**Supplemental material**

**Contrasting Rural and Urban Caloric Intake**

In rural areas of low-income countries where food is scarce, maternal undernutrition during pregnancy and suboptimal breastfeeding can be determinants of intrauterine growth restrictions, linear-growth stunting, and subsequent non-communicable diseases in adulthood(1,2). Furthermore, normal weight individuals who undergo dietary energy restrictions and increased energy expenditure—resulting in a negative energy balance for extended periods of time—are at a greater risk of decreased skeletal muscle mass, decreased physical performance, and an increased susceptibility to injury(3,4).

At the same time, in low-income urban areas where energy dense, low-cost food is much easier to obtain, rates of obesity are growing rapidly(5-8). Low- and middle-income countries account for 93% of urban growth globally and the combination of reduced energy expenditure and increased energy intake creates the inverse of the rural experience. The result is high undernutrition in rural areas while urban obesity rates surge(7).

**Previous Data on Energy Expenditure and Head-Hauling Water or Hand Pounding Grain**

The Compendium of Physical Activity, hereinafter “the Compendium,” which amalgamates energy expenditure values for different activities, bases its average MET value for water fetching (4·3 MET) on three relatively small studies(9). The activities measured in the studies include opening irrigation canals (4.0 MET) as well as fetching water from a stream (4·3 MET), but only Rao *et al.*(10) disaggregate water fetching into drawing from a well (3.6 MET), using a handpump (3·4 MET), and carrying two 10-litre containers of water (6.1 MET)(10-12). The FAO provides an additional amalgamation of energy expenditure values reported in physical activity ratio (PAR). However, the only values useful for estimating water fetching energy expenditure include ~4·0 MET (4·5 PAR) for “women collecting water from a well” and ~3·5 MET (3·9 PAR) for “men carrying a 20–30 kg load on their head(13).”

Similarly, energy expenditure values for hand-pounding grain are rare, with the FAO and Nag and Chatterjee(14)  listing some of the only values for women pounding grain at ~5·0 MET (5·6 PAR) and ~5·7 MET (6·3 PAR)(13) . The Compendium does not include a specific value for hand-pounding grain, but values for similar activities—threshing rice by hand (4·8 MET) and cleaning grains (2·2 MET)—are present(9).

Using MET or PAR values is an appropriate energy expenditure estimation methodology in studies estimating energy expenditure for a given population. The utility of MET or PAR values is in their allowance for rapid estimation of energy expenditure based on activities performed. However, the values for activities like water fetching can be highly context-dependent; for example, terrain type, gradient slope, and type of water infrastructure should be considered, as should the population dynamics in which the measurements are conducted. More precise measurements of domestic activities, such as water fetching or hand-pounding grain, in low-income settings around the world with a focus on the variability of conditions in which these activities occur, would lend a higher level of confidence to energy expenditure estimations(13).

Furthermore, the FAO report on human energy requirements (13) specifically notes that field measurement techniques need to be compared against indirect calorimetry or doubly labeled water methods, which entail a participant drinking a sample of water containing easily identifiable isotopes that are traceable through the body. The rate of elimination of these isotopes is measured by sampling body fluids (saliva, urine, or blood) over a period of approximately 72 hours or longer(15). Given that the doubly labeled water methodology estimates energy expenditure over days or weeks, it is a poor measure of individual activities performed over minutes or hours(15).

**Supplemental Material References**

1. Black RE, Victora CG, Walker SP *et al.* (2013) Maternal and child undernutrition and overweight in low-income and middle-income countries. *Lancet* 382, 427-451.

2. Walker SP, Wachs TD, Gardner JM *et al.* (2007) Child development: risk factors for adverse outcomes in developing countries. *Lancet* 369, 145-157.

3. Carbone JW, McClung JP, Pasiakos SM (2012) Skeletal muscle responses to negative energy balance: effects of dietary protein. *Adv Nutr* 3(2), 119-126.

4. Kurpad AV, Muthayya S, Vaz M (2005) Consequences of inadequate food energy and negative energy balance in humans. *Public Health Nutr* 8, 1053-1076.

5. Caballero B (2007) The global epidemic of obesity: an overview. *Epidemiol Rev* 29, 1-5.

6. Prentice AM (2006) The emerging epidemic of obesity in developing countries. *Int J Epidemiol* 35, 93-99.

7. Malik VS, Willett WC, Hu FB (2013) Global obesity: trends, risk factors and policy implications. *Nat Rev Endocrinol* 9(1), 13-27.

8. Swinburn BA, Sacks G, Hall KD *et al.* (2011) The global obesity pandemic: shaped by global drivers and local environments. *Lancet* 378, 804-814.

