THEORY AND APPLICATION OF INTAKE-BALANCE ASSESSMENTS USING CRITERION AND SURROGATE MEASURES

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UI Health | UIC

GENERAL PLAN

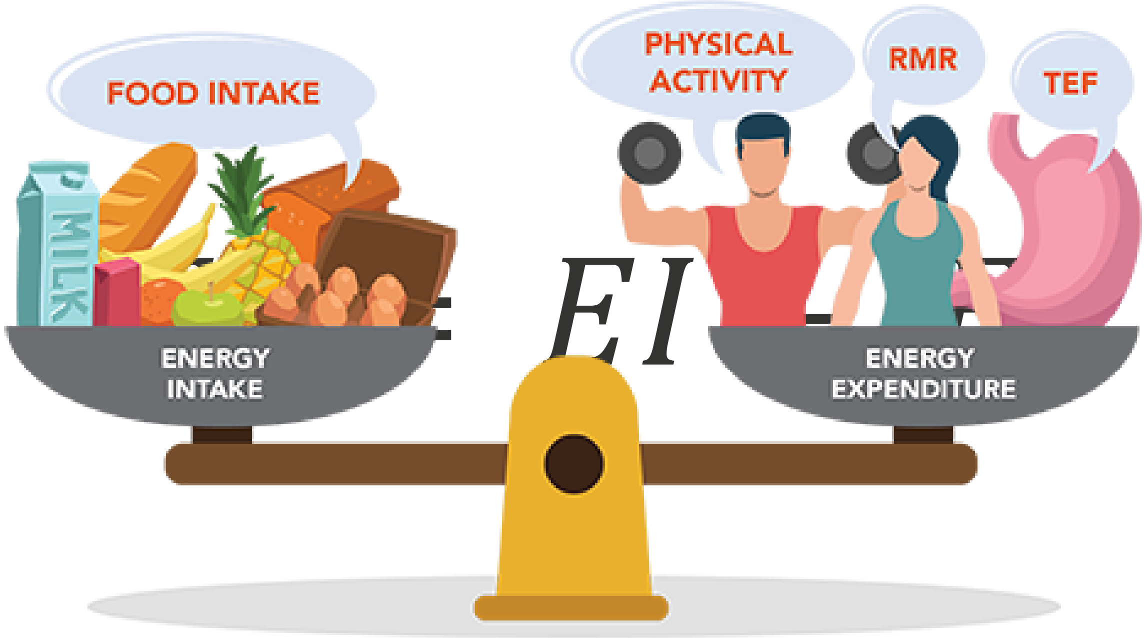
- Didactic overview of the intake-balance method

[Break]

- Interactive tutorial

DIDACTIC OVERVIEW OF THE INTAKE-BALANCE METHOD

WHAT IS THE INTAKE-BALANCE METHOD?



