**Supplementary Calculation S1**

*Total energy expenditure*

Rate constants and pool sizes are calculated from the slopes and intercepts of the log transformed data, with the rate of CO2 production, given by([36](#_ENREF_36)):

Where k and N refer to the rate constant and pool size respectively, with subscripts to indicate the isotope. The fractionation factors f1, f2, and f3, are given as 0.941, 0.991 and 1.037 respectively.

was converted to TEE using the energy equivalent of CO2 from Elia and Livesey([37](#_ENREF_37), [38](#_ENREF_38))with the Respiratory Quotient (RQ) fixed at 0.85 to reflect a typical Western diet:

694 invitations sent

247 responses received

88 participants non-DLW

105 participants invited to do DLW\*

100 participants completed DLW

* Did not pass pre-screening (n=13)
* Withdrew prior to booking (n=2)
* Unable to contact or attend appointment (n=36)

196 participants attended first clinic visit

* Did not pass screening (n=3)

193 participants

***\*Participants were allocated to DLW based on balancing sample across age, sex, BMI strata***

Excluded:

* Postponed appointment (n=3)
* Declined to do DLW (n=2)

93 participants enrolled into non-DLW arm of study (not reported in this paper)

Excluded from analysis (n=2):

Did not complete at least one Intake24 dietary recall during measurement period

**Included in DLW Validation study**

* Analysed datasets (n=98)
* Completed ≥ 2 24hr recalls (n=74)
* Completed ≥ 3 24hr recalls (n=53)

**Supplementary Fig. S1. Participant flow chart of the validation study**

**Study 3**

**Study 2**

**Study 1**

Previous participants of the Scottish Health Survey recruited by phone

Made contact

***n=*747**

Not eligible

***n=*71**

Agreed

***n=*384 (57%)**

Refused

***n=*239 (35%)**

Completed 4 or more recalls

***n=*133 (20%)**

Eligible

***n*=676 (100%)**

Unable

(due to illness/holiday)

***n=*53 (8%)**

Recruited via posters and leaflets displayed on campus, in shops and leisure centres.

Agreed

***n=*90**

Completed 4 or more recalls

***n=*46 (%)**

Completed 4 or more recalls

***n=*129 (44%)**

Agreed

***n=*291**

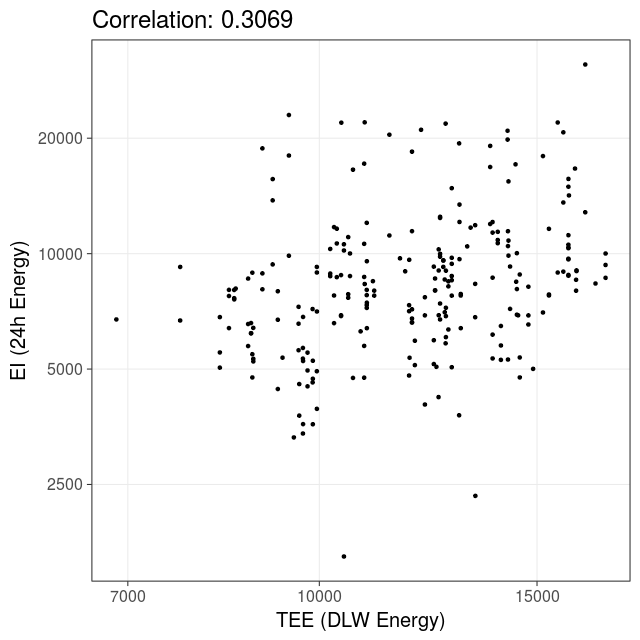
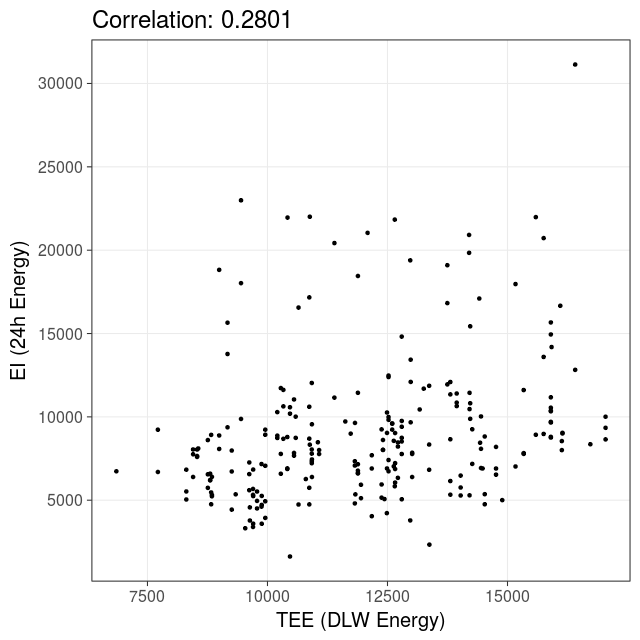
Recruited via letters home to secondary school children and on street recruitment.

