Energy Requirements

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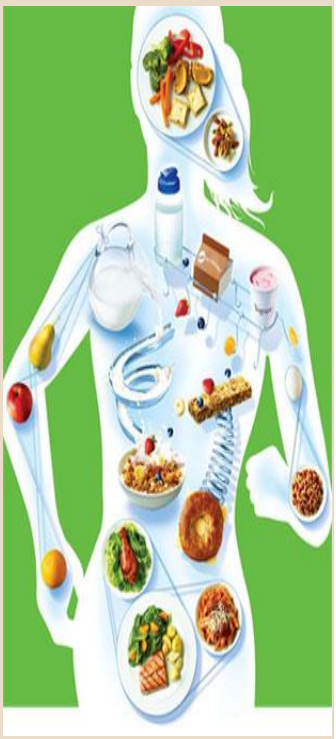
Learning objectives:

- **To understand the components of Total energy requirement (TER)**
- **To identify the factors affecting TER & BMR.**
- **To calculate TER for:**

1. **Normal person**
2. **Pregnant & lactating**
3. **Overweight person**

Energy:

- The ability to perform work, produce change, & maintain life.
- Energy exists in many forms; mechanical, chemical, heat, electrical, light, & nuclear.
- Each type can be converted from one form to another.
- In the body, chemical energy from food is converted to mechanical energy & heat.
- The major dietary sources of energy-yielding are ***CHO***, *fats & proteins.*



Calorie: it is the basic unit of energy.

It is the **amount of heat energy required to raise the temperature of one gram of water by 1°C at the standard temperature**.

But because the calorie is a small unit we usually use;

Kilocalorie (Kcal or Cal) =1000 calories:

- **Which is the amount of heat energy required to raise the temp. of a kilogram of water 1°C**.

Joule (J): is the work done (energy expended) when 1 kg is moved 1 m. by a force of 1 Newton.

How is the energy content of food found out?

Burning food in a bomb calorimeter.

NUTRITION INFORMATION

Servings per package: 1	**Average quantity**	
Serving Size: 170g	Per serving	Per 100g
Energy	410kJ	240kJ
Protein	5.2g	3.1g
Fat - total	2.8g	1.7g
- saturated fat	0g	0g
Carbohydrate	11.5g	6.7g
- Sugars	3.5g	2.1g
Dietary fibre	2.2g	1.3g
Sodium	30mg	17mg
Potassium	335mg	210mg
Gluten	0mg	0mg
Iron	2.0mg	1.2mg

The total calorie content of food can be measured by a device called **Bomb Calorimeter** It is design to burn food, the amount of energy produced/gram of protein, fat or CHO by Bomb calorimeter are;

- 1 gm of **protein** = ***4*** **Kcal**
- 1gm of **fat** = ***9*** **Kcal**
- 1gm of **CHO** = ***4*** **Kcal**

Usually the food content of; prot., CHO, fat , are taken from **food composition tables**.

E.g : **2 eggs =100 gm contain** ;

- 13% protein = 13 gm x 4 = 52 kcal
- 12% fat = 12 gm x 9 = 108 kcal
- 1% CHO = 1 gm x 4 = 4 kcal

Total = 164 kcal

Bread 100 gm contains ;

- 8% protein = 8 gm x 4 = 32 kcal
- 2% fat = 2 gm x 9 = 18 kcal
- 58% CHO = 58 gm x4 = 232 kcal