activehealth.sg

ACCELEROMETRY FOR INTAKE-BALANCE

stableisotope.tn-sanso.co.jp

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$$EI = \Delta ES + EE$$

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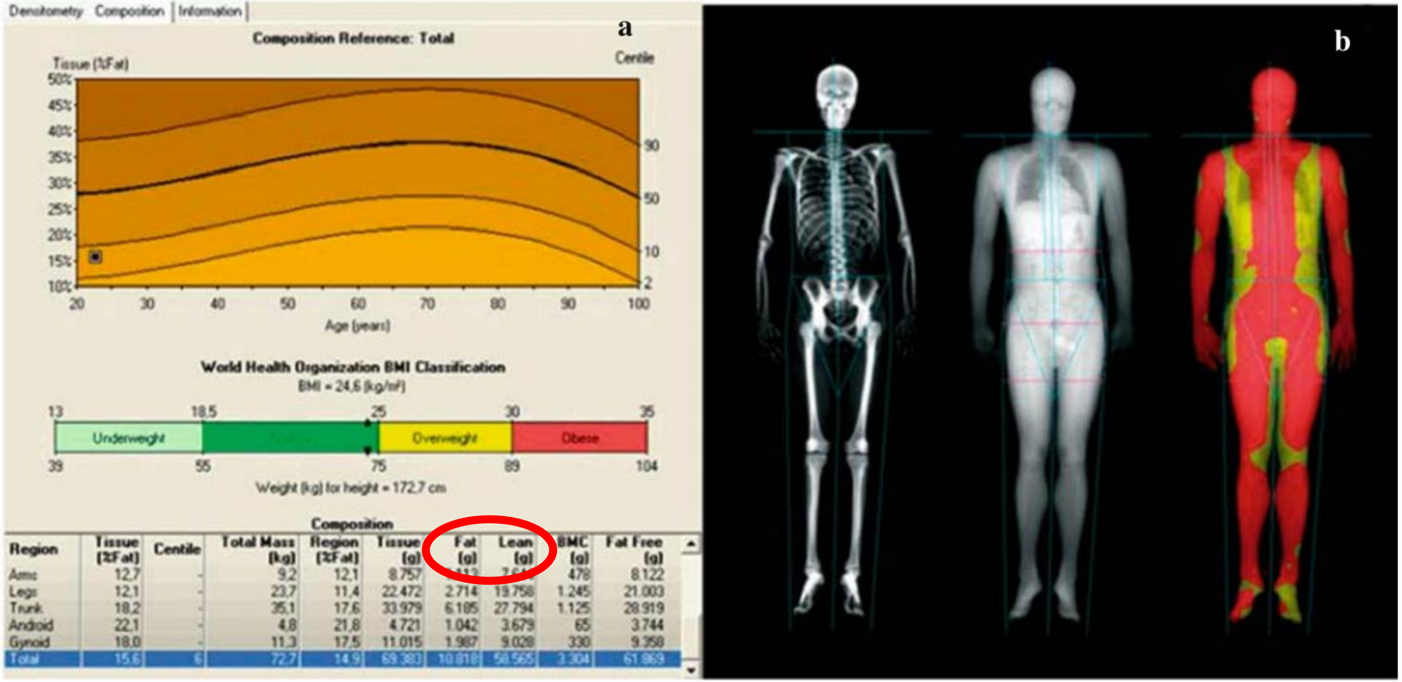
BODY COMPOSITION ASSESSMENT WITH DXA

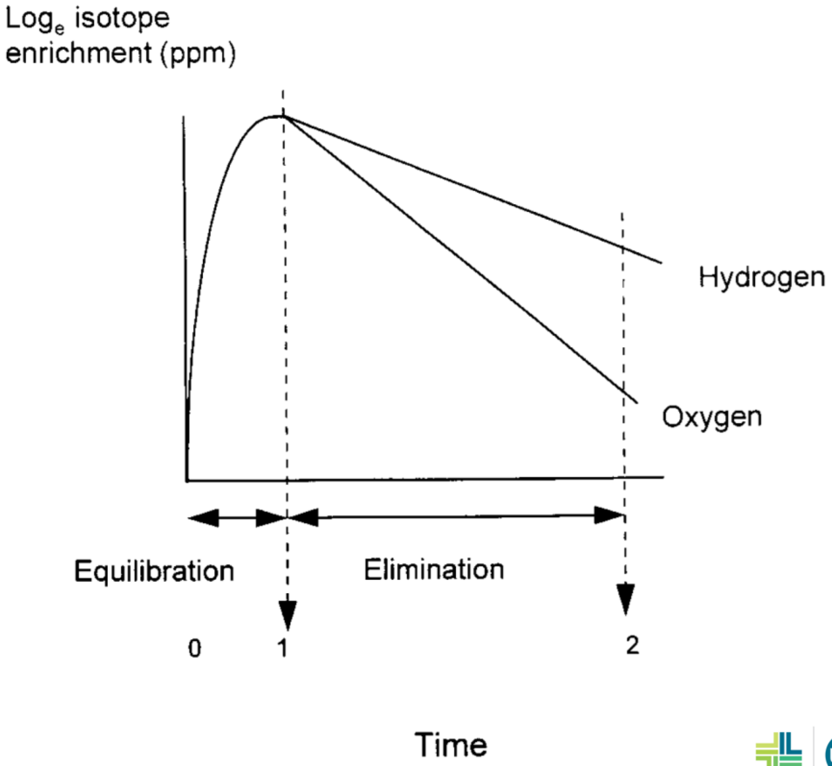


DOI 10.1007/s11547-009-0369-7

BODY COMPOSITION ASSESSMENT WITH DXA

- Strengths
  - Accuracy (DOI 10.1136/jim-2018-000722)
  - Ease of use
- Limitations
  - Involves radiation (very small dose < 10 μSv)
  - Requires certification in some locations
  - Cost
  - Not portable
  - Requires subject to lay motionless for several minutes

