Received: 31 August 2021 | Revised: 10 September 2021 | Accepted: 13 September 2021

DOI: 10.1002/oby.23308

Obesity A Research Journal | THE OBESITY SOCIETY | WILEY

PERSPECTIVE

Energy compensation and metabolic adaptation: “The Biggest Loser” study reinterpreted

Kevin D. Hall

Laboratory of Biological Modeling, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, Maryland, USA

Correspondence
Kevin D. Hall, National Institute of Diabetes and Digestive and Kidney Diseases, 12A South Drive, Room 4007, Bethesda, MD 20892, USA.
Email: kevinh@nih.gov

Funding information
This work was supported by the Intramural Research Program of the National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases.

Abstract

“The Biggest Loser” weight-loss competition offered a unique opportunity to investigate human energy metabolism and body composition before, during, and after an extreme lifestyle intervention. Here, I reinterpret the results of “The Biggest Loser” study in the context of a constrained model of human energy expenditure. Specifically, “The Biggest Loser” contestants engaged in large, sustained increases in physical activity that may have caused compensatory metabolic adaptations to substantially decrease resting metabolic rate and thereby minimize changes in total energy expenditure. This interpretation helps explain why the magnitude of persistent metabolic adaptation was largest in contestants with the greatest increases in sustained physical activity and why weight-loss interventions involving lower levels of physical activity have not measured similarly large metabolic adaptations. Additional longitudinal studies quantifying the interrelationships between various components of energy expenditure and energy intake are needed to better understand the dynamics of human body weight regulation.

INTRODUCTION

More than a decade has passed since I had the crazy idea to study energy metabolism in 16 contestants participating in a season of the televised weight-loss competition “The Biggest Loser”. My intention was to investigate whether the extreme exercise depicted on the TV show would translate into sparing of fat-free mass (FFM) and thereby prevent the usual fall in resting metabolic rate (RMR) during weight loss as promised by exercise and fitness gurus. Their logic was clear: exercise increases FFM, and RMR is positively related to FFM, which is its primary determinant.

Although “The Biggest Loser” contestants indeed spared FFM relative to similar weight losses attained via bariatric surgery (1), RMR fell disproportionately during the weight-loss competition—a phenomenon called “metabolic adaptation” (2). At the time, I interpreted the substantial metabolic adaptation during “The Biggest Loser” competition as an expected result of the drastic ~65% calorie restriction and the ongoing weight loss at the time of the RMR measurements (3). Therefore, I expected that suppressed RMR would normalize once active weight loss ceased and a more sustainable lifestyle was adopted. After all, metabolic adaptation in weight-stable individuals following long-term weight-loss interventions is typically much smaller than we observed in “The Biggest Loser” contestants (4).

My expectations were dashed when we found a ~500-kcal/d persistent metabolic adaptation of 6 years after “The Biggest Loser” competition when 14 of the original 16 participants completed a follow-up study after regaining an average of about two-thirds of their lost weight (5). Why this large sustained metabolic adaptation occurred was a mystery, and it was unclear whether the results could be extrapolated to less-extreme interventions. Nevertheless, our data were widely misinterpreted as evidence that weight-loss diets “destroy metabolism” and most lifestyle interventions are doomed to fail—even though “The Biggest Loser” contestants maintained a clinically meaningful average ~12% weight loss after 6 years.

Interestingly, the degree of metabolic adaptation at the end of “The Biggest Loser” competition was unrelated to subsequent weight regain, and contestants who maintained the greatest weight losses at 6 years also experienced the greatest ongoing metabolic adaptation (5). These observations suggested that metabolic adaptation was a response to the concurrent lifestyle intervention.

We measured total energy expenditure using the doubly labeled water method coincident with the RMR and body composition measurements. Physical activity expenditure was calculated by subtracting both RMR and the estimated thermic effect of food. Direct measurements of physical movement using accelerometry were not performed.

