Fats and Exercise

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FAT

- EVERYBODY WANTS TO LOSE IT BUT OUR BODIES LOVE IT!!!!
- WHY IS FAT SO IMPORTANT??????
- One of the three major macronutrients that contributes to the fuel our bodies need for every day tasks and is essential to exercise and competitive sports.

FUNCTIONS OF LIPIDS

- Provides our body with 9kcal/gram – the highest energy-yielding nutrient we can digest and absorb
- Aid in maintaining proper body temperature
- Protect vital organs from trauma through their surfactant characteristic
- Transport and facilitate the absorption of fat-soluble vitamins & carotenoids
- Function in cell signaling
- Contribute to the satiety value of food
- Regulators of many hormonal functions such as insulin action and inflammation

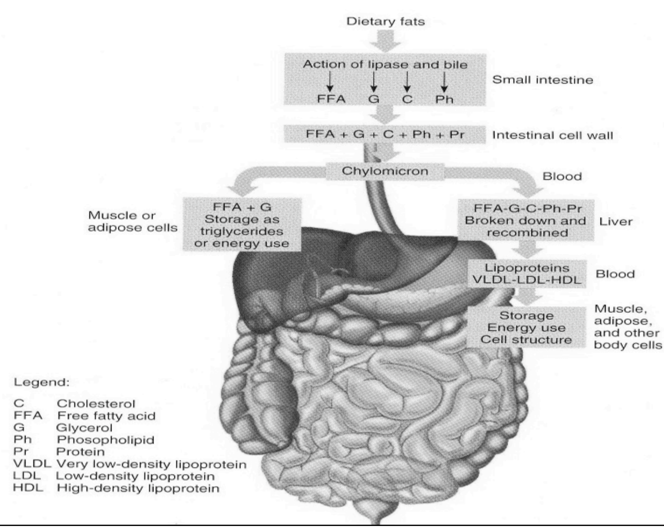
TYPES OF LIPIDS & FOOD SOURCES

- SATURATED FAT
  - No double bonds
  - Found in foods such as butterfat, coconut oil, palm oil
- MONOSATURATED FAT
  - One double bond
  - Plays a vital role in membrane structure
  - Found in foods such as olive oil, avocado, almonds & canola oil
- POLYUNSATURATED FAT
  - Contain more than one double bond
  - Essential fats can not be synthesized in the human body – Alpha-Linolenic and Linoleic Fatty Acids
  - Found in foods such as fish, shellfish, nuts, and vegetable & plant oils
  - Lend way to Omega 3 and Omega 6 fatty acids that reduce LDL blood levels, total cholesterol, decrease high blood pressure and protect heart from cardiovascular disease

RDA OF DIETARY FATS

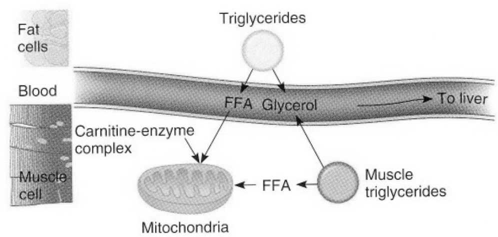
- Average adult population – 20% - 35% (all fat including MUFA and PUFA)
- Elite Athlete – Sport specific and tailored to their energy needs
  - Runners & Cyclists – 27% - 35%
  - Gymnasts and Figure Skaters – 15 % - 31%

Fat Metabolism



Fatty Acid Oxidation

- Limitations to oxidize fat include inability to
  - break down fatty acid (f.a.) in adipose tissue
  - transport f.a. to muscle
  - Uptake f.a muscle from plasma
  - Breakdown f.a. in muscle
  - Regulate f.a. movement in the mitochondria
- ↑Glucose available ↓ f.a. oxidation
- When fat is called to provide fuel to the body for exercise:
  - ↓Insulin ↑lipolysis
  - ↑Epinephrine ↑ lipolysis



Increase fatty acid oxidation by Training

- Trained athlete:
  - Expends more energy
  - Inhales more oxygen
  - Receives more energy from fat, less carbohydrate
- Metabolic adaptations during training:
  - Increased # mitochondria
  - Increased Fatty acid oxidation
  - Improved blood flow
  - Enhanced respiratory capacity

Fat Intake and Injury in Female Runners

Gerlach, K.E., Burton, H. W., Dorn, J.M., Leddy, J.J., & Horvath, P.J. (2008). Fat intake and injury in female runners. *Journal of the international society of sports nutrition,* 5(1), 1-8. doi: 10.1186/1550-2783-5-1

Purpose

- Purpose
  - The aim of the study was to investigate the association between fat intake, energy intake and energy availability with injury in female runners.
- Hypothesis
  - Female runners who develop overuse injury have lower energy intake, lower energy availability and lower fat intake than non-injured runners.