ENERGY EXPENDITURE ASSESSMENT WITH DLW



DOI 10.1093/ajcn/68.4.932S

ENERGY EXPENDITURE ASSESSMENT WITH DLW

- Strengths
  - Accuracy (DOI 10.1093/jn/118.11.1278)
  - Ability to assess in free-living

- Limitations
  - Cost
  - Time-, labor- and resource-intensive
  - Sensitive to many sources of error (DOI 10.1038/s41430-019-0492-z)
  - Lack of granularity

WHAT DOES ALL OF THIS MEAN FOR THE INTAKE-BALANCE METHOD?

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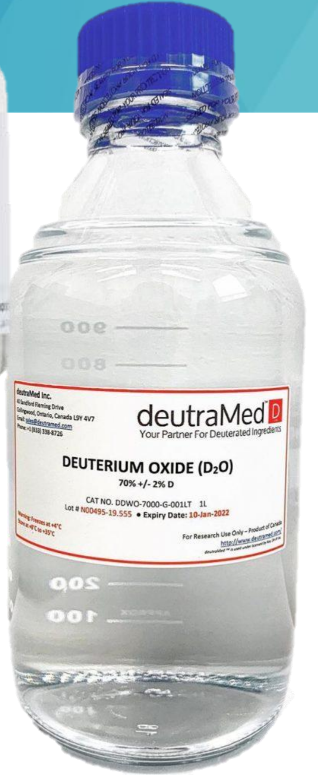

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$$EI = \Delta ES + EE$$

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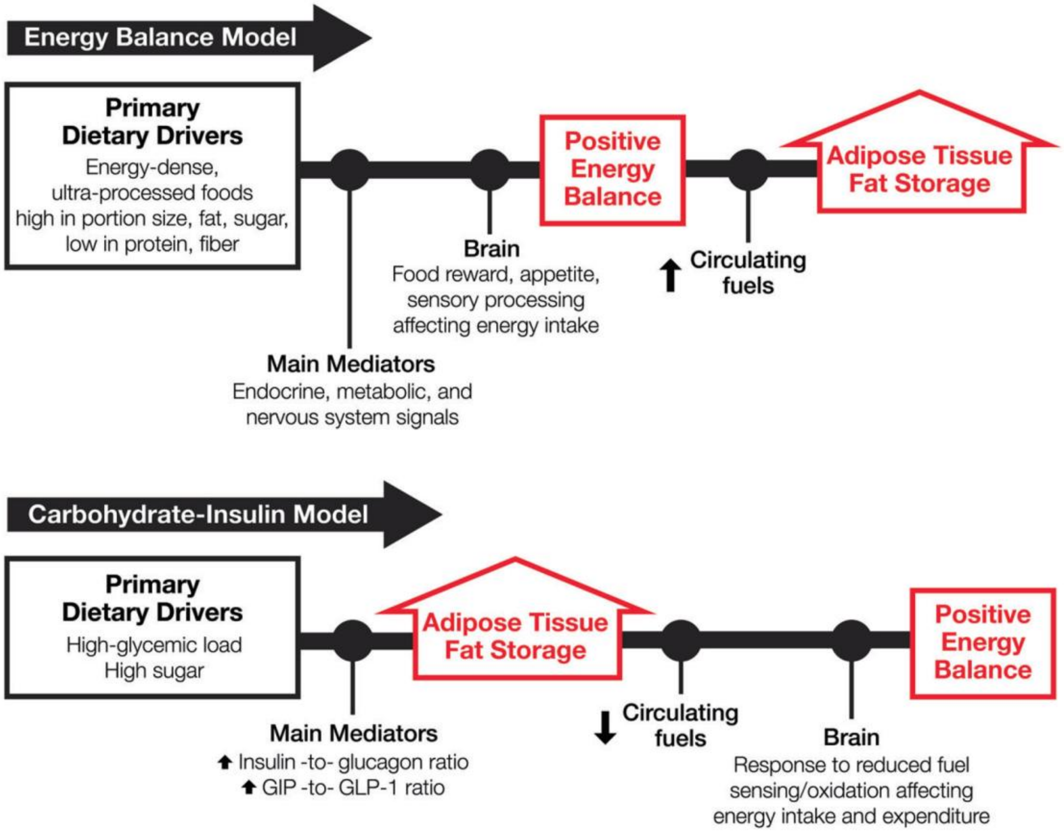
A KEY OBJECTION TO ENERGY BALANCE ITSELF



