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Effects of dietary medium-chain triglyceride on weight loss and insulin sensitivity in a group of moderately overweight free-living type 2 diabetic Chinese subjects

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Abstract

Prior studies of medium-chain triglyceride (MCT) suggest that MCT might be a useful tool for body fat mass management in obese nondiabetic humans. We now report a pilot study that tests if MCT is beneficial for moderately overweight subjects with type 2 diabetes mellitus. The study was conducted in a group of 40 free-living subjects in an urban area of China. The subjects were randomized into 2 test groups, with one given MCT and the other corn oil as control for long-chain triglycerides (LCTs). The test oil (18 g/d) was administered as part of daily food intake for 90 days. All subjects completed the study with self-reported full compliance. Body weight, waist circumference (WC), and serum samples were analyzed on days 0, 45, and 90. The MCT group showed an across-time reduction in body weight and WC, an increase in serum C-peptide concentration, a reduction in homeostasis model assessment of insulin resistance, and a decrease in serum cholesterol concentration ($P < .05$, repeated measures). No significant across-time difference for the above parameters was detected for the LCT group. These changes were associated with an involuntary reduction in energy intake in the MCT group ($P < .05$, repeated measures). A between-group comparison also shows reduced body weight, WC, and homeostasis model assessment of insulin resistance in the MCT group compared with the LCT group at the end of the study. Collectively, our results suggest a link between moderate consumption of MCT and improved risk factors in moderately overweight humans in a low-cost, free-living setting.

1. Introduction

Dietary medium-chain triglyceride (MCT) has been shown to induce fat loss in animals and humans [1-11] and reduces spontaneous energy intake [12,13]. Many of these prior studies used high doses of MCT (80 g/d). Recent studies indicate that moderate doses of MCT (5-10 g/d) also increase postprandial energy expenditure and reduce body fat mass [3,7,14]. The effect of long-term dietary MCT on insulin sensitivity remains not well established and warrants testing. A second concern regarding the use of MCT is related to controversial reports of its effect on blood triglycerides and cholesterol [15-19,3,20]. Nevertheless, few studies, especially long-term studies, have been conducted using MCT in free-living human subjects [3,7,21]. In this work, we conduct a pilot study to test how MCT affects body weight (BW), insulin sensitivity, and serum lipid profile when administered at a moderate dosage to free-living moderately overweight (type 2) diabetic urban residents in China.

2. Methods

2.1. Subjects

Forty subjects (8 males and 32 females) were recruited from 2 urban hospitals' outpatient departments, using the

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following criteria: (1) 5 to 10 years of type 2 diabetes mellitus; (2) ages 45 to 65 years; (3) stable BW over the last 3 months; (4) currently not using insulin; (5) regular dietary habits, rarely eat outside the home; (6) no cardiovascular, gastric, kidney, or other systemic disease, and normal thyroid function; (7) no hypertension; and (8) residents of an urban area of Guangzhou, the largest city in South China. Type 2 diabetes mellitus was diagnosed by 1 of the 3 criteria documented by World Health Organization in 1980 and modified by the American Diabetes Association in 1997 as follows: (i) random blood glucose of 200 mg/dL or greater with diabetic syndrome; (ii) fasting plasma glucose of greater than 126 mg/dL on 2 consecutive days; (iii) 2 hours postprandial plasma glucose of 200 mg/dL or greater tested by oral glucose tolerance test, after a one-time oral intake of 75 g glucose on 2 consecutive days. This study was approved by the Committee for Safe and Ethical Study of Humans of the Sun Yat-Sen University (Guangzhou, China).

2.2. Medication

At the time of recruitment, selected subjects were routinely taking prescription drugs (sulfonylureas, biguanides, or α-glucosidase inhibitors) for disease management (Appendix 1). Medication was maintained throughout the 90-day trial period.

2.3. Materials

Medium-chain triglyceride oil was purchased from Life Enhancement (Los Angeles, CA) and corn oil (long-chain triglyceride [LCT] control) from a local market. The fatty acid composition of MCT analyzed by gas-liquid chromatography was reported previously [8].