Total = 282 kcal

Body Weight & Body composition

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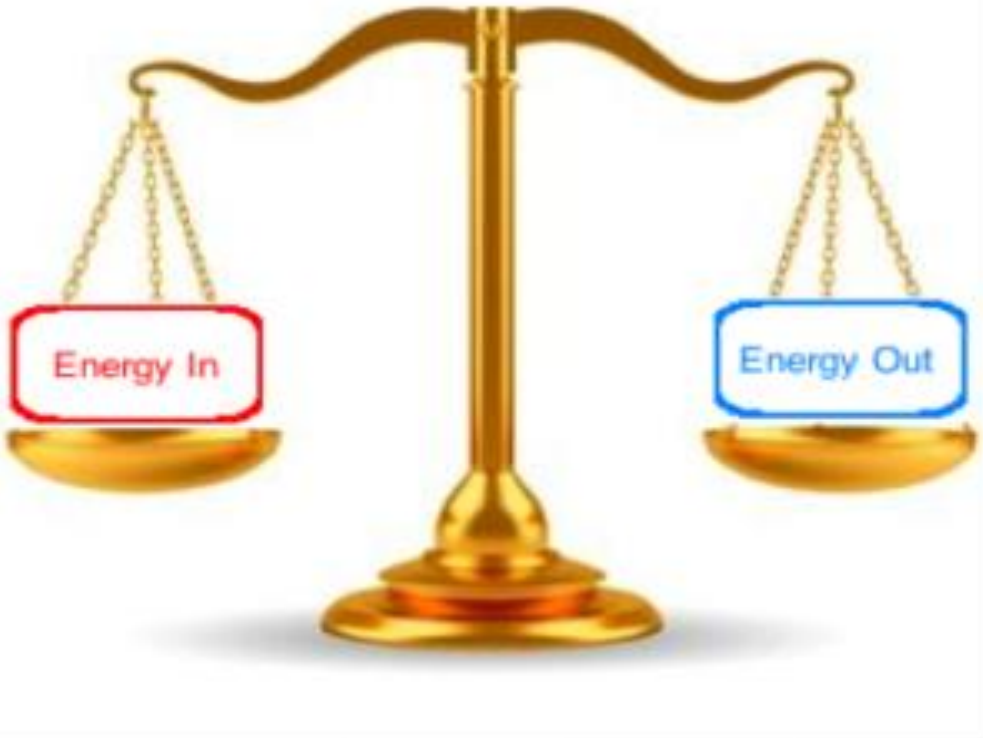
- Body composition : this term is used to describe the percentages of fat ,muscle, bone, water and other tissues that make up body weight.
- Achieving and maintaining a **healthy weight** is about managing energy balance and increasing the proportion of **lean** tissue **to fat**.
- Energy balance = energy in – energy out.

Neutral Energy Balance



Energy balance

Energy IN = Energy OUT

Energy intake 24h → Energy expenditure

Adipose tissues

Release fat →

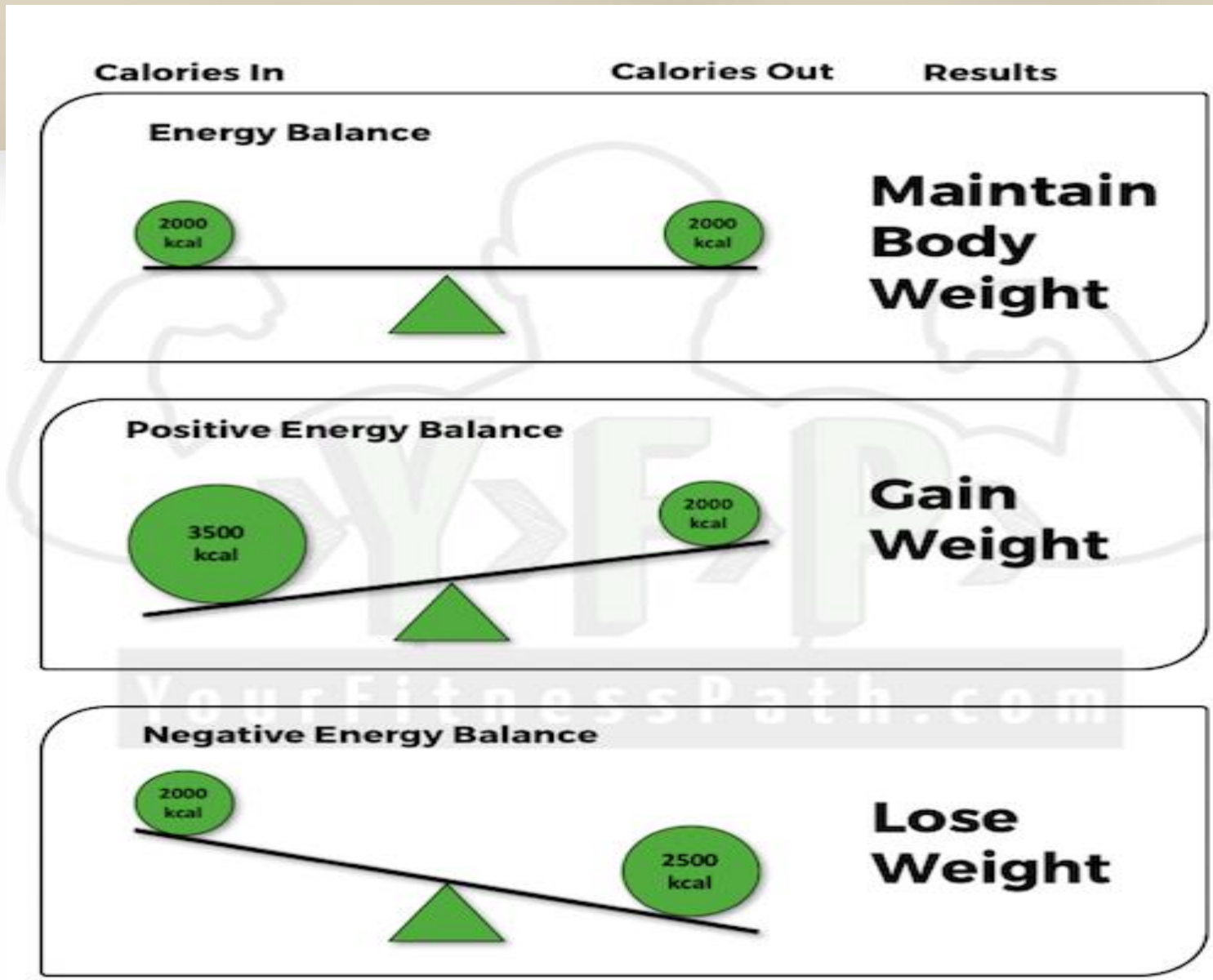
Energy intake inadequate (negative energy balance); decrease in body wt.

