Varastegan
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ENERGY

(Session 8)

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ENERGY

Components of Energy Expenditure

Thermic Effect of Food

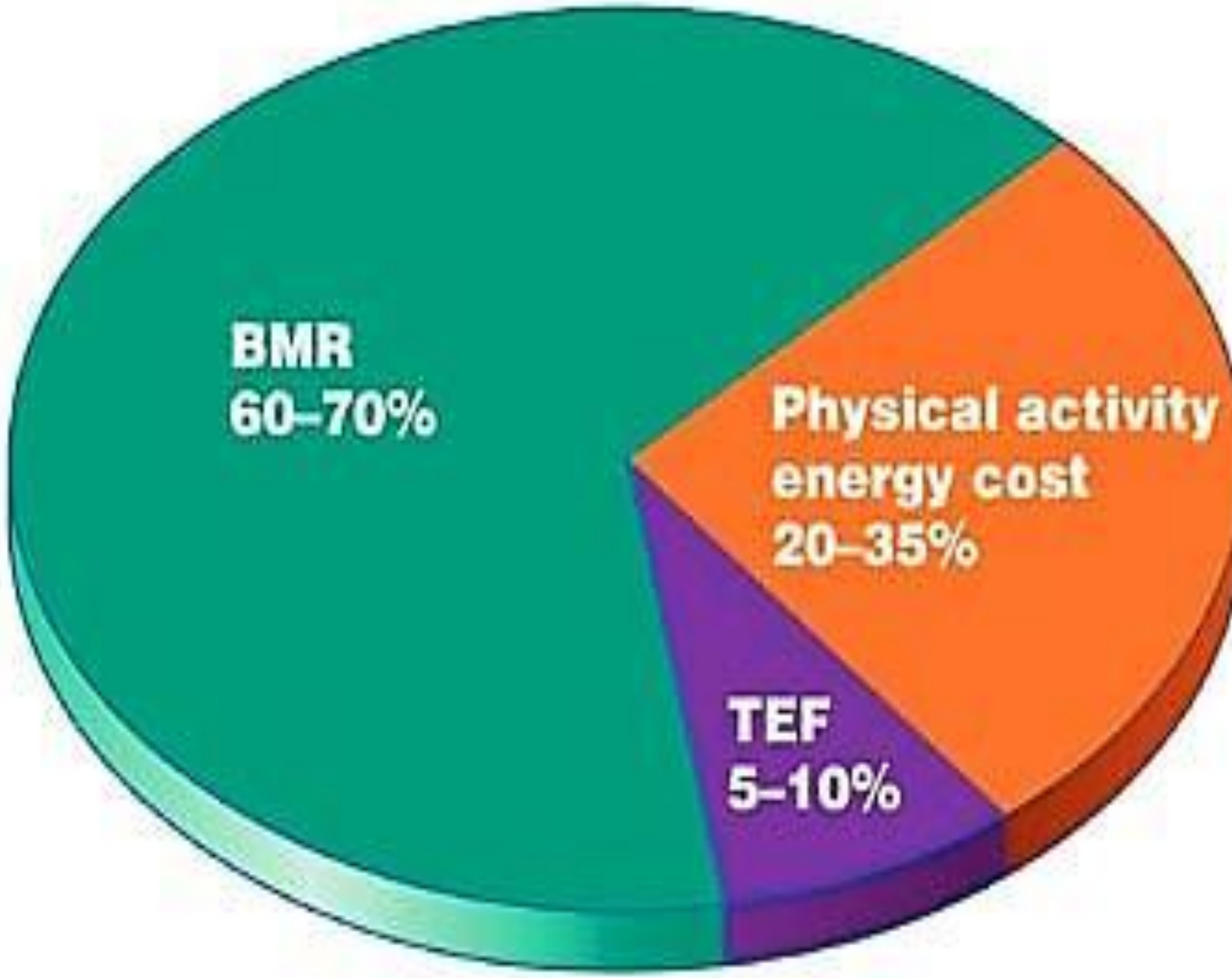
The thermic effect of food (TEF) is the increase in energy expenditure associated with the consumption, digestion, and absorption of food.

