Medium Chain Triglycerides & Energy Balance

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Outline

- Metabolism of medium and long chain triglycerides
- Role on energy balance
  - Energy expenditure
  - Body composition
- Hormone/Food intake pilot data
  - “New Insights”
- Conclusions
Definitions

- Short chain triglycerides:
  - Fatty acids with 2-4 carbon chains

- Medium chain triglycerides:
  - Fatty acids with 6-10 carbon chains
  - Inclusion of C12 is debatable

- Long chain triglycerides:
  - Fatty acids with >12 carbon chains
Metabolism of medium and long chain triglycerides

LONG AND MEDIUM CHAIN TRIGLYCERIDES

LONG CHAIN FATTY ACID → CHYLOMICRON → ADIPOSE TISSUE

Lipase

LCFA

MCFA

CO₂

COMPLEX LIPIDS

LCFA

MCFA

LIVER
Potential tool of MCT oil for weight management?

<table>
<thead>
<tr>
<th>Author</th>
<th>Treatment</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hashim et al, 1987</td>
<td>Pair-fed rats MCT or LCT</td>
<td>MCT-fed rats were smaller</td>
</tr>
<tr>
<td>Geliebter et al, 1983</td>
<td>Rats overfed MCT or LCT</td>
<td>MCT-fed rats had smaller fat depots</td>
</tr>
<tr>
<td>Tsuji et al, 2001</td>
<td>MCT or LCT, 12-week supplementation</td>
<td>Greater body fat loss with MCT supplementation</td>
</tr>
<tr>
<td>St-Onge and Bosarge, 2008</td>
<td>MCT or LCT, 16 week weight loss study</td>
<td>Loss of body weight, fat mass and trunk fat mass tended to be greater with MCT consumption</td>
</tr>
</tbody>
</table>
Potential tool of MCT oil for weight management?

Energy intake

Energy expenditure
Human studies

- 6 lean, 6 obese men
- meals containing 38g LCT or 30g MCT+8g LCT

- 12 pre-menopausal women
- 14 day consumption of:
  - 80% of fat as LCT or MCT
- d7 RQ greater with LCT; difference ns on d14


Controlled feeding studies

- Overweight & obese men and women
- Randomized cross-over controlled feeding trial, 4-week treatment phases
- Weight maintenance diets
  - 40% of energy as fat, 30% as treatment fat
  - Oils rich in MCT or LCT (beef tallow/olive oil)
- Measured energy expenditure, body composition, plasma lipid concentrations
Effects of MCT consumption on energy expenditure

St-Onge et al., Int J Obes Relat Metab 2003;27:95-102
St-Onge et al., Obes Res 2003;11:395-402
Average change in body composition after 27 d of beef tallow or MCT oil consumption

- Total body volume
- Total Adipose Tissue
- Subcutaneous Adipose Tissue
- Muscle

Liters

MCT oil
Beef tallow

Average change in body composition after 28 d of olive oil or MCT oil consumption

- **Total body volume**: P=0.17
- **Total Adipose Tissue**: 0.16
- **Subcutaneous Adipose Tissue**: 0.087
- **Muscle**: 0.027

* different from 0, p<0.05

St-Onge et al., Obes Res 2003;11:395-402.
Effects of MCT consumption on energy balance

- In controlled feeding studies, we have shown that MCT oil consumption, at approximately 20% of energy intakes, increased thermic effect of food and fat oxidation compared to LCT (beef tallow and olive oil)\(^1,2\)

- Body composition changes were observed using MRI as a result of the rise in thermogenesis: men consuming MCT oil for 4 wk had a reduction in fat mass that was not observed when they consumed olive oil for 4 wk\(^2\)

1 St-Onge et al., Int J Obes Relat Metab 2003;27:95-102
2 St-Onge et al., Obes Res 2003;11:395-402
Proposed Mechanism for Adipose Tissue Reduction with MCT Consumption