**Included in Repeatability study**

Figure 1. Participant contact and response

**Supplementary Fig. S2. Participant flow chart for the reliability study**

Supplementary Fig. S3. Scatterplots of EI (kJ) against TEE (kJ) on original (left) and log (right) scale\*

\*The correlations presented do not truly reﬂect the relationship between EI and TEE because of intra-individual variation.

Supplementary Table S1. Estimates and credible intervals for applying the linear mixed effects models to different subsets of the data

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Data** | **1 day** | **2 days (or fewer)** | **3 days (or fewer)** | **All** |
|  | Measurements | 98 | 172 | 225 | 247 |
| All covariates | (Intercept) | -0.1661  (-1.2377, 0.9139) | -0.3661  (-1.1522, 0.4367) | -0.1455  (-0.8073, 0.513) | -0.184  (-0.8091, 0.426) |
| Age | 0.0046  (-0.0007, 0.0099) | 0.0054  (0.0015, 0.0094) | 0.0063  (0.0031, 0.0096) | 0.0063  (0.0031, 0.0094) |
| Height (cm) | -0.0008  (-0.0067, 0.0052) | 0.0004  (-0.004, 0.0047) | -0.0009  (-0.0046, 0.0027) | -0.0009  (-0.0042, 0.0025) |
| BMI | -0.0035  (-0.015, 0.0078) | -0.0053  (-0.0139, 0.0036) | -0.0073  (-0.0147, 0.0001) | -0.006  (-0.013, 0.0011) |
| Gender (M) | -0.0354  (-0.1468, 0.0782) | -0.0302  (-0.114, 0.054) | -0.0013  (-0.0723, 0.0694) | -0.0026  (-0.0703, 0.0653) |
| Age only | (Intercept) | -0.4193  (-0.7137, -0.1266) | -0.4474  (-0.6593, -0.2387) | -0.4961  (-0.6762, -0.3168) | -0.4847  (-0.6552, -0.313) |
| Age | 0.0046  (-0.0007, 0.01) | 0.0055  (0.0016, 0.0093) | 0.0063  (0.0031, 0.0096) | 0.0061  (0.003, 0.0091) |

For each covariate, the standalone number represents the average effect on the validity measure. For example, for the ﬁrst day log-ratios, an increase in the age by 1 year corresponds to, on average, an increase of 0.0046 in the log-ratio. Whether such an effect is signiﬁcant is determined by whether 0 is in the 95% credible interval (CI), which is reported in the bracketed pair underneath.

