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ENERGY

(Session 9)

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ENERGY

Estimating Energy Requirements

Equations for Estimating REE

There appears to be four equations in current use:

1) Harris-Benedict (HB)

2) WHO/FAO/UNU

3) Owen

4) Mifflin-St Jeor (Mifflin)

The HB equations (1919) were developed using predominantly white normal-weight men aged 16–63 years (n=136); and women aged 15–74 years (n=103) over a ten year period.

Men: kcal/day = 66.47 + 13.75 (wt, kg) + 5.00 (ht, cm) – 6.76 (age, y)

Women: kcal/day = 655.10 + 9.56 (wt, kg) + 1.85 (ht, cm) – 4.68 (age, y)

The HB formulas have been found to overestimate REE in normal weight and obese individuals by 7% to 27%.

The WHO/FAO/UNU equations (1985) were developed from data on young European military/police recruits, 2279 men and 247 women, 45% of Italian descent, aged 19–82 years.

Men:

18–30 years: 15.3 × weight (kg) + 679

31–60 years: 11.6 × weight (kg) + 879

Men:

18–30 years: 15.4 × weight (kg) – 27 × height (m) + 717

31–60 years: 11.3 × weight (kg) + 16 × height (m) + 901

Women

18–30 years: 14.7 × weight (kg) + 496

31–60 years: 8.7 × weight (kg) + 829

Women

18–30 years: 13.3 × weight (kg) + 334 × height (m) + 35

31–60 years: 8.7 × weight (kg) – 25 × height (m) + 865

The Owen equation (1986/87) for men was based on a sample of 60 subjects aged 18–82 years, and the women's equation from 44 women aged 18–65 years.

Men: kcal/day = 879 + 10.2 (wt, kg)

Women: kcal/day = 795 + 7.2 (wt, kg)

The Mifflin equations (1990) was derived from 498 normal-weight, overweight, obese and severely obese individuals; aged 19–78 years.

Men: kcal/day = 9.99 × (wt, kg) + 6.25 × (ht, cm) – 4.92 × age (y) + 5

Women: kcal/day = 9.99 × (wt, kg) + 6.25 × (ht, cm) – 4.92 × age (y) – 161

A study comparing measured REE with estimated REE using the Mifflin, Owen, and HB equations for both males and females found that the Mifflin equations were the most accurate in estimating REE in both normal weight and obese people.

All of these four equations were developed for use in "normal" healthy individuals, and their application to any other population is questionable.

The WHO/FAO/UNU and HB equations appear to have become less applicable over time.

In all equations, their strengths and weaknesses appears to lie in how representative they are. (e.g. if an individual being measured is underrepresented in the original study, then the chances of the estimation being wrong, and the extent to which it is wrong, will be greater).

Estimating Energy Requirements from Energy Intake

Traditionally, recommendations for energy requirements were based on self-recorded estimates (e.g., diet records) or self-reported estimates (e.g., 24-hour recalls) of food intake, however, it is now clear that these methods do not provide accurate or unbiased estimates of an individual's energy intake.

The percentage of people who underestimate or underreport their food intake ranges from 10% to 45%, depending on the person's age, gender, and body composition (e.g. underestimating tends to increase as children age, is worse among women than men, and is more prevalent and severe among obese people).

Energy Requirements Prediction Equations

Estimated Energy Requirements (EER)

EER is the average dietary energy intake that is predicted to maintain energy balance in a healthy adult of a defined age, gender, weight, height, and level of physical activity consistent with good health.

EER has been developed for men, women, children, and infants and for pregnant and lactating women.

EER for children and pregnant and lactating women also includes the energy needs associated with the deposition of tissues or secretion of milk at rates consistent with good health.

EER (for people of normal weight) and TEE (for various overweight and obese groups, as well as for weight maintenance in obese girls and boys) prediction equations have been developed to maintain current body weight (and promote growth when appropriate) and current levels of physical activity for all subsets of the population, hence they are not intended to promote weight loss.

The EER incorporates age, weight, height, gender, and level of physical activity for people ages 3 years and older.

Although variables such as age, gender, and feeding type can affect TEE among infants and young children, weight has been determined as the sole predictor of TEE needs.

The EER among infants, young children, children ages 3-18 years, and for pregnant and lactating women is the sum of TEE plus the caloric requirements for energy deposition.