Store fat. ←

Excess energy intake (positive energy balance); Increase in body wt

Energy balance

- Energy in = calories consumed per day.
- Energy out = basal metabolic rate (BMR) + thermic effect of foods + physical activity per day.
- Small increments in calories consumed per day or week can **contribute to weight gain over time.**


Calories In
Calories Out
Results
Energy Balance
2000 kcal
2000 kcal
Maintain Body Weight
Positive Energy Balance
3500 kcal
2000 kcal
Gain Weight
Negative Energy Balance
2000 kcal
2500 kcal
Lose Weight
www.yourfitnesspath.com

Sources of Stored Energy

When food is not available ,as during sleep, or longer periods of fasting or extreme stress of starvation , the body draws energy from Its(3)stores

1- Glycogen

A 12-to 48 hour reserve of glycogen exists in liver and muscles and quickly depleted if not replenished by daily food intake .

For example, glycogen stores maintain normal blood-glucose levels for body functions during sleep hours

2-Adipose tissue

Although fat storage is larger than glycogen , the supply varies from person to person , and the balanced amount needs to maintained as an added resource.

3-Muscle mass

Energy stored as protein exist in limited amounts in muscle mass, but this lean mass must be maintained for health.

Only during longer periods of fasting or starvation the body turns these tissues for energy.

Total energy requirement (TER):

- This depends on summation of 3 components:

1-Basal metabolic rate.