Supplementary Table S2. Reliability analysis - Mean of 4 recalls, lower and upper quartiles of intake of energy and nutrients for all participants and split by age group

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **All ages** | | | **11-16 year olds** | | | **17-24 year olds** | | | **25-64 year olds** | | | **65 years +** | | |
|  | **Mean** | **Lower Upper** | | **Mean** | **Lower Upper** | | **Mean** | **Lower Upper** | | **Mean** | **Lower Upper** | | **Mean** | **Lower Upper** | |
| Energy (kJ) | 7600 | 5835 | 8849 | 7020 | 5497 | 8002 | 7985 | 6058 | 9416 | 7385 | 6087 | 8773 | 8329 | 6562 | 9146 |
| Fat (g) | 67.7 | 48.0 | 82.0 | 58.7 | 42.6 | 65.0 | 72.9 | 51.7 | 85.1 | 65.9 | 48.4 | 79.2 | 78.0 | 60.6 | 93.5 |
| Protein (g) | 66.9 | 50.3 | 78.5 | 56.6 | 44.1 | 67.2 | 70.1 | 52.9 | 80.3 | 71.3 | 56.7 | 79.8 | 75.5 | 62.9 | 94.2 |
| Carbohydrate (g) | 237.1 | 180.0 | 283.0 | 242.7 | 185.2 | 278.6 | 245.5 | 186.2 | 295.5 | 218.1 | 167.0 | 256.1 | 226.9 | 184.7 | 250.8 |
| Total Sugar (g) | 111.3 | 75.1 | 131.7 | 121.4 | 83.6 | 141.7 | 115.6 | 83.1 | 143.1 | 95.1 | 69.0 | 112.5 | 99.1 | 61.1 | 113.3 |
| NMES\* (g) | 74.1 | 41.7 | 92.4 | 91.7 | 55.2 | 106.0 | 76.6 | 43.5 | 95.6 | 54.3 | 28.3 | 73.3 | 53.5 | 34.3 | 65.7 |
| Calcium (mg) | 829.8 | 590.9 | 997.4 | 792.7 | 551.6 | 953.7 | 818.7 | 593.8 | 992.6 | 871.8 | 649.5 | 1038.8 | 902.7 | 708.0 | 1099.3 |
| Vitamin C (mg) | 105.1 | 48.7 | 143.7 | 125.7 | 58.0 | 150.5 | 101.4 | 48.1 | 144.0 | 88.4 | 43.3 | 129.8 | 96.3 | 48.8 | 136.0 |
| Iron (mg) | 9.9 | 7.1 | 11.8 | 8.6 | 6.1 | 10.6 | 10.1 | 7.3 | 11.9 | 10.7 | 8.7 | 12.5 | 11.6 | 8.8 | 12.3 |

\*NMES = non milk extrinsic sugar

Supplementary Table S3. Reliability analysis Bland-Altman analysis – Split by age group

