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PAPER

Medium- versus long-chain triglycerides for 27 days increases fat oxidation and energy expenditure without resulting in changes in body composition in overweight women

M-P St-Onge[1], C Bourque[1], PJH Jones[1]*, R Ross[2] and WE Parsons[1]

[1]*School of Dietetics and Human Nutrition, McGill University, Ste-Anne-de-Bellevue, Québec, Canada; and* [2]*School of Physical and Health Education, Queen's University, Kingston, Ontario, Canada*

OBJECTIVE: To determine the effects of long-term consumption of medium chain (MCT) versus long chain triglycerides (LCT) on energy expenditure (EE), substrate oxidation and body composition.
HYPOTHESIS: MCT consumption will not result in greater EE, substrate oxidation, and body weight loss compared with LCT consumption.
RESEARCH METHODS AND PROCEDURES: Seventeen healthy obese women participated in this randomized, crossover inpatient trial. Meals were prepared and consumed on site for two periods of 27 days. Diets containing 40% of energy as fat, with treatment fat comprising 75% of the total fat, were designed to supply each subject with their individual weight-maintaining energy needs. The MCT diet contained 67% of treatment fat as MCT oil (49% octanoate, 50% decanoate) whereas the LCT diet contained exclusively beef tallow as treatment fat. Body composition was assessed by magnetic resonance imaging (MRI) on day 1 and 28 of each phase while energy expenditure was measured on day 2 and 27.
RESULTS: Changes in total and subcutaneous adipose tissue volumes following consumption of MCT and LCT were not different (-0.61 ± 0.38 l *vs* -0.54 ± 0.48 l and -0.58 ± 0.35 l *vs* -0.48 ± 0.40 l, respectively). Average EE and fat oxidation were greater ($P < 0.05$) during MCT than LCT consumption (0.95 ± 0.019 *vs* 0.90 ± 0.024 kcal/min, respectively, for EE and 0.080 ± 0.0026 *vs* 0.075 ± 0.0022 g/min, respectively for fat oxidation).
DISCUSSION: These results show that long-term consumption of MCT enhances EE and fat oxidation in obese women, when compared to LCT consumption. The difference in body composition change between MCT and LCT consumption, although not statistically different, was consistent with differences predicted by the shifts in EE. It can be concluded that substitution of MCT for LCT in a targeted energy balance diet may prevent long-term weight gain via increased EE.
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Keywords: medium chain triglycerides; body composition; magnetic resonance imaging; energy expenditure

Introduction

The contribution of dietary fat to daily caloric intake has long been recognized. Diet fat is efficiently stored, being an important factor in the growing problem of obesity in North America. However, all fats may not be partitioned for storage with similar efficiency. Animal studies have shown decreased weight gain and smaller fat depots with medium chain triglyceride (MCT) consumption compared to long chain triglyceride (LCT),[1–3] suggesting a lower feed efficiency of MCT. The more rapid oxidation of MCT also results in greater energy expenditure (EE) when compared to LCT in both animals[2,4–6] and humans.[7–10] Greater EE and lower respiratory quotients (RQ) in humans consuming single or several meals containing MCT compared to LCT have been observed by various groups.[7–9] MCT consumption resulted in a thermic effect of food (TEF) close to 50% greater compared to LCT consumption in men consuming MCT or LCT containing diets for up to 7 days.[11] The results of these short-term

***Correspondence: PJH Jones, School of Dietetics and Human Nutrition, 21 111 Lakeshore Road, Ste-Anne-de-Bellevue, Québec, H9X 3V9, Canada.**
E-mail: jonesp@macdonald.mcgill.ca
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studies on both animals and humans have prompted researchers to conclude that consumption of MCT, found in butter and coconut oil, may be useful in the treatment or prevention of weight gain associated with the development of obesity. However, studies have been of limited duration; with few experiments exceeding 7 days. One controlled study showed that the difference in EE between LCT and MCT consumption is reduced after 14 days of consumption compared to 7 days.[10] The same researchers, using doubly-labeled water methodology to assess total energy expenditure, found no difference between MCT and LCT consumption on total EE (2246 *vs* 2186 kcal/day, respectively) after one week of intake.[12] However, close to 60% of the fatty acids in the high MCT diet contained 16 or more carbons, while only 8% were octanoic and decanoic acids.[10] The similar fatty acid composition of the diets may explain this lack of agreement with previous research.

