Original Research

Medium Chain Triglyceride Oil Consumption as Part of a Weight Loss Diet Does Not Lead to an Adverse Metabolic Profile When Compared to Olive Oil

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Objective: Medium chain triglyceride (MCT) consumption may have a beneficial impact on weight management, however, some studies point to a negative impact of MCT oil consumption on cardiovascular disease risk. This study examined the effects of MCT oil consumption, as part of a weight loss diet, on metabolic risk profile compared to olive oil.

Design: Thirty-one men and women, age 19–50 y and body mass index 27–33 kg/m^2, completed this randomized, controlled, 16-week weight loss program. Oils were consumed at a level of ~12% of the subjects' prescribed energy intakes in the form of muffins and liquid oil.

Results: After controlling for body weight, there was a significant effect of time on fasting serum glucose ($P = 0.0177$) and total cholesterol ($P = 0.0386$) concentrations, and on diastolic blood pressure ($P = 0.0413$), with reductions in these variables occurring over time; there was no time-by-diet interaction for any of the parameters studied. Two of the 3 subjects in the MCT oil group with evidence of the metabolic syndrome at baseline did not have metabolic syndrome at endpoint. In the olive oil group, 6 subjects had the metabolic syndrome at baseline; 2 subjects no longer had metabolic syndrome at endpoint, 1 person developed metabolic syndrome, and 4 subjects did not have any change in their metabolic syndrome status.

Conclusions: Our results suggest that MCT oil can be incorporated into a weight loss program without fear of adversely affecting metabolic risk factors. Distinction should be made regarding chain length when it comes to discussing the effects of saturated fats on metabolic risk factors.

INTRODUCTION

Saturated fats are considered to be unhealthy and several health authorities recommend limiting their intake in the diet [1]. These recommendations stem from studies linking higher intakes of saturated fat and heart disease [2]. However, saturated fats are quite heterogeneous in nature and potentially also in their health effects. In fact, based on their structure, saturated fats can be sub-classified into short chain, medium chain, and long chain fats whereas mono- and polyunsaturated fats are all long chain fats. Short chain fatty acids are considered to have 6 or fewer carbon atoms, medium chain fatty acids (MCFA) have 8–10 carbons, and long chain fatty acids (LCFA) generally have 12 or more carbon chains.

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Most studies comparing the effects of saturated fats to unsaturated fats have focused on fats that contained a large proportion of their fatty acids as LCFA. Very few clinical studies have examined the impact of MCFA on cardiovascular disease (CVD) risk factors [3–7]. Some of those studies have found that MCFA consumption increased total cholesterol (TC) and low-density lipoprotein cholesterol (LDL-C) to the same extent as palm oil [3] and led to higher levels of triglycerides (TG) than palm oil and sunflower oil [3], an other diet rich in LCFA [5,8], or soybean oil [4]. Reductions in HDL-C [5] and absence of effects on TC, LDL-C, and HDL-C have also been noted with MCFA consumption [4]. Our previous studies with medium chain triglyceride (MCT) oil showed reductions in TC and LDL-C and no change in HDL-C or TG [6,7] but our MCT oil was fed along with plant sterols, which are known to reduce TC and LDL-C [9,10], and safflower oil, an oil rich in n-3 polyunsaturated fats. Hu et al. [11], however, have found that MCT did not increase the risk of coronary heart disease in the Nurses' Health Study whereas consumption of long chain saturated fats did. Therefore, whether MCT oil truly has a negative impact on CVD risk remains to be firmly established. This is particularly important since MCT oil has been taunted as a potential weight-lowering agent [12–16].

The purpose of this study was thus to examine the effects of MCT oil, compared to olive oil, on lipid profile and other metabolic risk factors such as glucose, insulin, and blood pressure, when consumed as part of a 16-week weight loss program in overweight men and women. MCFA (chain lengths of 10 carbons or less) are found in greatest concentrations in coconut oil, approximately 14% by weight but can also be found in butter (approximately 9.2%) and palm kernel oil (approximately 7.2%) [17]. In the US, the average consumption of MCFA is approximately 2% of total fat intake [18].

