Original Article

A good response to oil with medium- and long-chain fatty acids in body fat and blood lipid profiles of male hypertriglyceridemic subjects

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A double blind clinical trial was carried out to clarify the effects of oil with medium- and long-chain triglyceride (MLCT) on body fat and blood lipid profiles in hypertriglyceridemic subjects. One-hundred-and-twelve subjects were enrolled and divided into two groups; those that consumed MLCT oil and those that consumed long-chain triglyceride (LCT) oil for 8 weeks. All subjects were requested to consume 25-30 g of the oils daily and maintain a fixed level of energy intake and exercise. Anthropometric and blood biochemical parameters were measured when the study was initiated and completed. The LCT group consisted of 50 subjects (34 men and 16 women), while the MLCT group consisted of 51 subjects (33 men and 18 women) who completed the study. Larger decreases in body weight, body mass index, waist circumference, body fat, total fat area and subcutaneous fat area in the abdomen and serum triglycerides, low-density lipoprotein cholesterol, apolipoprotein B, C2, C3 and E were observed in male subjects in the MLCT group than those in the LCT group. However, no significant differences in these parameters between the female subjects in the two groups were observed. Data from this study indicate that consumption of medium-and long-chain triglycerides can reduce body weight and body fat and improve blood lipid profiles in male hypertriglyceridemic subjects.

Key Words: medium-chain fatty acids, long-chain fatty acids, hypertriglyceridemia, sex, Chinese

INTRODUCTION

Hypertriglyceridemia is well known as an independent risk factor for cardiovascular disease.[1] Since the risk of coronary heart disease (CHD) in hypertriglyceridemic populations is higher for male than for female subjects,[2] many clinical studies have focused on men, which have resulted in a significant decrease in the mortality of male patients suffering from cardiovascular diseases.[3] However, women have experienced a continuous rise with regard to death from CHD,[4] and this disease remains an unaddressed medical concern. Abnormal lipidemia is closely related to lifestyle-related diseases such as obesity and metabolic syndrome.[5] A poor diet, particularly a high intake of fat, is thought to be an important causative factor of these disorders. Control of both the amount and type of dietary fat may help prevent obesity and abnormal lipidemia. Medium-chain triglyceride (MCT) has been used therapeutically since the 1950s in the treatment of fat malabsorption, cystic fibrosis and epilepsy because of its unique structural, absorption and metabolic characteristics.[6] MCT is easily hydrolyzed in the gastrointestinal tract and the fatty acids are transported directly to the liver through the portal venous system, in contrast with long-chain fatty acids, which are incorporated into chylomicrons for transport through the lymphatic system or peripheral circulation. Medium-chain fatty acids (MCFAs) do not require carnitine to cross the double mitochondrial membrane of the hepatocyte, thus they quickly enter the mitochondria and undergo rapid β-oxidation to ketones,[7] whereas most long-chain fatty acids are packaged into triglycerides (TG) in the hepatocyte. So it is reasonable to presume that daily intake of MCT as a part of dietary fat may decrease accumulation of fat in the human body and a lower TG level in blood. Due to its lower smoke point, MCT can not be easily used as cooking oil. Recently, a new oil composed of medium- and long-chain triglyceride (MLCT) in the same glycerol molecule produced by a transesterification technique was permitted to be used as cooking oil.[8] Recent research found that MLCT

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might be useful in the control of body weight and abdominal fat accumulation in both men and women.[9] Our previous report found similar results.[10] We also found that MLCT consumption reduced body weight, body fat and blood triglyceride, and improved apolipoprotein profiles in hypertriglyceridemic subjects under the age of 60 years, but not in subjects over 60 years of age (Xue C, unpublished data). In the present study, we further investigated whether hypertriglyceridemic subjects of the different sexes respond differently to MLCT in terms of body fat and blood lipid profiles.

MATERIAL AND METHODS

Subjects and protocol

One hundred and twelve Chinese hypertriglyceridemic (1.7-5.6 mmol/L) men (n=76) and women (n=36) aged 18-65 years (53.7±12.7), were recruited from the Chinese People's Liberation Army (PLA) General Hospital. All subjects had no history of hypertension, diabetes, hepatic or renal disease. The study protocol was approved by the Human Ethical Committee of Chinese PLA General Hospital, and conformed to the provisions of the Declaration of Helsinki in 1995 (as revised in Edinburgh, 2000). Informed consent forms were signed before the study was initiated.

