Body Composition and Energy Expenditure Changes During a 25-Week Weight Loss Program

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Introduction

Obesity continues to be a major health threat in the United States. Results from the National Health and Nutrition Examination Survey (NHANES) 2007-2008 indicate 68% of adults are overweight or obese (Flegal, Carroll et al. 2010). Not surprisingly, the majority of Americans are concerned about their weight, with 54% actively engaged in weight reduction (International Food Information Council Foundation 2010).

Overweight and obese individuals use a variety of strategies for weight loss. Those most commonly identified include reducing caloric intake, altering the types of food eaten and participating in physical activity (International Food Information Council Foundation, 2010). Previous research suggests that these methods can be effective in decreasing total body mass (TBM) (Franz, VanWormer et al. 2007; Lopez-Fontana, Sanchez-Villegas et al. 2009). While much of the TBM loss is from fat mass (FM), there is frequently a reduction in fat-free mass (FFM) as well (Chomentowski, Dube et al. 2009; Weinheimer, Sands et al. 2010). Furthermore, resting energy expenditure (REE) may be lowered as a consequence of caloric restriction and body composition changes (Doucet, St-Pierre et al. 2001; Goele, Bosy-Westphal et al. 2009; Redman, Heilbronn et al. 2009).

Target Metabolism is a commercial weight loss company operating in the Midwestern United States. The goal of its structured 25-week program is to reduce TBM, through FM loss, with a combination of individualized REE-based caloric restriction (target of 90% REE) and cognitive behavior therapy. Target Metabolism obtains serial measurements of body composition by air displacement plethysmography and REE by indirect calorimetry from all clients. These technology-based assessments provide a unique opportunity to investigate changes during the weight loss process. The purpose of the current study was to describe changes in body composition and resting energy expenditure (REE) in adults during weight reduction.

Study Objective

The objective of the retrospective study was to identify conditions that promote fat mass loss, minimize resting energy expenditure declines and protect fat-free mass during the weight loss process.

Methodology

Sample: The study utilized previously collected data from Target Metabolism, Inc.

Data collection: All information was obtained retrospectively from client records in a de-identified form following approval from the Ball State University Institutional Review Board. The following data were analyzed:

- Demographic information (including age and gender) - provided by clients at program entry.
- Total body mass (TBM) and body composition - including fat-free mass (FFM), fat mass (FM) and body fat percentage - assessed by air displacement plethysmography (Bod Pod S/T, Life Measurement, Inc., Concord, California) at program entry and fortnightly thereafter.
- Measured resting energy expenditure (REE) - determined by indirect calorimetry (ReeVue indirect calorimeter, *Korr Medical Technologies*, Salt Lake City, Utah) at program entry and at weeks 13 and 25.
- Predicted REE – calculated from measurements of FFM, FM and/or age using an equation derived from linear regression analysis.

Statistical procedures: Data were analyzed using SPSS, version 17.0 (SPSS Inc., Chicago, IL). Repeated measures analysis of variance (ANOVA) evaluated total body mass, fat-free mass, fat mass and resting energy expenditure at baseline, week 13 and week 25. Paired t-test compared measured and predicted REE at weeks 13 and 25. The level of significance was set at $P \leq 0.05$.

Results

General: Data from 312 subjects (264 females and 48 males) were included in the analysis. At program entry, female subjects were 43.7 ± 10.8 years old with 47.0 ± 7.4 percent body fat, and male subjects were 43.0 ± 10.1 years old with 38.2 ± 8.1 percent body fat. Table 1 summarizes physical characteristics and REE of subjects at baseline, week 13 and week 25.

Table 1

Body Composition and Resting Energy Expenditure at Baseline, Week 13 and Week 25

	Baseline	Week 13	Week 25
Total Body Mass (Pounds)	208.3 ± 49.8[a]	194.6 ± 46.0[b]	189.2 ± 45.5[c]
Fat-Free Mass (Pounds)	111.2 ± 23.7[a]	110.7 ± 23.3[a]	110.4 ± 23.1[a]
Fat Mass (Pounds)	97.0 ± 35.6[a]	84.2 ± 33.4[b]	78.8 ± 32.8[c]
Body Fat (Percent)	45.7 ± 8.2[a]	42.2 ± 9.1[b]	40.5 ± 9.3[c]
Resting Energy Expenditure (Kilocalories)	1709.0 ± 401.0[a]	1578.9 ± 352.3[b]	1591.8 ± 370.4[b]

Identical letters after values for each time of each variable indicate no significance between times.

Ascending letters after values for each time of each variable indicate significance between times.

n=312

Values shown are means ± SD.

P<0.001.

Body Composition

TBM: Overall, subjects experienced a significant decline in TBM over the course of the 25-week program ($P < 0.001$), with TBM significantly lower at weeks 13 (194.6 ± 46.0 lb) ($P<0.001$) and 25 (189.2 ± 45.5 lb) compared to baseline (208.3 ± 49.8 lb) ($P<0.001$). Average TBM was also significantly lower at week 25 compared to week 13 ($P<0.001$).

