Kinesiology 3600 – Physiology of Muscular Activity

- BODY COMPOSITION

Body Build, Size, and Composition

Body build is the form or structure of the body.
- Muscularity
- Linearity
- Fatness

Body size is determined by height and weight.

Body composition refers to the chemical composition of the body.
- Fat mass
- Fat-free mass

PHYSIQUE - refers to the body form of an individual, or the configuration of the entire body, rather than specific features.

SOMATOTYPING (one of the most useful methods of evaluating Physique) is a quantification of the shape and composition of the human body in terms of:

Endomorphy - relative fatness
(...characterized by a roundness and softness of the body, featuring a predominance of the abdomen over the chest/thorax, high square shoulders, and a short neck)

Mesomorphy - relative musculoskeletal robustness
(...characterized by a square body with hard, rugged, and prominent muscularization. The bones are large and covered with thick muscles. The chest/thorax is large and the waist relatively slender.

Ectomorphy - relative linearity
(The "leanness component" ...characterized by linearity, fragility, and delicacy of the body. Bones are small and muscles thin. Limbs are long and trunk short. The shoulder girdle lacks support and the scapulae "wing out")

A somatotype rating provides an overview of the total physique that is independent of size.

Carter, J.E.L., Mirwald, R.L., Heath-Roll, B.H., and Bailey, D.A. (1997) Somatotypes of 7- to 16- Year-Old Boys in Saskatchewan, Canada. Am J Human Biol 9:257-272.

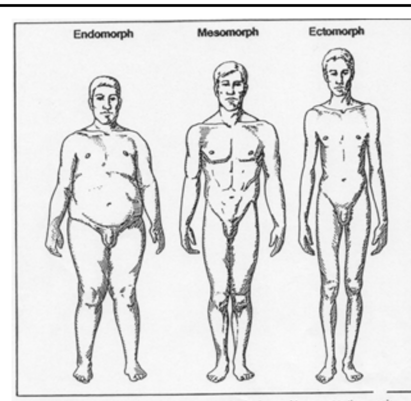
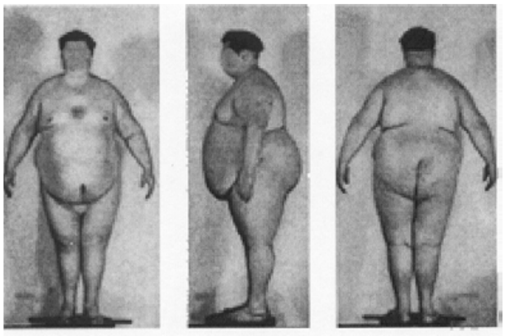
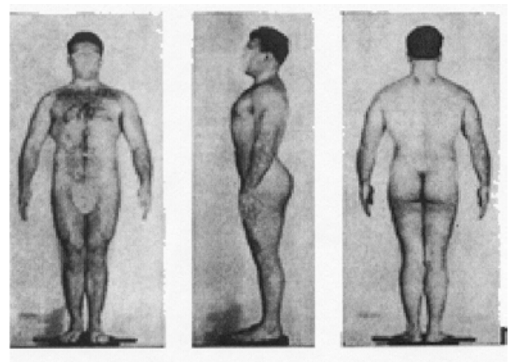


Figure 1. Somatotyping is a system of classifying body shape with respect to t' . . basic categories related to genetically-determined tissue types.