2.4. Dietary intervention

Subjects were randomized into 2 test groups with matching medication conditions, age, sex, and initial BW (Appendix 1). The subjects were not informed of the nature of the oil but were instructed not to heat up the oil before consumption. Each subject consumed 18 g/d of test oil to replace part of the daily cooking oil, with no additional dietary restriction. A food consumption survey was conducted for 3 days during the first week of the trial. The subjects were instructed not to change food components throughout the 90-day trial period. This concept was reenforced during each of the biweekly telephone interviews. A few subjects reported slight stomachache and diarrhea on the first 1 or 2 days, but the symptoms disappeared thereafter. All subjects completed the study with self-reported full compliance. At the end of the trial, the food survey was repeated to assess the effects of the test oil on daily energy intake. Each food item was weighed to the nearest gram and the nutrient content was calculated using the China Food Composition [22]. The energy content was computed as follows: 17 kJ protein, 17 kJ/g carbohydrate, and 39 kJ/g fat [23].

2.5. Measurements

Body weight and waist circumference (WC) were measured on days 0, 45, and 90. The WC was measured as the circumference through the middle point between the lowest abdominal costal margin and anterior superior iliac spine. This measurement was performed by the same investigator throughout the study to minimize random error. Fasting blood samples were taken at the same times for glucose, insulin, triglycerides, cholesterol, low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), apolipoprotein (apo) A, apo B, and C-peptide. Insulin sensitivity was evaluated based on fasting glucose and fasting insulin concentrations using the homeostasis model assessment of insulin resistance (HOMA-IR [24]).

2.6. Statistics

Results were presented as means ± SD. Statistics were conducted using SPSS 13.0 for Windows (SPSS, Chicago, IL). For baseline results, differences between groups were assessed using independent-samples t test. Changes of the outcomes in the same group were analyzed by repeated measures in the general linear model; and the differences between groups at the same time point were assessed using analysis of covariance (ANOVA), whereas the baseline data were regarded as covariates and Tukey post hoc test was applied. $P < .05$ is considered to be significant.

3. Results

3.1. Effects of MCT on BW and WC

For all subjects, the initial BW and WC were in the range of 44 to 94 kg and 65 to 104 cm. Subjects were randomly assigned to each test group (BW, 60 ± 11.5 and 61.7 ± 10.7 kg for MCT and LCT groups, respectively, $P = .64$; WC, 81.3 ± 9.6 and 84.6 ± 9.8 cm for MCT and LCT groups, respectively, $P = .292$). The BMI distribution for the MCT group was 14 (BMI <25), 5 (BMI >25 to <30), and 1 (BMI >30). The BMI distribution for the LCT group was 12 (BMI <25), 7 (BMI >25 to <30), and 1 (BMI > 30). Among the 20 MCT subjects, 12 showed a reduction in BW and 11 in WC on day 45. The numbers increased to 13 and 15, respectively, on day 90. One MCT subject showed a 2.5-kg gain in BW on day 45 but returned to zero gain on day 90. Another MCT subject showed a 1-kg gain in BW on day 90 (Appendix 1). Six MCT subjects did not show changes in BW or WC. The results for the LCT group were more scattered, with 10 showing an increase in BW and 12 in WC on day 45. The numbers changed to 8 and 11, respectively, on day 90. There were also 9 LCT subjects that showed a decrease in BW and 6 in WC on day 45. The number changed to 5 and 7, respectively, on day 90. The reductions of BW and WC in the LCT group were generally less compared with those found in the MCT group (Appendix 1). Interestingly, most of the

Table 1
Dietary intervention and changes in BW, WC, fasting glucose, insulin, and blood lipid profiles