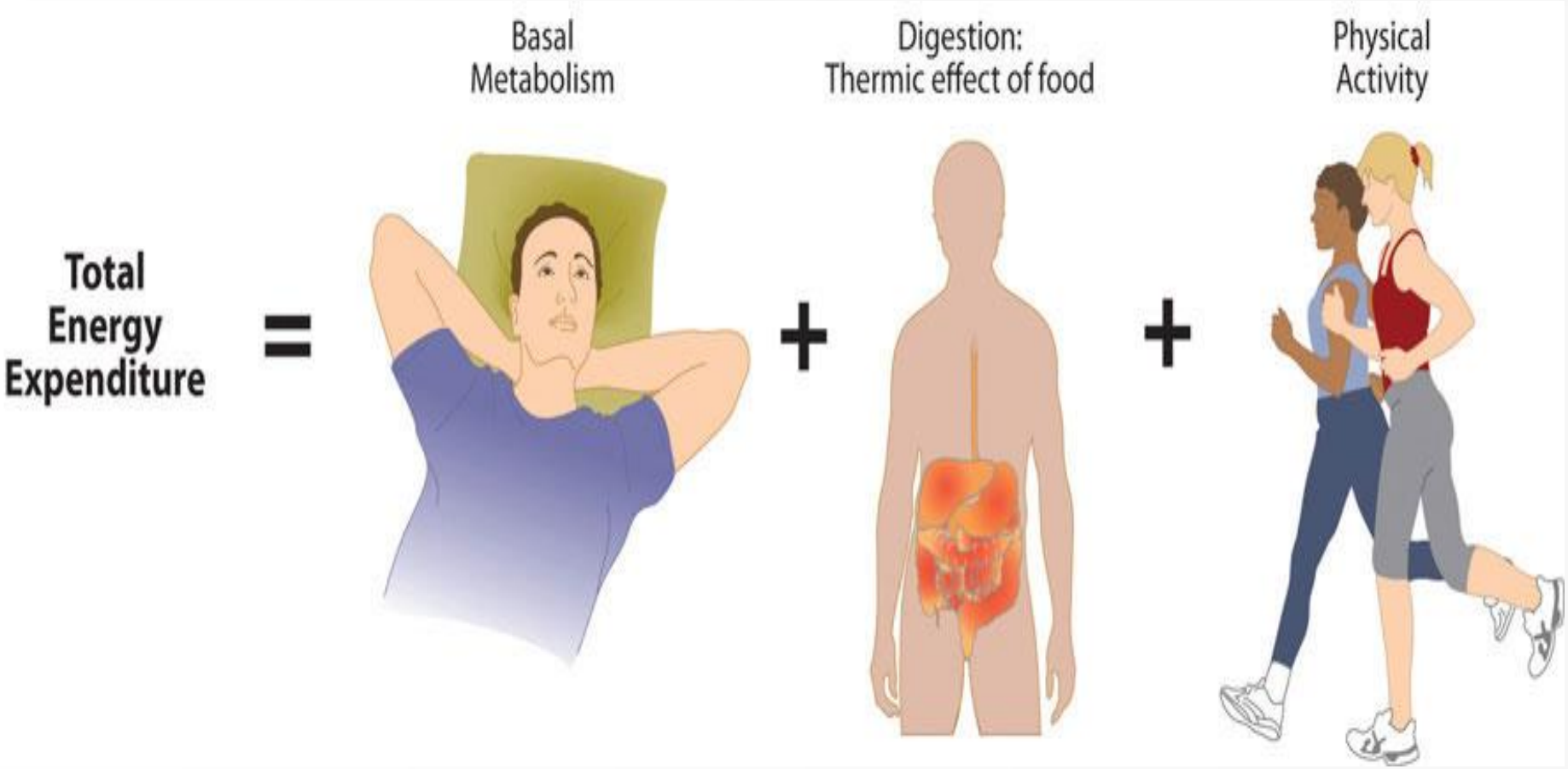
2-Physical activity.

3-Specific dynamic action of food (S.D.A.)= thermic effect of food (TEF)

4-Other factors like growth, pregnancy, lactation &temperature regulation

Energy requirement =BMR+ physical activity +TEF

Total energy requirement (TER):



Basal metabolic rate(BMR)

- Which is the **minimum amount of energy needed by the body at rest in fasting state (post absorptive state) to sustain life processes.**
- Basal energy expenditure is measured as BMR by **direct & indirect calorimeter**.

Conditions to measure BMR:

The person should be;

- At complete physical & mental rest.
- Relaxed but not sleep.
- At least 12 h. after last meal.
- Several hours after strenuous exercise or activity.
- In a comfortable temp. & environment.

Factors Affecting BMR:

- **A-Primary Factors:**

1-Surface area: BMR more in taller person (more surface area).

2-Gender: BMR lower in female 5-10% than male of the same wt. &Ht. (smaller body size and more body fat).