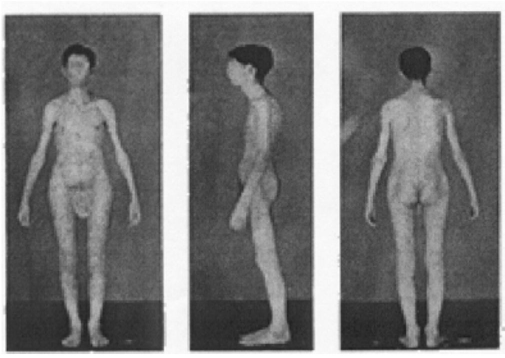
ENDOMORPHY



MESOMORPHY



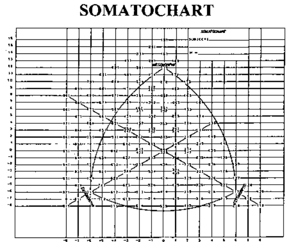
ECTOMORPHY



Heath-Carter Somatotype

1. Endomorphy
   a. the sum of the triceps, subscapular, and supraspinale skinfolds (mm) "corrected" for height by multiplying $(170.8/Ht_{cm})$ = Ht corrected $skinfolds_{mm}$
2. Mesomorphy
   a. (Humerus width + Femur width + corrected Arm + corrected Calf girths) - Height
3. Ectomorphy
   a. (Ponderal Index) = $Ht/Wt^{0.333}$

SOMATOCHART



y = 2(Meso) - (Ecto + Endo)

x = Ecto - Endo

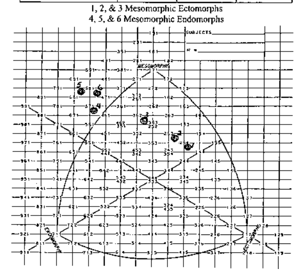
Note: the "degree/amount" of each somatotype component is expressed numerically from 1 to 7 where 1 represents the least amount and 7 the greatest

Female Pentathletes	2.5 - 3.9 - 2.8
Female Triathletes	3.1 - 4.3 - 2.6
Male Marathoner	1.4 - 4.3 - 3.5
Male Body Builders	2.3 - 6.2 - 1.2

SOMATOTYPE OF SELECTED JUDOKA

Competition Class/Wt	Endomorphy	Mesomorphy	Ectomorphy
1 Juvenile Men/-40	1.755	4.666	4.010
2 Junior Men/-56	1.887	4.801	3.309
3 Senior Men/-60	2.710	5.681	2.127
4 Juvenile Men/+75	5.170	7.049	1.275
5 Junior Men/-95	5.146	7.520	0.468
6 Senior Men/-95	4.333	7.250	0.750

1, 2, & 3 Mesomorphic Ectomorphs
4, 5, & 6 Mesomorphic Endomorphs



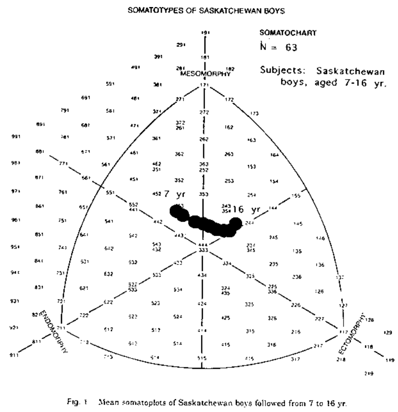


Fig. 1 Mean somatoplots of Saskatchewan boys followed from 7 to 16 yr.

Body Build, Size, and Composition

Somatotype/Body Build is the form/structure of the body.

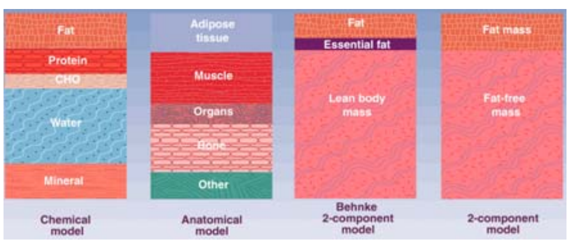
- Muscularity (mesomorphy)
- Linearity (ectomorphy)
- Fatness (endomorphy)

Body size is determined by height and weight (BMI).

