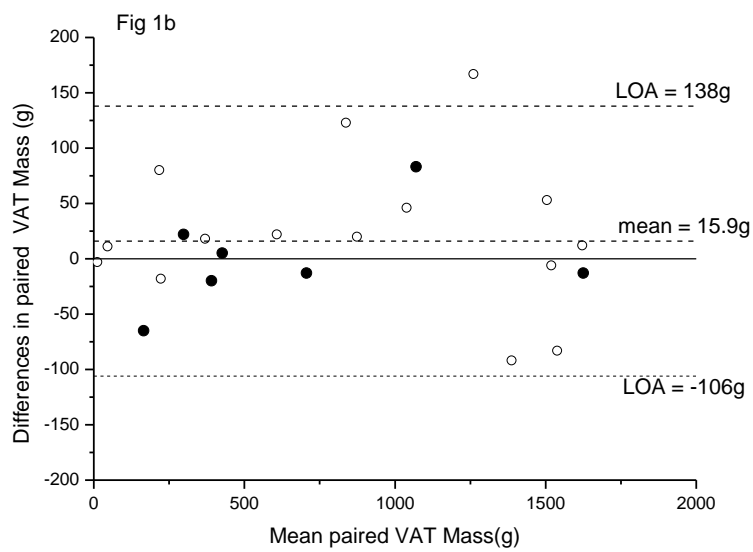
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