Abdominal adipose tissue distribution: regional differences

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Introduction. Evidence suggests that abdominal adipose tissue (AT) excess conveys increased health risk. MRI has been applied extensively for assessing AT content in human subjects, in particular, abdominal subcutaneous (SAT) and visceral AT (VAT). Regional AT distribution differences have been reported in men (1) and obese women (2). However, no study has been reported to assess the relationships between AT distribution with other important metabolic risk factors, such as intrahepatic lipid (IHL), plasma triglyceride (TG), glucose and free fatty acid (FFA) levels. Thus, this study had two objectives: 1) to evaluate the regional differences in SAT and VAT distribution in both lean (NO) and overweight/obese (OB) subjects, and 2) to assess the relationships between SAT and VAT from different regions and other metabolic risk factors.

Methods. Subjects: 58 non-diabetic subjects (14M/44F: NO=9M/17F with BMI ≤ 26 kg/m^2 and OB=5M/27F with BMI > 26 kg/m^2) were studied. MR Methods: All MR measurements were performed using a 1.5 T GE Signa MR scanner and were described elsewhere (3). In brief, T1-wt transaxial images covering from the diaphragm to the pelvic floor were acquired using a spin-echo sequences (TR/TE=400/14 ms, slice thickness=6 mm, gap=4 mm) with respiratory gating. SAT and VAT images were analyzed separately using a "threshold tool" in Adobe Photoshop® (3). SAT and VAT fat content from three 6-cm slabs covering 6 cm above L2-L3to L2-L3 (6-cm Up), L2-L3 to 6 cm below L2-L3 (6-cm Mid) and 6 cm to 12 cm below L2-L3 (6-cm Down) were evaluated. Intrahepatic lipid (IHL) content was obtained with water-suppressed ^{1}H MRS via a single voxel PRESS (TR/TE=4000/28 ms) with a GE body coil. Fasting plasma FFA, TG, and glucose concentrations were also measured.

Table 1. Subject Characteristics (mean ± SD)

Variables	NO + OB	NO	OB
Age, yr[a]	45.8±13.6	38.2±13.3	52.1±10.2
Wt, kg[a]	77.4±13.9	66.1±8.3	85.6±11.1
BMI, kg/m^2 [a]	27.7±5.2	23.0±1.8	31.5±3.7
Male/Female	14/44	9/17	5/27
SAT, kg			
6-cm Up [a]	0.78±0.43†‡	0.46±0.19†‡	1.05±0.38†‡
6-cm Mid [a]	1.07±0.52*‡	0.65±0.26*‡	1.41±0.42*‡
6-cm Down [a]	1.41±0.72*†	0.82±0.34*†	1.90±0.56*†
VAT, kg			
6-cm Up [a]	0.36±0.26	0.18±0.10	0.52±0.25
6-cm Mid [a]	0.36±0.26	0.18±0.10	0.51±0.25
6-cm Down [a]	0.34±0.18	0.21±0.09*†	0.45±0.17*†
IHL, mmol/kg wet wt[a]	36.4±34.4	22.4±22.9	48.5±38.2
FFA-b, mM	0.59±0.22	0.55±0.26	0.62±0.17
TG-b, mg/dl [a]	71.4±38.2	58.4±25.7	80.4±43.0
Glucose-b, mg/dl[a]	99.7±10.1	95.1±6.9	103.0±10.8

[a] p<.05: NO vs. OB; p<.05: *vs. 6-cm Up, † vs. 6-cm Mid, ‡ vs. 6-cm Down.

Results. 1) ***AT distribution***: SAT from 3 different regions, i.e., Up, Mid and Down, correlated strongly (data not shown). Similar correlations were also observed on VAT from the 3 regions. Taking the group as a whole, SAT in the 6-cm Down region exhibited highest fat content, followed by 6-cm Mid and then 6-cm Up regions (p<.001, Table 1). However, VATs from the 3 regions in the whole group were not different. When subjects were separated into two groups of lean (NO) and overweight/obese individuals (OB), similar trends for both groups were observed for SAT distribution as the whole group. Nevertheless, different VAT distributions were observed in NO and OB groups. In NO group, VAT at 6-cm Down region had significantly higher amount of fat content than 6-cm Up and 6-cm Mid regions (p<.05, Table 1). In contrast, the OB group had the least amount of VAT in 6-cm Down region compared to 6-cm Up and 6-cm Mid regions (p<.05). 2) ***Correlations with other metabolic variables***: Taking the entire group into consideration, IHL contents and fasting glucose levels were correlated similarly with SAT and VAT from 3 different regions, i.e., 6-cm Up, Mid and Down (Table 2). TG levels also exhibited similar correlations with VAT from 3 different regions. However, the correlations were different when NO and OB groups were analyzed separately. In the NO group, IHLs only correlated with SAT from 6-cm Down region, not with the other two regions. There was no significant correlation with VAT. On the other hand, IHLs of OB group correlated similarly with VAT from Up and Mid regions, but not with SAT. Fasting TG levels in NO group showed significant correlation with SAT from 6-cm Up and 6-cm Mid regions, but not with 6-cm Down region. TG levels in OB group, however, had no correlation with SAT in any of the 3 regions. Fasting glucose levels in NO group correlated with VAT from 6-cm Up region, not 2 other regions. Fasting plasma FFA levels in NO group had no correlation with either SAT or VAT. But it correlated significantly with SAT from 6-cm Up region in OB group.

Table 2. Pearson Correlations Between SAT or VAT and IHL and Metabolic Variables

	IHL			FFA-b			TG-b			Glucose		
	NO+OB	NO	OB	NO+OB	NO	OB	NO+OB	NO	OB	NO+OB	NO	OB
SAT												
6-cm Up	.46‡	.27	.30	.23	-.28	.42*	.23	.61†	-.06	.38†	.41	.12
6-cm Mid	.44‡	.37	.21	.17	-.32	.33	.21	.52†	-.14	.37†	.40	.05
6-cm Down	.40†	.45*	.10	.18	-.30	.33	.19	.39	-.13	.36*	.20	.08
VAT												
6-cm Up	.46‡	.05	.37	.12	-.25	.08	.35*	.40	.23	.30*	.56†	.01
6-cm Mid	.54‡	.03	.49†	.16	-.18	.17	.34*	.25	.23	.36†	.34	.15
6-cm Down	.53‡	.11	.48†	.14	-.25	.21	.34*	.33	.19	.43†	.36	.24

*p<.05, † p<.01, ‡ p<.001

Discussion and Conclusion. Both lean and overweight/obese subjects store more SAT in lower than mid/upper abdomen. However, lean subjects have a higher amount of VAT while overweight/obese subjects have less VAT in the lower abdomen compared to upper and middle regions. Further studies need to be done to understand if SAT and VAT regional distribution differences would be associated with the fat depot in liver (IHL) and insulin resistance. The relationships between SAT or VAT from different regions in the two groups of subjects with IHL, TG and glucose, etc are also different. Thus analysis of data from segmented abdominal regions may not always provide an accurate reflection of relationships between AT depot and metabolic variables.

Reference. 1. Abate N et al. Am J Clin Nutr 65:403-8, 1997. 2. Ross R. et al. Am J Clin Nutr 57:470-5, 1993. 3. Hwang J-H et al. Am J Physiol Endocrinol Metab 293: E1663-E1669, 2007.