Variable	MCT (n = 20)			LCT (n = 20)			*P*	
	0 d	45 d	90 d	0 d	45 d	90 d	p1	p2
BW (kg)	60.02 ± 11.48[a]	58.61 ± 10.17[b, *]	58.46 ± 10.07[b, *]	61.69 ± 10.66	62.19 ± 10.62 *	61.97 ± 10.16 *	.637	.012
WC (cm)	81.28 ± 9.55[a]	80.45 ± 7.90 *	79.45 ± 8.47[b, *]	84.55 ± 9.82	85.50 ± 9.05 *	85.90 ± 8.10 *	.292	.034
Fasting glucose (mmol/L)	8.17 ± 2.22	7.98 ± 1.51	7.77 ± 2.11	7.84 ± 1.51	7.46 ± 1.25	7.47 ± 1.28	.585	.803
Fasting insulin (mmol/L)	7.61 ± 6.61	8.05 ± 4.91	6.68 ± 4.27	10.62 ± 8.92	9.95 ± 4.60	10.32 ± 5.15	.232	.336
C-peptide (nmol/L)	0.46 ± 0.29[a]	0.52 ± 0.23	0.58 ± 0.23[b]	0.60 ± 0.27	0.59 ± 0.28	0.58 ± 0.23	.057	.219
HOMA-IR	2.71 ± 2.60	2.84 ± 2.00[a]	2.25 ± 1.61[b, *]	3.14 ± 1.54	3.33 ± 1.63	3.37 ± 1.73*	.531	.311
TG (mmol/L)	2.42 ± 1.79	2.27 ± 1.25	2.24 ± 1.14	2.33 ± 1.31	2.07 ± 0.86	2.42 ± 1.37	.851	.581
TC (mmol/L)	5.89 ± 1.20[a]	5.72 ± 0.97[a]	5.20 ± 1.02[b]	5.63 ± 1.27	5.48 ± 1.20	5.60 ± 1.32	.102	.097
LDL-C (mmol/L)	3.44 ± 0.95[a]	3.39 ± 0.74[a]	2.87 ± 0.68[b]	3.00 ± 0.87	3.00 ± 1.08	3.10 ± 0.93	.132	.018
HDL-C (mmol/L)	1.44 ± 0.29[a]	1.39 ± 0.28[a]	1.21 ± 0.26[b]	1.24 ± 0.47	1.41 ± 0.37	1.35 ± 0.38	.118	.002
Apo A (mmol/L)	1.29 ± 0.17	1.23 ± 0.15	1.24 ± 0.17	1.24 ± 0.22	1.24 ± 0.18	1.28 ± 0.22	.436	.237
Apo B (mmol/L)	1.12 ± 0.24	1.10 ± 0.21	1.03 ± 0.22	1.04 ± 0.41	0.97 ± 0.32	0.97 ± 0.28	.443	.499

TC indicates total cholesterol; TG, triglyceride; HOMA, homeostatic model assessment; a≠b, within-group comparison ($P < .05$, repeated measures); p1, *P* value of comparison of baseline data between groups (independent-samples *t* test); p2, *P* value of interaction between time and group (repeated measures).

* $P < .05$ (ANOVA); same time point between-group comparison.

subjects with an initial BMI of greater than 25 showed reduced BW after MCT diet, whereas those with lower initial BMI seemed to be less responsive (Appendix 1). Overall, the MCT subjects showed a significant decrease in BW and WC across time ($P < .05$, repeated measures; Table 1), whereas the changes within the LCT group across time did not reach statistical significance (Table 1). Between-groups comparison shows a significantly lower BW and WC in the MCT group than in the LCT group on days 45 and 90 ($P < .05$, ANOVA; Table 1). No significant effect of medication on BW or WC was detected in either group (Appendix 1).

3.2. Effects of MCT on insulin sensitivity

As shown in Table 1, there was a trend toward decreased fasting glucose concentrations across time in both the MCT and LCT groups, but the difference did not reach statistical significance. Fasting insulin concentration was essentially unchanged in the LCT group. There was a trend toward decreased fasting insulin concentration on day 90 in the MCT group, but the difference did not reach statistical significance. These data were used for the calculation of HOMA-IR, a parameter that measures body insulin resistance [24]. As shown in Table 1, a decrease in HOMA-IR was found within the MCT group between days 45 and 90 ($P < .05$, repeated measures). The HOMA-IR was not different between the MCT group and the LCT group on day 45, but was lower in the MCT group on day 90 ($P < .05$, ANOVA).

We then measured blood C-peptide concentration, an indicator of insulin secretion. As shown in Table 1, there was an across-time increase in C-peptide levels in the MCT group, with an increase on day 90 compared with day 0 ($P < .05$, repeated measures). No change in C-peptide was found in the LCT group across time. There was no between-group difference in C-peptide at any time points assessed, possibly because of a lower baseline C-peptide in the MCT group than in the LCT group (0.46 ± 0.29 vs 0.60 ± 0.27; $P = .057$, independent *t* test).