Subjects were randomly assigned to MLCT or long-chain triglyceride (LCT) oil. Neither the subjects nor the researchers knew the assignment of the subjects or oils until the end of the study when random codes were disclosed. Anthropometric and blood biochemical parameters were measured at the start and end of the study. Both oils were consumed for 8 weeks.

Before starting the study, all subjects were given thorough instructions on diet and exercise. Energy intake was calculated for each individual using the Harris-Benedict equation. All subjects were asked to consume 25-30 g of the oils, in the form of cooking oil, during their three daily meals using a set of specified spoons that was distributed to each subject. Oils were provided according to the amounts suggested by the Dietary guidelines released by the Chinese Nutrition Society.[11] Subjects were also advised to maintain a regular exercise pattern daily throughout the trial, including physical activities such as walking (4-5 km/h), housecleaning, babysitting, ascending stairs, and slow bike-riding (not exceeding 10 km/h). If subjects were unable to consume the specified quantities of oil or perform regular exercise for 3 days or more, they were advised to drop out.

All subjects were asked to fill out a form every day to record all foods consumed during the study. The duration of physical activity was also recorded daily. The record forms were collected every other week to confirm the diet and duration time of exercise. Daily intakes of energy, fat, protein, and carbohydrates were calculated from the daily dietary record forms, based on the China Food Composition Tables, revised in 2002 and 2004.

Oils

MLCT and LCT oil samples were provided by Nisshin Oillio Group, Ltd. The preparation of the MLCT oil was based on the method of Akoh et al.[12] The MLCT oil was prepared by transesterification of 14% (wt/wt) MCT (The Nisshin Oillio Group, Ltd. Tokyo, Japan) and 86% (wt/wt) canola oil (The Nisshin Oillio Group, Ltd.). After the transesterification, the MLCT oil was refined by the same method that was used for common edible oil. The fatty acids and TG compositions of LCT and MLCT oils were listed in Table 1.[13] Fatty acid compositions were determined by a gas-liquid chromatographic system (6890 series; Agilent Technologies, Palo Alto, CA) with a capillary column (Omegawax-320; Supelco, Bellefonte, PA), after methylation with sodium methoxide. The triglycerides compositions were determined by a gas-liquid chromatographic system (6890 series; Agilent Technologies, Palo Alto, CA) with a capillary column (DB-1HT; J&W Scientific, Folsom, CA). A 14g sample of MLCT contained 1.7 g MCFA, as determined by gas-liquid chromatographic analysis.

Position analysis of fatty acids on the glycerol backbone of MLCT oil molecules were conducted according to a method previously reported.[14] In brief, Grignard reagents (ethyl magnesium bromide) were prepared freshly and checked by regiopescific analysis of synthetic triglyceride using monoglyceride analytical intermediates. MLCT oil or 1,3-Distearoyl-2-oleoglycerol(2 mg), mixed with trinonade-canoyglycerol (0.5 mg) as an internal standard, was dissolved in 0.23 ml of anhydrous diethyl ether, and ethyl magnesium bromide solution(0.1 ml) was added. The mixture was vigorously shaken for 25 s, and then 2 ml of acetic acid/diethylether (1:200, v/v) followed by water (1 ml) was added to stop the reaction. The ethyl layer was washed once with 2% aqueous sodium bicarbonate (1 ml) and then with water. Ethyl evaporated at ambient temperature in a stream of nitrogen, and the remaining water evaporated in a similar manner in presence of tobuene. Each of the 1(3)- and 2-monoacylglycerol (MAG) was isolated by boric acid-impregnated silicic acid high-performance thin-layer chromatography using

Table 1. Composition of fatty acid and triglycerides of LCT and MLCT oil

Fatty acid	LCT oil (g/100g oil)	MLCT oil (g/100g oil)
8:0	ND†	9.7
10:0	ND†	3.3
16:0	6.2	3.8
16:1	0.2	0.2
18:0	2.5	1.7
18:1	48.8	51.2
18:2	30.2	18.4
18:3	9.4	9.0
20:0	0.6	0.6
20:1	1.1	1.2
22:0	0.4	0.3
22:1	0.2	0.3
24:0	0.2	0.1
24:1	0.2	0.2
total	100.0	100.0
Triglyceride		
L,L,L	100.0	55.1
L,L,M	ND	35.2
L,M,M	ND	9.1
M,M,M	ND	0.6
Total	100.0	100.0

†: not detected.

chloroform/acetone (96:4, v/v) for development. The MAG fractions extracted from the absorbents in diethyl ether were converted to fatty acid methyl ester by transesterification using 1 M sodium methoxide-methanol solution. Resulting methyl esters were analyzed by GLC (6890 series; Agilent Technologies, Palo Alto, CA) with a capillary column (Omegawax-320; Supelco, Bellefonte, PA). Fatty acids compositions of the sn-1 (3) and sn-2 positions of triglycerides (MLCT oil) were calculated from the results.