FFM and FM: There was no significant difference in FFM at baseline (111.2 ± 21.7 lb) and weeks 13 (110.7 ± 23.3 lb) and 25 (110.4 ± 23.1 lb) ($P>0.05$). In contrast, FM at weeks 13 (84.2 ± 33.4 lb) and 25 (78.8 ± 32.8 lb) was significantly lower than baseline (97.0 ± 35.6 lb) ($P<0.001$). FM at week 25 was also significantly lower than week 13 ($P<0.001$). Changes in FM led to significant reduction in percent body fat at weeks 13 (42.2 ± 9.1%) and 25 (40.5 ± 9.3%) compared to baseline (45.7 ± 8.2%) ($P<0.001$). Percent body fat was also significantly lower at week 25 compared to week 13 ($P<0.001$).

Energy Expenditure

Measured REE: Measured REE was significantly lower at weeks 13 (1578.9 ± 352.3 kcal) and 25 (1591.8 ± 370.4 kcal) compared to baseline (1709.0 ± 401.0) *(*$P<0.001$). Measured REE at weeks 13 and 25 was not significantly different ($P<0.05$).

Measured Versus Predicted REE: At baseline, subjects' measured REE was significantly correlated with FFM ($r=0.704$, $P<0.001$ for females; $r=0.706$, $P<0.001$ for males), FM ($r=0.632$, $P<0.001$ for females; $r=0.583$, $P<0.001$for males) and, in females only, age ($r= -0.239$, $P<0.001$). Equations were developed to predict REE in subjects at weeks 13 and 25. For females, REE = 398.7 + 9.9(FFM in lb) +3.7(FM in lb) – 3.6(age in years), and for males, REE =492.6 + 9.2 (FFM in lb) + 3.0(FM in lb). As summarized in Table 2, predicted REE was significantly greater than measured REE at weeks 13 (1897.0 ± 236.7 versus 1578.9 ± 352.3 kcal) and 25 (1906.8 ± 247.4 kcal versus 1591.8 ± 370.4 kcal) ($P<0.001$).

Table 2

Measured Versus Predicted Resting Energy Expenditure at Weeks 13 and 25

	Predicted REE	Measured REE
Week 13	1897.0 ± 236.7 [a]	1578.9 ± 352.3[b]
Week 25	1906.8 ± 247.4[a]	1591.8 ± 370.4[b]

Ascending letters after values for each time of each variable indicate significance between times.

n=312

Values shown are means ± SD.

P<0.001.

Discussion

Body Composition

TBM: Following a calorie-restricted diet (90% of REE), subjects experienced significant TBM reduction (19.1 lbs) during the 25-week program. These results are comparable to other studies using a variety of weight loss methods, such as diet, diet and exercise and manipulation of macronutrients (Redman, Heilbronn et al. 2007; Kerksick, Thomas et al. 2009; Redman, Heilbronn et al. 2009). This level of weight loss is consistent with recommendations by the National Institutes o f Health (NIH) and the American Dietetic Association (ADA) (National Institutes of Health 1998; American Dietetic Association 2009).

FFM and FM: During the 25-week program, subjects' FFM remained stable, while FM was significantly reduced (18.2 lb). This is in contrast to previous studies that reported significant reductions in both FFM and FM, regardless of weight loss methods used (Sweeney, Hill et al. 1993; Redman, Heilbronn et al. 2007; Kerksick, Thomas et al. 2009; Redman, Heilbronn et al. 2009). These results indicate that FM, not a combination of FM and FFM, was responsible for the significant TBM reduction observed in the current study.

Energy Expenditure

Measured: REE decreased significantly from baseline to week 13, but did not change from weeks 13 to 15. While adaptation of energy expenditure during weight reduction is common, the decline in the current study (13.5 kcal/kg TBM loss) was lower than observed in previous studies of calorie-restricted diets (19.31-52.6 kcal/kg TBM loss)(Schwartz and Doucet 2010). Setting target calories to 90% REE and identifying a lower caloric intake limit may have lessened the potential problem of metabolic adaptation among subjects.

Predicted versus Measured: In the current study, measured REE at weeks 13 and 25 was significantly lower than predicted. Similar trends have been reported in earlier weight loss studies (Doucet, St-Pierre et al. 2001; Goele, Bosy-Westphal et al. 2009; Tremblay and Chaput 2009). The discrepancy in measured versus predicted energy expenditure has been previously ascribed to metabolic adaptation; however, underlying factors have yet to be determined.

Conclusions and Recommendations

The current study has established that significant reduction of TBM can be achieved without sacrificing FFM. In addition, the study has demonstrated that REE losses can be attenuated. While these findings are striking, they do not fully explain the success of the 25-week weight loss program. To thoroughly understand the interaction of body composition and energy expenditure during weight reduction, caloric intake and physical activity data are needed in addition to information currently collected from clients. Inclusion of these variables in future studies can better describe the achievements of the program while optimizing client outcomes.

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