Body Composition and Metabolic Adaptations Contribute to the Decline in RMR during Weight Loss

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BACKGROUND

Obesity: Weight Loss Ineffective Over Time

- In 2015, 40% of U.S. adults were considered obese
- Obesity decreases life expectancy and quality of life
- Weight loss created by a negative energy balance is the only treatment method
  - A prolonged negative energy balance becomes ineffective and weight loss stagnates, causing a plateau and weight regain

Resting Metabolic Rate (RMR) Declines During Weight Loss

- RMR is energy expended during resting state
  - Largest component of daily energy expenditure
  - Declines as people lose weight and slows weight loss
- Declines in RMR can be explained by **changes in body composition** or **by conservation of energy**
  - Changes in body composition: Lean body mass (organs, skeletal muscle) and adipose tissue are energy expending tissues
  - Energy conservation hormones involved in metabolic energy regulation include leptin,T3, insulin, and IGF-1

PURPOSE

Objective: To understand the contribution of a) changes in body composition and b) metabolic adaptions to the decline in RMR during calorie restricted weight loss

Hypotheses

1. Loss of lean body mass will be a strong contributor to RMR declines
2. Leptin will exert a stronger effect on RMR than other metabolic hormones

MATERIALS & METHODS

Comprehensive Assessment of Long term Effects of Reducing Intake of Energy (CALERIE): Phase 2

- Two-year study – 25% calorie reduction
- 220 participants
- Normal and overweight participants (BMI 22-27.9)

Present Study:

- 117 Participants
- Complete Baseline and 12 Month data:
  - RMR (Indirect Calorimetry)
  - Body Composition (DXA)
  - Metabolic Hormones (Leptin, T3, Insulin, IGF-1)

Secondary Data Analysis:

- Quartiles based on weight loss, loss of fat-free mass and fat mass
- Estimation of RMR change based on organ and tissue expenditure (DXA)

RESULTS

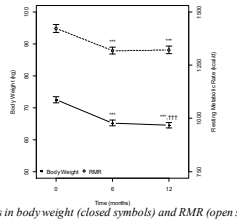

*Figure 1 Changes in body weight (closed symbols) and RMR (open symbols) over the course of the first 12 month of calorie-restricted weight loss. ***p<0.001 vs. month 0, †††p<0.001 vs. month 6*

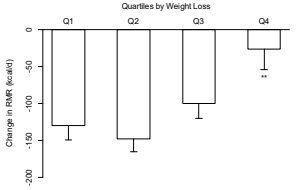

*Figure 2 Changes in RMR based on the amount of weight loss from baseline to month 12. **p<0.01 vs. Q1. All comparisons are adjusted for age, BMI, and gender.*

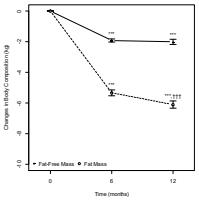

*Figure 3 Change in fat free mass (closed) and fat mass (open) over the first 12 months of calorie-restricted weight loss. ***p<0.001 vs. month 0, †††p<0.001 vs. month 6*

*Table 1 Baseline anthropometric information based on quartiles divided by the amount of weight loss over after month 12. *p <0.05 vs. Q1, **p <0.01 vs. Q1, ***p <0.001 vs. Q1*

	Quartiles by Weight Loss			
	Q1	Q2	Q3	Q4
Age (years)	42.1 ± 1.0	38.1 ± 1.3*	36.4 ± 1.5**	34.8 ± 1.3***
Sex (f/m)	15/15	17/12	23/6**	25/4**
Body Weight (kg)	77.7 ± 1.7	72.8 ± 1.5*	68.1 ± 1.6***	69.2 ± 1.8***
BMI (kg/m²)	26.0 ± 0.3	25.2 ± 0.3	24.4 ± 0.3***	24.6 ± 0.3***

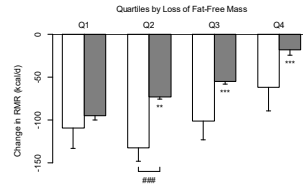

*Figure 4 Changes in RMR based on the amount of fat-free mass lost from baseline to month 12. White bars depict changes in RMR measured by indirect calorimetry, grey bars depict changes in RMR predicted from organ and tissue mass measured by DXA.). **p<0.01 vs. Q1, ***p<0.001 vs. Q1, ###p<0.001 for measured vs. predicted*