DOI 10.1038/s41430-022-01179-2

ACCELEROMETRY FOR INTAKE-BALANCE

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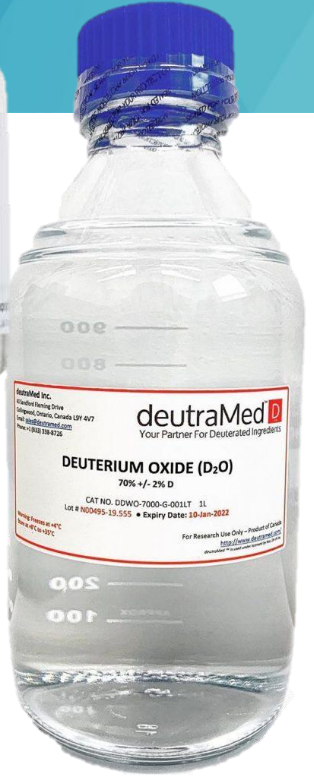

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$$EI = \Delta ES + EE$$

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ACCELEROMETRY FOR INTAKE-BALANCE

$$EI = \Delta ES + EE$$

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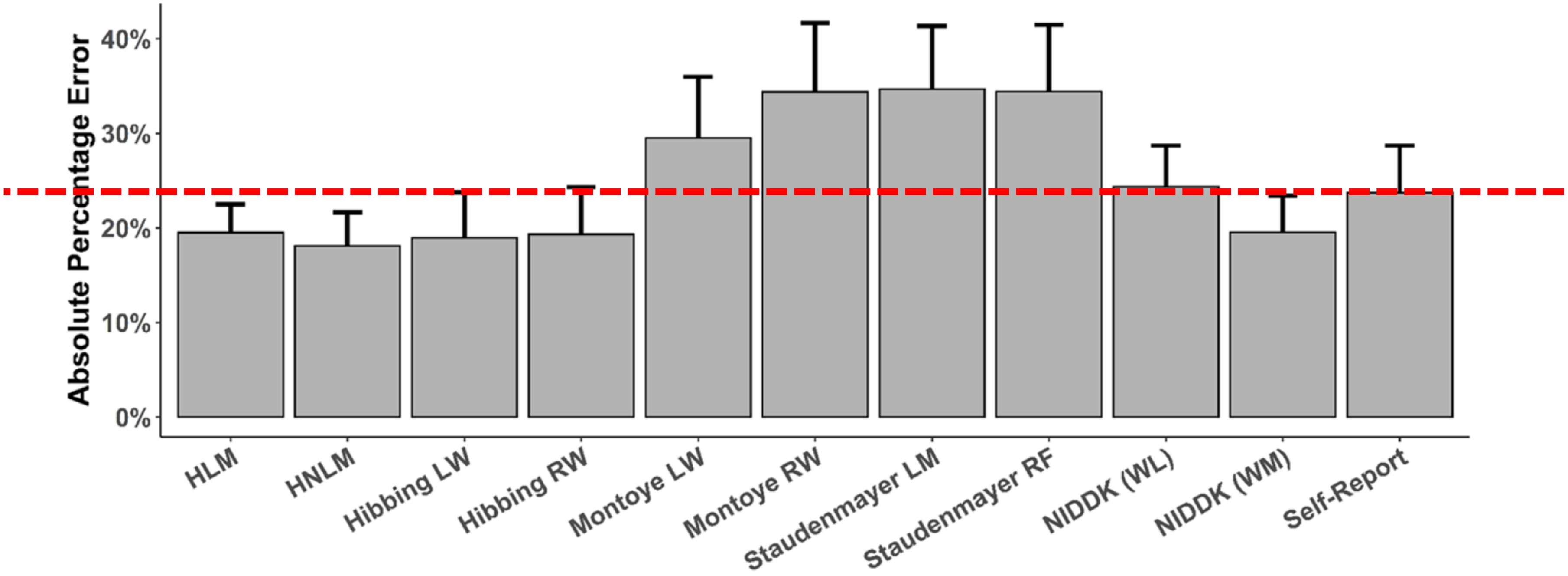
ACCELEROMETRY FOR INTAKE-BALANCE



