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Energy balance, energy turnover, and risk of body fat gain

Dear Editor:

We read with great interest the article by Hume et al. (1), "Low energy intake plus low energy expenditure (low energy flux), not energy surfeit, predicts future body fat gain." The study used the energy balance equation to determine the relation between energy balance, energy flux, and long-term changes in percentage of body fat. First, we show here that the study's representation of energy balance is equivalent to weight stability, and hence, the study is simply examining baseline expenditures in weight-stable individuals against long-term changes in percentage body fat, which has been well studied (2, 3). Second, we show that the established fat-free mass (FFM)–fat mass (FM) relation and the baseline relation between total energy expenditures (TEEs) adjusted for FFM and percentage body fat affect the dynamics of fat gain. Finally, we point out that examining the true influence of low energy turnover on fat gain requires adjusting TEE by resting metabolic rate (RMR). When adjusted accordingly, existing studies did not find high energy turnover to be protective against fat gain (2, 3).

By using the energy balance equation, ES = TEI − TEE, where TEI represents total energy intake and ES represents changed body energy stores, the study computed baseline TEI by using the following formula:

$$\mathrm{TEI} = 7800\frac{\Delta W}{14} + \mathrm{TEE} \qquad (1)$$

where ΔW is the change in weight over the baseline 2-wk doubly labeled water (DLW) measures of TEE. In this case, $= 7800\frac{\Delta W}{14}$. The study's primary analysis excluded individuals in whom TEI was >33% or <33% of their TEE. Formulaically, this is represented by the following inequality:

$$0.67\mathrm{TEE} \leq \mathrm{TEI} \leq 1.33\mathrm{TEE} \qquad (2)$$

The use of Equation *1* and substituting the mean values of TEE for studies 1 and 2 provided in the article's Supplemental Table 1 transforms the inequality to one in terms of ΔW:

$$-1.5 \leq \Delta W \leq 1.5 \qquad (3)$$

Thus, participants who remained in "energy balance" are essentially the weight-stable participants whose magnitude of weight change remained within 1.5 kg of baseline measures during the 2-wk DLW measurement period.

Second, we point out that several well-established relations influence the study results. The study defines energy flux as TEI + TEE. With the use of Equation *1* and considering only the weight-stable participants, where $\Delta W \approx 0$, we have

$$\mathrm{TEI} + \mathrm{TEE} \approx 0 + \mathrm{TEE} + \mathrm{TEE} = 2\mathrm{TEE} \qquad (4)$$

This relation influences a potentially spurious relation between RMR and EnFlux (energy flux) in the article's Figure 2 (1). Because RMR + TEF + AEE = TEE, where TEF is the thermic effect of feeding and AEE represents activity energy expenditures, plotting RMR against 2TEE should automatically result in a positive correlation.

The authors' Figure 1 essentially plots EnFlux = 2TEE/FFM_0 compared with change in percentage of body fat. Because FFM

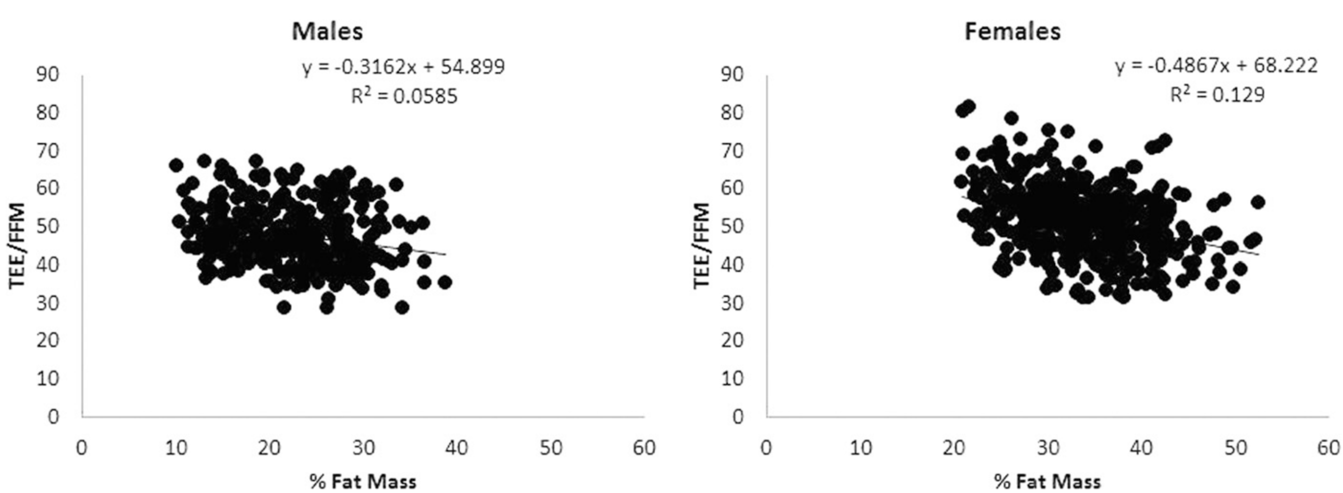

FIGURE 1 Sex-specific plots of TEE per kilogram of FFM compared with percentage of fat (6). FFM, fat-free mass; TEE, total energy expenditure.