Methods

- Participants
  - 90 healthy female runners, between 18 to 53 years old
- Preliminary measurements:
  - Medical
  - Menstrual
  - Training screening
  - Injury assessment

Methods cont.

- Participants completed all questionnaires at the first visit, except for the prospective follow-up injury questionnaire.
  - Food frequency questionnaire (FFQ) (energy intake)
  - Eating attitude questionnaire (probability of eating disorders)
  - 24-hour activity log
  - Leisure time physical activity questionnaire (daily, weekly and monthly energy expenditure in leisure activities)
  - Anthropometrics
    - Body fat percentage
  - Flexibility
  - VO_{2max}
  - Fatigue test
  - Ground reaction forces

Methods cont.

- Follow-ups were set every three months for one year period (prospective follow-up injury questionnaire)
- Values were calculated
  - Energy balance = Energy intake (from FFQ) - EEE (from activity log)
  - Energy availability = Energy intake - XEE (from Leisure time physical activity questionnaire)

Results

- 55% of subjects reported a running related injury
  - Foot, ankle, knee, or hip
- Both groups, injured and non-injured runners, had similar diets, except for fat intake (FFQ)
- Both groups ate only 2/3 of calories needed for their energy expenditure despite the fact that they maintained a steady weight
- Fat intake and fat vitamin intake were lower in injured group compared to non-injured group

Results cont

- Energy availability was low in both groups, concluding that there is not an association between injury and energy availability.
- Researchers found that there is a positive correlation between low fat intake and injured female runners, but they did not find a significant relationship between energy intake and energy availability with injury.

Study Discussion

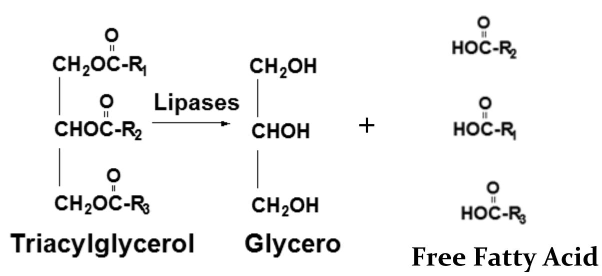
- Previous studies found similar results, linking low fat diets with injury
- Researchers had the limitation to have many uncontrolled variables that might confound the results.
- Competitive female's runners eating less than the recommended dietary reference intake for fat (30%) are at higher risk of overuse injury.

From Lipid to Energy

- Lipid Mobilization
- Transportation of FA in blood to Tissue
- Activation of FA as CoA Ester
- Transport into Mitochondria
- β-oxidation

Lipid Mobilization

- Occur in adipose tissue



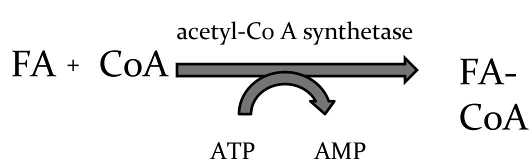
Lipase = Hormone Sensitive Lipase (HSL) and Monoglyceride Lipase (MGL)

Transportation of FA in blood to Tissue

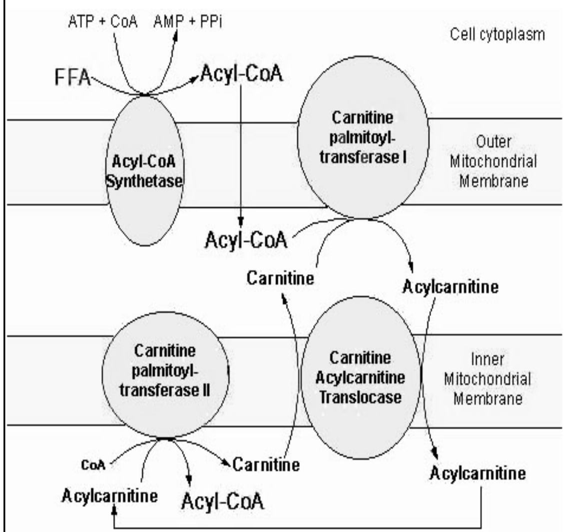
- Free FA bound with transport proteins, such as fatty acid binding protein (FABP) & fatty acid translocase to across adipose tissue membrane
- Then free FA released in blood, bound with albumin & moved to muscles
- At the muscle, albumin release FA, then FA binds with another FA binding protein to cross muscle cell membrane and allocate in cytoplasm to mitochondria for β-oxidation