In light of the findings on EE and fat oxidation with short-term MCT consumption, we expect that long-term consumption of MCT would result in negative energy balance. This would ultimately lead to different body weight trajectories with MCT consumption showing negative energy balance and decreased body weight and LCT consumption showing equilibrium and no body weight change. Assuming that the EE with consumption of triglycerides containing octanoate and decanoate remains elevated relative to LCT and that little or no adaptation occurs, then a weight loss in the order of 0.67 kg/month of consumption can be predicted by replacing LCT with MCT in the diet.[7] Tsuji *et al* recently reported a difference in body weight of 0.80 kg after 4 weeks of consumption of a diet containing MCT compared to one with LCT.[13] However, this study was not crossover and diets were not precisely controlled.

The present objective was therefore to determine whether MCT, when compared to LCT, consumption influences EE and substrate oxidation in overweight women consuming a controlled diet, targeted to meet energy balance, rich in MCT or LCT for 27 days. The specific aim was to establish whether a difference exists between MCT and LCT on EE and substrate oxidation in obese women and, if such a difference exists, whether it results in changes in body composition.

Subjects and methods

Subjects

Seventeen healthy obese women (mean age $\pm$ s.e.m. = 44.3 ± 3.8 y, mean body mass index = 31.8 ± 0.9 kg/m^2) were recruited by advertisement (Table 1). Subjects accepted into the study had plasma total cholesterol and triglyceride concentrations below 7.0 mmol/l and 3.0 mmol/l respectively, were not taking cholesterol-lowering drugs, had no history of cardiovascular disease and did not report having diabetes, gastrointestinal, or thyroid problems. Subjects were required to have been weight stable in the past 3 months and not perform more than 5 sessions of physical activity per week. The study protocol was approved by the Human Ethical Review Committee of the Faculty of Agriculture and Environmental Sciences of McGill University and all subjects signed informed consent forms prior to entrance into the protocol.

Table 1 Subject characteristics

Characteristic	Average (s.e.m.)
Age (y)	44.3 (3.8)
Weight (kg)	82.2 (2.7)
Height (cm)	160.6 (1.5)
Body mass index (kg/m^2)	31.8 (0.9)
Energy intake (kcal)	2458 (73)

Study design

This study was a randomized, crossover trial in which subjects became inpatients at the Mary Emily Clinical Nutrition Research Unit (CNRU) of McGill University (Ste-Anne-de-Bellevue, Canada) for two phases of 27 days each. During each experimental phase, subjects were required to reside in and consume all meals provided by the CNRU, but were not confined to the unit. Subjects were permitted to leave the research unit for work or to attend classes, although they were required to remain at the CNRU after the evening meal. Subjects were instructed that any physical activity performed in one experimental phase had to be repeated at the same intensity level and on the same day of the next experimental phase. Activity outside of the unit was not controlled, however, subjects were instructed not to deviate from habitual levels.

Meals were provided as a 3 day cycle menu. Subjects consumed an amount of energy required to maintain weight as calculated using the Mifflin equation[14] with an activity factor of 1.7. The activity factor was chosen since our group has shown that a factor of 1.7 was appropriate for weight maintenance.[15] Energy intake was adjusted for weight gain or loss during the first 7 days of the first phase of the research and remained constant for both phases thereafter. As a result, subjects consumed the same number of calories during both phases. Diets contained 40% of energy as fat, 15% as protein and 45% as carbohydrate. Of the total amount of fat, 75% was derived from either beef tallow (LCT) or a blend of saturated and unsaturated vegetable oils (MCT). In the MCT diet, 50% of the total fat was provided by MCT oil, rich in octanoate and decanoate (49 and 50% of total fatty acids, respectively (Neobee 1053, Stepan Company, Northfield, USA)), 10% by olive oil and 5% by each butter, coconut oil and flaxseed oil. Flaxseed oil was added as a source of n-3 fatty acids and olive oil was incorporated into the MCT diet to increase the level of monounsaturated fatty acids. The remaining 25% of total dietary fat was intrinsic to foods common to both diets. Table 2 shows the fatty acid composition of each experimental diet as determined using gas chromatography.