EER for Infants and Young Children 0-2 Years (Within the 3rd-97th Percentile for Weight-for-Height)

EER = TEE‡ Energy deposition

0-3 months (89 × Weight of infant [kg] – 100) + 175 (kcal for energy deposition)

4-6 months (89 × Weight of infant [kg] – 100) + 56 (kcal for energy deposition)

7-12 months (89 × Weight of infant [kg] –100) + 22 (kcal for energy deposition)

13-35 months (89 × Weight of child [kg] – 100) + 20 (kcal for energy deposition)

EER for Boys 3-8 Years (Within the 5th-85th Percentile for BMI§)

EER = TEE‡ Energy deposition

EER = 88.5 – 61.9 × Age (yr) + PA × (26.7 × Weight [kg] + 903 × Height [m]) + 20 (kcal for energy deposition)

EER for Boys 9-18 Years (Within the 5th-85th Percentile for BMI)

EER = TEE Energy deposition

EER = 88.5 – 61.9 × Age (yr) + PA × (26.7 × Weight [kg] + 903 × Height [m]) + 25 (kcal for energy deposition)

in which

PA = Physical activity coefficient for boys 3-18 years:

PA = 1 if PAL is estimated to be ≥ 1 < 1.4 (Sedentary)

PA = 1.13 if PAL is estimated to be ≥ 1.4 < 1.6 (Low active)

PA = 1.26 if PAL is estimated to be ≥ 1.6 < 1.9 (Active)

PA = 1.42 if PAL is estimated to be ≥ 1.9 < 2.5 (Very active)

EER for Girls 3-8 Years (Within the 5th-85th Percentile for BMI)

EER = TEE Energy deposition

EER = 135.3 – 30.8 × Age (yr) + PA × (10 × Weight [kg] + 934 × Height [m]) + 20 (kcal for energy deposition)

EER for Girls 9-18 Yr (Within the 5th-85th Percentile for BMI)

EER = TEE + Energy deposition

EER = 135.3 – 30.8 × Age (yr) + PA × (10 × Weight [kg] + 934 × Height [m]) + 25 (kcal for energy deposition)

in which

PA = Physical activity coefficient for girls 3-18 years:

PA = 1 (Sedentary)

PA = 1.16 (Low active)

PA = 1.31 (Active)

PA = 1.56 (Very active)

EER for Men 19 Years and Older (BMI 18.5-25 kg/m^2)

EER = TEE

EER = 662 – 9.53 × Age (yr) + PA × (15.91 × Weight [kg] + 539.6 × Height [m])

in which

PA = Physical activity coefficient:

PA = 1 (Sedentary)

PA = 1.11 (Low active)

PA = 1.25 (Active)

PA = 1.48 (Very active)

EER for Women 19 Years and Older (BMI 18.5-25 kg/m²)

EER = TEE

EER = 354 − 6.91 × Age (yr) + PA × (9.36 × Weight [kg] + 726 × Height [m])

in which

PA = Physical activity coefficient:

PA = 1 (Sedentary)

PA = 1.12 (Low active)

PA = 1.27 (Active)

PA = 1.45 (Very active)

EER for Pregnant Women

14-18 years: EER = Adolescent EER + Pregnancy energy deposition

First trimester = Adolescent EER + 0 (Pregnancy energy deposition)

Second trimester = Adolescent EER + 160 kcal (8 kcal/wk 1 × 20 wk) + 180 kcal

Third trimester = Adolescent EER + 272 kcal (8 kcal/wk × 34 wk) + 180 kcal

19-50 years: = Adult EER + Pregnancy energy deposition

First trimester = Adult EER + 0 (Pregnancy energy deposition)

Second trimester = Adult EER + 160 kcal (8 kcal/wk × 20 wk) + 180 kcal

Third trimester = Adult EER + 272 kcal (8 kcal/wk × 34 wk) + 180 kcal

EER for Lactating Women

14-18 years: EER = Adolescent EER + Milk energy output − Weight loss

First 6 months = Adolescent EER + 500 − 170 (Milk energy output − Weight loss)

Second 6 months = Adolescent EER + 400 − 0 (Milk energy output − Weight loss)

19-50 years: EAR = Adult EER + Milk energy output − Weight loss

First 6 months = Adult EER + 500 − 70 (Milk energy output − Weight loss)

Second 6 months = Adult EER + 400 − 0 (Milk energy output − Weight loss)

Weight Maintenance TEE for Overweight and At-Risk for Overweight Boys 3-18 Years (BMI >85th Percentile for Overweight)

TEE = 114 − 50.9 × Age (yr) + PA × (19.5 × Weight [kg] + 1161.4 × Height [m])

in which

PA = Physical activity coefficient:

PA = 1 if PAL is estimated to be ≥ 1.0 < 1.4 (Sedentary)

PA = 1.12 if PAL is estimated to be ≥ 1.4 < 1.6 (Low active)

PA = 1.24 if PAL is estimated to be ≥ 1.6 < 1.9 (Active)

PA = 1.45 if PAL is estimated to be ≥ 1.9 < 2.5 (Very active)

Weight Maintenance TEE for Overweight and At-Risk for Overweight Girls 3-18 Years (BMI >85th Percentile for Overweight)

TEE = 389 − 41.2 × Age (yr) + PA × (15 × Weight [kg] + 701.6 × Height [m])

in which

PA = Physical activity coefficient:

PA = 1 if PAL is estimated to be ≥ 1 < 1.4 (Sedentary)

PA = 1.18 if PAL is estimated to be ≥ 1.4 < 1.6 (Low active)

PA = 1.35 if PAL is estimated to be ≥ 1.6 < 1.9 (Active)

PA = 1.60 if PAL is estimated to be ≥ 1.9 < 2.5 (Very active)

Overweight and Obese Men 19 Years and Older (BMI ≥25 kg/m²)

TEE = 1086 − 10.1 × Age (yr) + PA × (13.7 × Weight [kg] + 416 × Height [m])

in which

PA = Physical activity coefficient:

PA = 1 if PAL is estimated to be ≥ 1 < 1.4 (Sedentary)

PA = 1.12 if PAL is estimated to be ≥ 1.4 < 1.6 (Low active)

PA = 1.29 if PAL is estimated to be ≥ 1.6 < 1.9 (Active)

PA = 1.59 if PAL is estimated to be ≥ 1.9 < 2.5 (Very active)

Overweight and Obese Women 19 Years and Older (BMI ≥25 kg/m²)

TEE = 448 − 7.95 × Age (yr) + PA × (11.4 × Weight [kg] + 619 × Height [m])

where

PA = Physical activity coefficient:

PA = 1 if PAL is estimated to be ≥ 1 < 1.4 (Sedentary)

PA = 1.16 if PAL is estimated to be ≥ 1.4 < 1.6 (Low active)

PA = 1.27 if PAL is estimated to be ≥ 1.6 < 1.9 (Active)

PA = 1.44 if PAL is estimated to be ≥ 1.9 < 2.5 (Very active)

Normal and Overweight or Obese Men 19 Years and Older (BMI ≥18.5 kg/m²)

TEE = 864 − 9.72 × Age (yr) + PA × (14.2 × Weight [kg] + 503 × Height [m])

in which

PA = Physical activity coefficient:

PA = 1 if PAL is estimated to be ≥ 1 < 1.4 (Sedentary)

PA = 1.12 if PAL is estimated to be ≥ 1.4 < 1.6 (Low active)

PA = 1.27 if PAL is estimated to be ≥ 1.6 < 1.9 (Active)

PA = 1.54 if PAL is estimated to be ≥ 1.9 < 2.5 (Very active)

Normal and Overweight or Obese Women 19 Years and Older (BMI ≥18.5 kg/m²)

TEE = 387 − 7.31 × Age (yr) + PA × (10.9 × Weight [kg] + 660.7 × Height [m])

in which

PA = Physical activity coefficient:

PA = 1 if PAL is estimated to be ≥ 1 < 1.4 (Sedentary)

PA = 1.14 if PAL is estimated to be ≥ 1.4 < 1.6 (Low active)

PA = 1.27 if PAL is estimated to be ≥ 1.6 < 1.9 (Active)

PA = 1.45 if PAL is estimated to be ≥ 1.9 < 2.5 (Very active)

The prediction equations include a physical activity (PA) coefficient for all groups except infants and young children.

PA coefficients correspond to four physical activity level (PAL; the ratio of TEE to BEE) lifestyle categories: sedentary, low active, active, and very active.

The energy spent during activities of daily living, the sedentary lifestyle category, has a PAL range of 1 to 1.39, but PAL categories beyond sedentary are determined according to the energy spent by an adult walking at a set pace.

The walking equivalents that correspond to each PAL category for an average-weight adult walking at 3 to 4 mph are 2, 7, and 17 miles per day, respectively.