Activation of FA as CoA Ester

- Occur in cytoplasm before FA cross mitochondria membrane



Transport into Mitochondria

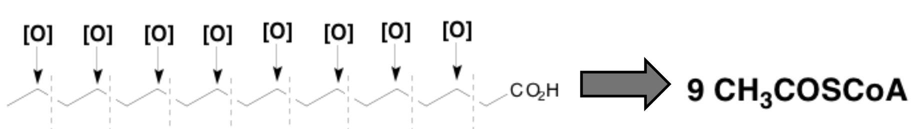


- CPT1 (outer membrane) to convert fatty acyl-Co A to acylcarnitine to be able to cross mitochondria membrane
- It is a rate limiting that can be inhibited by malonyl-Co A when the blood glucose level increases
- CPT2 (inner membrane) converts acylcarnitine back to fatty acyl-CoA for the β-oxidation

http://neuromuscular.wustl.edu/pathol/diagrams/carnitine.htm

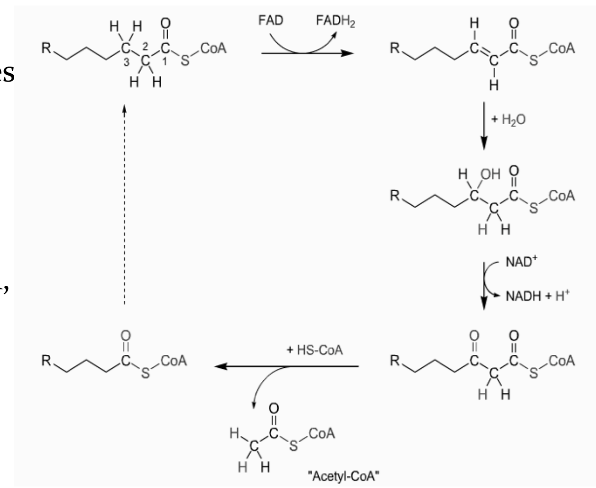
β-oxidation

- Occur in mitochondria
- Cleave Fa-CoA from the carboxyl end into two-carbon unit called acetyl-CoA



β-oxidation

- One cycle of β-oxidation produces one unit of acetyl-CoA, $FADH_2$ and NADH
- Finally acetyl-CoA, will enter to TCA cycle for energy production



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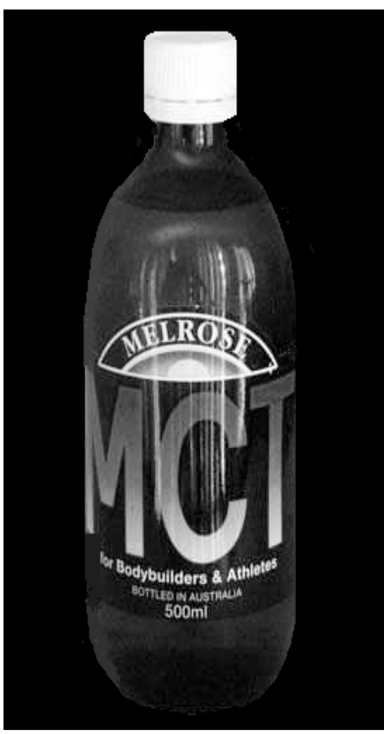
Energy Net

- 1 acetyl-CoA releases 12 ATP when it is completely reduced into oxygen and water in the TCA cycle
- By estimate, oxidation of fatty acid yield total energy higher three times, compared with glucose oxidation

Question??

How much net ATP is produced from palmitate (16 carbons)?