Table 2 Fatty acid content of the experimental diets determined by gas chromatography

Fatty acid (%)	MCT	LCT
C6:0	Trace	Trace
C8:0	19.4 ± 2.0	Trace
C10:0	23.6 ± 2.3	0.2 ± 0.1
C12:0	3.9 ± 0.6	0.3 ± 0.1
C14:0	2.6 ± 0.5	3.4 ± 0.4
C14:1	0.2 ± 0.1	0.6 ± 0.1
C15:0	10.1 ± 1.1	26.1 ± 0.9
C16:0	0.6 ± 0.2	2.7 ± 0.3
C16:1n7	3.8 ± 0.6	20.3 ± 1.1
C18:0	23.6 ± 3.5	38.5 ± 1.6
C18:1n9	7.1 ± 1.6	6.4 ± 1.6
C18:2n6	4.6 ± 1.3	0.8 ± 0.1
C18:3n3	0.3 ± 0.1	0.3 ± 0.1
C22:6n3	Trace	Trace

An unesterified plant sterol/stanol mixture (Forbes Medi-Tech, Vancouver, Canada), at a level of 22 mg/kg body weight/day, was added to the MCT diet to maintain normal levels of cholesterol concentrations. Results of plasma lipid concentrations with consumption of MCT and LCT are reported separately.[16] Subjects were randomly assigned to the MCT or LCT diet for the first experimental phase and consumed the alternate dietary fat during the second phase. Both phases were separated by a 4 or 8 week washout period during which subjects resumed their habitual lifestyles. This resulted in all measurements being taken in the same phase of the menstrual cycle for each subject.

Body weights were measured daily before breakfast. Body composition measurements were performed using magnetic resonance imaging (MRI) on days 1 and 28 of each experimental phase. For all women the MRI images were acquired using a Siemens 1.5 Tesla MRI scanner (Siemens, Mississauga, Canada) using a T-1 weighted, spin-echo sequence with a 210 ms repetition time and a 17 ms echo time. The MRI protocol is described in detail elsewhere.[18] Briefly, subjects lay in the magnet in a prone position with their arms straight overhead. Using the intervertebral space between the fourth and fifth lumbar vertebrae (L4–L5) as the point of origin, transverse images (10 mm slice thickness) were obtained every 40 mm from hand to foot, resulting in a total of approximately 41 images for each subject. The total time required to acquire all the MRI data for each subject was approximately 45 mins. All MRI data were analysed using specially designed image analysis software (Tomovision Inc, Montreal, Canada).

The model used to segment the various tissues has been fully described and illustrated elsewhere.[17] A multiple step procedure was used to identify tissue area (cm^2) for a given MRI image. In the first step a threshold was selected for adipose tissue (AT) and lean tissue (LT) based on the analysis of a sample of typical images and their respective grey level-histograms. Each image was then reviewed by an interactive slice editor program which allowed for verification, and where necessary, correction of the segmented results. The original grey level image was superimposed on the binary segmented image using a transparency mode to facilitate the corrections. In the final step, the observer labelled the different tissues by assigning them different codes. The areas (cm^2) of the respective tissues in each image were computed automatically by summing the given tissues' pixels and multiplying by the individual pixel surface area. The volume (cm^3) of the different tissues in each slice was calculated by multiplying the tissue area (cm^2) by the slice thickness (10 mm). The volume of the tissues for the space between two consecutive slices was calculated by using a mathematical algorithm given elsewhere.[17] The intra-observer differences for total, subcutaneous and visceral adipose tissue was calculated by comparing two analyses of 5 MRI data sets by a single observer. The intra-observer difference was 2.1 ± 1.2% for total, 1.8 ± 1.1% for subcutaneous and 8.1 ± 3.9% for visceral AT.

