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LETTER TO THE EDITOR

Order of Magnitude Misestimation of Weight Effects of Children's Meal Policy Proposals

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Introduction

We read with interest the recent article in *Childhood Obesity* by Freij and colleagues.[1] We applaud the authors for bringing quantitative thinking to the projection of potential effects of various policies. Using a multicomponent modeling procedure, the authors attempt to estimate the amount of weight gain that would be prevented among children if certain limitations were imposed on children's meals sold in chain restaurants.

The authors' model predicts that, for children who eat kids' meals accompanied with toys twice per week, 2 lbs of weight gain per year could be avoided if those meals were limited from 616 to 550 kcal or 4 lbs per year if limited to 485 kcal. They further contend that 3% of children ''could theoretically expect to avert weight gain of 27 pounds per year'' if calories in children's meals were limited to 550 kcal. The authors conclude the article by expressing their ''hope that this study can be of assistance to policy makers as they consider developing more toy ordinances to prevent childhood obesity in the future.''

However, any modeling results are only as good as the (1) data inputs provided to the model, (2) structure of the model itself, and (c) correct implementation (calculation) of the model with the data inputs. With respect to the article by Freij and colleagues, we believe that there was an important error in the model itself, which led to markedly erroneous conclusions.

The Nature of the Error

The difference between energy intake and expenditure determines energy balance. Considering the energy contained in 1 lb of human mass, Max Wishnofsky in 1952 proposed that a surplus energy balance of 3500 kcal will lead to 1 lb of weight gain while in protein and glycogen balance, and likewise a 3500-kcal decrement will lead to 1 lb of weight loss.[2] This 3500-kcal estimation was developed from weight loss data available from short-term dieting studies in small samples of obese adults, with discussion of the importance of equilibrium, age, and basal energy expenditure. Subsequently, this information has been used incorrectly by others to extrapolate linear changes in weight from fixed changes in energy intake or expenditure in what has come to be called the ''3500-kcal rule.''

Notwithstanding the fact that the 3500-kcal rule was never designed to predict weight changes in children, the rule fails to adjust for energy expenditure changes over time as body weight increases or decreases. Modern weight prediction models based on the laws of thermodynamics include the reduction in energy expenditures during weight change.[3,4] The validated dynamic models, including one validated in children,[4] generally predict significantly lower magnitudes of weight change than the 3500-kcal rule.[5–7]

The Impact of the Error

In Table 1, we use assumptions 1–8 from Freij and colleagues to calculate predicted difference in weight change based on limiting fast food meals from 616 kcal/meal to 600, 550, or 485 kcal. For assumption 9, we either use the invalid 3500-kcal rule used by Freij and colleagues or replace it with a modern, validated, mathematical model of childhood growth and energy balance dynamics.[3] Our calculations demonstrate that predictions from validated equations are dramatically attenuated, compared to the 3500-kcal rule. In the most extreme case, Freij and colleagues estimated that limiting kids' meals to 485 kcal would prevent 54.5 lbs of weight gain per child per year in 3% of the children. It is also important to note that the revised weight predictions also depend on age, with younger

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Table 1. Estimated Weight Change from Ages 6 to 7 and 6 to 12 Using the 3500-kcal Rule versus a Validated Model

kcal/meal[a]	Differential weight (lbs) from ages 6 to 7 (1 year): 485		550		600		Differential weight (lbs) from ages 6 to 12 (6 years): 485		550		600	
Model[b]	3500 kcal	Hall and colleagues	3500 kcal	Hall and colleagues	3500 kcal	Hall and colleagues	3500 kcal	Hall and colleagues	3500 kcal	Hall and colleagues	3500 kcal	Hall and colleagues
Fast food/week												
1–3	3.9	0.4	2.0	0.2	0.5	0.0	23.4	0.5	12.0	0.2	3.0	0.1
4–6	9.7	0.9	4.9	0.4	1.2	0.1	58.2	1.2	29.4	0.6	7.2	0.1
7	13.6	1.2	6.9	0.6	1.7	0.1	81.6	1.6	41.4	0.8	10.2	0.2
14	27.2	2.5	13.7	1.2	3.3	0.3	163.2	3.2	82.2	1.6	19.8	0.4
21	40.9	3.7	20.6	1.9	5.0	0.4	245.4	4.8	123.6	2.4	30.0	0.6
28+	54.5	4.9	27.5	2.5	6.7	0.6	327.0	6.5	165.0	3.3	40.2	0.8

[a]Freij and colleagues assume that the average kids' meal contains 616 kcal; thus, the caloric restriction per meal is assumed to be 131, 66, and 16 kcal for columns 485, 550, and 600, respectively.