7 cycles of β-oxidation	7 cycles x 5 ATP =	35	ATP
8 acetyl CoA oxidized	8 X 12 ATP =	96	ATP
Total ATPs produced	=	131	ATP
2 ATP from activation		- 2	ATP
Net ATPs		**129**	**ATP**



Medium Chain Triacylglycerol (MCT) Ingestion

MCT

- Triglyceride that has fatty acids containing a number of carbons between 6-12 atoms
- Differences of MCT from LCT
  - Higher solubility in biological fluids
  - Not require bile salt for absorption
  - Not be re-esterified in the small intestinal cells
  - Not depend on carnitine for crossing the mitochondria membrane
  - Provide immediate energy

- Therefore, in the views of exercise performance, many researchers expect that taking MCT as supplements may spare glycogen and can be used as fuel sources to increase endurance

Medium-Chain Triacyglycerols on Moderate and High-Intensity Exercise in Recreational Athletes

Nosaka, N., Suzuki, Y., Nagatoishi, A., Kasai, M., Wu, J., & Taguchi, M. (2009). Effect of ingestion of medium-chain triacylglycerols on moderate and high-intensity exercise in recreational athletes. *Journal of Nutritional Science and Vitaminology, 55*(120-125). Retrieved September 2, 2010, from http://www.jstage.jst.go.jp/article/jnsv/55/2/55_120/_article

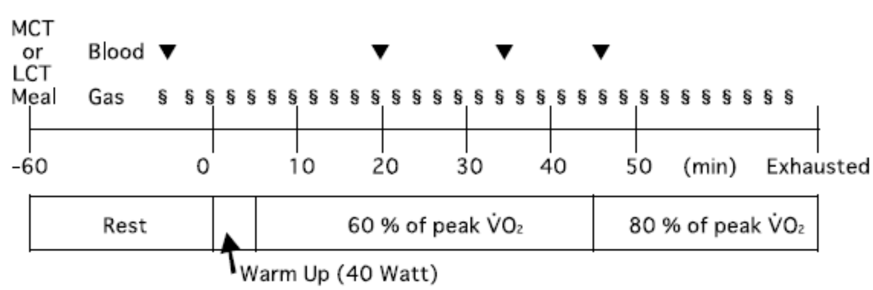
Purpose

- To investigate the effect of short-term ingestion of food containing a small amount of MCT on fat and CHO utilization

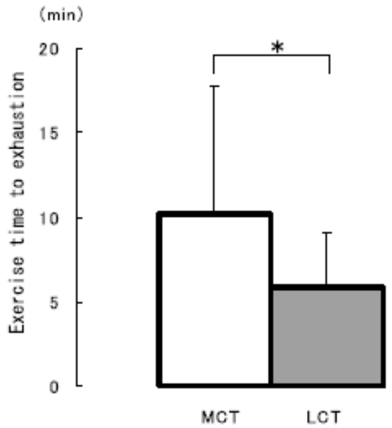
Methods

- Subjects were administered food containing MCT or LCT for 14 d. and instructed to perform cycle ergometer exercise a workload corresponding to 60% peak VO2 for 40 min follow by workload corresponding to 80% peak VO2 until exhaustion
- Gas exchange, blood glucose & lactate, and Rate of Perceived Exertion (RPE) measurements