3.3. Effects of MCT on blood lipid profile

As shown in Table 1, blood triglycerides did not change within each group across time or between groups at each time point. This is in agreement with previous studies [7,21]. There was a gradual decrease in total blood cholesterol in the MCT group across time, but the difference only reached

Table 2
Nutrient content of diets

Index	MCT group (n = 20)		LCT group (n = 20)		*P*	
	0 wk	12 wk	0 wk	12 wk	p1	p2
Total energy (kJ/d)	7.17 ± 1.53[a]	6.50 ± 1.42[b, *]	7.19 ± 1.44[b]	7.89 ± 2.27[a, *]	.895	.008
Fat (g)	43 ± 9	38 ± 7 *	44 ± 8[b]	56 ± 17[a, *]	.692	.006
Fat (% cal)	23.4 ± 5.2	22.8 ± 4.4 *	23.8 ± 4.1	27.6 ± 8.1 *	.351	.041
Protein (g)	76 ± 25[a]	65 ± 15[b]	73 ± 21[b]	77 ± 25[a]	.647	.040
Protein (% cal)	19.1 ± 6.1	18.0 ± 4.1	18.3 ± 5.1	17.6 ± 5.5	.323	.523
CHO (g)	235 ± 41	219 ± 50	237 ± 44	246 ± 45	.893	.102
CHO (% cal)	57.8 ± 10.0	59.3 ± 13.5	58.0 ± 10.9	54.8 ± 14.6	.347	.783
Cholesterol (mg)	343 ± 167[a]	273 ± 167[b, *]	360 ± 166	373 ± 183 *	.794	.034

CHO indicates carbohydrate; a≠b, within-group comparison ($P < .05$, repeated measures); p1, *P* value of comparison of baseline data between groups (*t* test); p2, *P* value of interaction between time and group (repeated measures).

* $P < .05$ (ANOVA); same time point between-group comparison.

statistical significance on day 90 ($P < .05$, repeated measures). Both LDL-C and HDL-C were reduced across time in the MCT group, and the difference reached statistical significance on day 90 ($P < .05$, repeated measures). The LCT group did not show significant changes in total cholesterol, LDL-C, or HDL-C levels. The between-group difference did not reach statistical significance for total cholesterol ($P = .097$, repeated measures), but did so for LDL-C ($P = .018$, repeated measures) and HDL-C ($P = .002$, repeated measures). Secretion of apo A and apo B was not significantly different for either test group across time or between groups. A detailed list of blood profile change in each individual is presented in Appendix 2.

3.4. Effects of MCT on energy intake

As stated in the Methods section, subject energy intake was measured during the first and the last weeks of the study. The results are shown in Table 2. The total energy intake was decreased in the MCT group, but increased in the LCT group, after the 90-day dietary intervention ($P < .05$, repeated measures). Interestingly, the reduction in total energy intake across time was balanced without changing the intake ratio of fat, protein, and carbohydrates in the MCT group, whereas the increase of total energy intake across time in the LCT group was accompanied with more fat and less carbohydrate but no change in protein intake. At the end point, we also detected a lower intake of total energy ($P < .05$, ANOVA) and fat-derived energy ($P < .05$, ANOVA) in the MCT group than in the LCT group. Probably related to the reduction in protein and fat intake, the MCT group also showed a reduction in cholesterol intake ($P < .05$, repeated measures; Table 2). There is a trend of increased cholesterol intake in the LCT group, but the difference did not reach statistical significance. At the end point, cholesterol intake was significantly lower in the MCT group than in the LCT group ($P < .05$, ANOVA).

4. Discussion

To the best of our knowledge, this the first human study of MCT oil in an urban Chinese population, which has a different genetic background from most of the previously studied subjects. Our results indicate that, compared with LCT, consumption of a moderate amount of MCT correlates with a spontaneous reduction in total energy intake, BW, and WC. This was found to be associated with improved insulin sensitivity evidenced by decreased HOMA-IR and increased C-peptide secretion, as well as reduced blood cholesterol concentrations, effects that may be secondary to the weight loss.