9. Ainsworth BE, Haskell WL, Herrmann SD *et al.* (2011) 2011 Compendium of physical activities: a second update of codes and MET values. *Med Sci Sports Exerc* 43, 1575-1581.

10. Rao S, Gokhale M, Kanade A (2008) Energy costs of daily activities for women in rural India. *Public Health Nutr* 11(2), 142-150.

11. Brun TA, Geissler CA, Mirbagheri I *et al.* (1979) The energy expenditure of Iranian agricultural workers. *Am J Clin Nutr* 32, 2154-2161.

12. Bleiberg FM, Brun TA, Goihman S *et al.* (1980) Duration of activities and energy expenditure of female farmers in dry and rainy seasons in Upper-Volta. *Br J Nutr* 43(1), 71-82.

13. FAO (2004) *Human Energy Requirements: Report of a Joint FAO/WHO/UNU Expert Consultation*. Rome, Italy: FAO

14. Nag PK, Chatterjee SK (1981) Physiological reactions of female workers in Indian agricultural work. *Hum Factors* 23, 607-614.

15. Speakman JR (1998) The history and theory of the doubly labeled water technique. *Am J Clin Nutr* 68, 932s-938s.

**Table S1.** Mean (standard deviation) MET values, heart rate and volume of oxygen consumed by activity for all participants

|  |  |  |  |
| --- | --- | --- | --- |
| **Activity** | **MET** | **Heart rate**  **bpm** | **VO2**  **ml****min**–1 **kg**–1 |
| **Resting (n=36)**† | 1·2\*  (0·4) | 73·7  (12·2) | 4·1  (1·3) |
| **Sitting (n=39)** | 1·1  (0·3) | 80·2  (10·3) | 3·9  (1·2) |
| **Standing (n=40)** | 1·1  (0·4) | 92·6  (11·5) | 3·8  (1·4) |
| **Sweeping (n=39)** | 2·5  (0·8) | 102·2  (13·7) | 8·6  (2·6) |
| **Head-hauling 20 litres of water (20·5 kg, including container) (n=39)** | 4·3\*  (0·9) | 130·7  (17·6) | 15·0  (3·3) |
| **SMT - 3**·**2 km h**–1 **0% slope (n=38)** | 3·5  (0·6) | 117·7  (14·7) | 12·4  (2·1) |
| **SMT - 4**·**8 km h**–1 **0% slope (n=38)** | 4·3\*  (0·7) | 125·4  (16·3) | 15·0  (2·6) |
| **SMT - 2**·**7 km h**–1 **0% slope (n=38)** | 3·1  (0·5) | 114·6  (14·3) | 10·8  (1·7) |
| **SMT - 3**·**2 km h**–1 **5% slope (n=36)** | 4·1  (0·6) | 123·4  (14·6) | 14·4  (2·0) |
| **SMT - 2**·**7 km h**–1 **10% slope (n=36)** | 4·7  (0·8) | 130·1  (15·6) | 16·3  (2·6) |
| **Using a pilão (n=39)** | 3·7  (1·2) | 141·2  (21·6) | 13·1  (4·2) |

Note: MET values represent the final 2 minutes of each 5- and 3-minute activity, in order to reach respiratory and heart rate equilibrium.

\* Mean value for study females significantly different than mean values for study males (p<0·01)

† Not all participants completed all activities due to power outages during four measurement periods and one face mask seal failure. Only completed activities were included in the analysis, which explains the variation in reported sample sizes.

**Table S2.** Mixed model parameter estimates, standard errors (n 260 values from 39 participants) (Equation 1)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Men** | | **Women** | |
| **Effect** | Estimates | Standard Error | Estimates | Standard Error |
| **Intercept** | -49·925 | 12·413 | -24·572 | 3·425 |
| **Heart rate (bpm)** | 0·231 | 0·028 | 0·240 | 0·012 |
| **Weight (kg)** | 0·634 | 0·202 | 0·054 | 0·054 |
| **Breathing rate (bpm)** | 0·149 | 0·069 | 0·026 | 0·026 |

**Table S3**. Results of type III tests of fixed effects for mixed model (Equation 1)

|  |  |  |  |
| --- | --- | --- | --- |
| **Effect** | **Degrees of Freedom** | **F-value** | **P-value** |
| **Sex** | 1, 32·5 | 21·286 | 0·000 |
| **Heart rate x Sex** | 1, 249·5 | 453·452 | 0·000 |
| **Weight x Sex** | 1, 32·5 | 7·248 | 0·011 |
| **Breathing rate X Sex** | 1, 240·9 | 9·922 | 0·002 |