Energy expenditure was measured using a metabolic monitor (Delta-Trac, Sensor Medics, Anaheim, USA) for 30 mins before breakfast (baseline) and 30 mins during each hour for 6 h after breakfast on days 2 and 27 of each experimental phase. A transparent ventilated hood was placed on subjects' heads with Collins tubing connecting the hood to the monitor, as previously described.[10] The metabolic cart was calibrated daily, after an overnight warm-up period, with calibration gas containing 96% O_2 and 4% CO_2 and local atmospheric pressure. In addition, accuracy and precision of the metabolic cart were verified using the weighed methanol burning test and respiratory quotient test, respectively, at the beginning of the trial. During EE tests, expired gases were collected and analysed against ambient air and readings from the monitor were collected every minute. Fat and carbohydrate oxidation rates were calculated minute-by-minute using the equations derived by Lusk.[18] Total daily EE was calculated as the difference between energy intake and the sum of the changes in body AT, LT, and fecal energy excretion. Fecal energy excretion was calculated by measuring fecal fat excretion and multiplying by 9 kcal/g of fat.

$$\text{Total EE} = \text{E intake} - (\Delta \text{ total AT} + \Delta \text{ LT} + \text{E excreted}) \quad (1)$$

Change in total AT was converted to its change in AT energy store by multiplying the change in AT volume by 0.9 to convert from l to kg,[19] further multiplied by 7700 kcal/kg of fat and divided by 27 days of intake. Similarly for the conversion of change in LT stores to change in energy content of LT, the change in LT was multiplied by 1.1 to convert from l to kg,[19] further multiplied by 2920 kcal/kg, taking into account approximately 73% hydration,[20] and divided by 27 days of intake.

Total fecal samples were collected for 3 days at mid-point through each experimental phase for determination of fecal fat excretion. Samples were diluted by 50% with water, aliquoted and dried. Fecal lipids were extracted from approximately 3 g of the combined 3 day dried samples

with each day of sampling being proportionately represented. Lipid extraction was carried out in duplicate using the method of Folch *et al*[21] Dried lipid extracts were saponified then methylated using boron trifluoride methanol and heated at 80°C for 55 min. Methylated samples were analysed using gas chromatography (Hewlett Packard, GC 5890, Series II) equipped with 30 m fused silica capillary column (0.25 mm ID, 0.20 μm film, Supelco, Bellefonte, USA). Total fatty acid recovery was calculated by summing individual fatty acids and comparing their quantities with C 17:0 as internal standard.

Statistical analyses

Analysis of variance of results was carried out using a mixed model procedure with diet (MCT or LCT), day (2 or 27), hour (each half hour period between 0 and 6.5 h), and sequence as factors in the model. Interactions between diet and day and between diet, day and hour were also examined. Paired Student's *t*-test was then used to determine differences between diets at each hour on each individual day. Paired Student's *t*-test was also used to establish differences between MCT and LCT consumption on fecal fat excretion and changes in body composition. All statistical analyses were conducted using SAS statistical software (SAS/STAT version 6.12, SAS Institute, Cary, USA). A *P*-value of 0.05 was taken as statistically significant. Data are reported as means ± s.e.m.

Sample size determination

Dulloo *et al* found that subjects consuming MCT had an increase in total daily energy expenditure of 5%, which was equivalent to 113 kcal/day.[7] Results from White *et al* suggest that the difference in total energy expenditure between LCT and MCT diets could be as high as 160 kcal/day.[10] Assuming that subjects expand 160 kcal/day over total energy expenditure for the entire 28 day period, a total of 4500 kcal will be ended. The result of this increase in EE will be loss of approximately 600 g of body fat mass. A sample size of 18 subjects was found to be required to detect a change in AT stores of 600 g over the total experimental phase with 95% confidence.[22]

Results

Twenty-two subjects were recruited into the study and five did not complete. Reasons for failure to complete the study included intolerance to the LCT diet ($n=2$) and personal reasons ($n=3$). Compliance with the study protocol and feeding regimen within subjects completing the trial was considered high as only 2% of the meals were not consumed at the research unit due to exceptional circumstances. We assume that consumption of non-study foods was low since study foods were consumed under supervision and subjects did not gain weight. Although an exercise room was available for use by the subjects, only two subjects used it sporadically. These individuals followed instructions to repeat similar exercise level at approximately the same day during each experimental phase.

Eight of the women were post-menopausal. For the remaining nine women, four were in the follicular phase of their menstrual cycle during the first EE measurement period, three were in the luteal phase and the remaining two were in their menstrual period during this initial measurement period.