The weight reduction effect of MCT has been reported in a number of previous studies and has been attributed to increased energy expenditure and reduced food intake. To date, the effect of MCT on energy expenditure has been widely documented [3,6,11,25-27]. In contrast, the effect of MCT on satiety in humans was mostly based on a single study that compared energy intake in subjects with free access to experimental high-fat diets (61.5% of energy as fat) with different MCT contents [13]. A second study on satiety was conducted by feeding subjects with MCT at breakfast and measuring subsequent energy intake during the day [12]. These studies indicate that MCT immediately suppresses energy intake. Relatively less is known about the effects of MCT on satiety after long-term consumptions. Our results contribute to fill in this knowledge gap in this area and suggest that moderate intake of MCT might be useful for limiting spontaneous energy intake over time. The observation of a proportional reduction in fat, protein, and carbohydrates suggests that MCT has no specific effect on food choice. In contrast, LCT appears to induce a shift to a choice of foods with higher fat contents. These different satiety effects might contribute, at least in part, to the changes of BW and WC throughout the study (Table 1). It is noteworthy that our subjects had a relatively low fat content in their habitual diets (23%-24% energy derived from fat) as compared with the typical Western diets (40% energy derived from fat). The observation of an involuntary increase in fat intake in the LCT group (from 24% to 28%) suggests that voluntary increase in fat consumption might lead to a spontaneous preference for high-fat foods. This prediction, together with the rapid spread of high-fat fast foods across many developing countries, might be considered a warning for subsequent prevalence of obesity and metabolic syndrome.

It is now well recognized that moderate reduction in BW can cause significant improvement in insulin resistance [28-30]. Consistent with this, we found an association between BW loss and increased C-peptide concentration as well as reduced HOMA-IR in the MCT group. An increase in C-peptide reflects an improvement in pancreatic beta-cell function, whereas a reduction in HOMA-IR indicates an improvement of peripheral insulin sensitivity [24]. Considering that the subjects in this group all had a 5- to 10-year history of type 2 diabetes mellitus, these changes suggest that a long-term moderate supplement of dietary MCT might have a remarkable health benefit. Additional studies with a larger population are warranted to test this hypothesis and further evaluate the possible application of MCT in the dietary management of BW.

An unexpected finding from this study is the reduction in blood cholesterol in the MCT subjects (Table 1). Several previous studies show that MCT increases blood cholesterol when fed at high dosage or has no effect when fed at a low dosage, with a reduction in cholesterol only detected when MCT was fed together with plant sterols [19,31,32]. Although the exact mechanisms are not clear, we suggest that the changes found in our study might be related to the involuntary reduction in cholesterol intake resulting from reduced protein and fat consumption in the MCT subjects (Table 2) because most of the protein and fat consumed by our subjects were from animal products, which were also the

main source of dietary cholesterol. The observation that the MCT group exhibited a coherent decrease in total cholesterol, LDL-C, and HDL-C also suggests a reduction in cholesterol substrate in general rather than a specific effect on the enzymes in selected metabolic pathways. Our data, however, cannot rule out the possibility that MCT diet may interfere with the hepatic lipoprotein metabolism.

In summary, this study tested a new protocol for feeding MCT to free-living human subjects. The protocol is low-cost and easy to comply. Our study focused on a group of moderately overweight middle-aged (type 2) diabetic urban residents. This is a group of subjects commonly seen in real life today. A recent survey reveals that the risk for metabolic syndrome increases drastically in moderately overweight subjects [33]. There is also evidence that fat mass in middle age predicts physical dysfunction and metabolic risk in advanced age [34]. Therefore, a feasible and low-cost intervention to regulate BW in this subpopulation will have a substantial social and economical impact. Our results suggest that this group of subjects could benefit from long-term consumption of moderate dose of MCT in a free-living environment.