Anthropometric measurements

Anthropometric measurements were performed by trained investigators. Waist circumference (WC) was measured at the umbilical level and hip circumference (HC) was obtained at the level of the greatest posterior protuberance. Both WC and HC were measured to the nearest 0.1 cm in a standing position. A BCA-2A Body Analysis Instrument (Tongfang Ltd, Beijing, China) was applied to measure body compositions. Computed tomography (CT) scanning at the umbilical level in all subjects was performed in Chinese PLA General Hospital using a Pro 16 CT (GE, Fairfield, Connecticut, USA). The total fat area (TFA), subcutaneous fat area (SFA) and visceral fat area (VFA) were obtained from the CT images by the method reported earlier.[15]

Blood sampling and analysis

Fasting blood samples were collected in the morning and anthropometric parameters were measured on the same day. Blood biochemical variables including aspartate aminotransferase (AST), alanine aminotransferase (ALT), blood glucose, total cholesterol (TC), triglyceride (TG), high density lipoprotein cholesterol (HDL-C), low density lipoprotein cholesterol (LDL-C), apolipoprotein A1 (apoA1), apolipoprotein B (apoB), apolipoprotein C2 (apoC2), apolipoprotein C3 (apoC3) and apolipoprotein E (apoE) were measured on a 7600 automated system in the Biochemistry Division of Chinese PLA General Hospital.

Statistical analysis

Data were expressed as means±SD and *t*-test was used when significance occurred after one-way ANOVA. Differences in values, changes in values, and rates of change in measurements between the MLCT and LCT group were compared using the Student's *t*-test. Differences of values in the same group between the initial and final time of the study were examined using the paired *t*-test. All statistical analyses were performed using SPSS Version 13.0 for Windows.

RESULTS

Eleven subjects were excluded from the study for various reasons. There were 34 men and 16 women left in the study in the LCT group, and 33 men and 18 women in the MLCT group (Table 2). No sex differences were noted between the two groups ($x^2=0.1227$, $p>0.05$).

Energy and nutrients intake

There were no significant differences in terms of daily intakes of energy, protein, fat, and carbohydrates, time and energy expenditure from daily physical activity be-

Table 2. Average daily intake of energy, protein, fat, carbohydrate, time and energy expenditure of physical activity in male and female subjects consuming either LCT or MLCT oil at the initial and final average of the study.

	Time	LCT (n=50)		MLCT (n=51)	
		Male (n=34)	Female (n=16)	Male (n=33)	Female (n=18)
Energy (kcal/d)	initial†	1862±220	1619±211	1795±202	1746±149
	final average ‡	1754±143	1762±94.9	1773±104	1719±83.4
Protein (g/d)	initial	63.2±12.4	54.2±14.4	62.3±12.3	60.3±9.7
	final average	60.2±4.5	63.1±5.0	63.0±7.6	59.7±7.2
Fat (g/d)	initial	52.5±8.8	47.3±9.5	51.5±8.7	51.5±6.4
	final average	51.4±3.7	53.1±3.0	52.7±4.4	49.9±6.1
Carbohydrate (g/d)	initial	274±44.4	236±36.3	261±33.7	253±23.4
	final average	254±30.3	249±21.6	250±16.8	251±12.7
Protein (% of total energy)	initial	13.5±2.0	13.2±2.4	13.8±1.7	13.9±1.4
	final average	13.6±0.8	14.3±0.9	14.1±1.1	13.8±1.2
Fat (% of total energy)	initial	25.4±3.7	26.2±3.9	25.4±4.0	27.2±2.3
	final average	26.5±2.2	27.3±2.1	26.9±1.8	25.8±2.6
Carbohydrate (% of total energy)	initial	58.8±5.6	58.6±6.0	58.4±4.6	57.5±3.2
	final average	57.8±2.9	56.3±2.7	56.8±2.5	58.3±3.1
Physical activity time (min/d)	initial	123±49.0	112±38.0	109±36.4	133±27.9
	final average	122±25.6	119±22.3	127±20.4	115±17.1
Energy expenditure (kcal/d)	initial	459±193	377±152	404±148	394±183
	final average	454±124	390±78.2	442±107	387±96.0

†: Average values at the initial of the study, ‡: Average values during 8 weeks of the study.