There was a decrease ($P<0.01$) in body weight, as measured using a standard scale, within each dietary phase but no difference in weight loss between the two phases (-0.87 ± 0.16 kg *vs* -0.84 ± 0.22 kg during MCT and LCT consumption, respectively). Figures 1 and 2 show individual changes in total and subcutaneous body AT compartments, respectively, between day 1 and day 28 of each dietary phase. There was no effect of diet or day on any of the body compartment volumes. Total AT varied from 37.7 ± 2.4 l on day 1 of MCT consumption to 37.1 ± 2.5 l on day 28. During LCT consumption, total AT volume was 37.9 ± 2.6 l on day 1 and 37.3 ± 2.6 l on day 28. Average

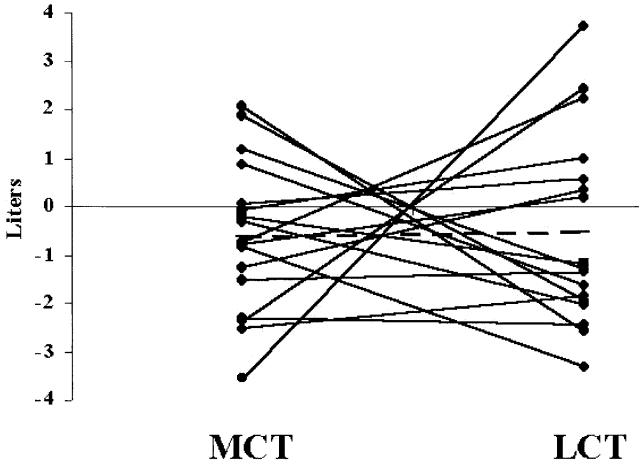

Figure 1 Individual changes in volume of total adipose tissue with consumption of MCT and LCT diets.

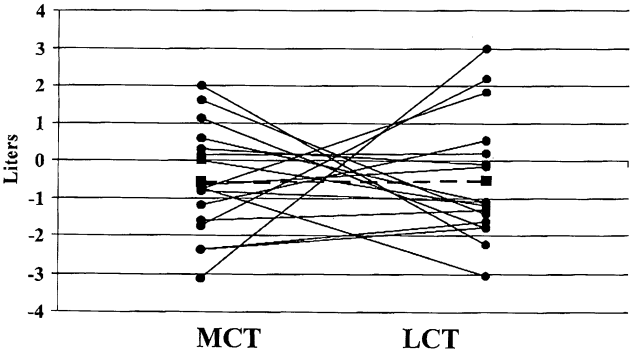

Figure 2 Individual changes in volume of subcutaneous adipose tissue with consumption of MCT and LCT diets.

subcutaneous AT volume at the onset of the MCT phase was 33.5 ± 2.2 l and 32.9 ± 2.3 l after 28 days. At the start of the LCT phase, average subcutaneous AT volume was 33.6 ± 2.3 l *vs* 33.1 ± 2.4 l at the end of the phase. Mean muscle volume was 19.6 ± 0.6 l on both days 1 and 28 during the MCT phase and, similarly, for the LCT phase, average muscle volume was 19.5 ± 0.6 l on day 1 and 19.4 ± 0.6 l on day 28. Inter-individual coefficients of variation for total body volume, total AT and subcutaneous AT volumes were 28.7%, 25.2% and 23.0%, respectively.

Resting metabolic rate (RMR) was not different between MCT and LCT consumption. On day 2 of the MCT phase, RMR was 0.84 ± 0.02 kcal/min *vs* 0.82 ± 0.03 kcal/min during the LCT phase. On day 27, RMR was 0.81 ± 0.03 kcal/min and 0.79 ± 0.02 kcal/min for the MCT and LCT phases, respectively.

Thermic effect of food was calculated as the difference between post-prandial (PP) EE and RMR at each time point after breakfast. Average TEF was 0.15 ± 0.01 kcal/min on day 2 and 0.17 ± 0.01 kcal/min on day 27 of MCT consumption whereas it was 0.14 ± 0.02 kcal/min for both day 2 and 27 of LCT consumption. Average PP EE was 0.99 ± 0.02 kcal/min on day 2 and 0.97 ± 0.02 kcal/min on day 27 of MCT consumption *vs* 0.96 ± 0.03 kcal/min and 0.93 ± 0.03 kcal/min on day 2 and 27 of LCT consumption.

