

# Understanding Bioimpedance

(Adapted from Biodyncorp)

**Phase Angle:** is a measurement of your body's overall health. Phase angle is based on total body resistance and reactance and is independent of height, weight and body fat. Lower phase angles appear to be consistent with either cell death or a breakdown of the cell membrane. Higher phase angles appear to be consistent large quantities of intact cell membranes and body cell mass. All living substances have a phase angle. In fresh uncooked vegetables phase angle can exceed 45 degrees. In cooked vegetables phase angle is zero because they are dead.

Phase Angle is a predictor of outcome and indicates the course of disease or increases as the result of optimal health based on good nutrition and consistent exercise. Usually, a phase angle of 6 or greater is desired for men and 5 or greater is desired for women.

As we get older our phase angle will decrease and will be approximately 4 or less when we die. Fit adolescents may have a phase angle greater than 10. This effect is a result of cell integrity due to age. Low phase angles are consistent with:

- Malnutrition HIV/AIDS infection
- Cancer (most types)
- Abusive life style
- Chronic Alcoholism
- Old Age (80 - 100 years)

## **Body Capacitance (C)**

A high capacitance indicates large amounts of intact cellular membranes. A low capacitance indicates lower amounts.

Capacitance is proportional to the size of the body cell mass compartment or number of cells and to the integrity of cellular membranes. Increasing capacitance is always good because it represents an increase in the number of cells, their quality, or both. However, if capacitance is decreasing, it is important to remember that this may be due to a decrease in body cell mass related to weight loss in an otherwise healthy patient.

Normal values are from 500 to 1000 pF. High capacitance (C) causes high reactance (X).

## **Resistance (R)**

A low resistance is consistent with large amounts of fat-free mass. A high resistance is consistent with low amounts of fat-free mass. Low resistance, indicating high conductivity, is due to large amounts of water in the body. Since water is contained solely within fat-free mass, resistance in the body is proportional to the amount of fat-free mass.

## **Reactance (X)**

Reactance is caused by the capacitance or the energy storage characteristic of the body due to intact (healthy) cell membranes.

## **Body Cell Mass (BCM)**

Body cell mass contains the metabolically active (living cells) components of the body, including muscle cells, organ cells, blood cells and immune cells. BCM also including the "living" portion of fat cells but not the stored fat lipids and also includes the water inside living cells called intracellular water. The main electrolyte of intracellular water is potassium.

**Extracellular Mass (ECM)**

Extracellular mass contains the metabolically inactive parts of the body components including bone, minerals, and blood plasma. ECM also includes water contained outside living cells.

**Fat-Free Mass (FFM)**

Also called lean body mass, fat-free mass is the total amount of nonfat (lean) parts of the body. Fat-free mass contains virtually all the body's water, all the metabolically active tissues, and is the source of all metabolic caloric expenditure.

**Fat Mass (FM)**

Fat mass is all the extractable lipids from adipose and other tissues in the body.

**ECM/BCM**

The ratio of extracellular mass to body cell mass. A low value is desirable and indicates a high ratio of body cell (living) mass to extracellular (non-living) mass. Normal values are typically near 1.0, indicating a 50/50 distribution of body cell mass and extracellular mass.

**Body Mass Index (BMI)**

A commonly used index of body composition equal to the ratio of the body's weight in kilograms to the square of height in meters.

**Basal Metabolic Rate (BMR)**

Basal metabolic rate is the number of calories consumed at a normal resting state over a 24-hour period. BMR is based solely on an individual's fat-free mass.

**Intracellular Water (ICW)**

Intracellular water is the water volume of the body cell mass.

**Extracellular Water (ECW)**

Extracellular water is the water volume outside of the body cell mass.

**Total Body Water (TBW)**

Total body water is the sum of ICW and ECW. It is the amount of water contained in the body.