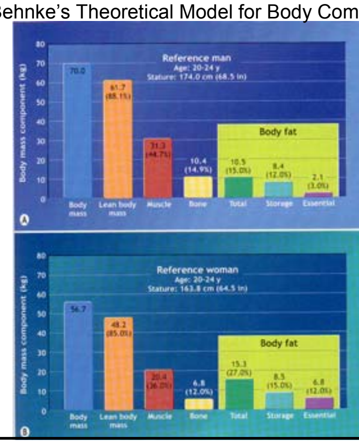
Body composition refers to the chemical composition of the body.

- Fat mass
- Fat-free mass

MODELS OF BODY COMPOSITION



Behnke's Theoretical Model for Body Composition



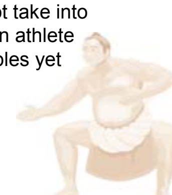
McArdle, Katch, Katch pg. 761

Did You Know…?

Fat-free mass is composed of all of the body's nonfat tissue including bone, muscle, organs, and connective tissue. **Lean body mass** includes all fat-free mass along with essential fat. Lean body mass is difficult to measure so the fat mass/fat-free mass model is most often used.

Did You Know…?

Body composition is a better indicator of fitness than body size and weight. Being overfat (not necessarily overweight) has a negative impact on athletic performance. Standard height-weight tables do not provide accurate estimates of what an athlete should weigh because they do not take into account the composition of the weight. An athlete can be overweight according to these tables yet have very little body fat.



BODY COMPOSITION FOR A YOUNG REFERENCE MAN AND WOMAN

	Man	Woman
Age (years)	20-24	20-24
Stature (cm)	170.0	163.8
Mass (kg)	70	56.7
Total %fat	15.0%	27.0%
% storage fat	12.0%	15.0%
% essential fat	3.0%	12.0%
Muscle	44.8%	36.0%
Bone	14.9%	12.0%
Remainder	25.3%	25.0%
LBM (kg)	61.7	48.5
essential fat	3.0%	14.0%
muscle	50.0%	42.0%
bone	17.0%	14.0%

Evaluation and Regulation of Body Build and Composition (p. 123) A.R. Behnke and J.H. Wilmore 1974. Englewood Cliffs NJ. Prentice Hall

(Spirduso W. **Physical Dimensions of Aging** (p. 63) Human Kinetics, 1995)

RATING BODY FAT PERCENTAGES

FAT LEVEL	MEN	WOMEN
Very Low	7 to 10	14 to 17
Low	10 to 13	17 to 20
Average	13 to 17	20 to 27
High	17 to 25	27 to 31
Very High	above 25	above 31

(adapted from http://www.sirius.on.ca/running/bodyfat.html)

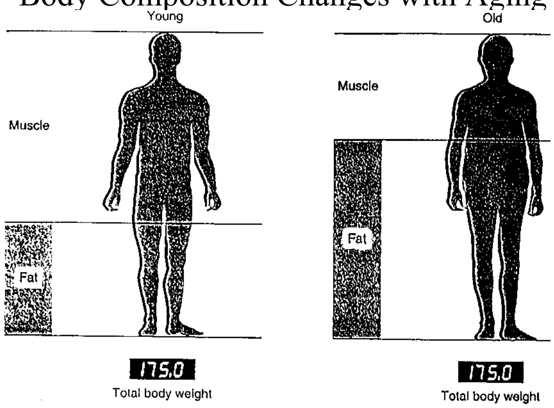
Per Cent Body Fat in Champion Female Athletes[1]

Athletes	Range of Per Cent Body Fat
Olympic Track Sprinters/Hurdlers	12.4–13.7
Olympic Jumpers	8.4–14.1
Olympic Divers	11.5–13.9
Olympic Gymnasts	11.0–14.7
Olympic Swimmers	14.5–16.6
Distance Runners	15.2–16.8
Volleyball Players	25.3
Shot, Discus and Javelin Throwers	27.0–33.8

Per Cent Body Fat in Champion Male Athletes[1]