THERMIC EFFECT OF FOOD

The thermic effect of food is the caloric cost of digesting and processing different macronutrients in your diet. Protein has a thermic effect upward of five times greater than carbohydrates or fat.

The TEF accounts for approximately 10% of TEE.

The TEF may also be called diet-induced thermogenesis, specific dynamic action, or the specific effect of food.



Components of energy expenditure

TEF can be separated into obligatory and facultative (or adaptive) subcomponents.

Obligatory thermogenesis is the energy required to digest, absorb, and metabolize nutrients.

Adaptive thermogenesis is the "excess" energy expended in addition to the obligatory thermogenesis and is attributable to the metabolic inefficiency of the system stimulated by sympathetic nervous activity.

TEF varies with the composition of the diet, with energy expenditure increasing directly after food intake, particularly after consumption of a meal higher in protein compared with a meal higher in fat.

Fat is metabolized efficiently, with only 4% wastage, and this factor contributes to the obesity-promoting characteristics of fat.

TEF decreases after ingestion over 30 to 90 minutes.

Meal rich in	TEF (% of calories consumed)
Proteins	20% to 30%
Carbohydrates	5% to 10%
Fats	0% to 3%

	Macronutrient Composition			TOTAL TEF* (1,400 kcal diet)
	PRO	CHO	FAT	
High-PRO	35%	30%	35%	166 kcals (11.9%)
High-CHO	15%	65%	20%	128 kcals (9.1%)
Balanced	20%	50%	30%	133 kcals (9.5%)

Spicy foods enhance and prolong the effect of the TEF.

Meals with chili and mustard may increase the metabolic rate as much as 33% over that after an un-spiced meal, and this effect may last for more than 3 hours.

Caffeine, capsaicin, and different teas (e.g. green tea) may also increase energy expenditure and fat oxidation.

To measure the TEF, it would be necessary to determine BEE and the energy expended in excess of BEE every 30 minutes for at least 5 hours after a meal.