Mean EE during day 2 and 27 on each dietary treatment are shown in Figure 3. Inter-individual coefficient of variation was calculated to be 2.3% for EE. The mean rates of EE measured in the 30 min interval immediately after breakfast are shown as time 0 h on both days. Average EE on day 2 of the MCT phase was 0.97 ± 0.023 kcal/min compared to 0.94 ± 0.028 kcal/min for the LCT phase. On day 27 of the MCT phase, average EE was 0.95 ± 0.024 kcal/min *vs* 0.90 ± 0.019 kcal/min for the LCT phase. There was a main effect of diet ($P < 0.01$), day ($P < 0.01$) and hour ($P < 0.01$) on EE but there was no diet by day interaction. Area under the curve (AUC) was greater ($P < 0.01$) with MCT compared to LCT intake. MCT consumption resulted in greater EE than LCT consumption and EE was lower on day 27 than day 1 for both dietary phases.

Figure 4 shows basal and PP fat oxidation on days 2 and 27 with each diet. Average fat oxidation on day 2 of the MCT phase was 0.081 ± 0.0035 g/min compared to 0.077 ± 0.0033 g/min for the LCT phase. On day 27, average values were 0.080 ± 0.0026 g/min and 0.075 ± 0.0022 g/min for the MCT and LCT phases, respectively. Area under the curve was greater ($P < 0.05$) with MCT consumption compared to LCT consumption. There was a main effect of diet ($P < 0.05$) and hour ($P < 0.01$) and a treatment by day by hour interaction ($P < 0.01$) on fat oxidation. The inter-individual coefficient of variation for fat oxidation was calculated to be 0.3%.

Fecal lipid analyses showed a trend ($P = 0.10$) towards greater fat excretion with LCT consumption compared to MCT consumption. The fat content of the fecal collection on the MCT diet was 0.47 ± 0.09 g/day compared

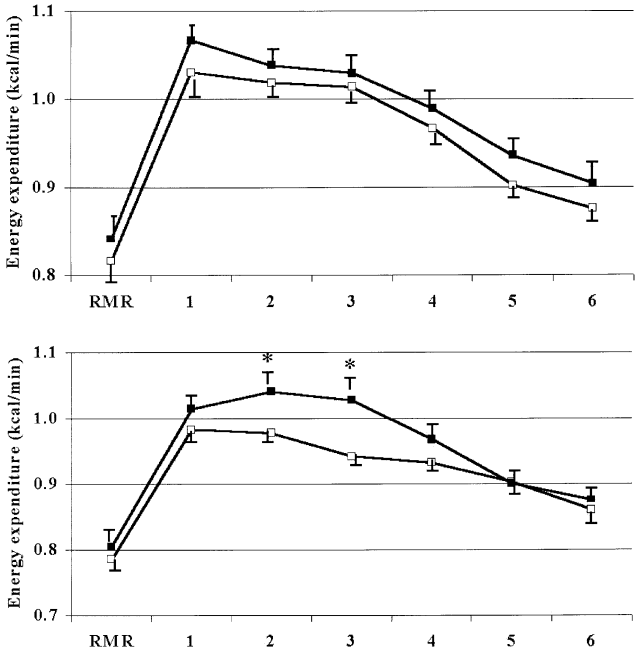

Figure 3 Energy expenditure after consumption of a breakfast containing MCT or LCT on day 2 (A) and day 27 (B). Closed squares = MCT phase; open squares = LCT phase. Values are means ± s.e.m., $n = 17$. *MCT significantly different from LCT, $P < 0.05$.

