Methods of Measuring Adherence

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Energy Intake and Adherence

- A reduction in energy intake (EI) from habitual levels, is a key intervention in many clinical weight loss trials

- Determining a dose-response relationship between calorie restriction (CR) and physiologic changes requires a robust assessment of EI at baseline and throughout the intervention.

- Intervention trials attempting to establish a relationship between diet and chronic disease require careful measurement of adherence to dietary protocols.

Methods of Measuring Adherence

- Traditionally, clinical studies designed to measure dietary adherence have involved weighing and measuring all foods and drinks consumed. Such labor-intensive methods make studies of large numbers of participants impossible

- Many of the current options for estimating EI and %CR in clinical trials have limited accuracy

- Self-reported energy intake is recognized to be inaccurate, with a bias towards under-reporting, particularly among obese individuals

- Weight change is also an imperfect quantitative indicator of EI and %CR, in part because individuals differ in the degree of metabolic adaptation in response to a given level of CR

- Only objective measure is the doubly-labeled water method, which is the gold standard for quantifying TEE in free-living individuals

Self-Reported Measures of Dietary Adherence

24-hour recall:

- Participants are asked to recall their food intake during the previous day

- Interviews are conducted by trained interviewers or nutritionists

- Drawback:
  dietary intake is highly variable from day to day,
  multiple days of dietary intake are usually required
  extremely time-consuming

- May be inadequate for characterizing individual adherence but can serve the purpose of measuring dietary adherence of a large group

Self-Reported Measures of Dietary Adherence

Food frequency questionnaires (FFQ):

- List of foods with a frequency response section for participants to report how often each food was consumed

- Can be self or interviewer administered

- Method is inexpensive even if repeated assessments of dietary intake are required on large groups of participants because the form processing is computerized

- The drawback:

  May have limited validity for individual nutrient intakes;
  Generally assumed that individual assessment of nutrient intakes from the FFQ may be useful only in ranking individuals according to categories of nutrient intakes.

Self-Reported Measures of Dietary Adherence

Dietary Records or Food Diaries:

- Detailed records of types and quantities of food and beverages consumed during a specified period, usually 3 –7 days.

The advantages:

- No recall of past dietary intake
- Allows participant to measure their portion sizes
- Multiple days are recorded, so the problem of day-to-day variation is reduced

Drawbacks

- Extensive data entry and management that is required. Additionally, these records may not represent usual intake.
- Considerable burden on the participant, which limits its use to highly motivated participants.

Limitations –Self Report

Because of the potential inaccuracies of self-reported data, ongoing research is evaluating the usefulness of objective biomarkers (blood and urine) that may soon play a role in calibrating and improving the dietary data collection methods used to measure adherence to a dietary intervention.

Intake-Balance Technique for Assessment of Dietary Accuracy

- If total energy expenditure and energy balance are measured accurately, energy intake can be validated because:

Energy Intake = Total Energy Expenditure +Δ Energy Balance/Stores

- TEE can be assessed objectively by the doubly-labeled water method, which is the gold standard for quantifying TEE and EI in free-living individuals

- This approach is based on changes in concentrations of the nonradioactive isotopes deuterium and ^{18}O in body fluids over 7 to 14 days following administration of DLW

Natural Abundance

Element	Isotope	Abundance (%)
Hydrogen	^{1}H	99.9844
	^{2}H	0.0156
Oxygen	^{16}O	99.7630
	^{17}O	0.0375
	^{18}O	0.1995