- Travel through the portal circulation
- Rapid oxidation leading to enhanced thermogenesis
  - Likely not mediated by UCP3
- Increased adipose triglyceride lipase in white adipose tissue and hormone sensitive lipase and adipose triglyceride lipase in brown adipose tissue
  - Promote triglyceride hydrolysis in adipose tissue
Effects of MCT on adipose tissue triglyceride mobilization

Effects of MCT consumption energy balance

The other side of the equation...
Effect of MCT vs LCT consumption on food intake

- 6 men
- 61.5% fat diet for 14 d
- Either 20, 30, or 41% of energy as MCT

- Subjects consumed breakfast containing olive oil, lard, MCT, or fat substitute
- Food intake measured at lunch and dinner

Stubbs & Harbron, IJO 1996;20:435-44.
Van Wymelbeke et al., AJCN 1998;68:226-34.
MCT: “new insights” into appetite regulation

- We conducted a pilot study to test the effects of MCT oil, vs corn oil, on appetite-regulating hormones.
- Overweight men consumed 20 g of oil in a test breakfast and blood samples were obtained over a 3-hour period.
- 10 men were given an ad lib lunch 3 hours after breakfast.
- 7 men were given yogurt containing 10 g of the test oil 3 hours after breakfast and an ad lib lunch 1 hour later.
MCT: “new insights” into appetite regulation

<table>
<thead>
<tr>
<th>Time, min</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Breakfast</td>
</tr>
<tr>
<td>15</td>
<td>Blood sample</td>
</tr>
<tr>
<td>30</td>
<td>Blood sample</td>
</tr>
<tr>
<td>45</td>
<td>Blood sample</td>
</tr>
<tr>
<td>60</td>
<td>Blood sample, questionnaires</td>
</tr>
<tr>
<td>75</td>
<td>Blood sample</td>
</tr>
<tr>
<td>90</td>
<td>Blood sample</td>
</tr>
<tr>
<td>120</td>
<td>Blood sample, questionnaires</td>
</tr>
<tr>
<td>180</td>
<td>Blood sample, questionnaires</td>
</tr>
<tr>
<td>180</td>
<td>Ad lib meal (phase 1)</td>
</tr>
<tr>
<td>240</td>
<td>Ad lib meal (phase 2)</td>
</tr>
<tr>
<td>240</td>
<td>Pre-load, questionnaires</td>
</tr>
</tbody>
</table>
MCT: “new insights” into appetite regulation

- Percent change from baseline analysis, MCT vs corn oil
  - Lower rise in glucose, $P = 0.058$
    - Significant for phase 2 only, $P = 0.0023$
  - No effect on insulin, $P = 0.39$
  - Lower rise in TG, $P = 0.016$ (phase 2 only)
  - Greater rise in leptin, $P = 0.0063$
  - No effect on active ($P = 0.80$) or total ghrelin ($P = 0.12$)
  - No effect on PYY ($P = 0.14$—direction expected)
  - Greater rise in GLP-1, $P = 0.065$
Glucose
$P = 0.058$

Triglycerides
$P = 0.016$

GLP-1
$P = 0.065$
### Intakes at the test meal

<table>
<thead>
<tr>
<th>Test oil</th>
<th>Phase 1 (no pre-load)</th>
<th>Phase 2 (pre-load)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCT oil</td>
<td>608.7 ± 109.8</td>
<td>532.0 ± 147.2</td>
</tr>
<tr>
<td>Corn oil</td>
<td>662.5 ± 127.0</td>
<td>804.9 ± 183.7</td>
</tr>
<tr>
<td>Difference</td>
<td>-53.8 kcal</td>
<td>-272.9 kcal</td>
</tr>
</tbody>
</table>

Taken together, differences in energy expenditure and food intake would predict a negative energy balance of up to 320 kcal/day (approximately 270 kcal reduction in intake + 50 kcal increase in thermogenesis) with the replacement of LCT oils for MCT oil.
Potential tool of MCT oil for weight management?