Athletes	Range of Per Cent Body Fat
Elite Marathon Runners	2.7–4.3
Elite Middle/Long-Distance Runners	1.4–5.0
Olympic Jumpers	6.8–8.2
Olympic Gymnasts	7.0–9.9
Olympic Track Sprinters/Hurdlers	8.2–10.1
Olympic Wrestlers (bantam & featherweight)	1.2–12.7
Olympic Basketball Players	8.4–13.2
Olympic Swimmers	9.0–12.0
Olympic Rowers	14.1–15.4
Olympic Decathloners	13.4–18.0
Olympic Throwers (shot, discus, hammer)	29.4–30.9
Professional Football Players	
Offensive Backs and Receivers	9.4
Defensive Backs	9.6
Linebackers	14.0
Offensive Linemen and Tight Ends	15.6
Defensive Linemen	18.2
Baseball Players	11.8–14.2
Jockeys	14.1
Ice Hockey Players	15.1
Body Builders	6.6–9.3
Power Lifters and Olympic Lifters	9.7–13.9

Body Composition Changes with Aging



Assessing Body Composition

- Densitometry (hydrostatic weighing)
- Skinfold fat thickness
- Bioelectric impedance
- Infrared interactance

METHODS OF BODY COMPOSITION MEASUREMENT
(+/- 3 to 4 %)

1. **DENSIOMETRY - HYDROSTATIC WEIGHING**
2. **SKINFOLD TECHNIQUES**
   Durnin; J-P; AAHPERD; O-Scale
3. **STATURE INDEXES**
   BMI (Wt kg/Ht*Ht m); W:H; PI (Ht/Wt*Wt*Wt)
4. **Bioimpedance**
5. **Near-infrared Interactance (NIR)**
6. **Dual Photon Absorptiometry (DPA)**
   Computer assisted tomography (CAT)
7. **Dual-energy X-ray Absorptiometry (DEXA)**
   (CAT)
8. **Total Body Water**
   K40, Ca isotopes; plasma vol.; extracellular fluid

Table 10.1 Methods used to determine body composition

Williams pg. 356

Anthropometry	Measures body segment girths to predict body fat
Bioelectrical impedance analysis (BIA)	Measures resistance to electric current to predict body-water content, lean body mass, and body fat
Body plethysmography	Whole-body plethysmograph measures air displacement and calculates body density. Comparable to water displacement protocol used in underwater weighing
Computed tomography (CT)	X-ray scanning technique to image body tissues. Useful in determining subcutaneous and deep fat to predict body-fat percentage. Used to calculate bone mass
Dual energy X-ray absorptiometry (DEXA; DXA)	X-ray technique at two energy levels to image body fat. Used to calculate bone mass
Dual photon absorptiometry (DPA)	Beam of photons passes through tissues, differentiating soft tissues and bone tissues. Used to predict body fat and calculate bone mass
Infrared interactance	Infrared light passes through tissues, and interaction with tissue components used to predict body fat
Magnetic resonance imaging (MRI)	Magnetic-field and radio-frequency waves are used to image body tissues similar to CT scan. Very useful for imaging deep abdominal fat
Neutron activation analysis	Beam of neutrons passes through the tissues, permitting analysis of nitrogen and other mineral content in the body. Used to predict lean body mass
Skinfold thicknesses	Measures subcutaneous fat folds to predict body-fat content and lean body mass
Total body electrical conductivity (TOBEC)	Measures total electrical conductivity in the body, predicting water and electrolyte content to estimate body fat and lean body mass
Total body potassium	Measures total body potassium, the main intracellular ion, to predict lean body mass and body fat
Total body water	Measures total body water by dilution techniques to predict lean body mass and body fat
Ultrasound	High frequency ultrasound waves pass through tissues to image subcutaneous fat and predict body-fat content
Underwater weighing (Hydrodensitometry)	Underwater-weighing technique based on Archimedes' principle to predict body density, body fat, and lean body mass