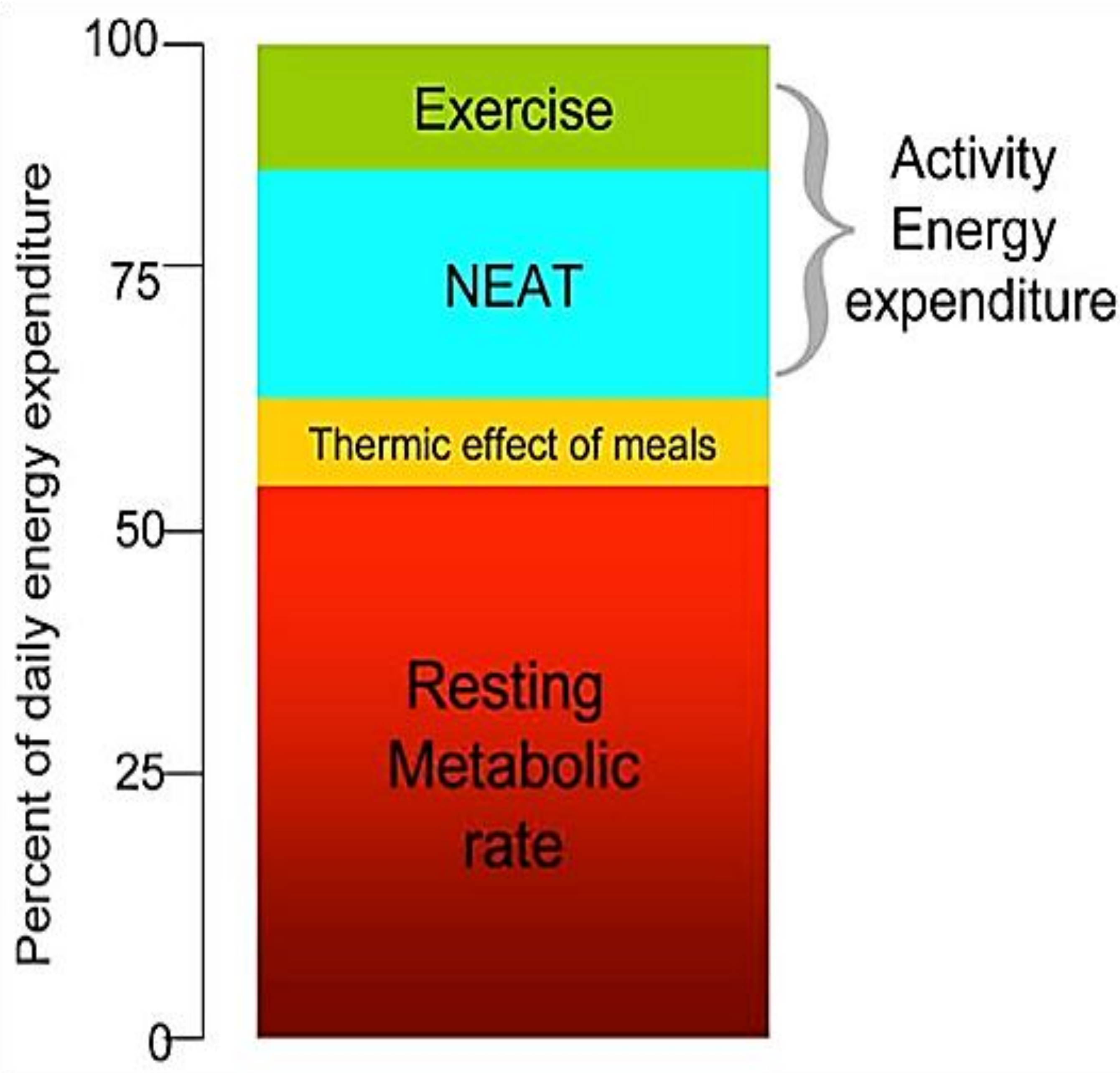
For practical purposes, TEF is calculated as no more than an additional 10% of the REE added to the sum of the REE and the activity thermogenesis.

Activity Thermogenesis

Beyond REE and TEF, energy is expended in activity.

Energy expended in activity can be broken down into two categories: 1) activity or exercise thermogenesis (AT) and 2) non-exercise activity thermogenesis (NEAT).

In other words, AT is the energy expended during sports or fitness exercise, while the energy expended during activities of daily living is referred to as NEAT.


100
75
50
25
0
Percent of daily energy expenditure
Exercise
NEAT
Thermic effect of meals
Resting
Metabolic
rate
Activity
Energy
expenditure

The contribution of physical activity is the most variable component of TEE, which may be as low as 100 kcal/d in sedentary people or as high as 3000 kcal/d in athletes.

NEAT represents the energy expended during the work day and during leisure-type activities (e.g., shopping), which may account for vast differences in energy costs among people.

Individual AT varies considerably, depending on body size and the efficiency of individual habits of motion.

The level of fitness also affects the energy expenditure of voluntary activity because of variations in muscle mass.

AT tends to decrease with age, a trend that is associated with a decline in FFM and an increase in fat mass.

In general, men have a greater skeletal muscle than women and thus, a higher AT.

Excess post-exercise oxygen consumption (EPOC) affects energy expenditure.

The duration and magnitude of physical activity increase EPOC, resulting in an elevated metabolic rate even after exercise has ceased.

E.P.O.C.