Table 3. Changes in anthropometric measurements in male and female subjects consuming either LCT or MLCT oil at the beginning and end of the study

	Sex	Time (week)	LCT (n=50)			MLCT (n=51)		
			X bar±s	⊿†	⊿%‡	X bar±s	⊿†	⊿%‡
BW (kg)	Male	0	74.5±7.5			73.9±10.4		
		8	73.9±7.9	-0.6±2.0	-0.8±2.7	71.8±10.4*	-2.1±2.0**	-2.9±2.7**
	Female	0	66.4±8.1			68.3±12.5		
		8	65.9±8.1	-0.6±1.6	-0.8±2.3	67.0±12.4*	-1.3±1.5	-1.9±2.0
BMI (kg/m^2)	Male	0	27.1±4.1			25.6±2.7		
		8	26.9±4.3	-0.2±0.8	-0.9±2.9	24.8±2.7*,**	-0.8±0.7**	-3.1±0.7**
	Female	0	24.9±3.9			26.4±4.1		
		8	24.7±4.1	-0.2±0.6	-1.0±2.4	25.9±4.1*	-0.5±0.6	-1.9±2.0
WC (cm)	Male	0	90.9±6.2			90.6±8.4		
		8	90.5±6.1	-0.3±1.8	-0.4±2.0	89.4±8.6*	-1.2±1.2**	-1.3±1.3**
	Female	0	84.8±7.2			87.2±7.5		
		8	84.7±7.1	-0.1±2.0	-0.1±2.5	86.1±7.2*	-1.1±1.0	-1.2±1.1
HC (cm)	Male	0	97.7±4.5			97.9±6.0		
		8	97.7±4.5	-0.1±1.1	-0.1±1.1	97.3±6.2*	-0.6±1.2	-0.6±1.2
	Female	0	100.7±6.9			101.2±9.8		
		8	99.5±6.7	-0.6±1.2	-0.6±1.2	101.0±9.8	-0.2±0.8	-0.2±0.8
WHR	Male	0	0.9±0.1			0.9±0.1		
		8	0.9±0.1	-0.0±0.0	-0.3±1.8	0.9±0.1*	-0.0±0.0	-0.7±1.3
	Female	0	0.8±0.0			0.9±0.1		
		8	0.8±0.1	0.0±0.0	0.6±2.3	0.9±0.1	-0.0±0.0	-0.7±1.0
BFW (kg)	Male	0	16.4±2.8			16.1±3.7		
		8	15.9±2.9	-0.5±1.6	-2.9±9.8	14.5±3.7*	-1.6±1.6**	-9.8±9.9**
	Female	0	21.2±4.4			20.7±7.2		
		8	20.8±4.3	-0.4±1.1	-1.8±4.8	19.7±7.1	-1.0±1.3	-4.8±5.5
BF%	Male	0	22.0±3.0			21.7±3.4		
		8	21.5±3.0	-0.6±1.7	-2.3±7.4	20.1±3.5*	-1.6±1.6**	-7.3±7.7**
	Female	0	31.7±3.4			30.0±5.9		
		8	31.4±3.5	-0.3±0.9	-1.0±3.0	29.5±5.9	-0.4±0.8	-1.4±2.4
TFA (cm^2)	Male	0	303±71.7			315±88.4		
		8	318±60.5*	15.5±31.1	7.1±12.4	299±87.8*	-16.0±40.6**	-4.7±10.6**
	Female	0	383±102.2			376±125		
		8	384±95.8	4.5±37.6	2.4±11.3	360±140	-16.6±40.4	-5.5±11.4
VFA (cm^2)	Male	0	148±49.4			156±60.9		
		8	167±44.9*	18.8±29.6	19.8±29.0	159±60.3	3.2±35.0	5.0±38.6**
	Female	0	126±24.0			140±53.3		
		8	133±25.4	9.8±19.8	9.5±18.4	139±69.8	-0.4±29.2	-1.8±18.3
SFA (cm^2)	Male	0	156±39.4			162±38.6		
		8	152±37.8	-3.4±17.2	-1.6±10.7	146±39.5*	-15.4±18.0**	-9.4±11.6**
	Female	0	259±85.8			237±90.2		
		8	257±86.3	-2.0±24.6	-0.5±11.8	221±86.3	-16.2±43.1	-6.6±18.2