Effect of ingestion of MCT on Exercise

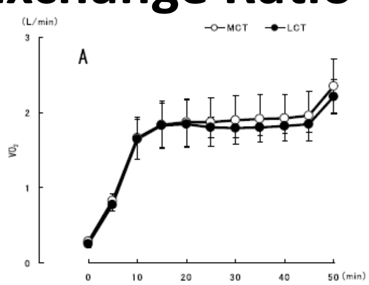


Exercise Time to Exhaustion

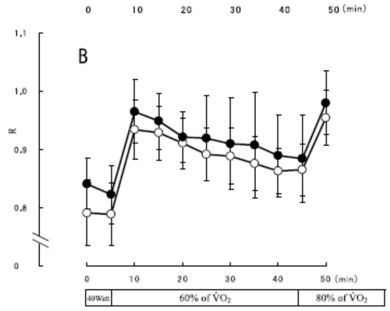


•Taking MCT is sig increase exercise time to exhaustion compared to taking LCT

Oxygen Uptake & Respiratory Exchange Ratio

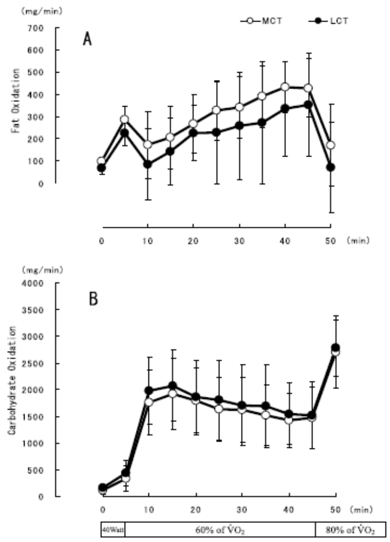


•VO2 : No sig different btw MCT & LCT



•$R_{MCT} < R_{LCT}$ (not sig)

Fat Oxidation & Carbohydrate Oxidation



- Fat Oxidation of MCT > LCT (not sig)

- CHO oxidation of MCT slighly lower than LCT (not sig)

Blood Concentration Data

Workload, % of peak $\dot{V}O_2$		0	60		80
Exercise time, min		0	20	35	45
Blood glucose, mg/dL	LCT	119±16	82±6	86±9	90±11
	MCT	124±24	80±11	87±13	94±16
Blood lactate, mmol/L	LCT	2.0±0.6	6.1±4.0	5.8±4.7	7.7±3.7
	MCT	1.4±0.5	4.1±1.9*	3.4±1.7	5.0±1.4
Ratings of perceived exertion	LCT	6.0±0.0	14.3±1.0	16.1±1.5	18.8±1.2
	MCT	6.0±0.0	13.6±1.1*	15.1±1.1	18.0±0.9

Values are means±SD. *Statistically significant difference from the value of LCT trial ($p<0.05$).

Conclusion

- Taking small amount of MCT in short term suppresses the increase in the [blood lactate] & RPE during moderate-intensity exercise

  & more prolong exercise time in high-intensity exercise compared to LCT consumption

Effects of a low fat diet:

- A low fat diet for athletes is considered <15% total energy intake.
- Implications:
  - Fatty acid deficiency
  - Fat soluble vitamin deficiency
  - Amenorrhea (in female athletes)
  - Low testosterone (in male athletes)
  - Problems regulating body temperature.

Effects of a low fat diet con't.:

- A diet lacking in fat is also more likely to be deficient in total energy as well
  - More difficulty in sustaining a competitive level of performance
- There is little evidence to suggest a positive benefit in consuming diets very low in fat and performance.
- A very low fat diet is not recommended for athletes.

Fatty acid deficiency:

- Not very common
- Symptoms include:
  - Rash: scaly, dry skin
  - Poor wound healing
  - Decreased immune system: susceptible to infection
  - Growth retardation
  - Decreased hair growth

Effects of a high fat diet:

- Coincides with a high saturated fat and high cholesterol intake
- Implications:
  - Cardiovascular disease
    - Coronary heart disease
    - Atherosclerosis
    - Stroke
    - Heart attack
  - Diabetes: related to obesity and insulin intolerance
  - A variety of other diseases related to obesity and a high fat or high cholesterol diet

Effects of a high fat diet con't:

- To prevent cardiovascular disease from a high fat diet recommend:
  - 20-35% total energy from fat
  - ≤10% saturate fat
- Keep in mind that exercise helps prevent cardiovascular disease, but that does not mean that athlete are invisible.

The Effect of Increased Lipid Intake on Hormonal Responses during Aerobic Exercise in Endurance-Trained Men

Christ E. R., Zehnder M., Boesch C., Trepp R., Mullis P.E., Diem P., & Decombaz J. (2006). The effect of increased lipid intake on hormonal responses during aerobic exercise in endurance-trained men. *European Journal of Endocrinology*, 154, 397-403.

Purpose

- To determine the possible connection between high and low dietary fat intake and the levels of ghrelin and leptin before and during aerobic exercise.
- **Hypothesis:** The researchers aimed to prove that "dissimilar lipid intake will have an opposite impact on ghrelin and leptin, as well as insulin and cortisol levels during standardized aerobic exercise.