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Appendix A. Subject information: medication, BW and WC, and calculated BMI at baseline, on day 45, and on day 90 of dietary intervention

	Med	BW0	BMI0	BW45	BMI45	BW90	BMI90	BW45-0	BW90-0	WC0	WC45	WC90	WC45-0	WC90-0
MCT														
1	B	44.4	17.9	44.4	17.9	44.4	17.9	0.0	0.0	65	65	64	0	−1
2		65.9	29.7	63.9	28.8	63.9	28.8	−2.0	−2.0	94	88	87	−6.5	−7
3	B	53.9	23.7	50.5	25.3	52.4	24.6	−3.4	−1.5	78	81	76	3	−2
4		54.4	22.5	53.4	22.1	53.9	22.3	−1.0	−0.5	77	78	77	1	0
5		52.0	22.8	54.5	23.9	52.0	22.8	2.5	0.0	78	77	72	−1	−6
6	AB	58.5	26	58.5	26	58.5	26	0.0	0.0	89	85	81	−4	−8
7	A	58.9	24.2	57.5	23.63	57.0	23.42	−1.4	−1.9	84	83	83	−1.5	−1.5
8	B	93.1	35.9	85.0	32.8	84.0	32.41	−8.0	−9.1	99	93	96	−6	−3.5
9	AC	47.0	19.8	47.0	19.8	46.0	19.4	0.0	−1.0	70	70	73	0	2.5
10	B	65.1	25.1	62.5	24.1	63.0	24.3	−2.6	−2.1	80	78	78	−2	−1.5
11	AB	56.6	21.7	55.0	21.1	54.0	20.7	−1.6	−2.6	75	78	76	3	1
12	AC	50.5	20.1	47.5	18.9	49.0	19.5	−3.0	−1.5	71	69	70	−1.5	−0.5
13	AB	64.1	25.2	60.5	23.78	61.0	23.98	−3.6	−3.1	83	81	81	−1.5	−1.5
14	BC	69.0	26.8	67.0	26.01	65.0	25.23	−2.0	−4.1	85	84	82	−1.5	−3
15	A	82.5	29.76	81.0	29.22	81.5	29.4	−1.5	−1.0	101	98	100	−3	−1.5
16		55.0	22.89	54.0	22.48	53.0	22.06	−1.0	−2.0	76	80	75	4	−1.5
17	AB	61.0	23.68	61.0	23.68	62.0	24.07	0.0	1.0	83	83	84	0.5	1
18	BC	60.0	23.88	60.0	23.88	60.0	23.88	0.0	0.0	90	88	88	−2.5	−2
19	AB	55.0	16.71	55.0	18.38	55.0	18.38	0.0	0.0	72	72	73	0	1
20		53.5	23.74	54.0	24.65	53.5	24.42	0.5	0.0	78	81	77	3	−1.5
LCT														
1	B	61.5	27.5	61.0	27.3	60.6	27.1	−0.4	−0.9	85	90	91	5.5	6.5
2	C	66.0	25.3	67.0	25.7	66.0	25.3	1.0	0.0	86	87	86	1	−0.5
3	AB	69.1	28.4	69.6	28.6	67.9	27.9	0.5	−1.2	97	95	93	−2	−4
4	B	64.9	26	65.9	26.4	64.9	26	1.0	0.0	95	94	90	−1	−5
5	AB	62.6	24.3	61.6	23.9	60.0	23.3	−1.0	−2.6	85	86	81	0.5	−4
6	AB	58.6	25.2	60.0	25.8	59.5	25.6	1.4	0.9	83	87	87	3.5	4
7	BC	59.9	23.4	63.0	24.6	64.5	25.2	3.1	4.6	78	81	84	2.5	5.5
8	A	88.0	30.1	86.6	29.6	87.1	29.8	−1.5	−0.9	104	106	104	2	0.5
9	A	80.1	28.9	82.6	29.8	80.4	29	2.5	0.3	97	97	97	0.5	0.5
10	AC	46.0	22.8	45.6	22.6	47.0	23.31	−0.4	1.0	71	71	87	0	16
11	A	55.5	21.82	55.0	21.62	55.5	21.82	−0.5	0.0	82	83	83	1	0.5
12	AB	70.1	26.7	69.0	26.3	69.5	26.48	−1.1	−0.6	95	93	97	−2	2
13		69.0	25.5	69.5	25.7	69.0	25.5	0.5	0.0	91	88	88	−2.5	−3
14		50.4	20.2	49.4	19.8	51.0	20.43	−1.0	0.6	65	70	73	4.5	8
15	AB	58.4	24.3	57.5	23.93	56.0	23.31	−0.9	−2.4	80	81	78	1	−1.5
16		50.0	21.93	55.0	24.12	54.0	23.68	5.0	4.0	81	79	80	−2.5	−1
17		66.6	23.6	67.5	23.92	67.0	23.74	0.9	0.4	88	88	88	0	0

18	AC	47.0	19.82	46.5	19.61	47.0	19.82	−0.5	0.0	71	72	72	1	1
19		52.0	22.81	53.5	23.46	54.5	23.9	1.5	2.5	77	83	78	6	1.5
20	AB	58.0	20.8	58.0	20.8	58.0	20.8	0.0	0.0	83	83	83	0	0

A indicates sulfonylureas; B, biguanides; C, α-glucosidase inhibitor; Med, medication.