SUBJECTS AND METHODS

Subject Characteristics

Men and women, age 19 to 50 y, with a body mass index (BMI, in kg/m^2) of 27–33 were recruited from the Birmingham, AL, greater metropolitan area through newspaper advertisements and flyers. Inclusion criteria included stable weight for at least 6 months, normal score on the Brief Symptoms Inventory questionnaire [19], and absence of chronic diseases. Persons whose blood pressure, glucose, or lipid levels were under stable, medical control were permitted to participate as long as their medication remained constant throughout the study. Individuals were excluded if they were currently participating in active weight loss with drug treatment or taking any medication known to affect weight. Women who were pregnant, planning to become pregnant, or less than 1 year post-partum or breast-feeding were excluded from the study. The study was approved by the University of Alabama at Birmingham (UAB) Institutional Review Board. All subjects provided informed consent prior to starting the study. The clinicaltrials.gov identifier for this study is NCT00529919.

Protocol

Upon entry into the study, subjects were randomized to one of 2 weight loss groups: MCT oil or olive oil. Weight loss was achieved through weekly group counseling sessions at the UAB Pittman General Clinical Research Center (GCRC) for a period of 16 weeks. Subjects were counseled to reduce their caloric intakes to 1500 kcal/d for women and 1800 kcal/d for men. This caloric prescription included study muffins (either cranberry or blueberry flavor; Krusteaz, Seattle, WA) that contained 10 g of the test oil, either MCT oil (Neobee 1053, Stepan Company, Northfield, IL) or olive oil (Filippo Berio, Salov North American Corporation, El Paso, TX). The fatty acid profile of both oils is shown in Table 1. Subjects were also required to incorporate 8 or 14 g of their assigned oil, for women and men, respectively, in their foods during cooking. Therefore, all subjects received approximately 12% of their prescribed caloric intakes in the form of the study oil (18 g for women and 24 g for men); an amount which was previously found to produce significant increases in energy expenditure [14], which is believed to be the main mechanism of action for weight loss with MCT oil. The subjects, along with the Dietitian and Clinical Coordinator, were blinded to oil assignment. Details of the weight loss counseling are reported elsewhere [20].

Body weight and waist circumference were measured at each weekly session by the Clinical Coordinator. At baseline, 8 weeks, and 16 weeks, subjects reported to the GCRC in a fasted state for blood sampling and blood pressure measurement. Blood samples were processed using routine protocols and

Table 1. Fatty Acid Profile of MCT Oil and Olive Oil per 100 g of Oil

Fatty acid	MCT oil	Olive oil[1]
C8:0	55.0	0
C10:0	45.0	0
C12:0	0	0
C14:0	0	0
C16:0	0	11.290
C16:1	0	1.255
C17:0	0	0.022
C17:1	0	0.125
C18:0	0	1.953
C18:1	0	71.269
C18:2	0	9.761
C18:3	0	0.761
C20:0	0	0.414
C20:1	0	0.311
C22:0	0	0.125

[1] From the USDA National Nutrient Database for Standard Reference, Release 17 (2004). U.S. Department of Agriculture, Agricultural Research Service. 2004. USDA National Nutrient Database for Standard Reference, Release 17. Nutrient Data Laboratory Home Page, http://www.nal.usda.gov/fnic/foodcomp

analyzed for fasting concentrations of TC, LDL-C, HDL-C, TG, insulin, and glucose.

Statistical Analyses

Data were analyzed using SAS Software for Windows version 9.1 (SAS Institute, Cary, NC). All data was analyzed using repeated models ANOVA with subject id as a random subject variable and race, time, and diet as fixed variables. A diet-by-week interaction term was also included in the model and change in body weight was included as a quantitative variable. Data were also analyzed using body weight as a quantitative variable. The results would not change our interpretation of the data and therefore data are reported with change in body weight as a quantitative variable. Since only one subject was Hispanic, race was coded as Caucasian and non-Caucasian. Conducting all analyses without this one Hispanic subject did not change the interpretation of the results. All data were analyzed for completers only. Data are reported as means ± SEM.