- What is it?
  - Excess Postexercise Oxygen Consumption
- What does it mean E.P.O.C.?
  - Oxygen consumed to bring physiological variables to resting level

Habitual exercise does not cause a significantly prolonged increase in metabolic rate per unit of active tissue, but it causes an 8% to 14% higher metabolic rate in men who are moderately and highly active, respectively, because of their increased FFM.

Measurement of Energy Expenditure

The standard unit for measuring energy is the calorie, which is the amount of heat energy required to raise the temperature of 1 ml of water at 15^0 C by 1^0 C.

Because the amount of energy involved in the metabolism of food is fairly large, the kilocalorie (kcal), 1000 calories, is used to measure it.

The joule (J) measures energy in terms of mechanical work and is the amount of energy required to accelerate with a force of 1 Newton (N) for a distance of 1 m.

One kcal is equivalent to 4.184 kilojoules (kJ).

calories

(noun)

Tiny creatures that live in your closet and sew your clothes a little bit tighter every night.

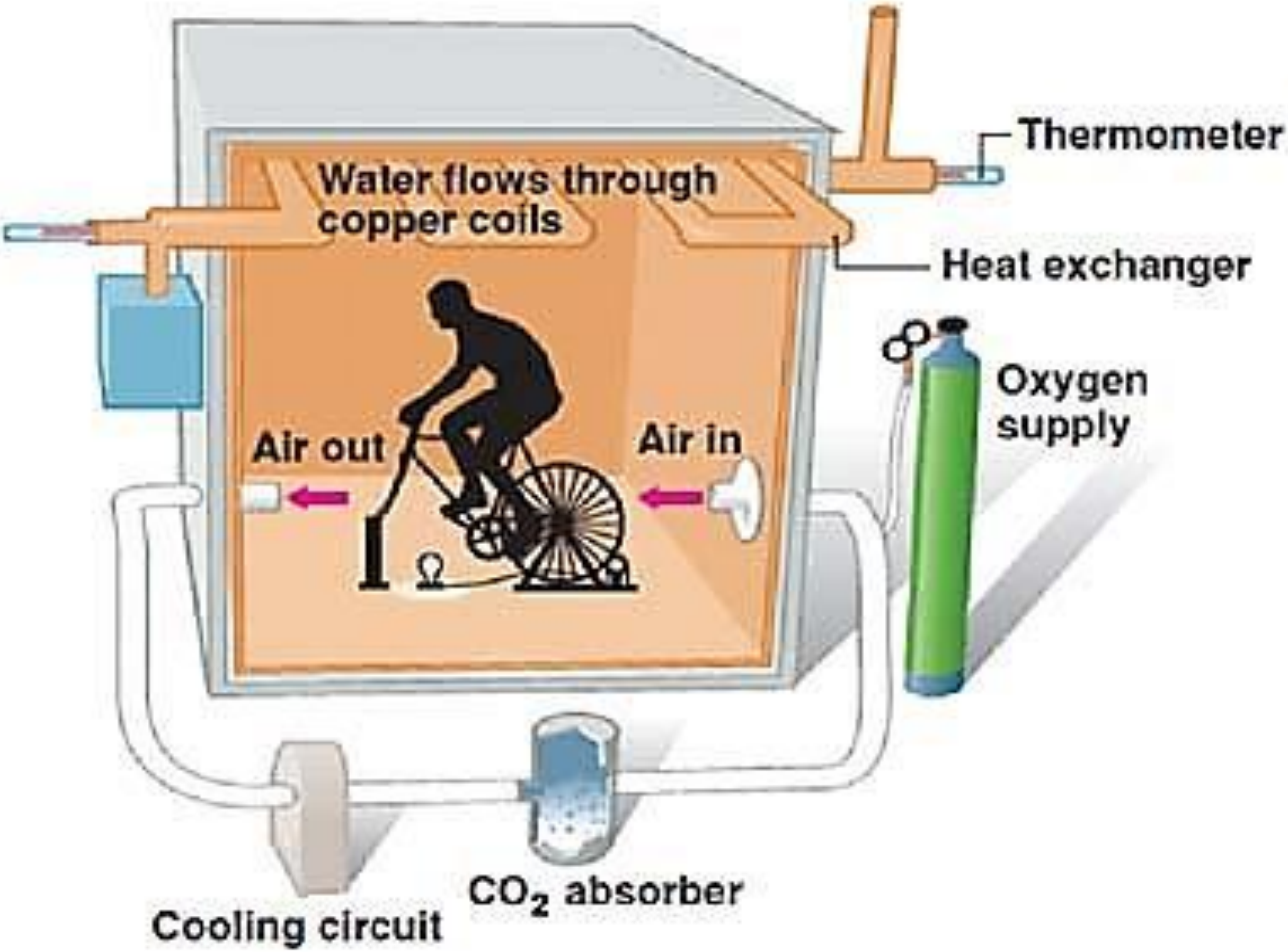
Scientific Definition

Calorie - the quantity of heat needed to raise the temperature of 1kg (kilogram) of water from 0 to 1^{o}C.

Direct Calorimetry

An individual is placed in a whole-room calorimeter that permits a moderate amount of activity and includes equipment that monitor and measure the energy expenditure by identifying the amount of heat produced by the individual inside.

Limitations: 1) It provides no information on the kind of fuel being oxidized; 2) The measurement of TEE using this method is not representative of a free-living individual in a normal environment; 3) High cost; 4) complex engineering; and 5) scarcity of appropriate facilities around the world.



Thermometer
Water flows through copper coils
Heat exchanger
Oxygen supply
Air out
Air in
CO2 absorber
Cooling circuit

Indirect Calorimetry