†: 8 week value minus 0 week, ‡: change rate against 0 week, * $p<0.05$, different from 0 week, ** $p<0.05$, different from LCT group. *t*-test was used when significance occurred after ANOVA.

tween the male and female subjects in the two groups at the baseline or over the 8-week duration of the study. Although energy expenditure of daily physical activity was found to be less in female subjects and more in male subjects when compared respectively with those at the baseline in MLCT group (Table 2).

Anthropometric measurements

Anthropometric measurements at the beginning of the study were not significantly different in the male or female subjects between two groups. The male subjects consuming MLCT oil demonstrated significant decreases in body weight, BMI, WC, HC, WC/HC, body fat weight, BF%, TFA and SFA after 8 weeks, in comparison with the values at the beginning of the study. The female subjects consuming MLCT oil showed significant decreases in the levels of BW, BMI, WC and body fat weight. Furthermore, greater decreases in body weight, BMI, WC, body fat weight, BF%, TFA and SFA were observed in the male subjects in the MLCT group than the LCT group

Table 4. Changes in blood TG, lipoproteins, apolipoproteins, hepatic enzymes, glucose and TC in male and female subjects consuming either LCT or MLCT oil at the beginning and end of the study.

	Sex	Time (week)	LCT (n = 50)			MLCT (n = 51)		
			X bar±s	⊿†	⊿%‡	X bar±s	⊿†	⊿%‡
TG (mmol/L)	Male	0	2.6±0.7			2.7±0.8		
		8	3.2±1.2*	0.6±1.1	25.2±45.8	2.2±1.0*·**	-0.5±1.0**	-16.6±31.8**
	Female	0	2.6±0.9			2.7±1.0		
		8	2.6±1.0	0.1±0.9	5.5±36.8	2.3±0.9	-0.4±0.9	-10.8±31.2
apoA1 (mmol/L)	Male	0	1.1±0.2			1.1±0.2		
		8	1.2±0.2	0.1±0.3	8.3±25.2	1.1±0.2	0.0±0.2	2.8±18.8
	Female	0	1.2±0.2			1.2±0.2		
		8	1.4±0.2	0.2±0.2	15.4±14.3	1.3±0.2	0.1±0.2	11.8±20.2
apoB (mmol/L)	Male	0	1.1±0.2			1.1±0.2		
		8	1.2±0.2	0.1±0.2	5.0±16.2	1.1±0.2	-0.1±0.2**	-4.8±19.2**
	Female	0	1.1±0.2			1.2±0.3		
		8	1.2±0.3	0.2±0.2	5.1±15.3	1.2±0.2	0.0±0.3	5.9±22.4
HDL-C (mmol/L)	Male	0	1.3±0.3			1.3±0.2		
		8	1.3±0.4	-0.0±0.2	-2.5±11.7	1.3±0.3	0.0±0.3	1.6±19.2
	Female	0	1.5±0.3			1.2±0.2		
		8	1.4±0.3	-0.1±0.2	-4.9±10.5	1.3±0.2	0.1±0.2	4.2±15.7
LDL-C (mmol/L)	Male	0	2.6±0.7			2.8±0.6		
		8	3.0±0.6*	0.4±0.5	18.3±25.8	2.7±0.6	-0.0±0.4**	0.4±16.2**
	Female	0	3.0±0.8			3.2±0.6		
		8	3.4±0.7	0.4±0.7	19.4±37.2	3.1±0.8	-0.0±0.8	1.4±26.0
apoC2 (mg/dl)	Male	0	7.5±2.5			6.6±2.6		
		8	7.8±3.4*	0.8±1.8	9.5±28.0	5.6±2.8*·**	-1.1±1.4**	-16.9±20.6**
	Female	0	6.9±2.9			6.1±1.7		
		8	6.7±3.1	-0.2±1.2	-3.4±14.0	5.8±1.9	-0.3±1.4	-2.6±24.0
apoC3 (mg/dl)	Male	0	13.7±3.6			14.1±5.6		
		8	14.8±4.9	1.1±3.7	8.7±26.1	11.3±3.8*·**	-2.8±3.6**	-17.6±18.5**
	Female	0	14.0±3.9			13.1±3.9		
		8	14.3±4.0	0.4±2.1	3.8±17.9	13.3±4.9	0.2±4.4	3.9±28.8
apoE (mg/dl)	Male	0	5.2±2.0			5.4±2.0		
		8	5.9±1.8*	0.7±1.8	20.9±36.3	5.2±1.4	-0.2±1.7**	2.8±32.2**
	Female	0	5.1±1.7			5.4±2.1		
		8	5.6±1.8	0.5±1.4	11.9±28.0	5.6±1.8	0.3±1.7	10.3±34.0
ALT (U/L)	Male	0	26.9±16.4			25.5±15.5		
		8	28.8±17.2	1.8±15.2	15.7±51.7	26.5±15.2	1.0±10.1	14.7±63.8
	Female	0	22.6±8.2			24.8±14.2		
		8	25.7±9.0	4.9±8.3	29.6±48.5	25.4±13.0	0.7±13.6	13.2±45.6
AST (U/L)	Male	0	22.6±6.7			23.0±7.9		
		8	21.6±6.1	-0.1±6.8	-0.2±28.4	22.3±10.7	-0.6±12.2	3.6±53.6
	Female	0	21.1±4.8			25.0±10.7		
		8	24.0±4.8	3.1±6.6	17.6±34.7	25.0±18.7	-0.1±16.0	0.1±50.4
Glucose (mmol/L)	Male	0	5.0±0.7			5.1±0.8		
		8	5.1±0.7	0.2±0.8	4.5±15.0	5.2±0.9	0.1±0.3	2.1±6.1
	Female	0	5.5±1.1			5.8±1.2		
		8	6.0±1.6	0.5±0.9	7.8±16.9	5.9±1.4	0.1±0.7	2.1±12.1
TC (mmol/L)	Male	0	5.1±0.6			5.1±0.8		
		8	5.2±0.5	0.1±0.3	3.0±6.5	5.2±0.8	0.1±0.5	2.2±10.8
	Female	0	5.6±0.9			5.3±0.8		
		8	5.8±0.9	0.2±0.7	4.5±15.0	5.7±0.5	0.3±0.5	5.8±9.4