Ghrelin, Leptin & Cortisol

- **Ghrelin** – Hormone that stimulates hunger. Levels increase before meals and decrease after meals.
- **Leptin –** Regulates energy intake and energy expenditure (appetite & metabolism)
- **Cortisol -** Hormone released in conjunction to stress

Methods

- Small sample size
- 11 endurance-trained male athletes
- Reference controlled crossover trial
- Athletes kept journal of physical activity and diet
- Subjects underwent 3-h exercise session to reduce body stores before receiving strict HF or LF diet

STANDARD DIETS RANDOMLY GIVEN TO SUBJECTS

Low fat – 0.5 g fat/kg body weight for 2.5 days

High fat – 0.5 g fat/kg body weight for 1 day followed by 3.5 g fat/kg body weight for 1.5 days

Methods cont'd.

- Subjects were given standardized CHO snack in the morning
- Ghrelin, Leptin, Insulin, GH & Cortisol levels measured before and at regular intervals throughout 3 hour aerobic exercise test

Results

- **Pre-Exercise Hormone Concentrations**
  - HF diet resulted in lower pre-exercise leptin levels than the LF diet confirming that short-term diet affects leptin concentration
  - Ghrelin and cortisol pre-exercise levels were not affected by the diet.
- **During Exercise Hormone Concentrations**
  - LF diet resulted in increased ghrelin concentrations
  - LF diet decreased leptin levels
  - Inverse levels for HF diet for both
- Cortisol levels stayed fairly consistent
- **After Exercise Hormone Concentration**
  - Insulin level had significant decrease after exercise

Results & Discussion

- Hormonal regulation during a continuous exercise depends on availability of fuel prior to exercise.
- LF diets result in lower fuel stores which the body uses rapidly during the exercise.
- Leptin and ghrelin significantly change to restore energy balance by increasing appetite and food intake
- HF diet provided the body with the necessary amount of fuel to complete exercise.
- This study shows that "hormones involved in energy homeostasis respond differently when during negative energy balance
- Further proof that low-fat diets do not offer the body any nutritional benefits.
- Compromise important hormones

Fats and specific exercises:

- Fat requirements vary very little between sports
- The general recommendation for any sport that you can imagine: football, baseball, figure skating, field events, etc., is to meet carbohydrate and protein needs and then consume the remainder of energy from fat.
- In some cases, 1g fat/kg body weight is recommended, but still making sure that carbohydrate and protein needs are met first.

Fats and specific exercise con't.:

- Following these recommendations fat intake ends up being 20-35% total energy intake
- In conclusion, fat requirements for athletes does not differ significantly from regular everyday fat requirements
- Keep in mind that while the % of total energy is the same athletes consume more fat because the have greater energy needs overall

Fat adaptation:

- Definition: consuming a diet high in fat and lower in carbohydrates in order to increase fat oxidation and improve performance
- Why: By increasing fat oxidation, muscle glycogen stores can be spared and performance will improve
- Does is work: Overall conclusion- NO!

Fat adaptation followed by carbohydrate loading compromises high-intensity sprint performance

Havemann, L., West, S. J., Goedecke, J. H., Macdonald, I. A., St. Clair Gibson, A., Noakes, T. D., & Lambert, E. V. (2006). Fat adaptation followed by carbohydrate loading compromises high-intensity sprint performance. *Journal of Applied Physiology, 100*, 194-202.

- Purpose: to determine the effect of a high-fat diet followed by one day of carbohydrate loading on heart rate variability, effort perception, muscle recruitment, and **performance during a 100 km cycling time trial,** including high intensity sprints.

- Hypothesis: a high-fat diet will improve overall performance time.

Participants:

- 8 male, endurance trained, cyclists
- Previously free from disease and not taking any medications for chronic disorders

Preliminary measurements:

- Height, m
- Weight, kg
- Body fat %
- $VO_{2\,peak}$ (peak oxygen uptake)
- W_{peak} (peak power output)

Methods

- Each participant received both experimental diets. 6 days high-fat followed by one day carbohydrate (CHO) loading, and 6 days high-CHO followed by one day CHO loading
- Study design was a randomized, single-blind crossover with a 2 week washout period between trials
- High-fat diet consisted of 68% energy from fat
- CHO-loading consisted of 90% energy from CHO
- High-CHO consisted of 68% energy from carbs

Methods con't.