Indirect calorimetry (IC) is a more commonly used method for measuring energy expenditure.

An individual's oxygen consumption and carbon dioxide (CO_2) production are quantified over a given period, and the Weir equation and a constant respiratory quotient (RQ) value of 0.85 are used to convert oxygen consumption to REE.

The equipment usually involves an individual breathing into a mask that covers the nose and mouth or a ventilated hood that captures all expired CO_2.


Quark RMR
msi
Quark RMR

The protocol to follow before performing IC measurement:

1) For "normal" healthy people, a minimum of a 5-hour fast after meals and snacks is recommended.

2) Caffeine should be avoided for at least 4 hours and alcohol and smoking for at least 2 hours.

3) Testing should occur no sooner than 2 hours after moderate exercise or 14 hours following vigorous resistance exercise.

4) There should be a rest period of 10 to 20 minutes before the measurement is taken.

RQ = volume of CO_2 expired/volume of O_2 consumed

The RQ indicates the fuel mixture being metabolized:

RQ values:
1 = carbohydrate
0.85 = mixed diet
0.82 = protein
0.7 = fat
≤0.65= ketone production

RQs > 1 are associated with net fat synthesis (i.e. carbohydrate intake or total caloric intake is excessive), whereas a very low RQ may be seen under conditions of inadequate nutrient intake.

It is appropriate to use RQ as a marker for respiratory tolerance of the nutrition support regimen.

	Heat produced Kcal		
	Per litre of O_2 consumed	Per litre of CO_2 formed	$RQ = \frac{CO_2 \text{ formed}}{O_2 \text{ used}}$
Carbohydrates	5.05	5.05	1.00
Fats	4.75	6.67	0.71
Proteins	4.46	5.57	0.81

INDIRECT CALORIMETRY

- Portable bedside system measuring of EE and resp quotient by measuring and analysing the O2 consumed (VO2) and the CO2 expired (VCO2)
- Respiratory Quotient = CO2 production/O2consumption

RQ	Interpretation
> 1.00	overfeeding
0.9 – 1.00	CHO oxidation
0.8 – 0.9	Mixed nutrients oxidation
0.7 – 0.8	Fat and protein oxidation