DOI: 10.1186/s12966-023-01515-0

ACCELEROMETRY FOR INTAKE-BALANCE

$$EI = \Delta ES + EE$$

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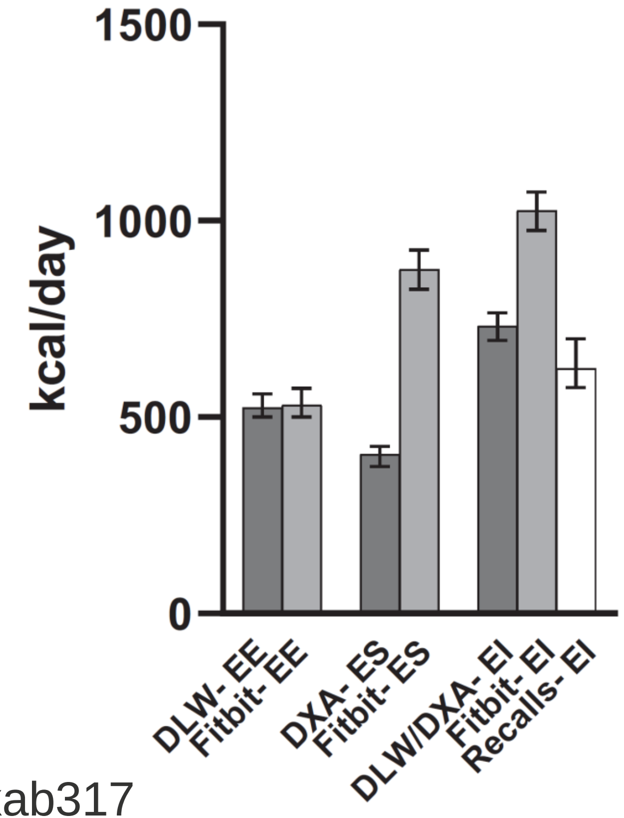
CONSUMER-GRADE TECHNOLOGY