3-Age: BMR higher in children < 2y than elderly people (more energy required for rapid growth) , also higher at puberty than adolescence **(BMR decrease 2% for each decade of life due to fat accumulation).**

4-Endorine secretion:

a- Thyroid gland hormones;

- In **hypothyroidism** BMR decr. by 30-50%.
- In **hyperthyroidism** BMR incr. by 50-75%.

b- Growth Hormon leads to incr. BMR

c- Sympathetic stimulation (stress, strain &emotion) incr. BMR.

d- Sex Hormon: fluctuation of BMR during the menstrual cycle;

-At a mid cycle → decr. BMR & incr. 7.7% in post ovulation.

5-Body composition: more in muscular tissues.

6-Pregnency: **20% incr**. BMR in the 3rd trimester

B- Secondary factors:

1- Nutritional Status:

In severe malnutrition & prolong starvation lead to 50% decrease in BMR (as adaptive mechanism).

2- Sleep ⟶ 10% decrease in BMR.

3-Fever ⟶ increase in BMR by 13% for each 1C above 37C

4-Muscle tone: in athletes (incr. muscle tone) ⟶ increase BMR (due to more O2 consumption during muscle contraction).

B- Secondary factors:

5-Climate:

* A low climate temp.increases heat loss and lead to increase in BMR 5% /10 C decrease. (more in Eskimo).

* An increase in climate temp lead to decrease in BMR (as in Africa)

6-Caffeine:

increase BMR.

B- Secondary factors:

5-Climate:

* A low climate temp.increases heat loss and lead to increase in BMR 5% /10 C decrease. (more in Eskimo).

* An increase in climate temp lead to decrease in BMR (as in Africa), but the *basal energy expenditure* will increase due to stimulation of sweating.

6-Caffeine:

increase BMR.

To calculate the energy requirement:

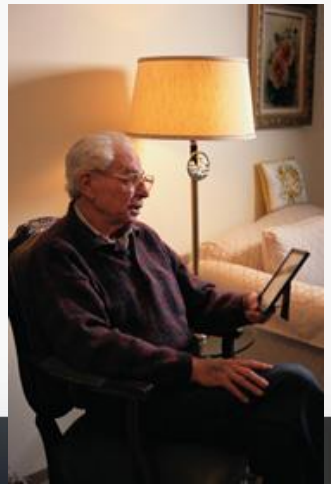
1-BMR

- **BMR for male= I.B.W. (kg)×1Kcal/kg /hr × 24hr**

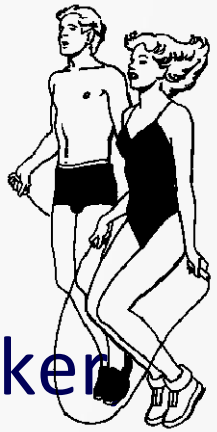
- **BMR for female= I.B.W. (kg)× 0.95 Kcal / kg/ hr × 24hr**
  I.B.W.= ideal body wt.

2-Physical Activity: to calculate physical activity either;

- **A-Physical activity=BMR × activity factor**
- **B-Rough classification of occupation =(activity);**
  (sedentary)- Light activity = 20-30% of BMR
  office worker, lawyer, doctor, teacher,
  shop worker.



- **Moderate activity= 40% of BMR** : industrial worker, farmer, student (studying:1- 2 kcal/min), solder (not in active service), housewife, carrying a load& cycling.



- **Heavy activity = 50% of BMR:** agriculture worker, unskilled laborer, mine worker, solder in active service, &walking with a load uphill.

Level of activity	gender	Activity Factor
Light	Male	1.6
	Female	1.5
Moderate	Male	1.7
	Female	1.6
Very active	Male	≥2.1
	Female	≥1.9

The effect of exercise on metabolism:

- Exercise increases the metabolism
  - Immediate increase in metabolism during exercise and post-exercise.
  - Over time, there is also a permanent increase in BMR as **lean muscle** tissue increases.
- Most important factor affecting the metabolic rate is the **intensity** or **speed** of the exercise.
- With continuous physical activity – body begins to adapt the stress of exercise, and causes health benefits.

3-Thermic Effect of Food (TEF): Specific Dynamic Action of food (SDA) = diet induced thermo-genesis:

Which is the amount of energy it spends by the body to digest , absorb, & metabolize the food ,

Reaches its maximum level **3-5 hours after ingestion of food**.