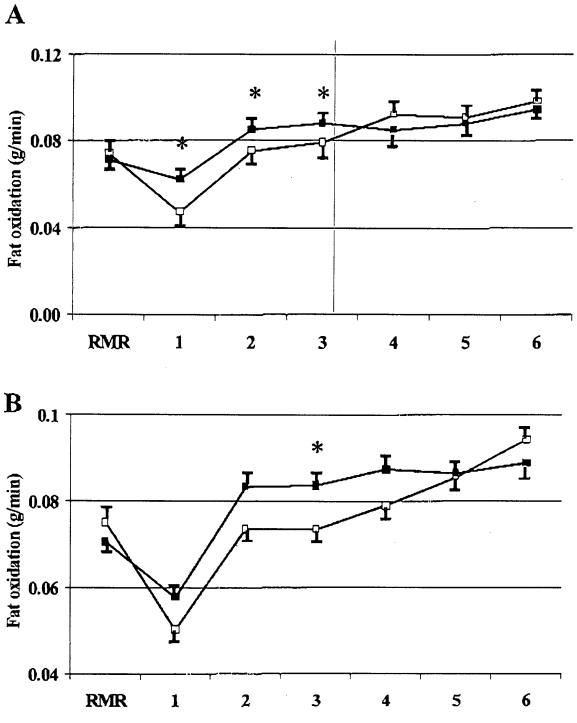

Figure 4 Fat oxidation after consumption of a breakfast containing MCT or LCT on day 2 (A) and day 27 (B). Closed squares = MCT phase; open squares = LCT phase. Values are means ± s.e.m., $n = 17$. *MCT significantly different from LCT, $P < 0.05$.

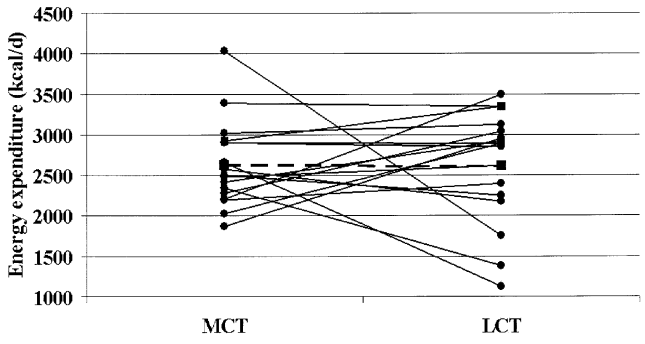

Figure 5 Calculated energy expenditure with consumption of diets containing MCT or LCT for 27 days.

to 0.61 ± 0.08 g/day on the LCT phase. This represents approximately 99.6% and 99.4% fat absorption during periods of MCT and LCT consumption, respectively.

The individual and mean calculated total EE during MCT and LCT consumption periods are shown in Figure 5. Total EE was 2640 ± 138 kcal after 27 days of MCT consumption and 2628 ± 177 kcal/day after LCT consumption (NS).

Discussion

The results of this 27 day inpatient trial show that controlled consumption of MCT increases EE and fat oxidation in obese women compared to a situation where energy intakes from LCT were equal. However, although EE was greater with MCT consumption throughout the 27 day period, this did not result in a measurable enhancement of weight loss during MCT consumption compared to the period of LCT consumption. Accordingly, no changes in total or regional AT distribution was observed with MRI consequent to these perturbations.

This study is unique since the inpatient and crossover controlled feeding design utilized precise monitoring of food intake. The use of MRI to assess body composition also allows very small differences in tissue volume to be observed. Magnetic resonance imaging is a well-established tool for measuring total and sub-components of total body fat and has been shown to accurately measure total body and sub-components of total AT when repeated contiguous slices are acquired.[23,24] The reliability of MRI as a tool in the assessment of body fat compartment volumes has been demonstrated by Ross *et al* who reported that the mean difference for repeat measurements of whole body AT and LT was $<3\%$ and $<2\%$, respectively.[24] These same researchers reported that the mean difference for subcutaneous and visceral AT for repeat measurements at the L4–L5 vertebrae was 1.1% and 5.5% respectively.[25] Magnetic resonance imaging thus measures the different AT compartments with an error of estimate of 2 to 10%.[22] More recently, Mitsiopoulos *et al* studied the reproducibility of MRI subcutaneous AT volume measurements by comparing the intra- and inter-observer estimates for MRI measurements.[26] The inter-observer and intra-observer differences were $-2.9 \pm 1.2\%$ and $1.5 \pm 1.5\%$, respectively, for subcutaneous AT.[26] It was reported that changes in subcutaneous and visceral AT compartments must be greater than 5 and 10%, respectively, to reach statistical significance.[23] The degree of weight loss observed in this trial was therefore below the threshold needed for MRI to identify the changes in AT volumes.