†: 8 week value minus 0 week, ‡: change rate against 0 week, * $p<0.05$, different from 0 week, ** $p<0.05$, different from LCT group. *t*-test was used when significance occurred after ANOVA.

after 8 weeks. However, no significant difference was noted with regard to these parameters in female subjects between two groups (Table 3).

Blood biochemicals

Blood biochemical parameters shown in Table 4 at the beginning of the study were not different in the male and female subjects between the two groups. The male subjects consuming MLCT oil demonstrated significant decreases in the levels of TG, apoC2, apoC3 after 8 weeks, in comparison to the levels at the beginning of the study, but no significant differences in these parameters were

found in the female subjects. There was also a significant decrease in TG, LDL-C, apoB, apoC2, apoC3 and apoE after 8 weeks in male subjects consuming MLCT oil in comparison with those consuming LCT oil. No significant changes were observed in the female subjects between the two groups. In addition, there were no significant differences in the concentrations of blood glucose, cholesterol, AST and ALT between the two groups, in both the male and female subjects (Table 4).

DISCUSSION

The role of MLCT-containing cooking oil in reduction of weight body, body fat and prevention of hypertriglyceridemia has been demonstrated in recent years. Kasai et al. have reported that subjects receiving MLCT for 12 weeks showed a significant reduction in body weight, body fat weight, visceral fat, subcutaneous fat and waist circumference compared with those receiving LCT.[16] However, only healthy subjects were involved in their study. In addition, researchers have only investigated the effect of MLCT on blood lipids in men rather than women in most studies.[17,18] A previous study involving women indicated that there were no significant changes in many variables between those receiving MCT and those receiving LCT.[19,20] For example, Yost and Eckel placed 16 obese women on two different hypocaloric regimens (800 kcal/day, and 30% energy as fat) for 4-12 weeks. The first regimen comprised only LCT, whereas the second consisted of 6% LCT and 24% MCT. There were no significant differences between the two groups with regard to body weight reduction. Additionally, Tsuji et al. reported that MCT suppressed the accumulation of body fat in healthy men but not women.[21] These data suggested that a different response to MLCT may exist in men and women. In our study, we found that consumption of MLCT significantly decreased body fat and blood TG in men, while female subjects consuming MLCT showed a similar response between the MLCT and LCT oil group.