This effect is not equal for all type of food;

- TEF of protein= **25-30%** of BMR
- TEF of CHO = **6%** of BMR
- TEF of fat = **4%** of BMR
- TEF for **mixed diet= 6-10 % of BMR**

Diet-Induced Thermogenesis:

- There is a significant elevation of the metabolism that occurs after ingestion of a meal, energy needed to absorb, transport, store and metabolize the food consumed.

— **Highest** elevation noticed **1-hr after a meal** and **lasts** for about **4 hours**.

- The greater the caloric content of the meal, the greater the effect on the metabolism.

- We can divide the need of fat according to its types ,only **10% saturated fat.**
- Fat should supply not more than **25- 30%** of the total calories of a healthy person on well balanced diet.
  - The majority of these calories, should consist of (unsaturated fat) rather saturated fat or Trans- fat.

- **E.g. Calculate the total energy requirement (TER) of a 4th year medical male student whose ideal body wt. is 60 kg? 10% of BMR for sleep**

(moderately active male 40% OF BMR)

- **BMR** =60kg ×1Kcal/kg/ hr ×24hr =1440 Kcal/day
- **Physical activity** = 1440 Kcal/day ×40 % = 576Kcal/day
- **TEF** = 6% × 1440 Kcal/day = 86 Kcal/day
- 10% of BMR for sleep= 0.1 × 1440=144 Kcal
- 1440 – 144 = 1296 Kcal/day
- **TER= 1296+ 576+86=1958 Kcal/day**

4-Other factors; Like growth, pregnancy & lactation:

- **Growth:** additional energy is required to cover the cost of increasing B.wt.& Ht.
- A growing infant may store **12-15%** of energy expenditure for growth & formation of new tissues.
- When the child gets **older** , his **rate of growth** is **diminish** &the caloric requirement for growth is reduced but the TER is increased because of increased ***body*** **size**.

Age		Energy (Kcal/kg)	
0-0.5m		108	
0.6-1y		98	
1-3y		102	
4-6y		90	
7-10y		70	
11-14y	(male)	55	(female) 47
15-18y	(male)	45	(female) 40

Pregnancy &Lactation:

During pregnancy women need extra kcal

- To build up their own tissues,
- To build fat stores for making breast milk
- To build the baby tissues and the placenta..

Pregnancy &Lactation:

- Additional calories are required to meet the energy cost of pregnancy &lactation will added to the TER of normal women.

- In pregnancy **300 Kcal/day** (esp. in 2nd & 3rd trimester) In lactation **500-600 Kcal/day** will be added.

E.g. Calculate the TER of a housewife woman her ideal body weight is 60 kg ?

(moderately active female 40% OF BMR)

- BMR=60kg×0.95Kcal/kg/hr×24hr=1368Kcal /day
- Phys. Act.=1368 Kcal/day×40%=547 Kcal/day
- TEF = 6% × 1368 Kcal/day = 82 Kcal/day
- 10% × 1368 = 136Kcal /day (1368-136)
- =1232 Kcal /day
- TER = 1232+547+82 = 1861 Kcal /day
- If she is **pregnant** add **300** Kcal/day
- If she is **lactating** add **500** Kcal/day

energy requirement in overweight

- The one commonly used technique to use is {adjusted weight}, which is the ideal weight plus [25%] of the difference between the observed and ideal weight.

Ideal weight+0.25× [observe wt-Ideal wt]

- **Example:** 46 years old lady, with Type 2DM , her weight now is 84kg, her ideal weight should be 68 kg, with light physical activity, calculate herTER?

Adjusted weight=ideal weight+0.25× [observe wt-ideal wt]

Adjusted weight=68+0.25× [84-68] =72kg

- BMR =0.95×72×24=1641 Kcal

TEF=6% OF BMR= 6/100×1641=98 Kcal

Physical activity is light 30% of BMR

=0.3×1641=492

For sleep 10% of BMR = 10/100×1641=164.16 Kcal

TER= [BMR-10%for sleep] +TEF+ physical activity

TER= [1641-164] +98+492=2067 Kcal