TECHNIQUE	DIRECTLY MEASURED PROPERTY	APPLICATION
HYDROSTATIC WEIGHING (DENSIOMETRY)	Total body tissue density	Fat has a lower mass density ($0.9 g/cm^2$) than non-fat ($1.1 g/cm^2$)
SKINFOLD TECHNIQUES	Thickness of the subcutaneous fat layer at specific locations	There is a correlation between the amount of subcutaneous fat (thickness) and total body fat content
BIO-IMPEDANCE ANALYSIS (BIA)	Electrical impedance of the body between the left hand and the right foot	Fat is basically non-conductive, whereas the water and electrolytes of the lean compartment are highly conductive
NEUTRON ACTIVATION ANALYSIS (NAA)	Total amount of nitrogen in the body	Fat contains no nitrogen, while the proteins and amino acids of the lean compartment contain a rather fixed fraction of nitrogen

Nord, R. H. and Payne, R. K. Body composition by DXA - A review of the technology. **Asia Pacific Journal of Clinical Nutrition** 1994:3 (suppl.), in press
Oxford Textbook of Sports Medicine p. 155-157

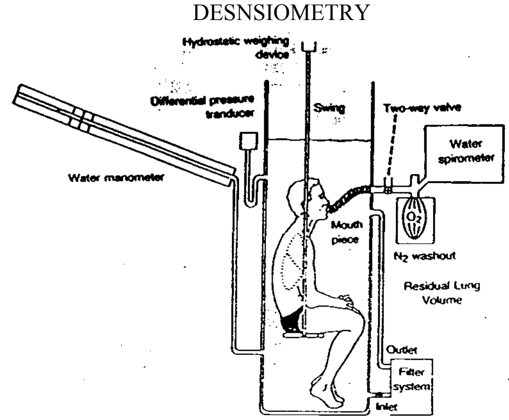
TECHNIQUE	DIRECTLY MEASURED PROPERTY	APPLICATION
TOTAL BODY POTASSIUM (TBK)	Total amount of radioactive K-40 in the body	Fat is potassium-free. The lean compartment contains a rather constant fraction of potassium and thus of potassium-40
DUAL-ENERGY X-RAY ABSORPTIO-METRY (DEXA)	Relative attenuation of two energies in an x-ray beam	The ratio of the attenuations at two x-ray energies is different for high atomic number elementts which are present as electrolytes only in lean compartment tissue
NEAR-INFRARED INTERACTANCE	Proportion of light energy transmitted that returns to a detector	The absorption spectrum varies with the substance and the wave length. Fat peaks at 930nm and Water at 970nm. Muscle is high in water so the relative absorption at two wave lenghts is indicative of the relative proportions of fat and muscle.

Nord, R. H. and Payne, R. K. Body composition by DXA - A review of the technology. **Asia Pacific Journal of Clinical Nutrition** 1994:3 (suppl.), in press
Oxford Textbook of Sports Medicine p. 155-157

Densitometry

- Body density = <u>Body mass</u>
  Body volume
- Body mass = measured on a regular scale
- Body volume = measured using hydrostatic (underwater) weighing accounting for water density and air trapped in lungs
- % body fat = (495 ÷ body density) – 450

DESNSIOMETRY



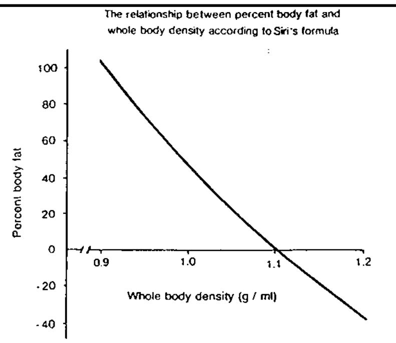


Fig. 6.17 Density assumptions and implications (Martin and Drinkwater).