St-Onge and Jones, J Nutr
Effects of free-living MCT consumption on body composition

- 101 Japanese men & women recruited
  - 78 completed: MCT n=41; LCT n=37
- BMI 24.7 kg/m²
- Controlled feeding study
  - Meals provided but diet supplemented by fixed amounts of prescribed foods
- Total energy intakes 2200 kcal/d, fat intake 60 g/d
- 10 g test oil/d
  - MCT vs. blend of rapeseed and soybean oil
  - Provide in bread to be consumed at breakfast

Change in body weight & fat mass with MCT & LCT supplementation

* p < 0.05

Weight loss study with MCT oil or olive oil consumption

- Weight loss study
- Subjects:
  - Men & women
  - Age 19-50
  - BMI 27-33 kg/m²
- Parallel arm:
  - MCT oil
  - Olive oil

- 16 wk supplementation period:
  - 20% of energy requirements (~22 g/d for women and 26 g/d for men)
  - 10 g provided in muffins, rest as liquid oil
Weight loss with MCT oil or olive oil consumption

St-Onge and Bosarge, Am J Clin Nutr 2008;87:621-6.
Weight loss with MCT oil or olive oil consumption

Diet*time, P = 0.07

St-Onge and Bosarge, Am J Clin Nutr 2008;87:621-6.
Summary

- There is strong evidence that MCT oil consumption increases thermogenesis.
- Our pilot data suggest a role of MCT in promoting satiety (PYY, GLP-1, leptin), not reducing hunger (ghrelin).
- Overall, and in conjunction with our weight loss study, evidence suggests a role of MCT oil for weight management.
- Coconut oil is the richest natural source of MCT...
  - Does that mean that coconut oil has similar effects???
### Fatty acid composition of coconut oil

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<th>Fatty acid</th>
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<th>MCT oil</th>
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<tr>
<td>Caprylic acid</td>
<td>8:0</td>
<td>7.5</td>
<td>67</td>
</tr>
<tr>
<td>Capric acid</td>
<td>10:0</td>
<td>6.0</td>
<td>27</td>
</tr>
<tr>
<td>Lauric acid</td>
<td>12:0</td>
<td>44.6</td>
<td></td>
</tr>
<tr>
<td>Myristic acid</td>
<td>14:0</td>
<td>16.8</td>
<td></td>
</tr>
<tr>
<td>Palmitic acid</td>
<td>16:0</td>
<td>8.2</td>
<td></td>
</tr>
<tr>
<td>Stearic acid</td>
<td>18:0</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td>Oleic acid</td>
<td>18:1</td>
<td>5.8</td>
<td></td>
</tr>
<tr>
<td>Linoleic acid</td>
<td>18:2</td>
<td>1.8</td>
<td></td>
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Coconut oil and thermogenesis

- Different fatty acids have different oxidation rates\(^1,2\):
  - Decreases with increasing carbon chain length
  - Decreases with increasing saturation level
  - \(12:0 > 18:3 > \text{tr} \ 18:1, 18:2, \cis \ 18:1 > 16:0, 18:0\)
  - \(12:0 > 14:0 > 16 > 18:0\)

- High-fat fed rats fed with coconut oil and safflower oil have lower fat gain efficiency than lard, fish oil, and olive oil fed rats\(^3\)

- Energy restriction in diet-induced obese rats causes greater reductions in SAT and peri-muscular fat pads if diet includes coconut oil compared to olive oil\(^4\)

2. McDonald et al., Gastroint Liver Physiol 1980;239:G141-50
Several questions to be posed...

- Is the amount of caprylic acid and capric acid in coconut oil sufficient to increase thermogenesis and improve energy balance regulation, when consumed in reasonable amounts?

- Does the lauric acid content of coconut oil contribute to the thermogenic effect of coconut oil and improvements in energy balance regulation?
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Conclusions

- There is a large body of evidence to claim that MCT consumption enhances thermogenesis.
- MCT may also promote satiety and lead to lower food intake compared to LCT.
- It is not unreasonable to propose that lauric acid would contribute to augment the thermic effect of coconut oil but studies need to be done to test this.
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