Physical activity expenditure increased markedly in "The Biggest Loser" contestants after starting the competition and this was in accord with their several hours of daily vigorous exercise (2,3). Interestingly, physical activity expenditure remained quite high 6 years later (5,6), with a median increase of ~80% at 6 years compared with baseline, corresponding to an increase of ~395 kcal/d or ~5.3 kcal/d per kilogram of body weight. There were four women and three men on either side of this median threshold, and the magnitude of metabolic adaptation was significantly greater in those contestants above versus below the median physical activity threshold (Figure 1A). The contestants who sustained the greatest increases in physical activity expenditure at 6 years also maintained the greatest weight losses (6), and Figure 1B shows that those who had the greatest sustained increases in physical activity expenditure also experienced the greatest magnitude of persistent metabolic adaptation ($r = -0.53$; $p = 0.049$).

About the same time as we were studying "The Biggest Loser" contestants, Herman Pontzer and colleagues were investigating energy expenditure in physically active hunter–gatherer populations, and the results were equally surprising. Despite their high levels of physical activity measured by accelerometry, total energy expenditure adjusted for body composition was not increased in hunter–gatherers compared with relatively sedentary Westerners (7). Such observations led to the constrained energy expenditure model whereby an increased energy budget for physical activity results in compensatory decreases in expenditure budgeted for other processes (8). Pontzer et al. speculated that metabolic adaptation may reflect decreases in pathophysiological processes that improve with increased physical activity, such as reduced chronic inflammation (8).

Could the large persistent metabolic adaptations experienced by the physically active *Biggest Loser* contestants represent an extreme case of the constrained energy expenditure model? Could "The Biggest Loser" contestants' sustained increases in physical activity have caused persistent metabolic adaptations to decrease RMR, thereby constraining overall changes in energy expenditure? If so, this potentially explains why similar degrees of metabolic adaptation have not been observed in response to long-term weight-loss regimens that don't involve greatly increased physical activity (4).

Additional support for this interpretation of "The Biggest Loser" study was recently provided in a cross-sectional analysis of a large doubly labeled water database demonstrating that people with higher physical activity energy expenditure also had lower RMR, and the effect was greatest for those with higher body fat (9). Importantly, physical activity expenditure in this new study was calculated using the same method as "The Biggest Loser" study and therefore it may also have included energy expenditure unrelated to physical activity that was not included in the RMR measurements or estimated thermic effect of food.

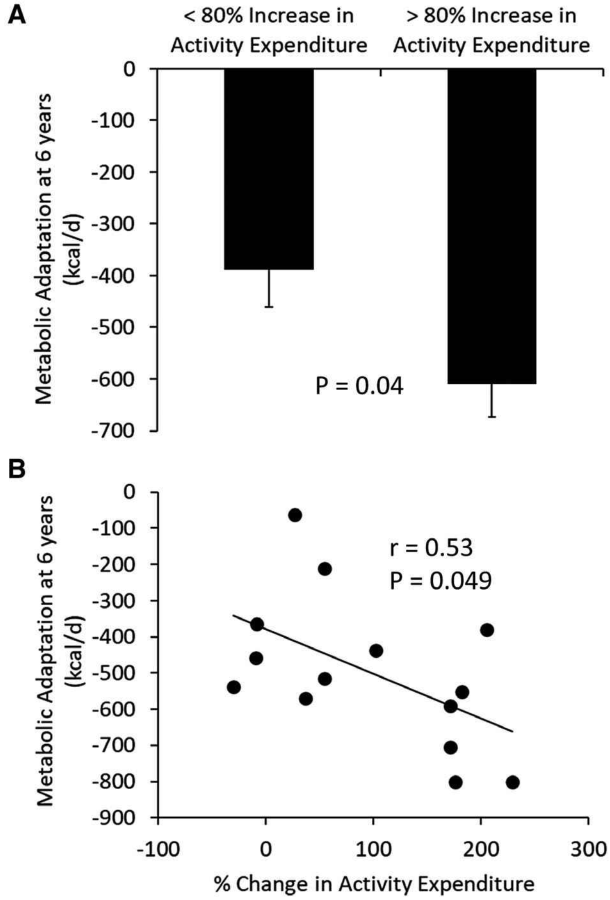

FIGURE 1 (A) Six years after "The Biggest Loser" competition, physical activity expenditure increased by a median of 80% compared with baseline, with four women and three men on either side of this threshold. Those exceeding the median increase in physical activity expenditure had the greatest degree of metabolic adaptation acting to decrease resting metabolic rate. (B) Participants with the greatest increases in physical activity expenditure also had the greatest magnitude of metabolic adaptation