Density = wt/vol or g/ml Fat = 0.9 g/ml Lean = 1.1 g/ml

BODY COMPOSISTION ASSESSMENT

HYDROSTATIC WEIGHING
(UNDERWATER WEIGHTING)

$$\text{DENSITY} = \frac{\text{WEIGHT IN AIR}}{(\text{WEIGHT IN AIR}) - (\text{WEIGHT IN WATER})}$$

$$\text{Dbody} = \frac{\text{Wt(air)}}{\text{Wt(air)} - \text{Wt(H20)} - (\text{RV} + \text{IG})}$$

BROZEK EQUATION

$$\%\text{FAT} = \frac{457}{\text{Dbody}} - 414.2$$

SIRI EQUATION

$$\%\text{FAT} = \frac{495}{\text{Dbody}} - 450.0$$

BODY WEIGHT	= 56.80 kg
UNDER H20 WT.	= 0.93 kg
RESIDUAL VOL.	= 1.60 l
INTESTINAL GAS	= 0.12 l

$$\text{DENSITY} = \frac{\text{WT. IN AIR}}{(\text{WT. IN AIR}) - (\text{WT. IN H20})}$$

$$D_{(\text{body})} = \frac{Wt_{(\text{air})}}{Wt_{(\text{air})} - Wt_{(\text{H20})} - RV - IG}$$

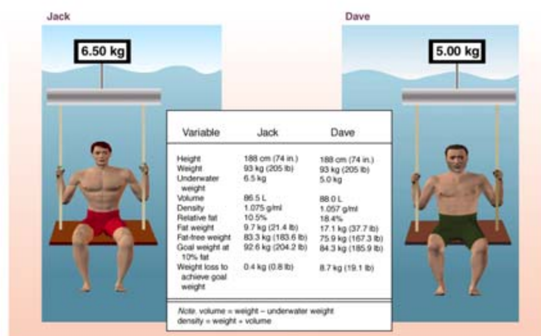
$$D_{(\text{body})} = \frac{56.8}{(56.8) - (0.93) - (1.60) - (0.12)}$$

$$D_{(\text{body})} = 1.05$$

BROZEK EQUATION $\%\text{Fat} = \frac{457}{D_{(\text{body})}} - 414.2$

$$\%\text{Fat} = \frac{457}{1.05} - 414.2 = 0.21 \text{ or } \underline{21\%}$$

UNDERWATER WEIGHING TECHNIQUE



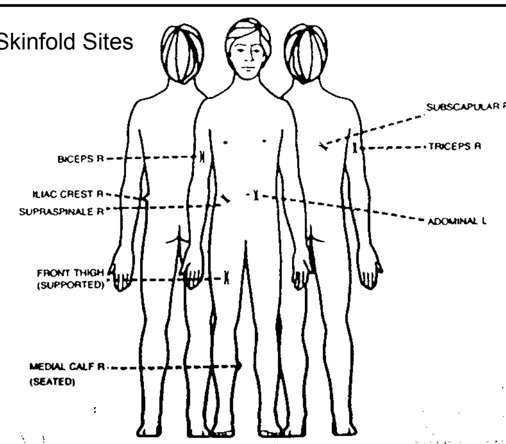
Variable	Jack	Dave
Height	188 cm (74 in.)	188 cm (74 in.)
Weight	93 kg (205 lb)	93 kg (205 lb)
Underwater weight	6.5 kg	5.0 kg
Volume	86.5 L	88.0 L
Density	1.075 g/ml	1.057 g/ml
Relative fat	10.5%	18.4%
Fat weight	9.7 kg (21.4 lb)	17.1 kg (37.7 lb)
Fat-free weight	83.3 kg (183.6 lb)	75.9 kg (167.3 lb)
Goal weight at 10% fat	92.6 kg (204.2 lb)	84.3 kg (185.9 lb)
Weight loss to achieve goal weight	0.4 kg (0.8 lb)	8.7 kg (19.1 lb)

Note. volume = weight − underwater weight
density = weight ÷ volume

Did You Know…?