Daily intake of ^{2}H and ^{18}O

Isotope	Intake (mg/kg/d)
^{2}H	6.9
^{18}O	133.4

Theoretical Basis of the Doubly Labeled Water Method

Energy Metabolism

Carbohydrate				
Fat	+	O_2	$\longrightarrow$	CO_2 + H_2O + Heat
Protein				

$$^{2}H_2{}^{18}O$$

Determination of Total Energy Expenditure
DLW Technique

Consuming a Weighed Mixed Dose of $^{2}H_2\,^{18}O$

↓ Urine Samples 14 day period

^{2}H → H_2O output

^{18}O → H_2O output + CO_2 production

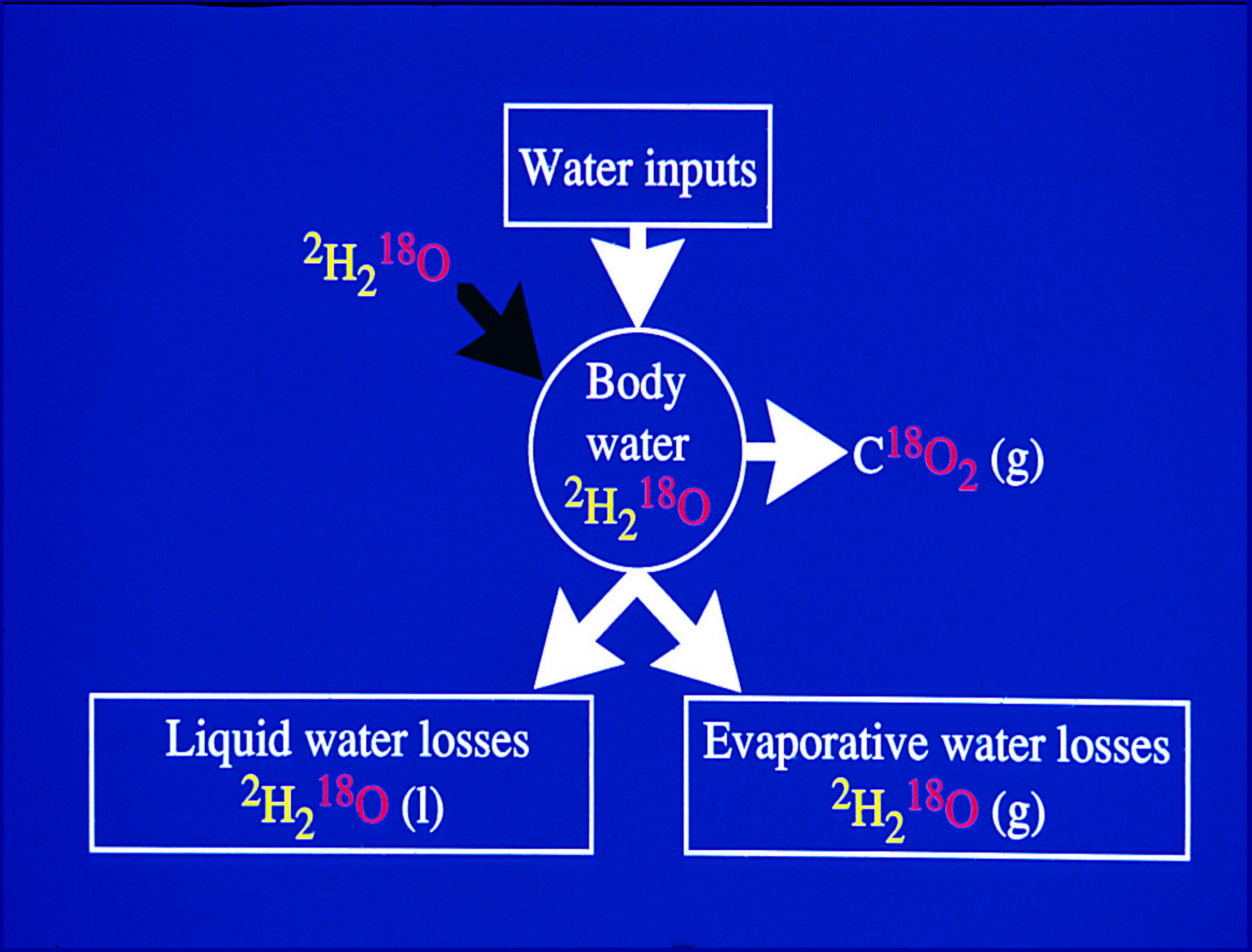
↓ Isotope ratio mass spectrometer

^{18}O - ^{2}H → CO_2 production

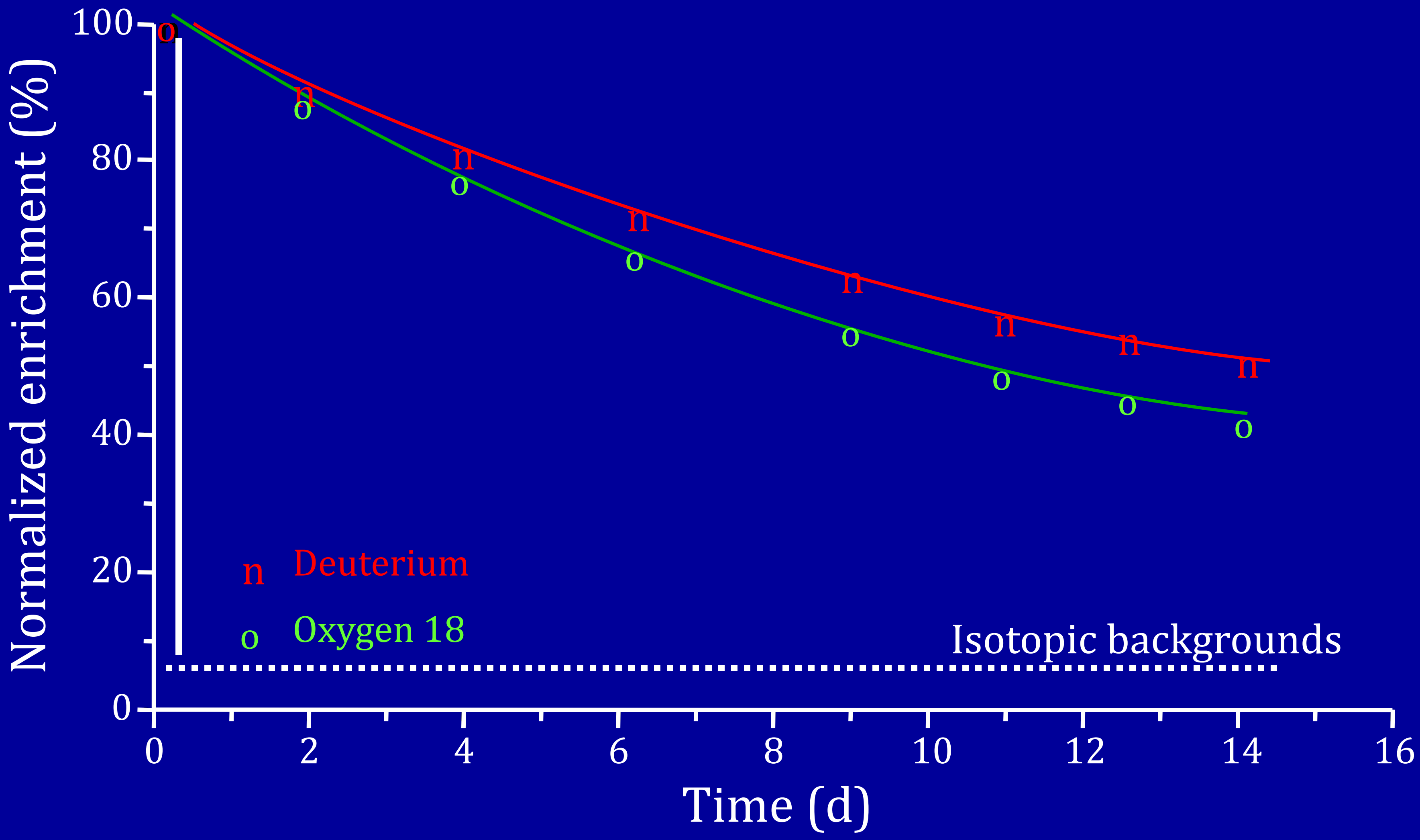
↓

CO_2 production → TEE

Energy Expenditure: Doubly Labeled Water Method



Energy Expenditure: Doubly Labeled Water Method



DLW: Equations

$$VCO_2 \text{ (mol/d)} = 0.4812 \times [(k_O \times N_O) - (k_H \times N_H)] - 0.0246 \times r_g$$

k_O = fractional turnover rate of ^{18}O (d^{-1})

k_H = fractional turnover rate of ^{2}H (d^{-1})

r_g = evaporative water loss (mol/d)

$= 1.05 \times (N_O \times k_O - N_H \times k_H)$

$$EE \text{ (kcal/d)} = VCO_2 (3.815/RQ + 1.2321)$$

RQ = provisional respiratory quotient of 0.86

Using DLW for Assessing Adherence

- **EI = TEE + ΔES**

  where EI is true energy intake
  TEE is total energy expenditure
  ΔBE is the change in body energy

- **You can compare this estimate of "true" EI to reported energy intake (ie. provided or prescribed) during CR to assess adherence**

EI and Adherence Calculations

$$CR\% = \frac{\text{Baseline EI} - CR_{(EI)}}{\text{Baseline EI}} \times 100$$

$$CR\% = \frac{TEE_{(BL)} - [\,TEE_{(CR)} + \Delta\,BES\,]}{TEE_{(BL)}} \times 100$$

TEE is measured at intervals we calculate a weighted TEE value. For example,

$$TEE_{0\text{-}6mo} = (TEE_{BL} \times 1 + TEE_{6mo} \times 5) / 6$$

for the BL to 6 mo period

Calculation of Body Energy Stores

Changes in body weight (g/day) are converted to ΔES (kcal/day) using the energy coefficient 7.4 kcal/g