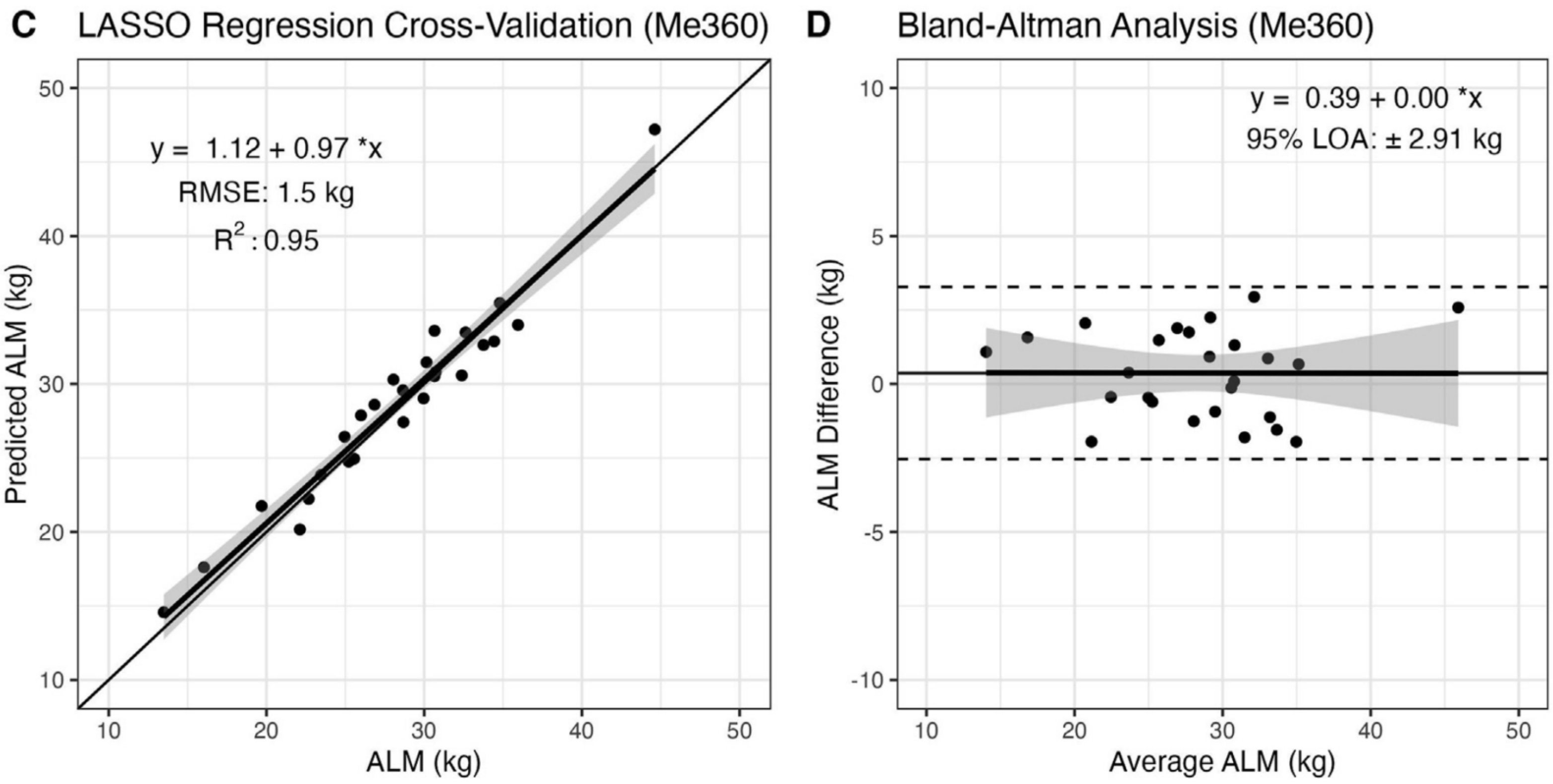
$$EI = \Delta ES + EE$$

CONSUMER-GRADE TECHNOLOGY



DOI: 10.1093/jn/nxab317

OTHER POSSIBILITIES: BODY COMPOSITION



DOI: 10.1016/j.ajcnut.2023.02.003

OTHER POSSIBILITIES: ENERGY EXPENDITURE

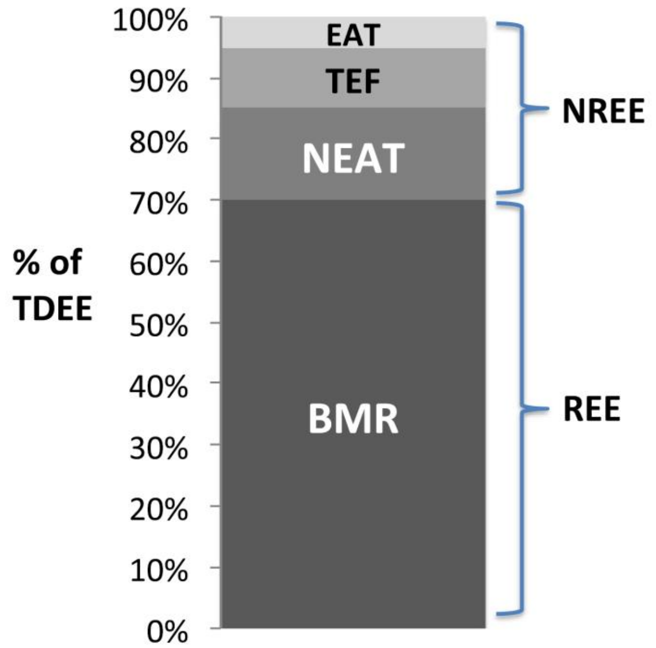
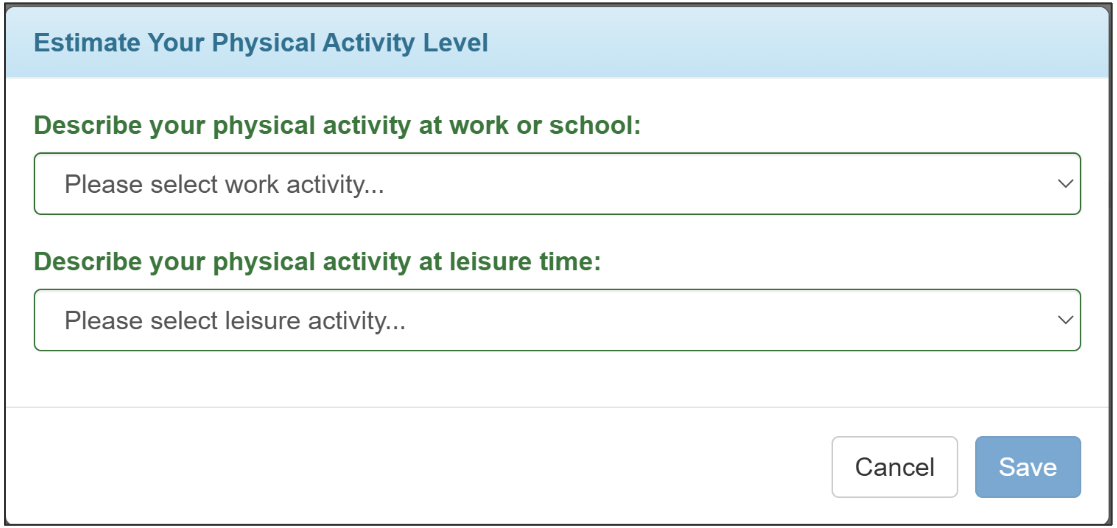