Inaccuracies in densitometry are due to variation in the density of the fat-free mass from one individual to another. Age, sex, and race affect the density of fat-free mass.

Skinfold Sites



Determining an "ideal" Body Weight

$$IdealBodyWt = \frac{LeanBodyMass}{1 - ideal\%Fat}$$

$$IBdWt = \frac{44.9}{1 - 0.156}$$

$$IBdWt = \frac{44.0}{0.844}$$

$$IBdWt = 53.19kg$$

@13.48% & LBM 44.9_{kg} Wt=51.9_{kg}

FEMALE JUDOKA (competes in -56kg wt. Class)
Weight = 56.8 kg Body Fat = 21%
(note: female judoka normally have 15% body fat)

Fat Weight = 0.21 X 56.8 or **<u>ll.9 kg</u>**

Lean Body Mass = Total Weight - Fat Weight

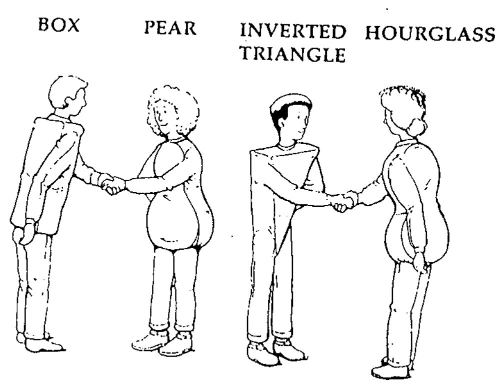
LBM = 56.8 - 11.9 or **<u>44.9 kg</u>**

$$\text{Desirable Body Weight} = \frac{\text{LBM}}{[1 - \text{Ideal \% Body Fat}]}$$

$$\text{Desirable Body Weight} = \frac{44.9\text{ kg}}{[1 - 0.15]} \text{ or } \frac{44.9\text{ kg}}{[0.85]} = 52.82\text{ kg}$$

Desirable Body Weight = **<u>52.82 kg</u>**

Body Shapes



APPLE AND PEAR SHAPES

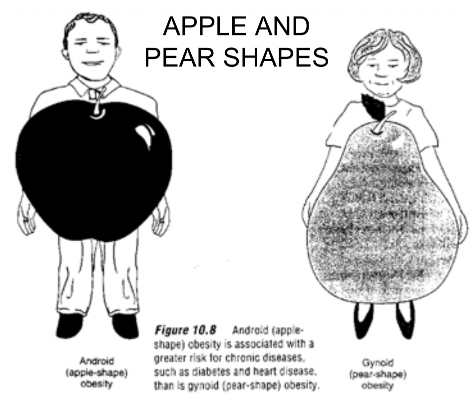


Figure 10.8 Android (apple-shape) obesity is associated with a greater risk for chronic diseases, such as diabetes and heart disease, than is gynoid (pear-shape) obesity.

Williams 5th ed pg 330

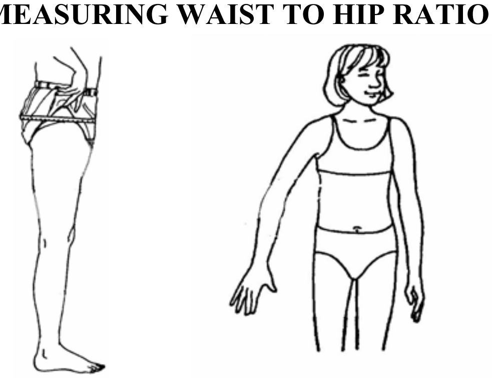
<u>WAIST HIP RATIO</u>

	Women	Men
17 - 39 yrs.	**0.80**	**0.90**
inc. with age to	**>0.90**	**>0.98**

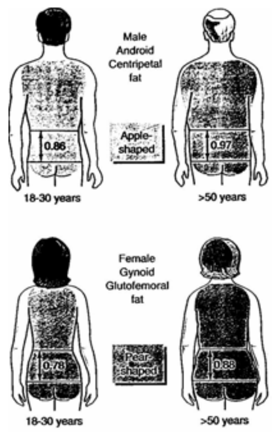
(ideally should always be <1.0)