Physical Activity Level Categories and Walking Equivalence*

PAL Category	PAL Values	Walking Equivalence (miles/day at 3-4 mph)
Sedentary	1-1.39	
Low active	1.4-1.59	1.5, 2.2, 2.9 for PAL = 1.5
Active	1.6-1.89	3, 4.4, 5.8 for PAL = 1.6
		5.3, 7.3, 9.9 for PAL = 1.75
Very active	1.9-2.5	7.5, 10.3, 14 for PAL = 1.9
		12.3, 16.7, 22.5 for PAL = 2.2
		17, 23, 31 for PAL = 2.5

From Institute of Medicine, The National Academies: Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein, and amino acids, Washington, DC, 2002/2005, The National Academies Press.

PAL, Physical activity level.

*In addition to energy spent for the generally unscheduled activities that are part of a normal daily life. The low, middle, and high miles/day values apply to relatively heavyweight (120-kg), midweight (70-kg), and lightweight (44-kg) individuals, respectively.

Estimated Energy Expended in Physical Activity

Energy expenditure in physical activity can be estimated using the method shown in the following appendix, which represents energy spent during common activities and incorporates body weight and the duration of time for each activity as variables.

APPENDIX 28. Physical Activity and Calories Expended per Hour

		Body Weight							
Activity	**Type**	**(110 lb)**	**(130 lb)**	**(150 lb)**	**(170 lb)**	**(190 lb)**	**(210 lb)**	**(230 lb)**	**(250 lb)**
Aerobics class	Water	210	248	286	325	364	401	439	477
Aerobics class	Low impact	263	310	358	406	455	501	549	596
Aerobics class	High impact	368	434	501	568	637	702	768	835
Aerobics class	Step with 6- to 8-inch step	446	527	609	690	774	852	933	1014
Aerobics class	Step with 10- to 12-inch step	525	621	716	812	910	1003	1097	1193
Backpack	General	368	434	501	568	637	702	768	835
Badminton	Singles and doubles	236	279	322	365	410	451	494	537
Badminton	Competitive	368	434	501	568	637	702	768	835
Baseball	Throw, catch	131	155	179	203	228	251	274	298
Baseball	Fast or slow pitch	263	310	358	406	455	501	549	596
Basketball	Shooting baskets	236	279	322	365	410	451	494	537
Basketball	Wheelchair	341	403	465	528	592	652	713	775
Basketball	Game	420	496	573	649	728	802	878	954
Bike	10-11.9 mph, slow	315	372	430	487	546	602	658	716
Bike	12-13.9 mph, moderate	420	496	573	649	728	802	878	954
Bike	14-15.9 mph, fast	525	621	716	812	910	1003	1097	1193
Bike	16-19.9 mph, very fast	630	745	859	974	1092	1203	1317	1431
Bike	>20 mph, racing	840	993	1146	1299	1457	1604	1756	1908
Bike	50 watts, stationary, very light	158	133	215	243	273	301	329	358
Bike	100 watts, stationary, light	289	341	394	446	501	552	603	656
Bike	150 watts, stationary, moderate	368	434	501	568	637	702	768	835
Bike	200 watts, stationary, vigorous	551	652	752	852	956	1053	1152	1252
Bike	250 watts, stationary, very vigorous	656	776	895	1015	1138	1253	1372	1491
Bike	BMX or mountain	446	527	609	690	774	852	933	1014

Energy expenditure in physical activity can also be estimated using information in the following DRI table (which represents energy spent by adults during various intensities of physical activity) and expressed as metabolic equivalents (METs).

Intensity and Effect of Various Activities on Physical Activity Level in Adults*

Physical Activity	METs†	Δ PAL/10 min‡	Δ PAL/hr‡
Daily Activities			
Lying quietly	1	0	0
Riding in a car	1	0	0
Light activity while sitting	1.5	0.005	0.03
Watering plants	2.5	0.014	0.09
Walking the dog	3	0.019	0.11
Vacuuming	3.5	0.024	0.14
Doing household tasks (moderate effort)	3.5	0.024	0.14
Gardening (no lifting)	4.4	0.032	0.19
Mowing lawn (power mower)	4.5	0.033	0.20
Leisure Activities: Mild			
Walking (2 mph)	2.5	0.014	0.09
Canoeing (leisurely)	2.5	0.014	0.09
Golfing (with cart)	2.5	0.014	0.09
Dancing (ballroom)	2.9	0.018	0.11
Leisure Activities: Moderate			
Walking (3 mph)	3.3	0.022	0.13
Cycling (leisurely)	3.5	0.024	0.14
Performing calisthenics (no weight)	4	0.029	0.17
Walking (4 mph)	4.5	0.033	0.20
Leisure Activities: Vigorous			
Chopping wood	4.9	0.037	0.22
Playing tennis (doubles)	5	0.038	0.23
Ice skating	5.5	0.043	0.26
Cycling (moderate)	5.7	0.045	0.27
Skiing (downhill or water)	6.8	0.055	0.33
Swimming	7	0.057	0.34
Climbing hills (5-kg load)	7.4	0.061	0.37
Walking (5 mph)	8	0.067	0.40
Jogging (10-min mile)	10.2	0.088	0.53
Skipping rope	12	0.105	0.63

Modified from Institute of Medicine of The National Academies: Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, protein, and amino acids, Washington, DC, 2002, The National Academies Press.

