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Diet versus Exercise in "The Biggest Loser" Weight Loss Competition

Kevin D. Hall

National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health, Bethesda, MD 20892

Abstract

The Biggest Loser television show is watched by millions of people worldwide. Obesity experts have criticized its portrayal of an unrealistic intervention that raises false expectations for weight loss. Here, I quantify the diet and exercise intervention using a validated computational model of metabolism to integrate data on energy expenditure, body weight and body fat collected during The Biggest Loser competition.Participant age, body mass index, weight, and percent body fat at baseline were 33 ± 11 y, 48.7 ± 10.1 kg/m^2, 144.9 ± 39.4 kg, and 49 ± 6 % (mean ± SD), respectively. During the first phase of the competition when the contestants were isolated in a boot camp environment, the average rate of weight loss was 0.4 ± 0.1 kg/d which decreased to 0.19 ± 0.1 kg/d after returning home for the final phase. The total weight loss was 58.2 ± 26 kg with 81.6 ± 8.4 % coming from body fat. The computer simulations closely matched the data and calculated that average energy intake during the first phase was 1300 kcal/d while participating in 3.1 h/d of vigorous exercise. After returning home, energy intake increased to 1900 kcal/d and vigorous exercise decreased to 1.1 h/d. Simulation of diet alone resulted in 34 kg of weight loss with 65% coming from body fat, whereas exercise alone resulted in a loss of 27 kg with 102% from fat. Simulated weight loss maintenance could be achieved with a modest 20 min/d of vigorous exercise and a 3000 kcal/d diet.

Keywords

diet; exercise; energy expenditure; weight loss

INTRODUCTION

Millions of people watch reality television programs depicting dramatic weight loss. The most popular is "The Biggest Loser" which began in 2004 in the U.S.A. and has since been replicated around the world, mirroring the rise of the global obesity pandemic (1). The show portrays a cast of obese people engaged in strenuous exercise and rapidly losing a large amount of weight. While the focus of the television show is the exercise component of the

To whom correspondence should be addressed: Kevin D. Hall, Ph.D. National Institute of Diabetes & Digestive & Kidney Diseases, National Institutes of Health 12A South Drive, Room 4007 Bethesda, MD 20892 kevinh@niddk.nih.gov.

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weight loss program, the relative contribution of diet restriction is unclear. Here, I calculate the contributions of diet and exercise to the observed weight loss using a validated computational model of human metabolism (2) to simulate the body composition and energy expenditure data measured during the competition (3).

METHODS AND PROCEDURES

The methods and procedures used to collect the experimental data have been previously described (3). Briefly, 16 obese participants were housed on a ranch near Los Angeles, CA where 6 days per week they engaged in 90 minutes per day of directly supervised vigorous circuit training and/or aerobic training and were encouraged to exercise up to an additional 3 h/d on their own. Participants stayed on the ranch until being “voted off” every 6–11 days. At week 13, the 4 remaining participants at the ranch returned home. At week 30, all participants returned to Los Angeles for testing. Resting metabolic rate (RMR), fat mass (FM), and total energy expenditure (TEE) were measured at baseline, week 6 and week 30 in 11 participants who were the subject of the current analysis.

I used a validated computational model of human metabolism (2) to simulate the diet and exercise program required to match the average body weight (BW) change and TEE data. The computational model quantitatively tracks the metabolism of dietary macronutrients and simulates how diet and exercise changes result in adaptations of whole-body energy expenditure, metabolic fuel selection, and alterations in the major whole-body fluxes contributing to macronutrient balance and body composition change. The model simulates both the energy cost of exercise as well as its effect on fuel mobilization and utilization. To simulate the Biggest Loser intervention, I specified that the model parameter defining the average energy intake was a constant for the period of time on the on the ranch followed by another constant energy intake phase after the participants went home. The model parameter representing exercise was chosen to increase upon starting the program and ramp up linearly while on the ranch to represent a training effect. Upon returning home, the exercise parameter was assumed to be constant. No other model parameters were adjusted to fit the data.

The values of the four model parameters defining the average energy intake and exercise during periods on the ranch and at home were the only model parameters adjusted to fit the BW and TEE data. The best fit parameter values were determined using a downhill simplex algorithm (4) implemented in the Berkeley Madonna software (version 8.3; http://www.berkeleymadonna.com) to minimize the summed squares of the weighted residuals between the simulation outputs and the BW and TEE data. Note that the measurements of RMR and FM were not used in the model fitting process and comparison of the model predictions to these measurements provides a test of the model. Vigorous exercise was defined as a metabolic equivalent of 6 kcal/kg/h. The calculated average energy intake and hours of vigorous exercise are reported to two significant figures. To test the sensitivity of the model to the calculated parameters, I performed 1000 runs of the model, each time randomly sampling the four parameter values from normal distributions centered on the parameter best-fit values with standard deviations of 20%.

RESULTS

Participant age, body mass index, weight, and percent body fat at baseline were 33 ± 11 y, 48.7 ± 10.1 kg/m^2, 144.9 ± 39.4 kg, and 49 ± 6 % (mean ± SD), respectively. Figure 1A illustrates the BW and FM loss and Figure 1B shows the components of energy balance. While the contestants were on the ranch, the average rate of weight loss was 0.4 ± 0.1 kg/d which decreased to 0.19 ± 0.1 kg/d after returning home. The total weight loss was 58.2 ± 26 kg with 81.6 ± 8.4 % of the weight loss coming from body fat. The computer simulations closely matched the observed changes in BW, FM, RMR, and TEE.