Wellness Encyclopoedia p 24

MEASURING WAIST TO HIP RATIO



Waist to Hip Ratio Changes with Aging



BODY MASS INDEX (BMI)

$$BMI = \frac{Wt_{(kg)}}{Ht^2_{(m)}}$$

Female $Wt = 57_{(kg)}$ $Ht = 160_{(cm)}$

$$BMI = \frac{57}{(1.6)^2} = \frac{57}{2.56} = 22.3 = \text{"Normal"}$$

Male $Wt = 70_{(kg)}$ $Ht = 164_{(cm)}$

$$BMI = \frac{70}{(1.64)^2} = \frac{70}{2.69} = 26.0 = \text{"Mod.Obese"}$$

$$(23_{(BMI)})(1.64^2_{(Ht)}) = 61.87_{(Kg)}$$

BODY MASS INDEX (BMI) (Wt kg/Ht*Ht m)

	Women	Men
Normal Range	21 - 23	22 - 24
Upper Limit	27	25
Moderately Obese	27 - 30	25 - 30
Over Weight	>27.5	>28.5
Seriously Over Fat	>31.5	>33.0
Massively Obese	30 - 40	30 - 40

PSM V14 ,#3, Mar. 86, p 152; Wellness Encylopoedia p 23

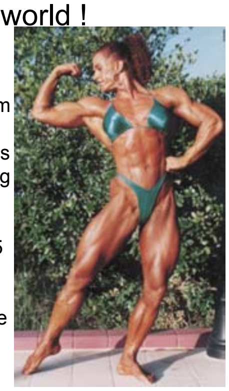
Nicole Bass, the largest woman bodybuilder in the world !

6’2”
181 cm

192 lbs
87.3 kg

BMI
26.55

Mod.
Obese



Laura Binetti

Toronto

Height 5’3” (154.3 cm)
Weight 150 to 175 lbs
(68.2 to 79.6 kg)

BMI 28.62 Mod. Obese
to 33.39 Massively Obese

Kevin Topka

Natural Bodybuilding Champion

Height 5’11”
(180 cm)

Weight 194 lbs
(88.2 kg)

BMI = 27.2

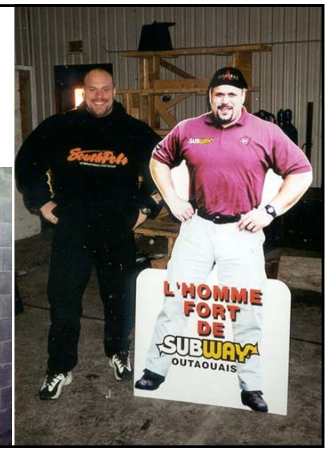
Moderately
Obese

Geoff Dolan (6'2" = 188 cm)
(310 lbs = 141 kg) **BMI = 40**
"Massively Obese?"

Hugo Girard

(6'2" = 188 cm)
(330 lbs = 150 kg)
BMI = 42.44

"Massively Obese?"



Morbidity/Mortality	BODY MASS INDEX (BMI)									
	26	27	28	29	30	31	32	33	34	35
Death/All Causes (versus BMI <19)			60%		110%			120%		
Death/Heart Disease (versus BMI <19)			210%		360%			480%		
Death/Cancer (versus BMI <19)			80%					110%		
Type II Diabetes (versus BMI 22-23)			1480%		2660%		3930%		5300%	
High Blood Pressure (versus BMI <23)		180%			260%			350%		
Degenerative Arthritis (versus BMI <25)						400%				
Gallstones (versus BMI <24)			150%			270%				
Neural Birth Defects (versus BMI 19-27)					90%					

Scientific American Aug'96p91