RESULTS

A total of 49 subjects were enrolled in the study and 31 completed (MCT, n = 16; olive oil, n = 15). Reasons for dropping out included scheduling conflicts (8), food complaints (5), injury unrelated to the study (1), family emergency (1), pregnancy (1), and loss to follow-up (2). Demographic characteristics of the subjects who completed the study are shown in Table 2.

Subjects lost weight with the weight loss intervention. Weight loss was greater in the group consuming MCT oil compared to the group consuming olive oil as part of the weight loss program. Details of the weight loss and body composition data have been published elsewhere [21].

There was no significant effect of time on insulin and TG and no significant effect of diet or diet-by-time interaction on any of the metabolic parameters after controlling for the change in body weight (Table 3). There was a significant effect of time on fasting glucose (P = 0.0143), TC (P = 0.0087), LDL-C (P = 0.0092), and HDL-C (P = 0.0316). The MCT group showed transient reductions in glucose concentrations at week 8 and both groups showed transient reductions in TC and LDL-C concentrations. The olive oil group had a modest increase in HDL-C concentrations but this was only significant between week 8 and week 16.

There was a significant effect of race on insulin concentrations (P = 0.0027) with the non-Caucasian group having higher insulin levels than Caucasians. Although racial differences were not a main outcome of the study, we examined the effects of diet and time in non-Caucasians only. In this sub-group, we found no significant effect of diet (P = 0.1706), time (P = 0.3830), or diet-by-time interaction (P = 0.8981) after controlling for the change in body weight. There were not enough Caucasian subjects in our study to conduct a separate analysis on this sub-group (n = 7).

There was no significant effect of diet, time, or diet-by-time interaction on systolic or diastolic blood pressure after controlling for the change in body weight. Race was also not a significant factor in the model.

When we examined the number of subjects with evidence of the metabolic syndrome at baseline and endpoint, we found that 6 subjects fulfilled the criteria for the metabolic syndrome at baseline and 5 at endpoint in the olive oil group. Two of the subjects who had evidence of the metabolic syndrome at baseline did not have the metabolic syndrome at endpoint whereas 1 person who did not have the metabolic syndrome developed metabolic syndrome over the course of the study (due to an increase in systolic blood pressure). In the MCT oil group, 3 subjects fulfilled the metabolic syndrome criteria at baseline and only 1 remained with the metabolic syndrome at endpoint. Reductions in blood pressure explained the resolution of metabolic syndrome in these 2 subjects. No subject developed the metabolic syndrome over the course of the study in the MCT oil group.

Table 2. Descriptive Characteristics of the Subjects Who Completed the Study[1]

Characteristic	MCT oil	Olive oil
Male/Female	2/14	1/14
Race, AA/C/H[2]	11/5/0	12/1/1
Age, y	36.5 ± 2.1	37.5 ± 2.0
Weight, kg	80.9 ± 3.6	78.8 ± 2.1
Body mass index, kg/m^2	29.5 ± 0.6	30.0 ± 0.6

[1] Data are means ± SEM. There was no difference between groups in baseline characteristics as determined using unpaired t-test.

[2] Abbreviations: AA, African-American, C, Caucasian; H, Hispanic. Race designation is by subject self-report of their racial background.

DISCUSSION

This study shows that long-term consumption of moderate amounts of saturated fats, in the form of MCT, does not have adverse effects on CVD risk factors. These results thus suggest discrimination between long chain saturated fats, which have repeatedly been shown to result in higher TC and LDL-C concentrations compared to unsaturated fats [22,23], and medium chain saturated fats. Our results show that MCT consumption leads to comparable effects on CVD risk factors as an equal amount of olive oil, an oil considered to have beneficial health effects [22].