[b]"3500 kcal" assumes that a change in 3500 kcal results in 1 lb of weight change, used in assumption 9 of Freij and colleagues.[1] For 1-year estimates, the values are taken directly from Freij and colleagues, whereas 6-year estimates are the 1-year estimates multiplied by 6 as implied by the 3500-kcal rule. The Hall and colleagues model represents a validated, dynamic model described by Hall and colleagues,[4] which is age dependent and therefore presented as from ages 6 to 7 and from ages 6 to 12.

children experiencing less of an impact on weight than older children under the same assumptions. Over 6 years, a weight differential of 327 lbs would be expected according to Freij and colleagues' model, whereas a validated method estimates that there would only be a difference of 6.5 lbs as the child ages from 6 to 12 years. Such extreme inaccuracies invalidate conclusions of the article.

Dissemination of This Idea

As recommended in a consensus statement by the American Society of Nutrition, unwarranted continued use of the 3500-kcal rule should be abandoned.[8] Even Wishnofsky himself recognized that "as weight loss occurs, caloric expenditure decreases," and that individuals at different weights are expected to have different weight loss trajectories on the same caloric regimens.[9] In the 1970s, Antonetti created more-realistic predictions of weight gain and weight loss from perturbations in energy balance,[5] and modern validated models have been created since then and widely published.[3,4,6] Each of these models differ in their final estimates, but each one reiterates that energy balance is dependent on many factors in free-living humans, and that the 3500-kcal rule is no longer accepted as a legitimate assumption in obesity science.[7,10]

Conclusion

Although we appreciate the authors' concern for obesity, and enthusiasm to provide mathematical support for formulating policies, the magnitude of the misestimation should not be ignored. The severity of the error is such that the calculations, results, discussion, and conclusions of the original article are no longer supported. The authors' suggestion to use their calculations to inform obesity policy regarding kids' meals is unwarranted. We recommend that if weight predictions are to be applied to policy recommendations, models that are tested and validated should be used.

Author Disclosure Statement

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Note from the Publisher

The retraction of the article by Freij and colleagues appears on page 546 of this issue.

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Authors' Response

We want to thank Dr. Brown and his colleagues for their letter and for recalculating the estimated weight effects of varying caloric reductions in kids' meals with toy giveaways according to updated estimates for weight prediction. It is regrettable that Dr. Hall's study, ''Dynamics of childhood growth and obesity: Development and validation of a quantitative mathematical model,''[1] was released after our article was already in review, and we appreciate the authors taking the time to rerun the calculations using its mathematical model. We are pleased that Dr. Brown's letter and our response are being published, as it seems we are not alone in continuing to use the simple, yet outdated, 3500-kcal rule.[2] Further, though recalculations by Dr. Brown and colleagues result in dramatically lower predictions of weight loss in the extreme cases of children who may eat fast food several times a day than those found using the 3500-kcal rule, some may still look positively upon the more modest predictions from the updated model, given how intractable childhood obesity has become.

While we thank Dr. Brown for this necessary correction to the individual-level outcome estimates for weight gain averted through caloric reductions in kids' meals with toy giveaways, we would like to point out that the population estimates are not in dispute, and that they still suggest opportunities to reach large numbers of children on a daily basis through targeted antiobesity interventions in fast food restaurants. With 33% of children age 12 years and under consuming fast food on a typical day,[3] and 25% of daily calories coming from fast food and other restaurants that do not provide meals meeting nutrition standards,[4,5] it is clear that there is the need for healthier options in this arena.[6] The evidence that aggressive marketing campaigns, including toy giveaways, influence food preferences and consumption patterns in children and adolescents,[7] and contribute to lifelong eating patterns,[8] exists. Questions remain as to what kinds of policies will make an impact and what kinds of evidence are needed to convince policy makers, practitioners, and consumers to make the necessary changes. Although, as stated previously, we regret that we were unable to use the model produced by Brown and colleagues in our original publication, we appreciate the opportunity to work with colleagues in the development of accurate models and evidence to affect appropriate change.

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