While the participants were on the ranch, the model calculated that their average energy intake decreased by 65%, eating only 1300 kcal/d, while engaging in an average of 3.1 h/d of vigorous exercise. During the last 17 weeks when the contestants were at home, the average energy intake increased to 1900 kcal/d and the time spent engaged in vigorous exercise decreased to 1.1 h/d. Randomly varying these parameters by 20% reproduced the approximately 10% standard error of the mean measured weight loss. Thus, the calculated parameter values have uncertainties of roughly 20%.

To investigate the relative contribution of exercise and diet, I simulated the results of either intervention alone and found that diet alone led to 34 kg of weight loss at week 30 with 65% coming from body fat, whereas exercise alone resulted in 27 kg of weight loss with 102% from fat loss. Thus, exercise alone was predicted to lead to slight increases in lean mass and 5 kg greater fat loss compared to the diet alone which led to a loss of 11.7 kg of lean mass. Exercise alone was predicted to decrease RMR by only 1% versus baseline whereas diet alone was predicted to suppress RMR by 25%.

Extending the duration of the computer simulations with the final average energy intake of 1900 kcal/d along with 1.1 h/d of vigorous exercise led to life-threatening reductions of body fat (<5 kg) after 1.3 years (not shown) thereby demonstrating that the diet and exercise intervention during the competition was not sustainable. Figure 1C depicts the simulated slow time course of weight regain if the contestants were to return to their original sedentary lifestyle and 3700 kcal/d diet. Figure 1D simulates maintained weight loss with 20 minutes of daily vigorous exercise along with a 3000 kcal/d diet. If this modest intervention were instituted from the start, the model predicted that only 17.5 kg of the total weight loss would have been achieved at the end of the 30 week intervention and about 4 years would be required to produce 95% of the remaining weight loss (not shown).

DISCUSSION

Nearly half of Americans believe that television shows like "The Biggest Loser" will have a positive effect on the obesity epidemic (5). Obesity experts generally disagree, arguing that the show perpetuates weight bias, raises false expectations for weight loss, and depicts an intervention that is unrealistic for most people (6–8). To help address the latter point, I quantified the diet and exercise intervention using a validated computational model to quantitatively integrate the experimental data.

The model calculated that the observed magnitude of rapid weight loss required huge changes in both diet and exercise that were especially striking during the period of time when the contestants were on the ranch. But even after returning home for the last phase of the competition, the contestants maintained an impressive amount of daily vigorous exercise and a substantial degree of caloric restriction that, in combination, would not be sustainable. However, model simulations suggest that maintenance of the weight loss could be achieved with a more feasible sustained behavior change comprising 20 minutes of daily vigorous activity along with an average energy intake of 3000 kcal/d. While the model predicts that the same eventual weight loss would be accomplished if this more modest intervention were instituted from the start, it would require many years to achieve.

If the contestants were to return to their original sedentary lifestyle and diet immediately after the competition, the model simulated a slow rate of weight gain. It takes many years to regain the lost weight because of the slow response time to changes in diet and physical activity (9). Thus, follow-up measurements demonstrating incomplete weight regain do not necessarily mean that a weight loss intervention was sustained – especially following substantial weight loss.

While simulation of the diet intervention alone was predicted to lead to more weight loss, 35% was due to loss of lean mass. In contrast, exercise alone led to greater body fat loss and a slight increase in lean mass despite the substantial negative energy balance. Of course, these model predictions could not be corroborated with experimental data in this group, but they are generally in line with the expected effects of energy restriction and exercise training (10–13).

The measured RMR and FM data compared favorably with the model simulations despite not being used in the parameter fitting process. This provides further validation of the computational model and illustrates that the model appropriately captured the effects of exercise to preserve lean mass while at the same time accurately representing the substantial metabolic slowing during rapid weight loss that was previously noted in The Biggest Loser contestants (3).

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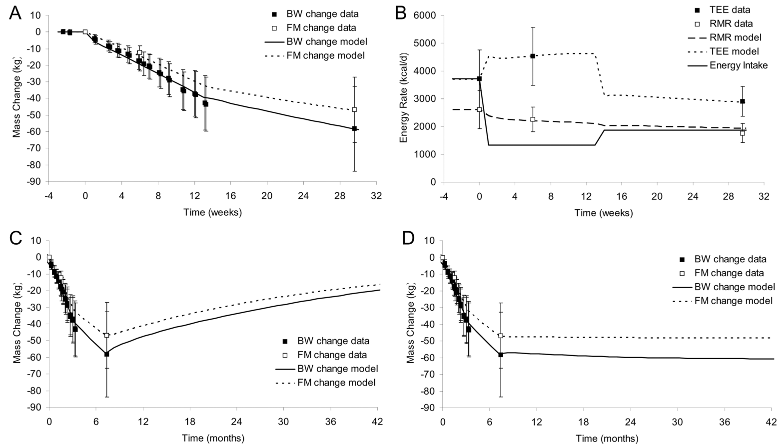

Figure 1.
A) Simulated (curves) and measured (boxes, mean ±SD) body weight (BW) and fat mass (FM) changes during The Biggest Loser competition. B) Components of energy balance including total energy expenditure (TEE), resting metabolic rate (RMR) and energy intake. C) Slow simulated regain of BW and FM upon return to the original diet and sedentary lifestyle after 7 months. D) Simulated maintenance of BW and FM loss with a sustained 3000 kcal/d diet and 20 minutes of daily vigorous exercise after 7 months.