MET, Metabolic equivalent; *PAL*, physical activity level.

*PAL is the physical activity level that is the ratio of the total energy expenditure to the basal energy expenditure.

†METs are multiples of an individual's resting oxygen uptakes, defined as the rate of oxygen (O_2) consumption of 3.5 ml of O_2/min/kg body weight in adults.

‡The Δ PAL is the allowance made to include the delayed effect of physical activity in causing excess postexercise oxygen consumption and the dissipation of some of the food energy consumed through the thermic effect of food.

Estimating Energy Expenditure of Selected Activities Using Metabolic Equivalents (METs)

METs are units of measure that correspond with a person's metabolic rate during selected physical activities of varying intensities.

A value of MET = 1 is the oxygen metabolized at rest (3.5 mL of oxygen/kg/min in adults) and can be expressed as 1 kcal/kg/hour; thus the energy expenditure of adults can be estimated using MET values (1 MET = 1 kcal/kg/hour)

For example, an adult who weighs 65 kg and is moderately walking at a pace of 4 mph (which is a MET value of 4.5) would expend 292.5 calories in one hour.

To estimate a person's energy requirements using the EER equations, it is necessary to identify a PAL value for that person.

A person's PAL value can be affected by various activities performed throughout the day and is referred to as the change in physical activity level (ΔPAL).

To determine ΔPAL, take the sum of the ΔPALs for each activity performed for 1 day from the DRI tables.

To calculate the PAL value for 1 day, take the total ΔPAL and add the BEE (1) plus 10% to account for the TEF (1 + 0.1 = 1.1).

For example, to calculate an adult woman's PAL value, take the sum of the ΔPAL values for activities of daily living, such as walking the dog (0.11) and vacuuming (0.14) for 1 hour each, sitting for 4 hours doing light activity (0.12), and then performing moderate to vigorous activities such as walking for 1 hour at 4 mph (0.20) and ice skating for 30 minutes (0.13) for a total of (0.7).

Then, to that value include the BEE adjusted for the 10% TEF (1.1) for the final calculation (0.7 + 1.1 = 1.8).

For this woman, the PAL value (1.8) falls within an active range, and the PA coefficient that correlates with an active lifestyle for this woman is 1.27.

A simplified way of predicting physical activity additions to REE is through the use of estimates of the level of physical activity, which are then multiplied by the measured or predicted REE.

