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Linear extrapolation results in erroneous overestimation of plausible stressor-related yearly weight changes

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We appreciate Kiecolt-Glaser and colleagues' enthusiasm for investigating depression and daily stressors as putative contributors to obesity (1). However, the use of the linear extrapolation known as the "3500 kcal rule" erroneously estimates the expected weight change contribution of these factors to obesity. The "3500 kcal rule" is an estimation of the calorie amount required to cause 1 lb of weight change that is frequently, but erroneously, used to calculate weight loss or gain from changes in energy intake and expenditure(2).

Kiecolt-Glaser and colleagues estimated the association between the number of prior day stressors and postprandial daily resting energy expenditure (referred to as REE in the original paper) over 6 hours after ingestion of a high fat meal (1). The authors report a significant interaction between time-post-meal and number of daily stressors on the association with predicted REE. For individuals with no prior-day stressors, they estimated that REE decreased by 54 kJ per hour, and each additional stressor decreased the slope by another 21 kJ/hr (e.g., for 1 stressor the decrease in REE would be 75 kJ/hr). In the conclusions of the abstract and paper, the authors indicate that the cumulative predicted difference between zero and one prior day stress in energy expenditure would be -435 kJ/d and would translate to a weight difference of about 11 lbs per year.

The calculation of the 11 lbs per year is consistent with the "3500 kcal rule," which describes the assumption that a 3500 kcal change in energy intake or expenditure will result in one pound of weight change (2). Wishnofsky, in his paper credited with establishing this 3500 kcal assumption, is careful to describe important caveats and constraints on the estimation of 3500 kcal per pound of fat, including assuming carbohydrate and protein homeostasis (3). Wishnofsky stated that "as weight loss occurs, caloric expenditure

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decreases" and that different individuals on similar caloric diets may have differing weight change outcomes (4) which indicates his understanding of metabolic adaptation during weight change. Unfortunately, Wishnofsky's writings are often stripped of such important considerations, and instead are used as a linear extrapolation (i.e., the "3500 kcal rule"). Because the rule is linear and assumes that humans do not metabolically adapt, under many circumstances, the model necessarily results in biologically implausible weight gain or loss, including zero and negative weights.

Modern models for weight change prediction have been developed and validated that incorporate metabolic adaptation (5,6). In Table 1, we compare the results of estimating changes in weight using data from Kiecolt-Glaser et al. using both the "3500 kcal rule" and a modern, validated model. Using the "3500 kcal rule," a change of -435 kJ/d in REE over one year estimated a weight change of 10.8 lbs, which rounds to the 11 lbs reported by Kiecolt-Glaser et al. However, estimations from a modern model are much less. Using the model developed by Hall and colleagues, for a woman approximating the average women in the Kiecolt-Glaser study, the validated model predicts a change of 6.4 lbs in one year. However, over 10 years, the "3500 kcal rule" would predict a change of 108 lbs, whereas the validated method predicts a change of only 12.3 lbs (7,8). The modern, validated models predict more realistic weight change in humans than the linear "3500 kcal rule".

Using a linear extrapolation such as the "3500 kcal rule" for long-term projections will grossly misestimate weight change leading to sensational predictions of the effects of factors on obesity. The American Society for Nutrition has stated that using the "3500 kcal rule" should be abandoned (9,10). Estimations of weight change are only as accurate as the inputs and methods used to estimate the change. Furthermore, the wisdom of extrapolating well beyond the confines of study results, such as making assumptions of yearly weight change from single day studies, is questionable. Although the results from this study add to the growing complexity of potential factors influencing obesity, the magnitude of weight gain that prior day stressors plausibly contribute to obesity as stated in the paper, are not plausibly supported by the data in the paper.

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Table 1

Predicted Weight Change based on Decreased Predicted REE

	1 year Weight Change (lbs)		10 year Weight Change (lbs)	
Estimated Energy Change	3500 kcal[a]	Hall Model[b]	3500 kcal[a]	Hall Model[b]
−435 kJ/d	10.8	6.4	108.4	12.3

[a] 3500 kcal: (X kJ x 0.239 kcal/kJ*365 days/year)/(3500 kcal/lb) = X lbs/year

[b] NIDDK Body Weight Simulator (6,7): For the body weight change using the simulator the following reference woman: 53 yr for age, 64 inches for height and 160 lbs for weight (BMI 27.5).