<b>Normal Values for Men</b>								
Age (y)	15-24	25-34	35-44	45-54	55-64	65-74	75-84	>85
Number	424	656	694	449	227	162	91	32
<b>Anthropometric (1)</b>								
<u>Height</u> (in)	69.9 ± 2.6	70.0 ± 2.6	69.6 ± 2.6	68.5 ± 2.5	68.2 ± 2.6	67.6 ± 2.5	67.2 ± 2.9	65.2 ± 2.7
<u>Weight</u> (lb)	154.6 ± 18.3	163.8 ± 19.8	166.3 ± 21.2	163.2 ± 20.3	165.8 ± 21.6	167.4 ± 23.8	160.1 ± 19.2	157.9 ± 19.6
<b>Impedance (1)</b>								
<u>Phase Angle</u> (°)	7.3 ± 0.8	7.5 ± 0.8	7.2 ± 0.9	7.2 ± 0.9	6.6 ± 0.9	6.1 ± 0.9	5.3 ± 0.9	4.6 ± 0.8
<u>Body Capacitance</u> (pF)	830	860	840	838	780	720	610	520
<u>Resistance</u> (ohms)	484 ± 52	474 ± 46	470 ± 50	469 ± 43	468 ± 45	466 ± 49	482 ± 50	486 ± 59
<u>Reactance</u> (ohms)	61.9 ± 9.2	62.1 ± 8.4	59.4 ± 8.7	58.8 ± 8.4	54.3 ± 8.1	49.9 ± 8.8	45.1 ± 8.6	39.1 ± 8.2
<b>Mass Distribution (2)</b>								
<u>Body Cell Mass</u> (% wt)	45.4	43.5	41.1	39.6	36.8	34.1	31.5	27.5
<u>Extracellular Mass</u> (% wt)	43.0	41.3	41.3	40.7	41.0	41.3	42.2	41.1
<u>Fat-Free Mass</u> (% wt)	88.4	84.8	82.4	80.3	77.8	75.4	73.7	68.6
<u>Fat Mass</u> (% wt)	11.6	15.2	17.6	19.7	22.2	24.6	26.3	31.4
<u>ECM/BCM Ratio</u>	0.95	0.95	1.00	1.03	1.11	1.21	1.34	1.49
<u>BMI</u> (kg/m <sup>2</sup> )	22.2 ± 2.1	23.5 ± 2.3	24.1 ± 2.7	24.4 ± 2.6	25.0 ± 2.8	25.7 ± 3.6	24.9 ± 2.7	26.2 ± 3.6
<u>Basal Metabolic Rate</u>	1934	1966	1938	1853	1825	1785	1669	1532
<b>Water Compartments (2)</b>								
<u>Intracellular Water</u> (% tbw)	61.0	60.6	59.1	58.4	56.0	53.8	51.1	48.5
<u>Extracellular Water</u> (% tbw)	39.0	39.4	40.9	41.6	44.0	46.2	48.9	51.5
<u>Total Body Water</u> (% ffm)	72.4	72.4	72.5	72.2	72.0	71.9	71.6	72.5
<u>Total Body Water</u> (% wt)	64.0	61.4	59.7	58.0	56.0	54.2	52.8	49.7

<b>Normal Values for Women</b>								
Age (y)	15-24	25-34	35-44	45-54	55-64	65-74	75-84	>85
Number	488	561	500	378	168	183	160	52
<b>Anthropometric (1)</b>								
<u>Height</u> (in)	65.6 ± 2.4	65.2 ± 2.4	64.5 ± 2.4	64.2 ± 2.3	63.4 ± 2.4	62.7 ± 2.4	62.0 ± 2.4	60.3 ± 2.8
<u>Weight</u> (lb)	128.6 ± 16.3	129.4 ± 16.8	129.4 ± 17.4	133.4 ± 20.5	138.5 ± 21.2	144.6 ± 24.5	138.0 ± 21.8	130.3 ± 24
<b>Impedance (1)</b>								
<u>Phase Angle</u> (°)	6.6 ± 0.8	6.6 ± 0.9	6.7 ± 0.8	6.5 ± 0.9	6.0 ± 0.8	5.4 ± 0.9	4.8 ± 0.9	4.5 ± 1.2
<u>Body Capacitance</u> (pF)	600	620	640	640	580	540	470	440
<u>Resistance</u> (ohms)	601 ± 60	582 ± 60	572 ± 56	557 ± 58	563 ± 62	555 ± 64	569 ± 67	570 ± 82
<u>Reactance</u> (ohms)	69.3 ± 10.1	66.8 ± 10.3	66.8 ± 9.9	63.3 ± 9.9	58.7 ± 10.0	52.6 ± 10.3	47.7 ± 10.3	44.7 ± 10.6
<b>Mass Distribution (2)</b>								
<u>Body Cell Mass</u> (% wt)	38.1	37.1	36.3	34.5	31.5	27.7	25.7	24.0
<u>Extracellular Mass</u> (% wt)	40.3	40.4	39.8	39.7	39.4	38.0	38.5	38.4
<u>Fat-Free Mass</u> (% wt)	78.4	77.5	76.1	74.2	70.9	65.7	64.2	62.4
<u>Fat Mass</u> (% wt)	21.6	22.5	23.9	25.8	29.1	34.3	35.8	37.6
<u>ECM/BCM Ratio</u>	1.06	1.09	1.10	1.15	1.25	1.37	1.50	1.60
<u>BMI</u> (kg/m <sup>2</sup> )	21.0 ± 2.3	21.4 ± 2.5	21.9 ± 2.7	22.7 ± 3.1	24.3 ± 3.5	25.9 ± 4.0	25.3 ± 4.0	25.2 ± 4.8
<u>Basal Metabolic Rate</u>	1426	1420	1395	1401	1388	1345	1254	1151
<b>Water Compartments (2)</b>								
<u>Intracellular Water</u> (% tbw)	55.6	54.7	54.4	53.0	50.2	47.2	45.0	43.6
<u>Extracellular Water</u> (% tbw)	44.4	45.3	45.6	47.0	49.8	52.8	55.0	56.4
<u>Total Body Water</u> (% ffm)	72.4	72.5	72.5	72.2	71.5	73.3	73.9	75.1
<u>Total Body Water</u> (% wt)	56.8	56.2	55.2	53.6	50.7	48.2	47.4	46.9