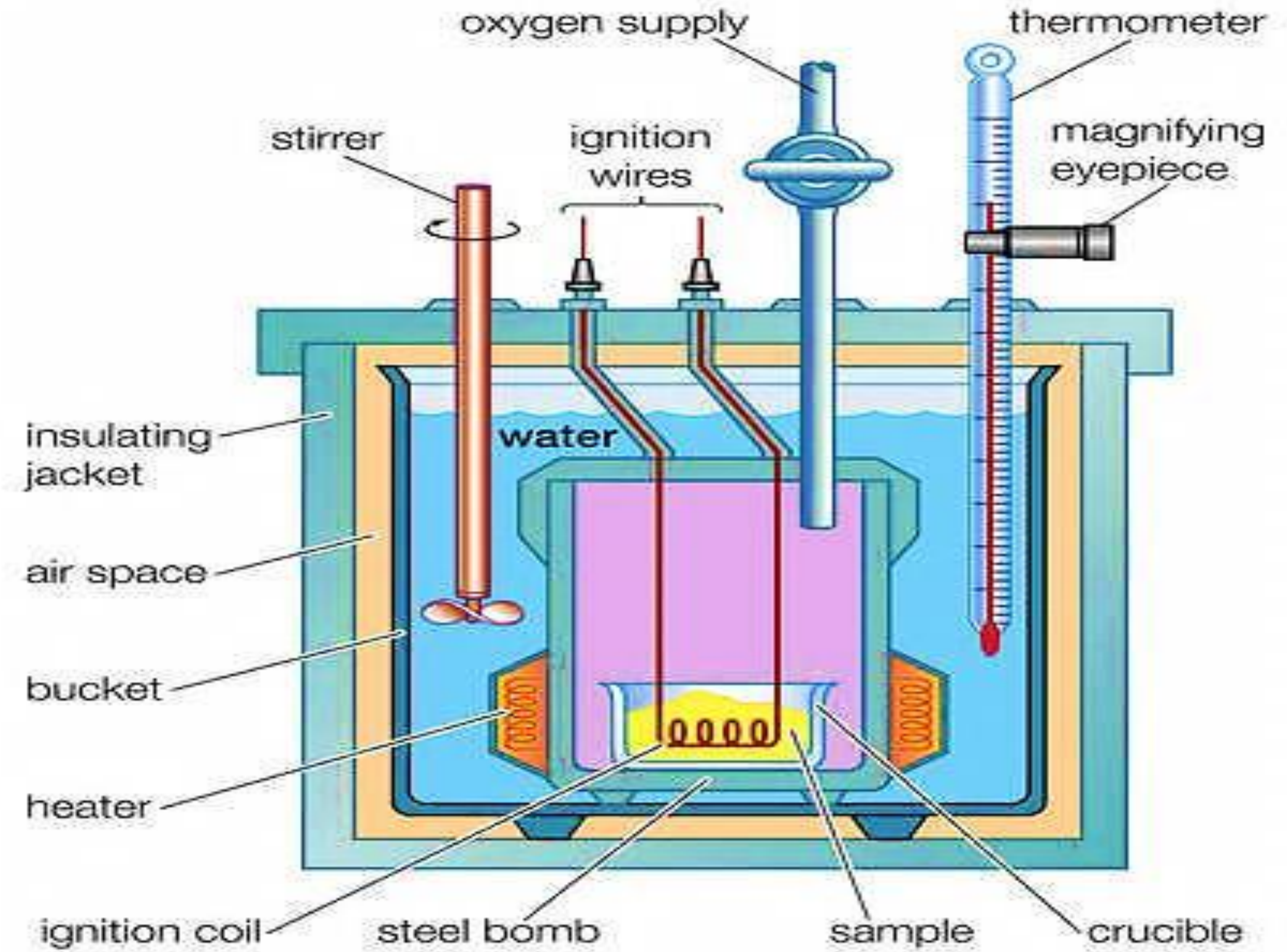
To estimate TEE for minimal activity, increase REE by 10% to 20%; for moderate activity, increase REE by 25% to 40%; for strenuous activity, increase REE by 45% to 60%.

Calculating Food Energy

The total energy available from a food is measured with a bomb calorimeter.

This device consists of a closed container in which a weighed food sample, ignited with an electric spark, is burned in an oxygenated atmosphere.

The container is immersed in a known volume of water, and the rise in the temperature of the water after igniting the food is used to calculate the heat energy generated.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crucible

Not all of the dietary energy is available to the body's cells because the processes of digestion and absorption are not completely efficient and also because the nitrogenous portion of amino acids is not oxidized but is excreted in the form of urea.

