Science Advances
AAAS

advances.sciencemag.org/cgi/content/full/5/12/eaax1065/DC1

Supplementary Materials for

Constraint and trade-offs regulate energy expenditure during childhood

Samuel S. Urlacher*, J. Josh Snodgrass, Lara R. Dugas, Lawrence S. Sugiyama, Melissa A. Liebert, Cara J. Joyce, Herman Pontzer*

*Corresponding author. Email: samuel_urlacher@baylor.edu (S.S.U.); herman.pontzer@duke.edu (H.P.)

Published 18 December 2019, *Sci. Adv.* **5**, eaax1065 (2019)
DOI: 10.1126/sciadv.aax1065

The PDF file includes:

Other Supplementary Material for this manuscript includes the following:

(available at advances.sciencemag.org/cgi/content/full/5/12/eaax1065/DC1)

Data file S3 (Microsoft Excel format). Expanded industrialized sample data.

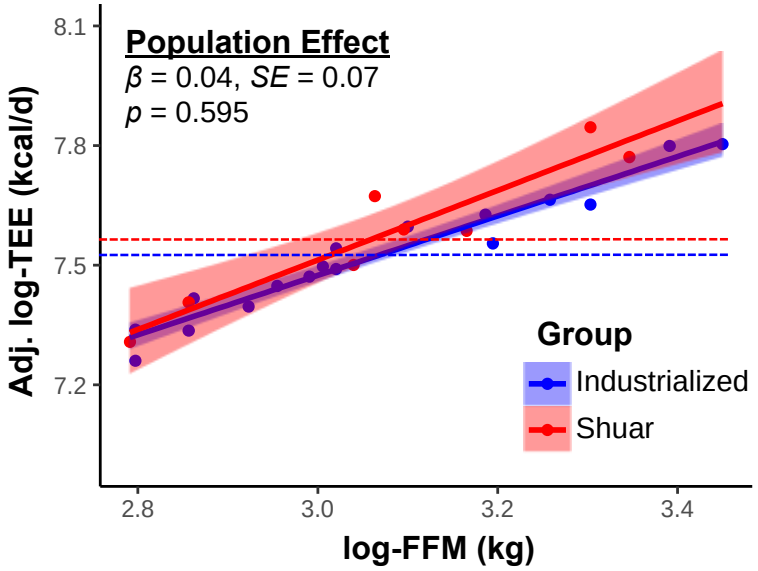

Fig. S1. TEE measures for Shuar children (red) and a larger and more diverse sample of industrialized cohorts (blue). Solid lines (shaded 95% confidence intervals) indicate regression of log-TEE on log-FFM adjusting for age, sex, and log-FM. Dotted lines denote group estimated marginal means from the final model that included log-FFM. No group difference was found in log-TEE (β = 0.04, SE = 0.07, p = 0.595). Data points represent sample-level mean values (binned by 2-year age and sex groups for Shuar and reported 1 to 5-year age and sex groups for industrialized cohorts). Industrialized cohorts (N = 17; N = 336 children; age 5-10 years; healthy and normal weight) were drawn from the US (16, 44, 45), UK (17), and Australia (46, 47). Data and sample details are provided in Data S3. TEE = total energy expenditure; FM = fat mass; FFM = fat-free mass