Although MCT are thought to lead to increases in TG concentrations, we did not observe this in the present study. This finding confirms our previous findings that MCT do not raise TG concentrations when consumed at levels 12–20% of energy intakes [6,7]. This also agrees with Asakura et al. [24] who did not observe any change in fasting TG concentrations

Table 3. Metabolic Profile of Subjects Consuming Either MCT Oil or Olive Oil as Part of a Weight Loss Diet for 16 Weeks

Diet	Time	TC[1,2,3]	LDL-C[3]	HDL-C[3]	TG	Insulin	Glucose[3]
MCT oil	Baseline	4.79 ± 0.22	3.01 ± 0.17	1.43 ± 0.09	0.84 ± 0.16	102.30 ± 10.56	5.17 ± 0.14
	Week 8	4.36 ± 0.21	2.55 ± 0.17	1.40 ± 0.09	0.76 ± 0.16	80.08 ± 10.56	4.81 ± 0.14
	Week 16	4.49 ± 0.21	2.67 ± 0.18	1.49 ± 0.09	0.77 ± 0.17	90.84 ± 10.56	5.19 ± 0.14
Olive oil	Baseline	4.79 ± 0.20	3.02 ± 0.19	1.21 ± 0.10	1.18 ± 0.18	86.19 ± 11.25	5.14 ± 0.15
	Week 8	4.29 ± 0.20	2.66 ± 0.19	1.16 ± 0.10	1.16 ± 0.18	78.96 ± 11.25	5.05 ± 0.15
	Week 16	4.51 ± 0.20	2.76 ± 0.19	1.27 ± 0.10	0.98 ± 0.18	79.73 ± 11.25	5.27 ± 0.15

[1] Abbreviations: HDL-C = high density lipoprotein cholesterol, LDL-C = low density lipoprotein cholesterol, MCT = medium chain triacylglycerols, TC = total cholesterol, TG = triacylglycerols.

[2] Data for TC, LDL-C, HDL-C, TG, and glucose are in mmol/L. To convert to mg/dL, divide by 0.0259 for TC, LDL-C, and HDL-C, by 0.0113 for TG, and by 0.0555 for glucose. Data for insulin are in pmol/L. To convert to μIU/mL, divide by 6.945. Data are means ± SEM.

[3] Significant main effect of time, $P < 0.05$. Data were analyzed using repeated models analysis of variance with id, race, change in body weight, time, diet, and time-by-diet interaction in the model.

with increasing MCT consumption up to maximum of 24 g/d for periods of 2 weeks each. It is possible that dose may have played a role in the earlier findings that MCT raise TG concentrations. In fact, in the studies by Hill et al. [4] and Swift et al. [5], where TG concentrations increased by 200 and 42%, respectively, subjects consumed 40% of energy in the form of MCT. The studies provided either 150% of weight-maintenance energy requirements [4] or 100% of weight-maintenance energy requirements [5]. In the study by Cater et al. [3], TG concentrations were higher after 3 weeks of MCT oil consumption at a level of 43% of energy intake compared to equivalent amounts of palm oil and high oleic sunflower oil. Swift et al. [5] had also recognized a potential dose effect when one of their study groups consuming half of the MCT dose of the MCT group (ie. 20% of energy intake) had no significant increase in fasting TG. Therefore, it is highly possible that MCT consumption at a level of 20–60 g/d, or 12–20% of energy intake, does not result in adverse effects on TG levels.

Our data also agree with those of Hill et al. [4] who found that overfeeding men with MCT oil for 6 d did not result in any change in TC or HDL-C. However, that study was very short in duration and potentially not long enough to effect changes in lipid parameters. Similarly, in a weight maintenance setting, the same group did not find any effect of MCT consumption for 6 d on TC or LDL-C but found reductions in HDL-C with MCT consumption [5]. We also did not find any change in TC, LDL-C, or HDL-C with MCT consumption. In fact, our data show that MCT consumption has a similar effect on plasma TC and LDL-C as olive oil when consumed at similar levels. This is in contrast with data comparing MCT oil consumption and high oleic sunflower oil [3]. In that study, MCT oil consumption led to higher TC and LDL-C concentrations than high oleic sunflower oil consumption after a 3 week period. This may be partly attributed to the higher plant sterol content of sunflower oil compared to olive oil [25,26]; plant sterols being well known for their hypocholesterolemic effect [10,27]. In the present study, olive oil thus proved to be an appropriate control oil to use since it had a neutral effect on lipid concentrations.