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Age group | Nutrient | Recalls 1&2 Geometric mean | Recalls 3&4 Geometric mean | Mean  Ratio | Limits of Agreement  Lower Upper | |
| 11-16 years | Energy (kJ) | 6686 | 6450 | 1.04 | 0.53 | 2.03 |
|  | Fat (g) | 54.6 | 51.4 | 1.06 | 0.42 | 2.65 |
|  | Protein (g) | 53.0 | 52.1 | 1.02 | 0.46 | 2.25 |
|  | Carbohydrate (g) | 228.9 | 221.5 | 1.03 | 0.50 | 2.13 |
|  | Total Sugar (g) | 109.3 | 102.3 | 1.07 | 0.43 | 2.66 |
|  | NMES\* (g) | 76.8 | 70.5 | 1.09 | 0.28 | 4.28 |
|  | Alcohol (g) | 0.0 | 0.0 | 0.92 | 0.19 | 4.43 |
|  | Calcium (mg) | 745.8 | 664.2 | 1.12 | 0.43 | 2.95 |
|  | Vitamin C (mg) | 97.6 | 76.1 | 1.28 | 0.26 | 6.26 |
|  | Iron (mg) | 7.9 | 8.0 | 0.98 | 0.41 | 2.33 |
|  |  |  |  |  |  |  |
| 17-24 years | Energy (kJ) | 7741 | 7281 | 1.06 | 0.51 | 2.20 |
|  | Fat (g) | 66.9 | 60.9 | 1.10 | 0.39 | 3.07 |
|  | Protein (g) | 64.3 | 63.9 | 1.01 | 0.41 | 2.45 |
|  | Carbohydrate (g) | 233.0 | 228.7 | 1.02 | 0.50 | 2.07 |
|  | Total Sugar (g) | 106.3 | 100.6 | 1.06 | 0.42 | 2.67 |
|  | NMES\* (g) | 65.4 | 57.7 | 1.25 | 0.09 | 17.45 |
|  | Alcohol (g) | 0.2 | 0.1 | 1.76 | 0.00 | >1000 |
|  | Calcium (mg) | 746.5 | 729.1 | 1.02 | 0.33 | 3.16 |
|  | Vitamin C (mg) | 69.4 | 65.8 | 1.05 | 0.15 | 7.34 |
|  | Iron (mg) | 9.3 | 9.2 | 1.00 | 0.39 | 2.60 |
|  |  |  |  |  |  |  |
| 25-64 years | Energy (kJ) | 6816 | 7034 | 0.97 | 0.54 | 1.75 |
|  | Fat (g) | 57.4 | 59.6 | 0.96 | 0.38 | 2.40 |
|  | Protein (g) | 63.4 | 68.3 | 0.93 | 0.41 | 2.12 |
|  | Carbohydrate (g) | 200.2 | 206.7 | 0.97 | 0.54 | 1.74 |
|  | Total Sugar (g) | 82.1 | 84.6 | 0.97 | 0.36 | 2.59 |
|  | NMES\* (g) | 37.5 | 39.4 | 0.95 | 0.20 | 4.46 |
|  | Alcohol (g) | 3.1 | 3.4 | 1.42 | 0.00 | >1000 |
|  | Calcium (mg) | 742.4 | 800.4 | 0.93 | 0.44 | 1.96 |
|  | Vitamin C (mg) | 62.2 | 65.8 | 0.95 | 0.15 | 5.92 |
|  | Iron (mg) | 9.5 | 9.7 | 0.99 | 0.42 | 2.32 |
|  |  |  |  |  |  |  |
| 65 years + | Energy (kJ) | 8071 | 7714 | 1.05 | 0.59 | 1.85 |
|  | Fat (g) | 75.0 | 71.1 | 1.05 | 0.40 | 2.78 |
|  | Protein (g) | 72.7 | 70.2 | 1.04 | 0.45 | 2.41 |
|  | Carbohydrate (g) | 219.0 | 212.4 | 1.03 | 0.66 | 1.62 |
|  | Total Sugar (g) | 89.5 | 87.2 | 1.03 | 0.47 | 2.23 |
|  | NMES\* (g) | 43.9 | 42.4 | 1.03 | 0.49 | 2.17 |
|  | Alcohol (g) | 24.1 | 18.4 | 0.74 | 0.00 | 712.6 |
|  | Calcium (mg) | 866.4 | 825.0 | 1.05 | 0.54 | 2.06 |
|  | Vitamin C (mg) | 83.0 | 62.7 | 1.32 | 0.25 | 6.99 |
|  | Iron (mg) | 10.8 | 10.3 | 1.05 | 0.62 | 1.79 |

Supplementary Table S4. Reliability analysis (ICC) of a single 24hr recall with sex as a covariate – by age group