Doubly Labeled Water

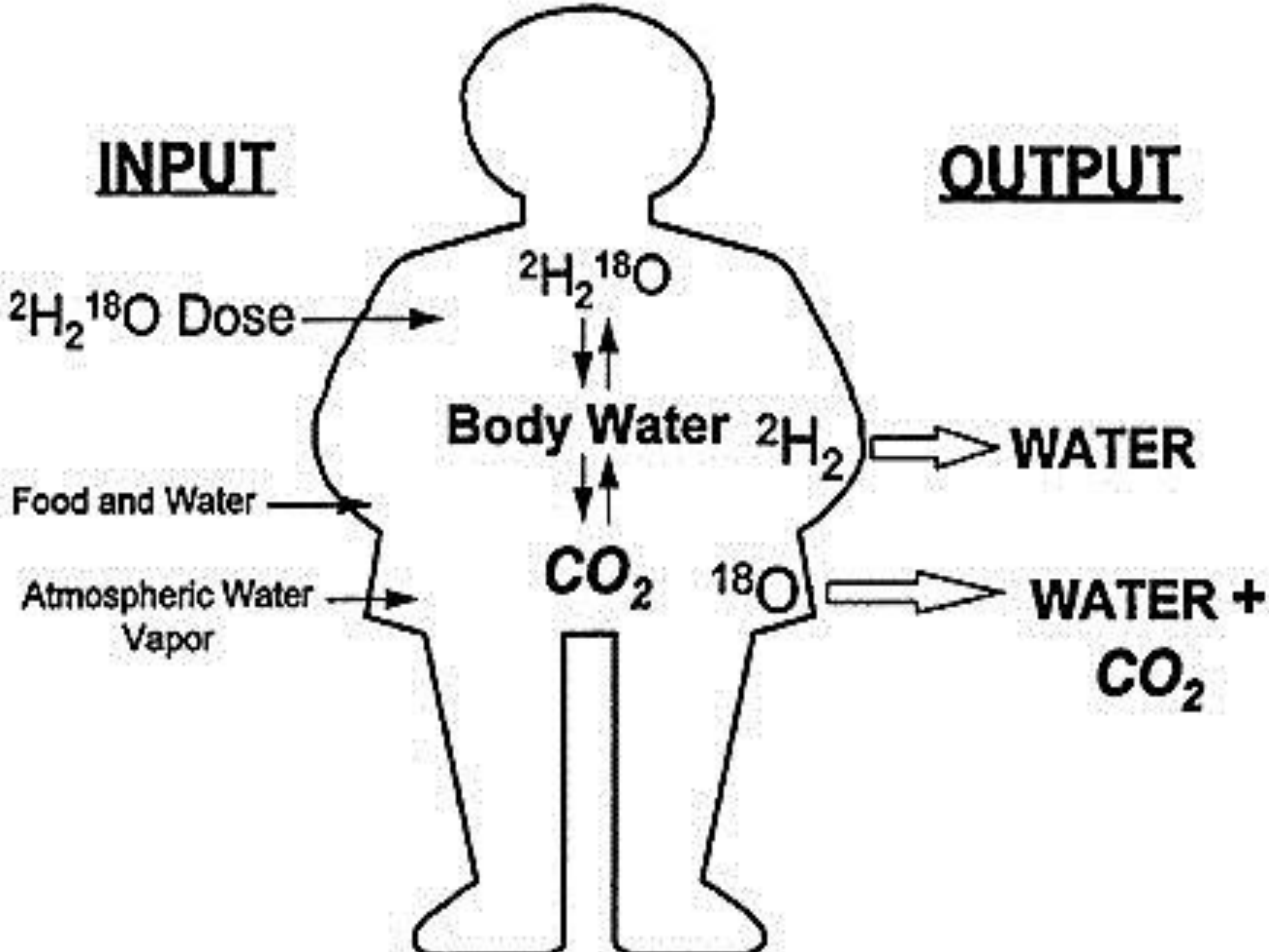
The doubly labeled water (DLW) technique for measuring TEE is considered the gold standard for determining energy requirements and energy balance in humans.