Appendix B. Subject information: plasma lipid profile for total cholesterol, triglycerides, LDL, HDL, apo A, and apo B

	TC1	TC2	TC3	TG1	TG2	TG3	LDL-C1	LDL-C2	LDL-C3	HDL-C1	HDL-C2	HDL-C3	Apo A-I	Apo A-II	Apo A-III	Apo B-I	Apo B-II	Apo B-III
MCT																		
1	4.96	5.43	4.06	0.77	0.81	1.68	2.96	3.03	3.02	1.95	2.08	0.98	1.47	1.49	1.22	0.92	0.95	1.02
2	4.46	4.77	5.65	1.79	1.34	1.49	2.63	2.98	2.48	1.44	1.28	1.1	1.44	1.17	1.15	0.92	0.99	0.92
3	5.7	6.62	5.25	1.53	1.58	2.2	3.74	4.46	2.39	1.48	1.54	0.96	1.35	1.3	1.02	1.22	1.36	0.99
4	7.61	4.88	4.84	1.51	0.98	0.92	5.29	2.54	2.58	1.81	1.89	1.7	1.38	1.47	1.37	1.47	0.87	0.86
5	5.21	6.69	6.61	2.56	1.99	1.82	2.86	4.93	2.81	1.45	1.24	0.99	1.3	1.07	1.21	0.94	1.53	1.1
6	5.53	5.5	5.64	2.81	1.77	1.75	2.46	3.59	2.05	1.45	1.33	1.32	1.22	1.17	1.29	0.94	1.06	1.26
7	6.05	6.02	5.03	1.52	1.41	1.89	3.12	3.6	2.89	0.98	1.48	1.1	0.98	1.39	1.1	1.11	1.18	1.02
8	6.9	5.85	5.98	2.37	2.56	2.78	4.47	4.02	3.82	1.13	1.02	0.96	1.15	1.02	0.96	1.52	1.28	1.34
9	7.81	6.09	7.16	1.26	1.94	1.55	5.11	3.8	4.88	1.77	1.45	1.58	1.44	1.31	1.22	1.55	1.24	1.42
10	5.17	4.44	4.98	1.5	2.94	5.06	3.26	2.08	2.26	1.25	1.19	1.14	1.2	1.2	1.2	1.06	0.89	0.91
11	7.2	5.85	5.87	2.08	2.59	2.64	4.37	3.64	3.26	1.79	1.48	1.34	1.62	1.32	1.22	1.44	1.15	1.13
12	5.11	6.02	4.71	2.01	2.36	2.12	2.97	3.68	2.63	1.37	1.32	1.17	1.25	1.18	1.05	1.01	1.26	0.86
13	4.54	4.2	4.47	1.91	1.75	1.55	2.7	2.75	2.93	1.06	0.96	1.01	1.08	0.93	0.99	0.94	0.9	0.9
14	5.26	4.95	5.06	1.35	1.72	1.9	3.07	2.78	2.72	1.76	1.65	1.83	1.58	1.37	1.47	0.95	0.93	0.85
15	5.04	5.3	5.19	2.02	1.74	1.23	3.33	3.6	3.55	1.15	1.17	1.11	1.05	1.05	1.16	1.06	0.82	1.1
16	6.4	6.47	5.83	3.67	3.22	3.1	3.64	3.74	3.05	1.55	1.45	1.28	1.31	1.14	1.31	1.21	1.17	1.16
17	6.73	7.59	3.58	8.91	5.99	2.58	2.81	2.94	2.57	1.19	1.39	1.29	1.28	1.3	1.66	1.02	1.07	1.11
18	4.06	4.53	2.69	4.27	3.77	3.05	1.59	2.13	1.84	1.09	1.00	0.96	1.25	1.09	1.41	0.67	0.84	0.61
19	5.6	5.43	5.18	0.91	0.92	0.66	3.65	3.36	3.23	1.69	1.47	1.45	1.3	1.36	1.41	1.03	0.99	0.66
