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National Diet and Nutrition Survey

Years 6 and 7 (2013/14-2014/15): Doubly labelled water (DLW) sub-study

User Guide

NatCen Social Research

MRC Elsie Widdowson Laboratory

UKDA version

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The Medical Research Council Elsie Widdowson Laboratory (MRC EWL), formerly called MRC Human Nutrition Research (HNR), conducts internationally-renowned research aimed at improving health through nutrition. Our mission is to conduct nutrition research and surveillance to improve the health of the population and to inform nutrition policy and practice.

NatCen Social Research
35 Northampton Square
London EC1V 0AX
www.natcen.ac.uk

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1.1 This dataset

A subsample of Year 6 (2013/14) and Year 7 (2014/15) participants who completed 3 or 4 food diary days were recruited for a Doubly Labelled Water (DLW) sub-study to measure energy expenditure. The DLW data is provided in this dataset - *NDNS_DLW_Yr6-7a*.

Data from the main survey is archived separately – see datasets and documentation for the Years 5/6 and Years 7/8 surveys (UKDA SN: 6533). The Years 5/6 and Years 7/8 documentation provides full detail of the survey background, design and protocols as well as links to the associated publications.

1.2 Using doubly labelled water (DLW) data

It is important to note the following when using the DLW data. The variable “BMR (kJ)” is calculated according to Schofield’s equations and the variable “TEE (kJ)” is calculated from Schoeller’s equation. For further details and the equations used refer to section 2 of this document.

2. Doubly labelled water (DLW)

DLW has been used to derive energy expenditure in a subsample of participants in Years 6 and 7 of the NDNS RP.[1] The information below provides background to how the variables in the dataset have been calculated.

2.1 Total Body Water (L)

From the assumption of a mono-compartmental model of water distribution with elimination following first-order kinetics it follows that the normalised enrichments should decay exponentially with time. Derivation of kinetic parameters from standardised mass spectrometric data was calculated and then transformed by taking the logarithm.

Linear regression was used to find the kinetic parameters N_H, k_H, N_O and k_O, where the subscripts H and O denote hydrogen and oxygen isotopes and N and k are the intercept (body water pool size) and rate constant respectively.

This gives the following equations:

$$Ln\{\Delta_H(t)\} = Ln\left\{\frac{1}{N_H}\right\} - k_H t$$

$$Ln\{\Delta_O(t)\} = Ln\left\{\frac{1}{N_O}\right\} - k_O t$$

This then allowed calculation of total body water (TBW_L), from which body composition can be derived.

$$TBW = \left(\frac{\frac{N_H}{1.04} + \frac{N_O}{1.01}}{2}\right)\left(\frac{18.02}{1000}\right)$$

Where TBW is calculated in kg, the subscripts H and O denote hydrogen and oxygen isotopes and both N_H, and N_O are in moles.

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[1] A DLW sub-study was also used for the same purpose in a subsample of Years 1 and 3 participants. See Years 1-4 dataset/documentation for further information.

NOTE N_H and N_O are corrected for non-aqueous exchange, with the factors 1.04 and 1.01 respectively.

2.2 Lean Body Mass (kg) and Fat Mass (kg)

Lean body mass (LBM_kg) and fat mass (FM_kg) in kg, was then derived by assuming that fat mass has no associated water and that lean mass is 73% hydrated.

$$LBM = \frac{TBW}{0.73}$$

Fat mass (FM) was calculated by subtracting LBM from body weight.

2.3 Basal Metabolic Rate (according to Schofield's equations, using age, sex, height and weight)

As total energy expenditure (TEE) is highly dependent on age and on the level of physical activity. It can be considered to have two contributing terms: the basal metabolic rate (BMR_kj_day_1), which is the energy requirement to maintain life, and the energy, expended in activity (AEE). The BMR was calculated from predictive equations, according to the following equations:

Age Range	BMR (MJday-1)	
Under 3 years	Female	$0.068W + 4.281H - 1.730$
	Male	$0.001W + 6.349H - 2.584$
3-10 years	Female	$0.071W + 0.677H + 1.553$
	Male	$0.082W + 0.545H + 1.736$
10-18 years	Female	$0.035W + 1.948H + 0.837$
	Male	$0.068W + 0.574H + 2.157$
18-30 years	Female	$0.057W + 1.184H + 0.411$

	Male	$0.063W - 0.042H + 2.953$
30-60 years	Female	$0.034W + 0.006H + 3.530$
	Male	$0.048W - 0.011H + 3.670$
Over 60 years	Female	$0.033W + 1.917H + 0.074$
	Male	$0.038W + 4.068H - 3.491$

Where W is the subject's weight (kg), and H height (m).

2.4 Total Energy Expenditure (kJ) (calculated according to Schoeller's methods)

The following equation was used to calculate carbon dioxide production. Total energy expenditure was calculated from the CO_2 production rate assuming that 12% of total energy is derived from protein oxidation.

$F_{CO_2} = \left(\frac{N_O k_O - N_H k_H}{2 f_3 + 2.1(f_2 - f_1)} \right)$ Where $f_1 = 0.941$, $f_2 = 0.991$, and $f_3 = 1.037$ are fractionation factors for ^2H leaving the body as water vapour, ^{18}O leaving via the same route, and the exchange of ^{18}O between carbon dioxide and water respectively. This is discussed fully by Coward and Cole.

$TEE = 22.4(15.480/RQ + 5.550)F_{CO_2}$ with the respiratory quotient RQ taken as 0.85.

Total Energy Expenditure (TEERep) has also been calculated by replacing the fixed RQ of 0.85 with an individually derived food quotient (FQ using dietary data.

$$FQ = \frac{(0.7107 * (protein) + (1.3771 * 9fat) + 0.746 * (CHO) + 0.973 * (alcohol)}{(0.8791 * (protein) + 1.9483 * (fat) + 0.746 * (CHO) + 1.461 * (alcohol)}$$

Where protein, fat, CHO and alcohol are in grams.

TEERep has been used in the calculation of the derived variables PAL (see section 2.5) and EI:TEE ratio has been calculated for Appendix X of the Years 1 to 4 report[2] and will be calculated for future reports.

2.5 Physical activity level (PAL)

PAL is the ratio of TEE and BMR and was calculated as follows:

$$PAL = \frac{TEE}{BMR}$$

PAL values usually range between 1.2 and 2.4, corresponding to bedbound subjects at the low end and those engaged in strenuous work or sports activity at the high end.

[2] https://www.gov.uk/government/statistics/national-diet-and-nutrition-survey-results-from-years-1-to-4-combined-of-the-rolling-programme-for-2008-and-2009-to-2011-and-2012