The DLW method is based on the principle that CO_2 production can be estimated from the difference in the elimination rates of body hydrogen and oxygen.

After administering an oral loading dose of water labeled with deuterium oxide (^2H_2O) and oxygen-18 ($H_2{}^{18}O$), the ^2H_2O is eliminated from the body as water, and the $H_2{}^{18}O$ is eliminated as water and CO_2.

The elimination rates of the two isotopes are measured for 10-14 days by periodic sampling of body water from urine, saliva, or plasma.

The difference between the two elimination rates is a measure of CO_2 production, which can then be equated to TEE using standard IC techniques for the calculation of energy expenditure.



^{18}O elimination (water + CO_2) - $^{2}H_2$ elimination (water) = CO_2 Production

Advantages of using DLW method for measuring TEE:

1) It provides a measure of energy expenditure that incorporates all the components of TEE (i.e. REE, TEF, and AT).

2) It is easy, and the person is able to engage in typical activities of daily living throughout the measurement period; hence, the technique provides a measure of the person's usual daily TEE.

3) It provides a method by which more subjective estimates of energy intakes (e.g. diet recalls, records) and energy expenditure (e.g. physical activity logs) can be validated.

4) The method is accurate and has a precision of 2% to 8%.

Disadvantages of DLW method for daily use by clinicians:

1) The stable isotopes are expensive.

2) Expertise is required to operate the sophisticated and costly mass spectrometer for the analysis of the isotope enrichments.

Measuring Activity-Related Energy Expenditure

Doubly Labeled Water

The caloric value of AT can be estimated by using the DLW method in conjunction with IC.

After the postprandial REE (which includes a measure of the TEF) has been measured using IC, an estimated AT can be determined by subtracting the postprandial REE from the TEE that was measured using DLW.

Uniaxial Monitors

Uniaxial monitors measure the degree and intensity of movement in a vertical plane.

Among adults, the uniaxial monitor was found to be an effective tool for measuring energy expenditure when compared with the DLW technique.