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is algebraically related to FR through the validated Forbes model (4),

$$\mathrm{FFM} = 10.4 \ln\left(\frac{\mathrm{FM}}{C}\right) \tag{5}$$

where $C = \mathrm{FM}_0/\exp\left(\frac{\mathrm{FFM}_0}{10.4}\right)$, a second relation in the study's Figure 1 automatically exists. Moreover, individuals with a higher percentage of fat have a lower energy flux per kilogram of FFM (5), especially when both sexes are combined, as in the study's Figure 1A (1). This property is shown in the plots of the publicly available Institute of Medicine's DLW database (6) of TEE per kilogram of FFM compared with percentage fat (**Figure 1**). The Forbes equation indicates that individuals with higher baseline FM gain more FM than do their lean counterparts. Finally, the study's stated conclusions imply that individuals with a low energy turnover (or physically inactive individuals) are at risk of increased fat accretion over time. To show that physical inactivity is a risk factor for fat gain, TEE/RMR or the physical activity level (PAL) would need to be compared against change in percentage of fat. High PAL has not been found to protect against increased fat gain (2, 3).

In summary, the complex calculations presented in this study reduce simply to considering the relation between baseline TEE in weight stable participants to long-term changes in FM. In addition, the study omitted established relations between changes in fat and lean mass along with the property that individuals with higher percentage of fat have lower TEE per kilogram of lean mass. These omissions may have contributed to the correlations observed in the study results. Finally, to capture the role of activity on the risk of fat gain, the study should examine the relation of PAL compared with change in percentage of fat.

SmartLoss is a registered trademark of the Louisiana State University System, with the trademarked approach having been developed by DMT and colleagues. There are no direct benefits to DMT with the publication of this letter. DMT has no financial affiliations with the companies who conducted the work to develop the SmartLoss Virtual Weight Management Suite. Any licensing of SmartLoss could financially benefit Montclair State University and DMT. KW had no conflicts of interest to declare. DMT and KW collaboratively conducted all aspects of this letter.

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Reply to DM Thomas and K Westerterp

Dear Editor:

Thomas and Westerterp raised 3 points with regard to our article (1). First, they noted that the operationalization of energy balance, which was based on doubly labeled water–estimated habitual energy intake over a 2-wk baseline observation period minus estimated habitual energy expenditure over the same period, would be highly correlated with changes in weight over the 2-wk observational period. We would have assumed that participants who were in a positive energy balance would gain weight over the 2-wk observational period, whereas those who were in a negative energy balance would lose weight. Our data confirmed that our estimate of energy balance correlated with weight change over the 2-wk interval ($r = 0.97$, $P < 0.0001$), statistically controlling for body composition (kcal $\cdot$ kg fat-free mass$^{-1} \cdot$ d^{-1}). It is important to note, however, that the calculations that Thomas and Westerterp used assumed that change in weight was between -1.5 and 1.5 kg (i.e., that participants were largely weight stable), which was not the case. The data indicated that the weight change over the 2-wk doubly labeled water observation period actually ranged from -4.9 to 2.55 kg for the entire sample, as well as the "in flux" subsample that was used in some of our analyses.

The second point made by Thomas and Westerterp was that our definition of energy flux [total energy intake + total energy expenditure (TEI + TEE)] was equivalent to 2TEE; however, that calculation again assumed that the sample did not show marked weight change over the 2-wk observational period, which, as noted, was not correct. In addition, controlling for baseline body fat, 2TEE at baseline correlated with future body fat change in study 1 ($r = 0.18$, $P = 0.03$) but not in study 2 ($r = 0.06$, $P = 0.62$), whereas TEI + TEE predicted future body fat gain in both samples after baseline body fat was controlled for (1).

Third, Thomas and Westerterp state that "examining the true influence of low energy turnover on fat gain requires adjusting TEE by resting metabolic rate (RMR)." We did not do this because of experimental evidence that increasing TEE results in a subsequent increase in RMR (2). If increasing energy expenditure results in increased RMR, statistically controlling for RMR would needlessly remove variance from TEE, which would attenuate predictive effects. This did not seem to be useful from our perspective. Thomas and Westerterp also assert that "individuals with higher baseline FM [fat mass] gain more FM than do their lean counterparts." Curiously, however, our Tables 1 and 2 indicate that baseline body fat did not significantly predict future change in body fat over follow-up in either study.

Last, we should clarify that we did not argue or test whether high physical activity level would predict future body fat loss. Rather, our findings suggested that TEI + TEE did significantly predict future body fat change over 2–3 y of follow-up (1). In addition, TEE did not predict future change in body fat in either of our samples after baseline body fat was controlled for, which agrees with previous research that uses a much smaller sample (3). We hope that this clarifies the points raised by Thomas and Westerterp with regard to our article on the predictive effects of TEI + TEE on future body fat gain.

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