$$\Delta ES\ (kcal/d) = \Delta weight\ (g/day) \times 7.4\ kcal/g$$

Changes in body composition are converted to ΔES using
9.3 kcal/g as the energy coefficients of fat mass (FM)
and 1.1 kcal/g as the energy coefficients fat free mass (FFM)

$$\Delta ES\ (kcal/d) = \Delta FM\ (g/day) \times 9.3\ kcal/g + \Delta FFM\ (g/day) \times 1.1\ kcal/g$$

Recovery of Excess Energy in Under/Overfeeding Studies

- **Changes in body energy and energy expenditure during under/overfeeding must equal the change in intake unless non-compliance has occurred**
- **Adherence cannot be assessed if changes in both body energy and energy expenditure, are not conducted at the same time**
- **In the studies that did measure both outcomes, recoveries of energy sometimes differ substantially from 100%.**

Adherence Calculation Issues:

- Coefficients for RQ. Using group RQ versus subject-specific RQ values. Subject specific RQ determined from dietary FQ (food logs), how to deal with under-reporting of energy in food records
- Uncertainty in estimates of provided or prescribed food
- Uncertainty in estimates of TEE by DLW
- Range of weight loss for a given Energy Restriction
- Further assumptions (e.g., energy content of weight, FM and FFM change)
- Values for 'long-term' based on change in body energy by DXA (so the main assumption is that TEE is the same during measurements as between measurements

What we think about

- DLW and ES are measured intermittently but we would like to know adherence routinely and average over various study periods (consider comparing weight change between DLW and non DLW periods?)

- What is the best way to determine body energy change during weight loss in individuals (regressed weight change?, DXA?)

- Is DLW as good as we think it is, and are assumptions of no change in accuracy during -ve energy balance valid?

Thank You!