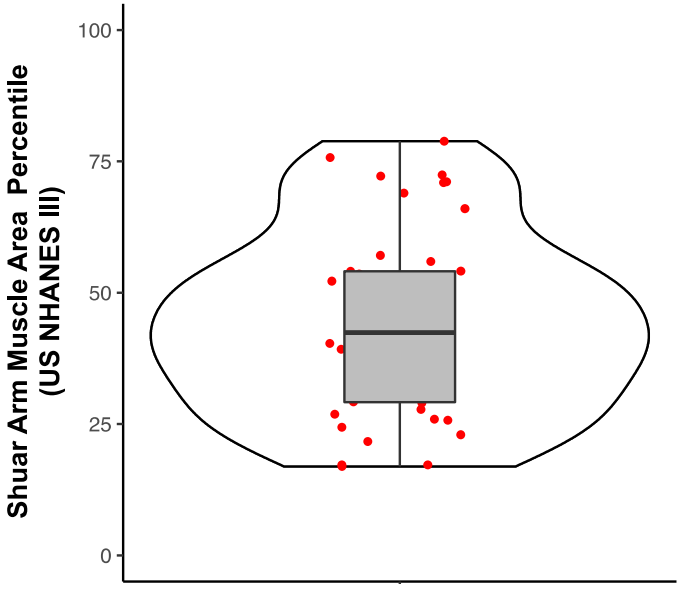

Fig. S2. Shuar arm muscle area (AMA) measures as percentiles of US age- and sex-matched references (NHANES III). Shuar mean AMA is equivalent to the US 44th percentile, indicating skeletal muscle mass approximating that of industrialized children. No difference in total FFM was observed between Shuar and US/UK children (Table 1), suggesting similar fat-free mass composition (i.e., skeletal muscle:organ mass ratio). Shuar AMA was calculated from arm skinfolds and circumference measures (48). Boxplot denotes 25th, 50th, and 75th quantiles.

Table S1. Parameter estimates [β (SE)] for final energetics GLM models.

	Model			
	log-REE (kcal/d)	log-TEE (kcal/d)	log-AEE (kcal/d)	PAL
Intercept	5.45 (0.19)***	4.70 (0.24)***	−0.66 (1.23)	−0.31 (0.43)
Age (yrs)	−0.02 (0.01)*	0.01 (0.01)	0.09 (0.05)	0.04 (0.02)*
Sex (male)	0.07 (0.02)**	0.04 (0.03)	−0.06 (0.13)	−0.03 (0.05)
log-FM (kg)	0.05 (0.03)	−0.09 (0.04)*	−0.52 (0.19)**	−0.24 (0.07)***
log-FFM (kg)	0.53 (0.09)***	0.96 (0.11)***	2.35 (0.56)***	0.70 (0.20)***
Population (Shuar)	0.19 (0.03)***	−0.04 (0.04)	-0.71 (0.18)***	-0.37 (0.06)***
Model adjusted. r^2	0.713	0.768	0.467	0.461

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table S2. Parameter estimates [β (SE)] for energetics GLM models that do not include FM as a predictor. Results were consistent with final models.

	Model			
	log-REE (kcal/d)	log-TEE (kcal/d)	log-AEE (kcal/d)	PAL
Intercept	5.32 (0.18)***	4.94 (0.23)***	0.71 (1.18)	0.31 (0.43)
Age (yrs)	−0.02 (0.01)**	0.01 (0.01)	0.11 (0.05)*	0.05 (0.02)*
Sex (male)	0.05 (0.02)**	0.07 (0.02)**	0.11 (0.12)	0.04 (0.04)
log-FFM (kg)	0.60 (0.08)***	0.81 (0.10)***	1.52 (0.50)**	0.32 (0.18)
Population (Shuar)	0.15 (0.02)***	0.03 (0.02)	−0.31 (0.12)*	−0.19 (0.04)***
Model adjusted. r^2	0.707	0.752	0.421	0.379

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table S3. Household-level lifestyle, economic, and dietary information for the Shuar study sample (*n* = 18 households).

Lifestyle and Economic Variables (% of total or mean [SD])	
Household size (# individuals)	7.4 (2.4)
Household member hunts (frequency/week)	2.1 (2.0)
Household member fishes (frequency/week)	5.4 (2.2)
Household member forages (frequency/week)	2.8 (1.6)
Income (total USD/month)	32 (31)
Dirt-floor home (vs. wood plank, %)	22%
Have running water (%)	0%
Boil water before drinking (%)	0%
Have latrine (%)	33%
Cook with wood (%)	94%
Sleep directly on floor (%)	39%
Sleep using mosquito net (%)	39%
Have light bulb (%)	94%
Dietary Variables (mean [SD])	
Consume garden item (frequency/week)	33.5 (4.5)
Consume hunted item (frequency/week)	1.3 (1.8)
Consume fished item (frequency/week)	3.7 (2.0)
Consume market carbohydrate item (frequency/week)	2.4 (3.6)
Consume market fat/sugar item (frequency/week)	3.0 (3.4)
Consume market protein item (frequency/week)	1.1 (2.0)

Market carbohydrate item = rice, pasta, bread; Market fat/sugar item = cooking oil, soda, potato chips, butter, cookies, sweets; Market protein item = beef, pork, milk

Table S4. Parameter estimates [β (SE)] for GLM models evaluating conservative values of Shuar REE that excluded initial (REEi) or single highest (REEh) repeated weekly measures. Results were consistent with final models.