Figure 1 Components of total daily energy expenditure (TDEE). BMR = basal metabolic rate; NEAT = non-exercise activity thermogenesis; TEF = thermic effect of food; EAT = exercise activity thermogenesis; REE = resting energy expenditure; NREE = non-resting energy expenditure. Adapted from Maclean et al., 2011.

DOI: 10.1186/1550-2783-11-7



https://www.niddk.nih.gov/bwp

PRECISION OF MEASUREMENT

$$\boxed{Calculated\ EI = 1020\frac{\Delta FFM}{\Delta t} + 9500\frac{\Delta FM}{\Delta t} + EE}$$

DOI 10.1093/jn/nxx029

PRECISION OF MEASUREMENT

$$Calculated\ EI = 1020\frac{\Delta FFM}{\Delta t} + 9500\frac{\Delta FM}{\Delta t} + EE$$

DOI 10.1093/jn/nxx029

Table 1. Participant characteristics and sample descriptives. Accelerometer-derived variables are grand averages across participants

	Control (*n* 8)*				TRE (*n* 11)†			
	Pre		Post		Pre		Post	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Body mass (kg)	103·6	26·8	102·7	25·8	94·0	21·6	90·9	21·3
Fat mass (kg)	48·8	19·7	48·1	19·4	41·1	16·8	39·4	16·4
Fat-free mass (kg)	54·9	9·3	54·6	8·4	52·9	10·3	51·5	10·3

DOI 10.1017/S0007114522003312

PRECISION: VARIOUS METHODS

TABLE 2 Absolute and relative test–retest reliability of the three body composition measurement devices

Measurement device	Absolute reliability: %BF Mean differences (Trial 1–Trial 2) [95% CI]	p-value[a]	SEM (%BF)	MD (%BF)	Relative reliability: $ICC_{2,1}$ [95% CI]
Skinfold callipers	0.54 [0.22, 0.87]	<0.001	0.63	1.74	0.991 [0.979, 0.995]
Ultrasound	0.17 [−0.25, 0.58]	0.43	0.78	2.16	0.988 [0.979, 0.993]
3DPS	−0.01 [−0.43, 0.40]	0.96	0.67	1.84	0.983 [0.968, 0.991]

DOI 10.1111/cpf.12716

PRECISION: BIOELECTRICAL IMPEDANCE ANALYSIS

TABLE 3 Test–retest reliability and variability of key bioelectrical impedance analysis (BIA) measurements.

			Variability between				
Measurement	Mean	SD	Participant	Day	Test	Range	ICC
Body fat (% body mass)	17.6	7.4	7.3	0.6	0.3	1.9 ± 0.9	0.998

DOI 10.3389/fnut.2024.1491931

PRECISION: AIR DISPLACEMENT PLETHYSMOGRAPHY

Table 4. Statistical measures of test–retest reliability of %BF and FFM measurements.

