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Association between dietary fat intake and MRI-determined visceral, subcutaneous, or hepatic fat in men and women from the general population

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Introduction

Increasing dietary fat intake - at the expense of dietary carbohydrate intake - may play an important role in the accumulation of adipose tissue at different sites and liver fat accumulation. Thus, the present study investigated the isocaloric substitution of dietary carbohydrates with fat, and its cross-sectional association with visceral adipose tissue (VAT), subcutaneous adipose tissue (SAT), and hepatic fat content as determined by MRI.

Subjects and Methods

Study Population

Data from 283 participants (mean age 56.1 ± 9.0 years) of the German population-based KORA FF4 study (2013/2014) study who underwent whole-body MRI were included (Table 1).

Methods

- VAT, SAT, and total body fat were quantified by a volume-interpolated VIBE-T1w-Dixon MR sequence. Hepatic fat content was determined as the proton density fat-fraction (PDFF) derived from multiecho-T1w MR sequence (Figure 1).
- Habitual dietary intake was estimated by combining the information from repeated 24-h food lists and a food frequency questionnaire (*Mitry et al., Front. Nutr. 6:145, 2019*)
- Cross-sectional associations were analyzed using linear regression models, substituting carbohydrates by total fat or fat subgroups.

Table 2: Results of the substitution models, replacing carbohydrates (5 E%) with isocaloric amounts of fat or fat subgroups

	VAT			SAT			Hepatic		
	ß	95%-CI	p-value	ß	95%-CI	p-value	ß	95%-CI	p-value
Fat	0.42	[0.04, 0.79]	**0.031**	0.15	[-0.47, 0.76]	0.642	1.23	[1.07, 1.42]	**0.004**
Fat*	0.63	[0.21, 1.05]	**0.003**	0.19	[-0.52, 0.91]	0.595	1.20	[1.01, 1.42]	**0.034**
SFA	-0.04	[-0.95, 0.86]	0.924	-1.65	[-3.11, 0.19]	**0.027**	1.30	[0.92, 1.80]	0.138
SFA*	-0.00	[-0.99, 0.98]	0.998	-1.34	[-3.02, 0.33]	0.115	1.26	[0.85, 1.88]	0.247
MUFA	0.98	[-0.32, 2.27]	0.138	2.58	[0.49, 4.68]	**0.016**	1.23	[0.76, 1.99]	0.399
MUFA*	1.89	[0.36, 3.42]	**0.016**	2.58	[-0.03, 5.19]	0.052	1.14	[0.61, 2.12]	0.680
PUFA	0.13	[-2.00, 2.26]	0.905	-1.81	[-5.25, 1.63]	0.302	1.01	[0.45, 2.25]	0.979
PUFA*	-1.12	[-3.69, 1.44]	0.388	-2.22	[-6.58, 2.14]	0.317	1.09	[0.39, 3.06]	0.859

Substitution models contained total energy intake, protein intake, alcohol intake and fat (subtype) intake and were additionally adjusted for age, sex and glycemic status. In the analysis of fat subtypes (SFA, MUFA and PUFA), adjustments were made for the other fat subtypes; * Normo-glycemic subjects only

Conclusions

In middle-aged adults, substitution of carbohydrates with total fat was associated with a higher volume of VAT and an increase of hepatic fat, while whole-grain associated carbohydrates show inverse associations. If reproduced in prospective studies, such findings would strongly argue for limiting dietary fat intake.