Table 2 Changes in organ and tissue mass and energy expenditure based on the amount of fat-free mass lost from baseline to month 12

	Quartiles by Fat-Free Mass Loss			
	Q1	Q2	Q3	Q4
Organ	Mass (kg)	Mass (kg)	Mass (kg)	Mass (kg)
Skeletal Muscle	**-1.8 ± 0.1**	**-1.2 ± 0.1*****	**-0.8 ± 0.1*****	**-0.3 ± 0.1*****
Adipose Tissue	-8.1 ± 0.5	-7.1 ± 0.6	-7.3 ± 0.7	-6.2 ± 0.5
Bone	0.1 ± 0.0	0.0 ± 0.0	0.0 ± 0.0*	0.0 ± 0.0*
Brain	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Heart	0.0 ± 0.0	0.0 ± 0.0*	0.0 ± 0.0***	0.0 ± 0.0***
Liver	-0.1 ± 0.1	-0.1 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Kidney	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Residual	-0.3 ±0.1	0.0 ± 0.1	0.4 ± 0.1*	1.1 ± 0.2***

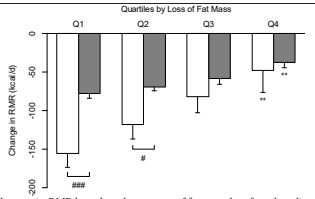

*Figure 5 Changes in RMR based on the amount of fat mass lost from baseline to month 12. White bars depict changes in RMR measured by indirect calorimetry, grey bars depict changes in RMR predicted from organ and tissue mass measured by DXA). *p<0.05 vs. Q1, **p<0.01 vs. Q1, ***p<0.001 vs. Q1,.*

Table 3 *Changes in organ and tissue mass and energy expenditure based on the amount of fat mass lost from baseline to month 12*

	Quartiles by Fat Mass Loss			
	Q1	Q2	Q3	Q4
Organ	Mass (kg)	Mass (kg)	Mass (kg)	Mass (kg)
Skeletal Muscle	-1.2 ± 0.1	-1.1 ± 0.2	-1.0 ± 0.2	-0.7 ± 0.2
Adipose Tissue	**-10.9 ± 0.4**	**-7.8 ± 0.9*****	**-6.1 ± 0.9*****	**-3.8 ± 0.4*****
Bone	0.0 ± 0.0	0.1 ± 0.0	0.0 ± 0.0	0.0 ± 0.0*
Brain	.02 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Heart	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Liver	-0.1 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Kidney	.0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Residual	0.7 ± 0.2	0.2 ± 0.1**	0.2 ± 0.2**	0.0 ± 0.2**

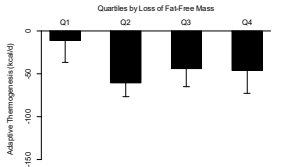

Figure 6 Changes in adaptive thermogenesis based on the amount of fat-free mass lost from baseline to month 12.

*Figure 7 Changes in adaptive thermogenesis based on the amount of fat mass lost from baseline to month 12. .*p<.05 vs Q1*

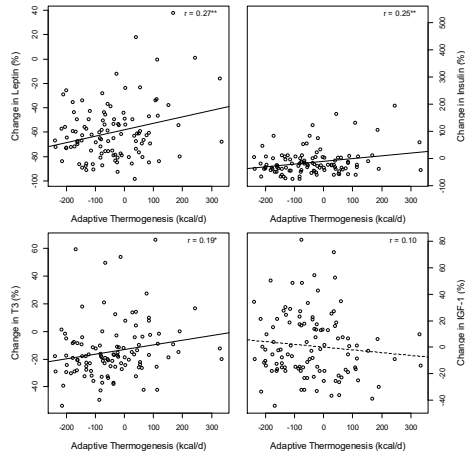

*Figure 8 Correlation between leptin (top left), insulin (top right), T3 (bottom left), and IGF-1 (bottom right) and adaptive thermogenesis. *p<0.05; **p<0.01*

CONCLUSIONS

- Most adaptations that slow RMR occur within six months of weight loss conditions
- Loss of fat-free mass is only a moderate predictor of declining RMR during weight loss
  - Primarily due to the loss of skeletal muscle
- Loss of fat mass appears to be a stronger predictor of RMR decline
  - Linked with decline in leptin?
    - Connection between leptin and T3 to reduce thermogenesis?

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