	Protocol	%BF (%)				FFM (kg)			
		TEM [1]	SEM	MDC	ICC(2,1) [2]	TEM	SEM	MDC	ICC(2,1)
All	Single	1.00	1.00	2.77	0.9914	0.675	0.673	1.867	0.9974
	Collins	0.69	0.69	1.91	0.9960	0.507	0.506	1.403	0.9985
	Tucker	0.70	0.70	1.93	0.9959	0.515	0.513	1.422	0.9985
	Median	0.62	0.62	1.72	0.9967	0.457	0.456	1.264	0.9988
Men	Single	0.88	0.88	2.44	0.9898	0.683	0.679	1.883	0.9934
	Collins	0.66	0.66	1.82	0.9944	0.552	0.549	1.522	0.9957
	Tucker	0.69	0.69	1.91	0.9938	0.576	0.573	1.588	0.9953
	Median	0.60	0.60	1.67	0.9953	0.510	0.508	1.407	0.9963
Women	Single	1.11	1.10	3.05	0.9866	0.668	0.664	1.840	0.9885
	Collins	0.72	0.71	1.98	0.9944	0.457	0.455	1.261	0.9948
	Tucker	0.71	0.71	1.96	0.9945	0.444	0.442	1.225	0.9951
	Median	0.64	0.63	1.76	0.9956	0.397	0.395	1.095	0.9961

DOI 10.3390/ijerph182010693

PRECISION: DXA

Table 2. Mean (±SD) weight and precision (% CV) of whole-body bone mineral, lean tissue, and fat tissue

Measurement site	BMC		Lean		Fat	
	g	% CV	g	% CV	g	% CV
Month 0						
Arms	254 ± 80	1.7 ± 0.7	3,837 ± 605	3.7 ± 1.7	2,421 ± 1,040	6.7 ± 1.7
Legs	783 ± 197	1.1 ± 0.5	13,675 ± 2,313	1.5 ± 0.6	8,460 ± 1,689	2.5 ± 1.2
Trunk	624 ± 202	2.4 ± 0.9	18,451 ± 2,380	1.3 ± 0.4	7,423 ± 2,603	4.1 ± 1.1
Total body	2,132 ± 522	0.8 ± 0.4	38,372 ± 5,213	1.1 ± 0.5	19,723 ± 5,497	2.7 ± 0.8
Month 9						
Arms	265 ± 85	2.0 ± 0.8	3,862 ± 721	2.9 ± 1.3	2,570 ± 1,010	4.3 ± 1.6
Legs	799 ± 193	1.2 ± 0.7	12,977 ± 2,249	1.7 ± 0.6	8,322 ± 1,217	2.4 ± 1.0
Trunk	653 ± 203	2.8 ± 1.2	17,380 ± 2,627	1.4 ± 0.2	7,634 ± 2,014	2.8 ± 0.6
Total body	2,184 ± 520	1.2 ± 0.6	36,570 ± 5,593	1.0 ± 0.5	19,981 ± 4,394	1.7 ± 0.5

DOI: 10.1007/BF02556113

PRECISION: DXA

Table 2
Total Body and Regional Body Precision Acquired by Lunar iDXA

Region	Variables	Mean (range)	RMS-SD	CV (%)	LSC
Total body	BMC (g)	2622 (1595−3766)	12.2	0.5	33.9
	Fat mass (kg)	17.3 (7.9−36.7)	0.18	1.0	0.49
	Lean mass (kg)	45.92 (32.60−72.70)	0.22	0.5	0.61
	Region % fat	27.2 (13.1−45.3)	0.25	—	0.68
	Tissue % fat	28.3 (13.7−46.6)	0.26	—	0.72

DOI: 10.1016/j.jocd.2012.02.009

PRECISION: ENERGY EXPENDITURE

- DLW generally ~6% (± ~2%), based on mean absolute errors from DOI 10.1038/s41430-019-0492-z
- For accelerometer-based measures, depends on the specific method, monitor, and population
  - Values of 10% to ≥30% are common (e.g., DOIs 10.1038/s41598-021-97299-z and 10.1016/j.jsams.2014.10.002)
  - Repeatability is not an issue; given the same data, the algorithms will produce the same output

RECAP: THINGS WE'VE COVERED

- What is the intake-balance method?
- How does it work, and when does it apply?
- How has it been implemented?
- What are some of the limitations and nuances of the method?

QUESTIONS/BREAK