In conclusion, short-term reductions in RMR during "The Biggest Loser" competition were commensurate with extreme caloric restriction during the period of active weight loss (3), but the large persistent metabolic adaptation long after the competition ended may have been the result of substantial sustained increases in physical activity. Despite long-term compensatory tradeoffs between RMR and physical activity expenditure, sustained increases in physical activity expenditure were associated with improved maintenance of lost weight for reasons that remain to be fully elucidated (6). One possibility is that increased physical activity expenditure attenuates the feedback signal controlling appetite because increased activity expenditure is only partially compensated by reduced RMR and therefore it still allows for greater energy intake at a given level of sustained weight loss

(10). A better understanding of human body weight regulation will be facilitated by additional longitudinal studies quantifying body composition changes and the interrelationships between various components of energy expenditure and energy intake.

CONFLICT OF INTEREST

The author declared no conflict of interest.

ORCID

Kevin D. Hall https://orcid.org/0000-0003-4062-3133

REFERENCES

1. Knuth ND, Johannsen DL, Tamboli RA, et al. Metabolic adaptation following massive weight loss is related to the degree of energy imbalance and changes in circulating leptin. *Obesity (Silver Spring)*. 2014;22:2563-2569.
2. Johanssen DL, Knuth ND, Huizenga R, Rood JC, Ravussin E, Hall KD. Metabolic slowing with massive weight loss despite preservation of fat-free mass. *J Clin Endocrinol Metab*. 2012;97:2489-2496.
3. Hall KD. Diet versus exercise in "The Biggest Loser" weight loss competition. *Obesity (Silver Spring)*. 2013;21:957-959.
4. Rosenbaum M, Hirsch J, Gallagher DA, Leibel RL. Long-term persistence of adaptive thermogenesis in subjects who have maintained a reduced body weight. *Am J Clin Nutr*. 2008;88:906-912.
5. Fothergill E, Guo J, Howard L, et al. Persistent metabolic adaptation 6 years after "The Biggest Loser" competition. *Obesity (Silver Spring)*. 2016;24:1612-1619.
6. Kerns JC, Guo J, Fothergill E, et al. Increased physical activity associated with less weight regain six years after "The Biggest Loser" competition. *Obesity (Silver Spring)*. 2017;25:1838-1843.
7. Pontzer H, Raichlen DA, Wood BM, Mabulla AZ, Racette SB, Marlowe FW. Hunter-gatherer energetics and human obesity. *PLoS One*. 2012;7:e40503. doi:10.1371/journal.pone.0040503
8. Pontzer H, Durazo-Arvizu R, Dugas L, et al. Constrained total energy expenditure and metabolic adaptation to physical activity in adult humans. *Curr Biol*. 2016;26:410-417.
9. Careau V, Halsey LG, Pontzer H, et al; IAEA DLW database group. Energy compensation and adiposity in humans. *Curr Biol*. 2021;31:4659-4666.e2. doi:10.1016/j.cub.2021.08.016
10. Polidori D, Sanghvi A, Seeley RJ, Hall KD. How strongly does appetite counter weight loss? Quantification of the feedback control of human energy intake. *Obesity (Silver Spring)*. 2016;24:2289-2295.

How to cite this article: Hall KD. Energy compensation and metabolic adaptation: "The Biggest Loser" study reinterpreted. *Obesity (Silver Spring)*. 2022;30:11–13. doi:10.1002/oby.23308