MCT consumption had no effect on glucose or insulin concentrations. This is similar to the observations of Hill et al. [4] in their overfeeding study with MCT and soybean oil and in a 12-week weight loss study comparing MCT and rapeseed oil/soybean oil consumption [28]. An early study by Yost et al. [29] also found that MCT consumption, at a level of 77.5% of total fat intake for 30 d, did not lead to reductions in fasting glucose or insulin concentrations in type 2 diabetics. It therefore appears that MCT consumption has little impact on glycemic control.

Olive oil consumption at a level of approximately 12% of energy intake did not have any significant impact on fasting plasma lipid concentrations. This is in agreement with earlier work showing that monounsaturated fatty acids are not as effective as polyunsaturated fatty acids in reducing plasma cholesterol concentrations [30]. Studies have, however, shown that olive oil consumption results in lower TC, LDL-C, and TG than consumption of an average American diet [22]. More recently, studies have shown that olive oil results in higher TC, LDL-C, and TG than sunflower oil or rapeseed oil consumption [25] or not different from an average American diet with regards to effects on TC, LDL-C, HDL-C, or TG [31]. Our results thus add to the increasing body literature showing that olive oil has a neutral effect on lipid concentrations. MCT oil consumption does not differ from olive oil in its effects on cardiovascular disease risk and may thus be considered to be a neutral dietary fat as well.

Our study has several limitations. First, we had a small sample size (n = 31) and may have been underpowered to detect changes in some metabolic variables (for example, trend for a reduction in LDL-C with MCT oil consumption and reduction in TG with olive oil consumption). Second, we did not have enough subjects in each racial category to adequately assess racial differences. There are well known metabolic differences between African Americans and Caucasians and those may lead to different responses to the diet. Similarly, few men participated in the study and we therefore could not assess gender differences in response to the diets. Future studies should be done with larger sample size in order to assess racial

and gender effects. Also, we did not assess food intake as part of this study. However, we did ask subjects to report deviations in muffin and oil consumption. Subjects reported study product consumption in a weekly log sheet. In both groups, subjects reported eating all of the study products on 90.6 and 90.8% of the study days, for the MCT group and olive oil group, respectively.

Another limitation of this study was the use of olive oil as a control oil. Olive oil is rich in monounsaturated fat and low in saturated fat, and therefore, as such, we did not have a long chain, saturated fat control oil. A more appropriate control fat, from that stand point, may have been beef tallow, since it is low in medium and short chain fatty acids and rich in long chain saturated fatty acids. Butter and coconut oil would not be as good as beef tallow as control fats since they both contain a significant amount of short and MCFA. However, we have used beef tallow as a control fat in a previous study [32] and have found it to be a poor control for MCT oil due to differences in physical characteristics and palatability. Beef tallow is solid at room temperature and would therefore not have enabled us to conduct this study in a double-blind fashion. Second, beef tallow has a distinct taste and smell that do not resemble MCT oil, unlike light tasting olive oil. Third, beef tallow is not used in household cooking very much and the results would therefore have less applicability for cooking recommendations. Finally, MUFA from olive oil are highly recommended for inclusion in a heart-healthy diet. It therefore seemed to us that comparisons of MCT oil to a highly recommended fat would be advisable. Our results show that consumption of MCT oil, or olive oil, as part of a weight loss diet, lead to similar changes in cardiovascular disease risk factors.

The results of the present study help explain the cardiovascular health effects observed in our earlier study of a functional oil combining MCT oil, plant sterols, and flaxseed oil [7]. The present data suggest that the previous reductions in TC and LDL-C observed in our earlier study were likely the result of phytosterol consumption and the lack of change in TG possibly due to the lack of effect of MCT and flaxseed oil on this parameter.

Finally, the results of this study show that MCT oil consumption, at a level of approximately 18–24 g/d, does not have detrimental effects on cardiovascular disease risk factors, after taking into consideration body weight. In fact, these data suggest that a distinction must be made when discussing the cardiovascular health effects of saturated fats as those of medium chain length do not seem to confer adverse health effects. This is of particular interest, especially in light of the effects of MCT oil consumption on energy balance and weight control [13].

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