Our research trial is the longest study to date to examine the effects of high intakes of MCT on EE and the first to look at corresponding changes in total body composition in obese women. Quantities of MCTs provided in the functional oil were much higher than those normally consumed in the general population. Sevenhuysen *et al* reported that middle-aged women consume on average 15 g/day of butter as added fat on bread and potatoes.[27] This would represent a MCT intake of approximately 0.52 g/day, considering that 3.5% of total fatty acids in butter are found as octanoic and decanoic acids.[28] Furthermore, the inpatient study design employed for this trial is the first of its kind in this area of nutrition research. With such a rigorous study design and analytical methods, it was thus possible to not only carefully study the effects of MCT on EE, but also the resulting effects on body composition that have been proposed previously.[7–9]

Our findings strengthen and extend previous observations wherein greater EE and fat oxidation were obtained with consumption of MCT compared to LCT.[8–11] However, the magnitude of the difference in EE between the MCT and the LCT diet appears to be lower than that observed in studies conducted on male subjects.[7–9,11] Binnert *et al* have also found that diet-induced thermogenesis after consumption of a bolus of a 50–50 mixture of MCT and olive oil, compared to olive oil alone, was lower in their female subjects than observed by Seaton *et al*.[29,8] In fact, Binnert *et al* failed to observe any difference in fat oxidation between MCT and olive oil intake in obese women.[29] This may be due to the small sample size ($n=8$) and the quality and quantity of the experimental oil, which was a 30 g bolus of a 1:1 mixture of MCT and olive oil. However, the extent of the difference in fat oxidation is similar to that observed in the present trial. It was suggested that obese women had greater deposition of fatty acid due to their larger AT stores and that they also had increased uptake of fatty acids per unit of fat.[23] This may partly explain the discrepancy between our results and those obtained with male subjects[7–9] in terms of differences in EE and fat oxidation with MCT and LCT consumption. Indirect calorimetry is a valid method for measurement of EE, with an intra-individual coefficient of variation of 3.6%, however, variability for fat oxidation is much higher (17.4%).[30]

Body weight variations observed in this trial are much smaller than those observed by Tsuji *et al*,[13] however, their trial was not as well controlled and included more men than women. Foods were not consumed under strict supervision and authors relied on food diaries to observe compliance with protocol. Subjects tend to underestimate food

consumption and therefore a negative energy balance in both groups could have caused the weight loss observed. Body weight change in the present experiment is known to have been the result of MCT consumption since energy intake in both phases was identical.

Our analyses of fecal fat excretion show almost complete fat absorption (99.4–99.6%). The total fat excretion observed was indeed similar to that observed by Lia *et al* who found that ileostomy patients consuming oat bran or wheat bran excreted 465 mg or 194 mg of fat/day, respectively.[31] These values correspond to 99.1 and 99.7% fat absorption for oat bran and wheat bran consumption, respectively. Earlier studies of the absorbability of fats in rats showed that coconut oil is 99.7% absorbed compared to 98% for lard.[32]

If we consider that RMR accounts for approximately 8 h daily and that the remaining time is spent in the post-meal period, then the average difference in EE with MCT consumption compared to LCT, as measured by indirect calorimetry, can be extrapolated to be 40.2 kcal on day 2 and 50.2 kcal on day 27. This would translate into a 0.14–0.18 kg weight loss over a 27 day period. Using the energy balance equation with precisely known energy intake, changes in body composition and fecal energy excretion, the daily energy difference between MCT and LCT consumption is 10 kcal (NS). This difference in EE over a 27 day period would result in a weight loss of 0.03 kg. Although not statistically significant, the magnitude of the difference in adipose tissue loss between MCT and LCT consumption in this study is similar to the weight loss that would be expected following the differences in EE between the two dietary periods. When consuming an equal number of calories, subjects lost an average of 0.076 l of AT more with the MCT-containing diet than the LCT-containing diet, which is equivalent to 0.07 kg. Therefore, although the difference in adipose tissue loss between the two diets is not statistically significant, the trends in body weight changes can be explained by the extrapolated differences in EE.

In conclusion, present results show that EE and fat oxidation are increased with MCT consumption compared to LCT consumption in healthy overweight women. Furthermore, raised levels of EE and fat oxidation remained consistently elevated during 27 days of consumption of a diet rich in MCT but were not associated with a detectable difference in effect on body fat depot size. Although it cannot be concluded that prolonged MCT consumption results in greater weight loss compared to LCT consumption, MCT intake resulted in increased EE and fat oxidation. This may promote long term weight maintenance in obese women.

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