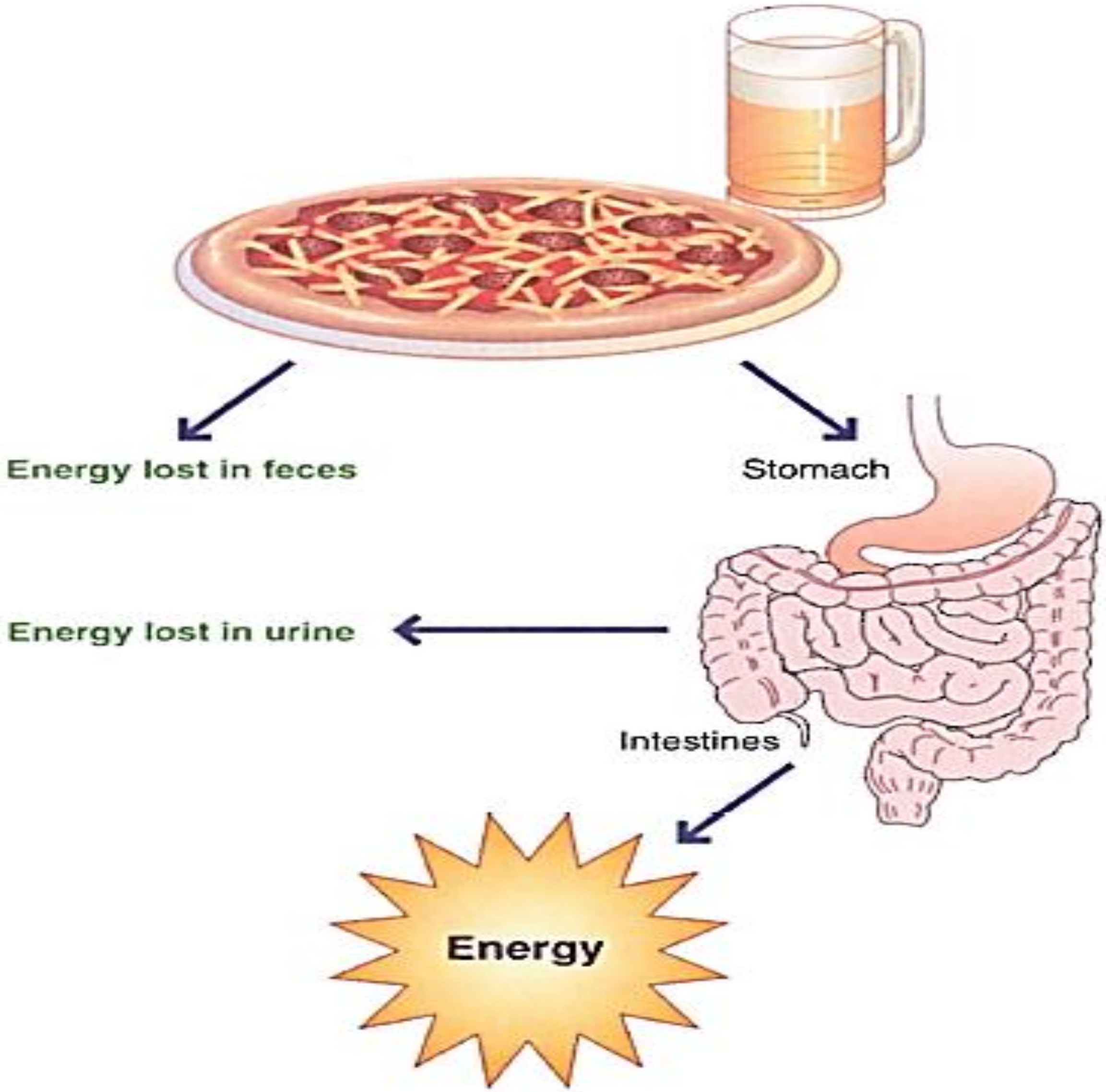
Therefore, **the biologically available energy from protein, fat, carbohydrate, and alcohol are 4, 9, 4, and 7 kcal/g, respectively, which are slightly below those obtained using the calorimeter.**

Fiber is "unavailable carbohydrate" that resists digestion and absorption; its energy intake is minimal.

TABLE 5.1 HEATS OF COMBUSTION, PHYSIOLOGIC ENERGY VALUES, HEAT EQUIVALENTS, AND CORRESPONDING VOLUMES OF OXYGEN AND CARBON DIOXIDE FOR CARBOHYDRATE, PROTEIN, FAT, AND ETHANOL OXIDATION

	ENERGY (kcal/g)			HEAT EQUIVALENTS			VOLUME	
FOOD	HEAT OF COMBUSTION	HUMAN OXIDATION	PHYSIOLOGIC VALUE	$\dot{V}O_2$ (kcal/L)	VCO_2 (kcal/L)	RQ	OXYGEN (L/g)	CO_2 (L/g)
Carbohydrate	4.1	4.1	4	5.05	5.05	1.00	0.81	0.81
Protein	5.4	4.2	4	4.46	5.57	0.80	0.94	0.75
Fat	9.3	9.3	9	4.74	6.67	0.71	1.96	1.39
Ethanol	7.1	7.1	7	4.86	7.25	0.67	1.46	0.98

RQ, respiratory quotient; VCO_2, carbon dioxide production; $\dot{V}O_2$, oxygen consumption.



Gross energy of food (heat of combustion) (kcal/g)	
Carbohydrates	4.10
Fat	9.45
Protein	5.65
Alcohol	7.10

Digestible energy (kcal/g)	
Carbohydrates	4.0
Fat	9.0
Protein	5.20
Alcohol	7.10

Metabolizable energy (kcal/g)	
Carbohydrates	4.0
Fat	9.0
Protein	4.0
Alcohol	7.0

Energy value of food

Although the energy value of each nutrient is known precisely, only a few foods, such as oils and sugars, are made up of a single nutrient, and more commonly, foods contain a mixture of protein, fat, and carbohydrate.