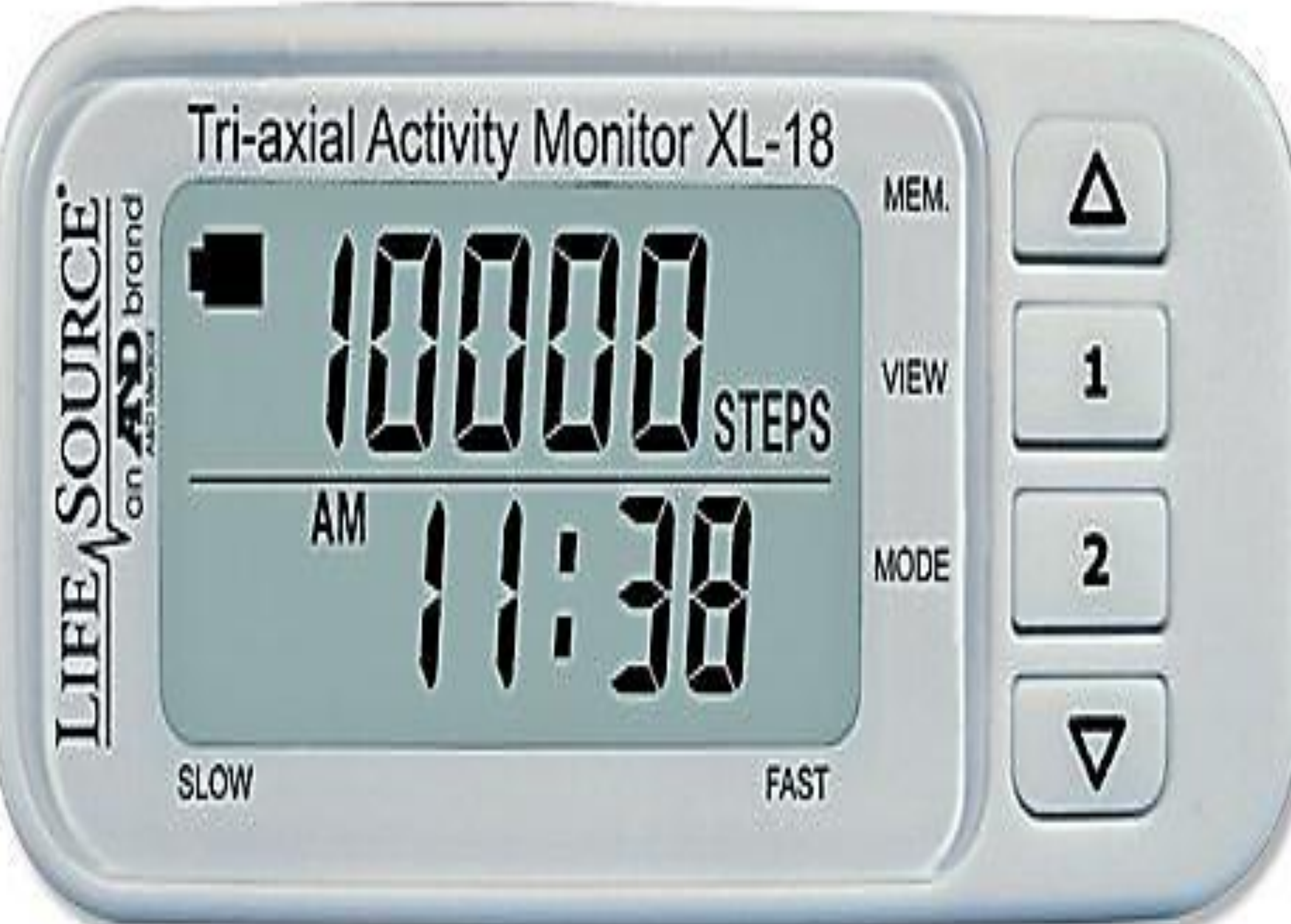
It may be acceptable for estimates of activity-related energy expenditure in groups of people, but it has limited use with individuals.


RT3™
from Stayhealthy™

Triaxial Monitors

Triaxial Monitors more efficiently measure multidirectional movement by employing three uniaxial monitors.

They are found to be correlated with energy expenditure measured using DLW technique.


Tri-axial Activity Monitor XL-18
LIFE SOURCE
an A&D brand
10000
STEPS
AM
11:38
MEM.
VIEW
MODE
1
2
SLOW
FAST

Physical Activity Questionnaire

Physical activity questionnaires (PAQs) are the simplest and least expensive tools for gaining information about an individual's activity level.

The International Physical Activity Questionnaire, the Seven-Day Recall and the Yale Physical Activity Survey are three commonly used questionnaires that are validated.

The Baecke questionnaire and an adapted version of the Tecumseh Community Health Study questionnaire are useful for determining whether a group or a person is active or inactive.

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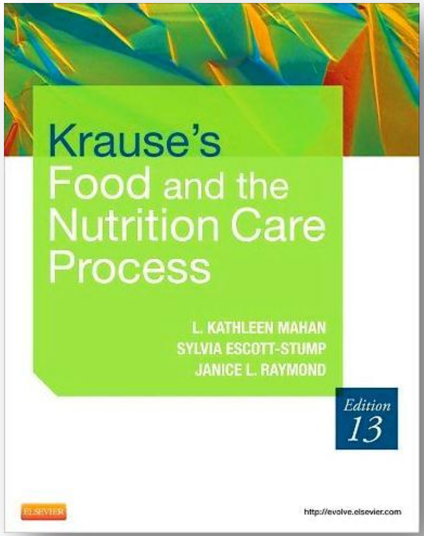

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