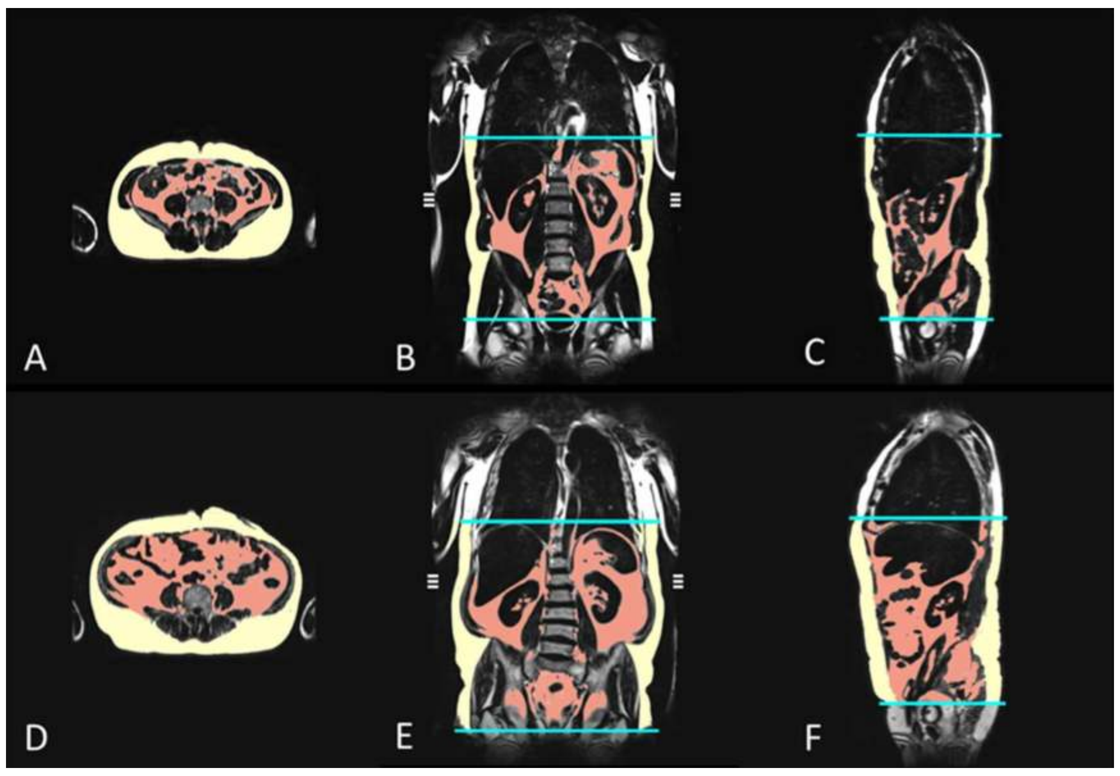

Figure 1: MRI-based assessment of adipose tissue depots in a 42-year-old male control (a–c); VAT_{volume} 2.8 l, SAT_{volume} 5.8 l, VAT_{area} 89.8 cm^2, SAT_{area} 259.4 cm^2) and an obese, 57-year-old male with prediabetes (d–f); VAT_{volume} 9.1 l, SAT_{volume} 10.8 l, VAT_{area} 302.3 cm^2, SAT_{area} 332.2 cm^2). The volumes of the different adipose tissue depots were measured automatically from the diaphragm to the femoral head by employing an in-house algorithm (b–c and e–f). VAT_{area} and SAT_{area} are derived from a single slice on the level of the umbilicus (a, d). (*red area* = VAT; *yellow area* = SAT). SAT, subcutaneous adipose tissue; VAT, visceral adipose tissue.

Results

Carbohydrate intake (in % of total energy intake (E%)) correlated significantly inversely with VAT (r=-0.34) and hepatic fat (r=-0,30), while fat intake (E%) correlated positively with hepatic fat content (r=0.16). Replacing total carbohydrates with an isocaloric amount of total fat was significantly positively associated with VAT and hepatic fat, while there was no significant association with SAT. The multivariable adjusted β-coefficient for replacing 5 E% carbohydrates with total fat was 0.42 (95% CI: 0.04, 0.79) for VAT. An increase in total fat intake by 5% of total energy was associated with an increase in liver fat content by 23% (Table 2). Dietary fiber intake was inversely associated with VAT and hepatic lipid content.

Table 1: Subject characteristics

	Men	Women
	(N = 161)	(N = 122)
Age, years	56.1 ± 9.4	56.1 ± 8.6
BMI, kg/m²	27.9 ± 4.1	27.0 ± 5.2
Waist circumference, cm	102.2 ± 11.7	90.2 ± 13.3
Carbohydrates, % en	41.3 ± 4.3	42.5 ± 3.5
Fat, % en	37.3 ± 3.5	38.7 ± 3.3
SFA, % en	16.8 ± 1.8	17.6 ± 1.8
MUFA, % en	13.4 ± 1.5	13.5 ± 1.4
PUFA, % en	4.8 ± 0.8	5.0 ± 0.7
Protein, % en	14.8 ± 1.5	15.8 ± 1.7
Alcohol, % en	5.9 ± 3.7	2.2 ± 2.3
Total energy intake, kcal/d	2062 ± 352	1555 ± 295
VAT, Visceral adipose tissue, l	5.5 ± 2.6	2.8 ± 2.1
SAT, subcutaneous adipose tissue, l	7.3 ± 3.1	8.7 ± 3.9
Hepatic fat, PDFF, %		
(median[1st quartile, 3rd quartile])	6.6 [3.7, 12.8]	3.0 [1.9, 5.4]

(% en, % of total energy intake;
Values are arithmetic means and standard deviation, unless otherwise indicated.)

Reference:
Meisinger C, Rospleszcz S, Wintermeyer E, Lorbeer R, Thorand B, Bamberg F, Peters A, Schlett CL, Linseisen J. Isocaloric Substitution of Dietary Carbohydrate Intake with Fat Intake and MRI-Determined Total Volumes of Visceral, Subcutaneous and Hepatic Fat Content in Middle-Aged Adults. Nutrients. 2019 May 23;11(5)