	Model	
	log-REEi (kcal/d)	log-REEh (kcal/d)
Intercept	5.42 (0.20)***	5.41 (0.20)***
Age (yrs)	−0.02 (0.01)**	−0.02 (0.01)*
Sex (male)	0.07 (0.02)**	0.07 (0.02)**
log-FM (kg)	0.06 (0.03)	0.05 (0.03)
log-FFM (kg)	0.53 (0.09)***	0.54 (0.09)***
Population (Shuar)	0.17 (0.03)***	0.15 (0.03)***
Model adjusted. r^2	0.681	0.669

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table S5. Parameter estimates [β (SE)] for GLM models using an alternative hydration constant of 0.75 for Shuar and US cohort FM and FFM calculation. Results were consistent with final models.

	Model			
	log-REE (kcal/d)	log-TEE (kcal/d)	log-AEE (kcal/d)	PAL
Intercept	5.46 (0.20)***	4.77 (0.26)***	−0.54 (1.30)	−0.21 (0.46)
Age (yrs)	−0.02 (0.01)*	0.01 (0.01)	0.11 (0.05)*	0.05 (0.02)**
Sex (male)	0.07 (0.02)**	0.05 (0.03)	−0.04 (0.13)	−0.02 (0.05)
log-FM (kg)	0.06 (0.03)	−0.08 (0.05)	−0.53 (0.22)*	−0.23 (0.08)**
log-FFM (kg)	0.52 (0.09)***	0.92 (0.12)***	2.30 (0.60)***	0.64 (0.21)**
Population (Shuar)	0.19 (0.03)***	−0.01 (0.04)	−0.63 (0.18)***	−0.33 (0.07)***
Model adjusted. r^2	0.714	0.748	0.448	0.426

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table S6. Measured TEE and FFM using CRDS and duplicate measures (TEEirms; FFMirms) obtained for six participants using isotope ratio mass spectrometry. Results demonstrate between-method reliability.

	TEE (kcal/d)	TEEirms (kcal/d)	TEEdif (kcal/d)	TEEdif (%)	FFM (kg)	FFMirms (kg)	FFMdif (kg)	FFMdif (%)
Child 1	1819	1978	-159	8.0	22.3	22.5	-0.1	0.7
Child 2	1973	1935	38	2.0	23.5	23.9	-0.4	1.7
Child 3	2052	2034	18	0.9	27.9	28.2	-0.3	1.1
Child 4	2209	2478	-269	10.9	24.1	24.4	-0.3	1.2
Child 5	1514	1403	111	7.9	15.9	15.9	0.0	0.0
Child 6	1678	1729	-51	2.9	18.1	18.3	-0.2	1.1
Mean (SD)	*1874(255)*	*1926 (355)*	*-52 (140)*	*5.4 (4.0)*	*22.0 (4.3)*	*22.2 (4.4)*	*-0.2 (0.1)*	*1.0 (0.6)*

Table S7. Measured REE and TEE for US/UK children and predicted values calculated by common prediction equations (that were developed using predominantly industrialized samples). Small differences between measured and predicted values support the treatment of the US and UK cohorts as generally representative of industrialized children.

	Measured[†] (kcal/d)	Predicted[‡] (kcal/d)	Difference (kcal/d)	Difference (%)
REE	1057	1027	30	2.8
TEE	1719	1651	68	3.9

[†]Unadjusted values; [‡]Predicted values for REE were calculated using the childhood-specific equations of Schofield (49; based on sex, age, weight, and height). Predicted values for TEE were calculated using the childhood-specific WHO equations (50; based on sex and quadratic weight).

Data file S1. Primary study data with variable list.

Data file S2. Daily physical activity summary data for the Canadian cohort.

Data file S3. Expanded industrialized sample data.