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **11-16 year olds** | | | **17-24 year olds** | | | **25-64 year olds** | | | **65 years +** | | |
|  | **ICC** | **95% CI** | | **ICC** | **95% CI** | | **ICC** | **95% CI** | | **ICC** | **95% CI** | |
| Energy (kJ) | 0.403 | 0.289 | 0.517 | 0.272 | 0.179 | 0.371 | 0.347 | 0.217 | 0.478 | 0.463 | 0.000 | 0.685 |
| Fat (g) | 0.334 | 0.220 | 0.452 | 0.337 | 0.242 | 0.436 | 0.312 | 0.183 | 0.446 | 0.001 | 0.000 | 0.003 |
| Protein (g) | 0.260 | 0.145 | 0.380 | 0.329 | 0.235 | 0.428 | 0.398 | 0.270 | 0.527 | 0.002 | 0.000 | 0.013 |
| Carbohydrate (g) | 0.417 | 0.306 | 0.532 | 0.301 | 0.207 | 0.400 | 0.338 | 0.207 | 0.473 | 0.449 | 0.231 | 0.659 |
| Total Sugar (g) | 0.498 | 0.388 | 0.605 | 0.370 | 0.276 | 0.466 | 0.187 | 0.013 | 0.329 | 0.525 | 0.319 | 0.717 |
| NMES\* (g) | 0.490 | 0.381 | 0.597 | 0.435 | 0.343 | 0.528 | 0.113 | 0.001 | 0.270 | 0.526 | 0.318 | 0.716 |
| Calcium (mg) | 0.350 | 0.236 | 0.466 | 0.192 | 0.099 | 0.289 | 0.455 | 0.328 | 0.580 | 0.294 | 0.000 | 0.584 |
| Vitamin C (mg) | 0.504 | 0.398 | 0.609 | 0.349 | 0.254 | 0.448 | 0.323 | 0.194 | 0.457 | 0.286 | 0.001 | 0.550 |
| Iron (mg) | 0.338 | 0.224 | 0.455 | 0.182 | 0.088 | 0.279 | 0.350 | 0.221 | 0.483 | 0.530 | 0.321 | 0.722 |

\*NMES = non milk extrinsic sugar

**Supplementary Table S5. Reliability analysis (ICC) of paired recalls (recalls 1&2 and recalls 3&4) by age group**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **11-16 year olds** | | | **17-24 year olds** | | | **25-64 year olds** | | | **65 years +** | | |
|  | **ICC** | **95% CI** | | **ICC** | **95% CI** | | **ICC** | **95% CI** | | **ICC** | **95% CI** | |
| Energy (kJ) | 0.591 | 0.436 | 0.712 | 0.370 | 0.200 | 0.518 | 0.631 | 0.480 | 0.746 | 0.697 | 0.420 | 0.856 |
| Fat (g) | 0.511 | 0.339 | 0.650 | 0.301 | 0.126 | 0.459 | 0.512 | 0.331 | 0.656 | 0.069 | -0.336 | 0.452 |
| Protein (g) | 0.427 | 0.239 | 0.584 | 0.465 | 0.306 | 0.599 | 0.691 | 0.559 | 0.790 | 0.169 | -0.258 | 0.534 |
| Carbohydrate (g) | 0.616 | 0.467 | 0.731 | 0.499 | 0.345 | 0.626 | 0.580 | 0.415 | 0.708 | 0.790 | 0.573 | 0.903 |
| Total Sugar (g) | 0.669 | 0.535 | 0.771 | 0.610 | 0.478 | 0.715 | 0.395 | 0.193 | 0.564 | 0.733 | 0.471 | 0.875 |
| NMES\* (g) | 0.664 | 0.528 | 0.767 | 0.662 | 0.543 | 0.755 | 0.342 | 0.134 | 0.522 | 0.863 | 0.709 | 0.939 |
| Calcium (mg) | 0.462 | 0.281 | 0.611 | 0.231 | 0.047 | 0.400 | 0.717 | 0.592 | 0.808 | 0.682 | 0.391 | 0.849 |
| Vitamin C (mg) | 0.643 | 0.501 | 0.751 | 0.524 | 0.375 | 0.647 | 0.530 | 0.352 | 0.670 | 0.713 | 0.449 | 0.864 |
| Iron (mg) | 0.489 | 0.311 | 0.634 | 0.278 | 0.097 | 0.442 | 0.532 | 0.356 | 0.672 | 0.857 | 0.681 | 0.930 |

\*NMES = non milk extrinsic sugar