- A registered dietitian developed the menu which was prepackaged to prevent deviations
- Participants came to the lab for training and testing on days 1, 3, 5, and 7
  - Day 1, 100 km time trial for reference. Day 3, 5, and 7, 60 minute steady-state ride.
  - V_{O2}, V_{CO2}, heart rate, and rate of perceived exertion (RPE), power output, and EMG (electromyography) amplitude were measured during every test/training session
  - On day 7 blood was drawn at rest and at 15 min. intervals to analyze plasma glucose, lactate, free fatty acids, and catecholamine concentrations

Methods con't.

- On day 8 participants completed a 100 km time trial
  - Subjects ingested a 10% glucose solution at 200 ml every 20 minutes
  - Blood was drawn at rest and the before 1 km sprints at 32, 52, 72, and 99 km.
  - EMG was measured at the mid-point of each 1 km sprints, each 4 km sprint, and at 3 non-sprint distances
- On days 7 and 8 isometric maximal voluntary contraction was measured

Results

- All subjects followed the experimental diets
- All subjects attended all training sessions
- However, 2 participants could only finish 45 of 60 minutes on day 5 during the high-fat diet

Significant findings

- There was no significant difference between the overall time trial performance
- Power output and sprint time decreased during the 4 km sprints in both time trials (no significant difference between diets)
- RPE increased after the 4 km sprints in both time trials (no significant difference between diets)

Significant findings con't.

- Power output and time of 1 km sprints was significantly lower following the high-fat diet
- RPE after 1 km sprints was not different between diets
- This is the first study to show that a high-fat diet can impair high-intensity sprint performance
- While this study showed a shift to a higher reliance on fat rather than CHO oxidation, it did not show any benefit from this

Study discussion

- Study is limited because only 8 subjects were tested for a short period of time, and subject were male only
- Strength was in the planned menu, which was individualized and prepackaged to ensure adherence
- In this study no measurement of muscle glycogen stores was conducted, so no comment can be made about how a high-fat diet may influence
- Results parallel other similar studies which find no benefit of a high-fat diet
- Following this study, research about fat loading seems to drop of leading to the conclusion that there really is no benefit.

Responses of LDL and HDL Particle Size and Distribution to Omega-3 Fatty Acid Supplementation and Aerobic Exercise

Wooten, J., Biggerstaff, K. D., Ben-Ezra, V. (2009). Responses of LDL and HDL Particle Size and Distribution to Omega-3 Fatty Acid Supplementation and Aerobic Exercise. *Journal of applied Physiology*, *107*: 794-800.

Purpose

- To determine the independent and combined effects of Omega-3 fatty acid supplementation and exercise on lipids and lipoprotein cholesterol concentrations

- **Hypothesis –** The combination of aerobic exercise and Omega-3 fatty acid supplementation would improve blood lipids than either effort alone.

Methods

- Participants – Normal, normoglycemic, nonsmoking men
- Between ages of 19-47 (11 subjects)
- Men randomly assigned to perform rest or exercise before Omega-3 supplementation
- Followed by 42 days of 4.55g/day Omega-3 supplementation and randomly assigned to rest or exercise
- During exercise, participants were assigned to treadmill exercise for 3 consecutive days at 60 min per session
- Diet diary required during study
- Blood samples were taken before and after exercise to measure lipid serum levels

Results

- Exercise greatly reduced total cholesterol and triglyceride serum concentration levels without Omega-3 supplementation
- Exercise also decreased LDL particle size
- Omega-3 supplementation increased HDL particle size, making it more buoyant
- The combination of Omega-3 and Exercise did not improve blood lipid levels but altered lipids and lipoproteins in various ways

Discussion

- Lack of research regarding combination of Omega-3 and exercise in regards to reducing blood lipid serums
- Small sample size – Benefit from increasing the number of participants
- Omega-3 supplementation very hot topic right now therefore more research should be emerging regarding the health benefits of supplementation.

HUMAN ECOLOGICAL THEORY

Relationship with your Client

Dietary Fat and Your Athlete

- Stigmatism regarding consumption of dietary fat must be addressed in a sensitive manner.
- Must educate client on importance of incorporating healthy dietary fat into meals so the body can perform optimally for specific sport
- Dispel any false information regarding fat
- Open line of communication

Conclusion

- Diet containing proper amount of dietary fat is critical to optimal performance and basic energy needs
- Low fat or high fat diets do not provide the body with the correct energy needs
- More research needs to be done regarding MCT supplementation and Omega-3 supplementation

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