The different effects of MLCT and LCT consumption on lipid metabolism in men and women may be due to several factors. Firstly, sample size of subjects may have influenced the results. Fewer women were enrolled in the present study even though there was no gender differences between the two groups. Secondly, there may be differences in energy intake between men and women. Energy intakes were not measured in some previously conducted MLCT or MCT trials, although the intake of oil was stipulated.[22] In our study, we stringently controlled both the amount of oil and the total energy intake under the instruction of dietitians. The energy intake recommended for men was significantly greater than that for women (1832±204 vs. 1516±88.1 in the LCT group and 1842±174 vs. 1589±123 in the MLCT group). However, at the end of the study, no significant difference in energy intake was observed between men and women in the LCT and MLCT group, which means that actual energy intake for women was significantly greater than that recommended (Table 2). A higher energy intake in female subjects might indicate a poor dietary compliance and a lower energy intake might be beneficial for reducing body fat and blood lipids for women consuming MLCT oil. Thirdly, there was some evidence that suggested that differences in lipid metabolism between men and women may be due to hormones. Many studies have considered that the incidence of cardiovascular disease, especially coronary heart disease (CHD), in women is significantly lower in menopause, a benefit that has been attributed to the effects of estrogen.[23] In general, CHD begins about a decade later in women than in men. Barrett-Connor have considered premenopausal protection, delaying the development of coronary artery disease by 10 to 15 years, on average, in women.[24] Women develop angina about 10 years later than men on average, and typically develop their first myocardial infarction about 20 years later than men.[25] Female subjects in our study were not divided into subgroups by menopause, and most of the female subjects were postmenopausal (the average age was 56.2±8.3 years in the LCT group and 54.8±7.9 years in the MLCT group). Therefore, the dull response to MLCT oil in lipid metabolism in female subjects with menopause may result from a deficiency of estrogen.

The drop in blood TG concentration after consecutive intake of MLCT oil might be due to changes in metabolism. Oxidation of fatty acids stimulated by intake of MCFAs might be the most possible mechanism for lowering TG after the consumption of MLCT oil. According to the report by Kasai et al, MLCT intake was also considered to possibly accelerate Diet-induced thermogenesis and suppress body fat accumulation.[26]

In conclusion, consumption of MLCT can reduce body weight, body fat and the concentration of blood triglyceride and can improve apolipoprotein metabolism in male hypertriglyceridemic subjects, with little effects in females. Further detailed and large-scale studies are needed.

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AUTHOR DISCLOSURES

The authors have no conflicts of interest. The authors also acknowledge that the work was granted by Nisshin Oillio Group, Ltd., and have no conflicts of interest with the company.

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Original Article

A good response to oil with medium- and long-chain fatty acids in body fat and blood lipid profiles of male hypertriglyceridemic subjects

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中长链脂肪酸食用油可改善男性高甘油三酯血症患者体脂肪和血脂水平

采用双盲临床试验方法，将 112 名高甘油三酯血症患者随机分为中长链脂肪酸食用油组和长链脂肪酸食用油组，研究期限为 8 周。所有受试者控制每日膳食摄入量及食用油摄入量（25-30 克/人/日），规定运动方式。分别于研究开始前和 8 周后对受试者进行人体組成测量及血生化指标检测。长链脂肪酸食用油组 50 例（男 34 例，女 16 例），中长链脂肪酸食用油组 51 例（男 33 例，女 18 例）完成了研究。男性中长链脂肪酸食用油组的体重、BMI、腰围、体脂肪重、腹部脂肪总面积、腹部皮下脂肪面积及血清甘油三酯、低密度脂蛋白胆固醇、载脂蛋白 B、C2、C3 和 E 指标降低的程度明显大于长链脂肪酸食用油组。但这些指标在两组之间的女性患者没有发现显著性差异。因此，本研究表明男性高甘油三酯血症患者使用中长链脂肪酸食用油可减轻体重和体脂肪含量，改善血脂谱。

关键字：中链脂肪酸、长链脂肪酸、高甘油三酯血症、性别、中国人