For example, the energy value of one medium (50 g) egg calculated in terms of weight is derived from protein (13%), fat (12%), and carbohydrate (1%) as follows:

Protein: 13% × 50 g = 6.5 g × 4 kcal/g = 26 kcal
Fat: 12% × 50 g = 6 g × 9 kcal/g = 54 kcal
Carbohydrate: 1% × 50 g = 0.5 g × 4 kcal/g = 2 kcal
Total = 82 kcal

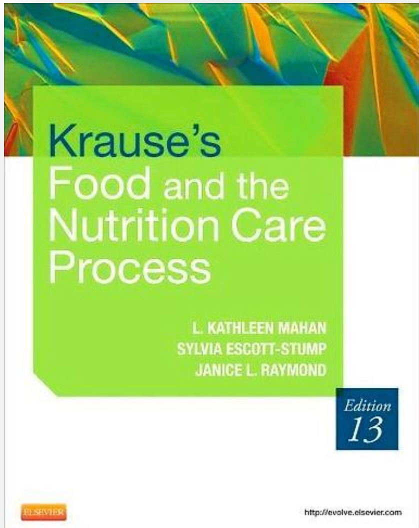
References:

1- Ireton-Jones CS. Intake: Energy. In: Mahan LK, Escott-Stump S, Raymond JL, editors. Krause's food & the nutrition care process. 13th ed. USA: Elsevier; 2012: 19-31.

2- Murray RK, Bender DA, Botham KM, Kennelly PJ, Rodwell VW, Weil PA, editors. Harper's Illustrated Biochemistry. 28th ed. USA: McGraw-Hill; 2009.

3- Ross AC, Caballero B, Cousins RJ, Tucker KL, Ziegler TR, editors. Modern Nutrition in Health and Disease. 11th ed. USA: Lippincott Williams & Wilkins; 2014.

4- Wikipedia, the free encyclopedia. Available from: URL: http://en.wikipedia.org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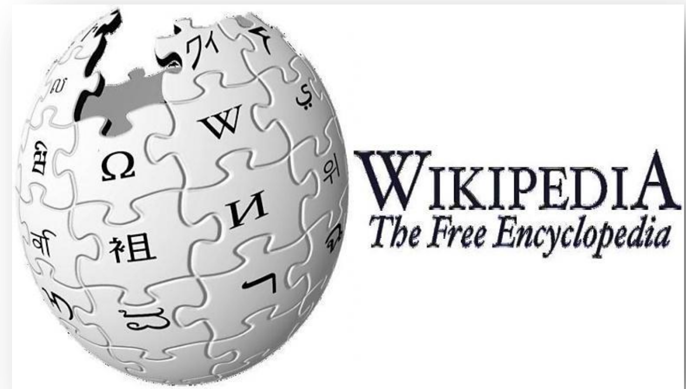
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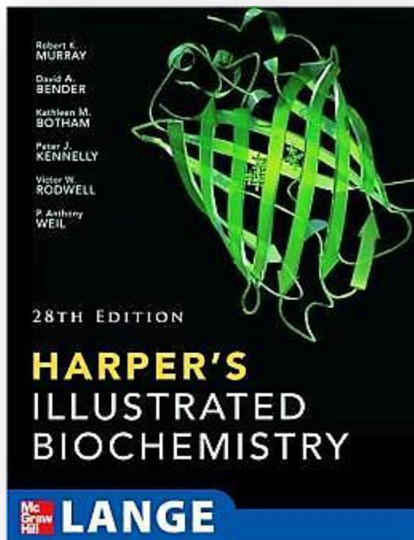
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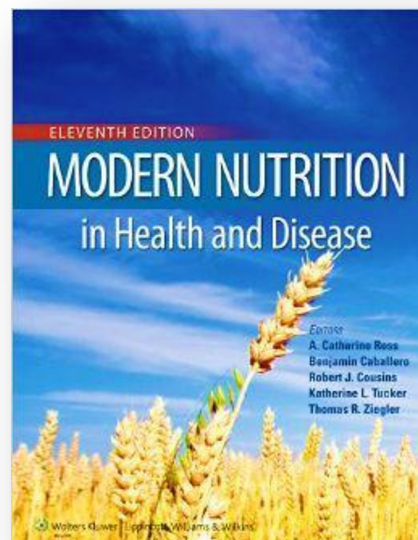
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