20	8.36	7.7	6.18	3.64	4.07	4.91	4.81	4.13	2.36	1.37	1.31	0.99	1.08	1.26	1.29	1.42	1.48	1.38
LCT																		
1	5.12	5.01	5.09	1.84	2.4	1.99	2.95	2.54	2.77	1.37	1.27	1.21	1.32	1.36	1.3	0.97	0.93	0.97
2	6.26	5.77	4.6	2.4	2.6	2.49	2.93	2.55	2.27	0.92	1.22	1.09	1.32	1.31	1.23	1.02	0.79	0.79
3	4.48	4.84	4.09	1.96	1.33	1.57	2.5	3.21	2.72	0.98	1.1	0.83	1.02	1.1	0.92	0.99	0.91	0.78
4	4.93	4.81	6.44	1.79	2.99	2.43	2.84	2.25	3.69	1.13	1.17	1.39	1.15	1.31	1.34	0.79	0.68	1.16
5	8.43	6.33	7.91	6.97	2.59	6.58	2.29	1.14	3.29	0.76	2.2	1.43	1.21	1.02	1.47	2.38	0.99	1.29
6	7.12	5.83	6.2	3.87	2.08	2.41	4.08	3.56	3.75	0.81	1.27	1.24	1.31	1.18	1.16	1.37	1.15	1.12
7	5.5	4.68	4.93	1.82	0.97	1.68	2.09	2.9	2.68	1.1	1.48	1.82	1.41	1.21	1.52	0.82	0.82	0.74
8	4.56	5.73	6.63	2.4	1.82	3.12	2.56	3.69	4.18	1.1	1.23	1.27	1.03	1.17	1.19	0.87	1.29	1.34
9	6.72	5.14	6.12	1.64	1.56	1.68	4.46	3.48	4.23	1.12	1.15	1.45	1.36	1.1	1.3	1.25	0.98	1.16
10	5.25	8.2	7.53	2.51	2.41	3.39	3.07	5.38	4.03	0.9	1.5	1.27	1.1	1.36	1.26	0.98	1.61	1.41
11	6.17	4.58	4.44	2.2	2.18	2.63	3.23	2.56	2.49	1.1	1.6	1.33	1.21	1.31	1.18	1.1	0.74	0.73
12	5.89	5.81	6.16	1.81	1.83	2.14	3.59	3.58	3.53	1.25	1.25	1.24	1.19	1.15	1.15	1.12	1.06	1.04
13	5.03	7.1	5.92	1.99	4.44	2.57	3.03	3.71	3.45	1.09	1.25	1.42	1.1	1.26	1.28	0.99	1.32	1.14
14	6.21	5.05	4.97	1.01	0.96	1.00	2.38	1.77	1.77	2.89	2.49	2.61	1.97	1.86	1.87	0.68	0.52	0.53
15	3.9	4.18	3.6	1.37	1.33	1.09	2.09	2.36	1.94	1.23	1.39	1.19	1.1	1.1	0.98	0.63	0.68	0.55
16	6.1	5.89	5.89	2.2	1.65	2.04	4.02	3.92	3.62	1.43	1.38	1.25	1.19	1.14	1.05	1.09	1.13	1.06
17	4.81	4.59	5.32	3.25	2.88	4.94	2.21	2.07	2.2	1.17	1.17	1.05	1.13	1.11	1.39	0.77	0.83	0.93
18	5.51	4.94	5.1	1.11	1.15	0.89	3.00	2.48	2.51	1.96	1.8	1.75	1.43	1.28	1.55	0.84	0.71	0.79
19	7.59	7.86	7.83	3.19	2.87	2.72	5.01	5.12	5.11	1.43	1.28	1.00	1.28	1.32	1.27	1.6	1.71	1.39
20	3.01	3.28	3.17	1.18	1.28	0.98	1.66	1.77	1.67	1.06	0.98	1.07	0.92	1.05	1.13	0.5	0.55	0.53

TC indicates total cholesterol; TG, triglyceride.

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