# ESTIMATING BODY COMPOSITION

## What is Body Composition?

Refers to the relative amounts of the different compounds in the body

## Why Study Body Composition?

- Overweight vs. Over fat vs. Obesity
- Risk for various diseases
- Monitor change from an intervention
- Some job requirements involve body composition standards
- Athletic/sports prowess

# BODY MASS INDEX (BMI)

The ratio of mass to height$^2$

$$\text{BMI} = \text{body mass (kg)} / \text{body height (m)}^2$$

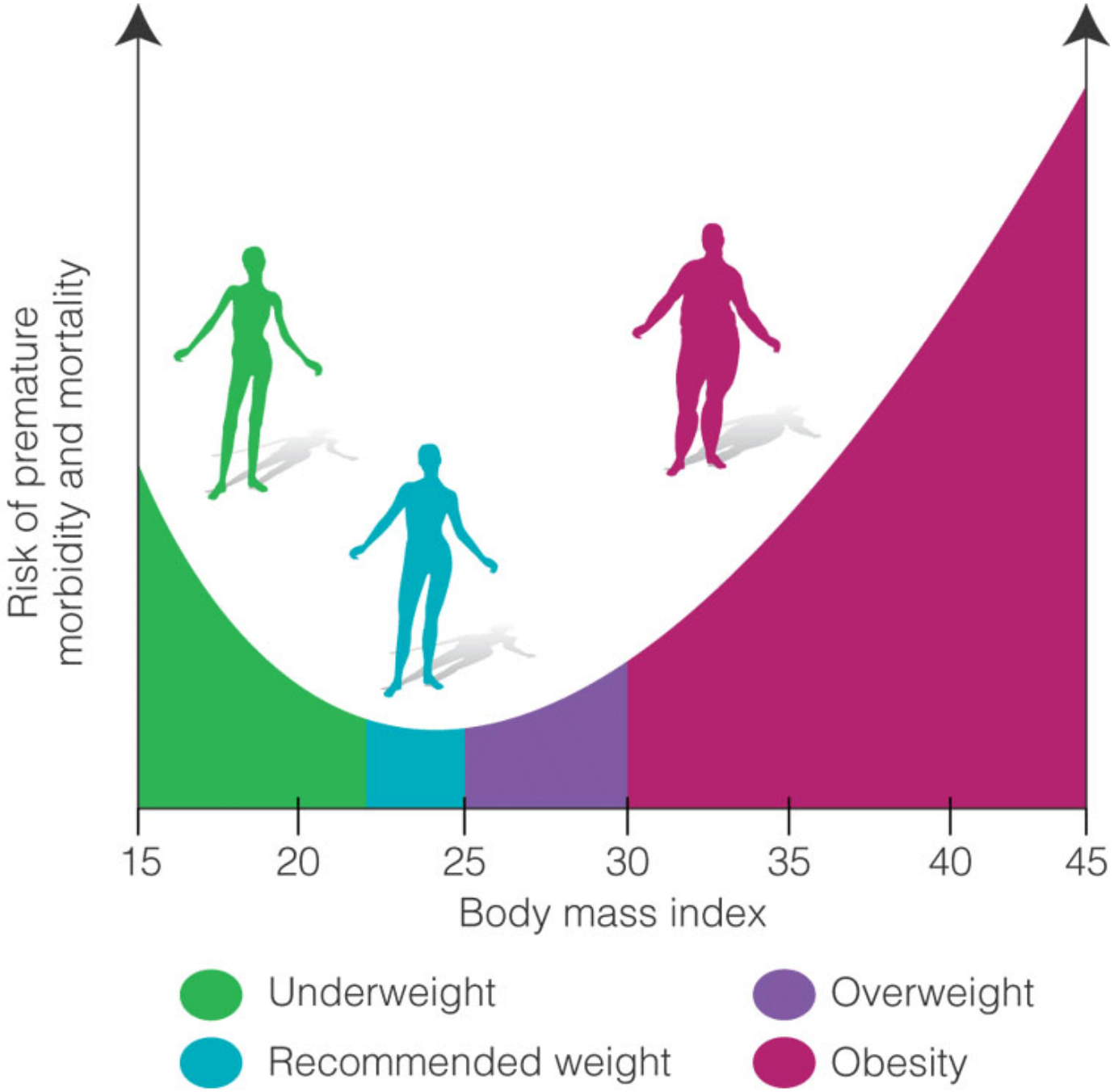
*for example*

$$\text{BMI} = 80 \text{ (kg)} / 1.7^2 \text{ (m)} = 27.68 \text{ kg/m}^2$$

*BMI < 20.0 is considered underweight*

A BMI > 30 is associated with greater prevalence of mortality from heart disease, cancer, and diabetes

| BMI | Disease Risk | Classification |
|---|---|---|
| <20.00 | Moderate to Very High | Underweight |
| 20.00 to 21.99 | Low | Acceptable |
| 22.00 to 24.99 | Very Low | |
| 25.00 to 26.99 | Low | Overweight |
| 27.00 to 29.99 | Moderate | |
| 30.00 to 39.99 | High | Obese |
| ≥40.00 | Very High | |



# Elementary parameters

- HEIGHT
- BODY MASS
- BODY SURFACE

Body surface S ($m^2$) - DuBois:

$$S = W^{0,425} \cdot L^{0,725} \cdot 0,007184$$

W – body mass (kg); L - height (cm)

MEN mean CZ 179 cm

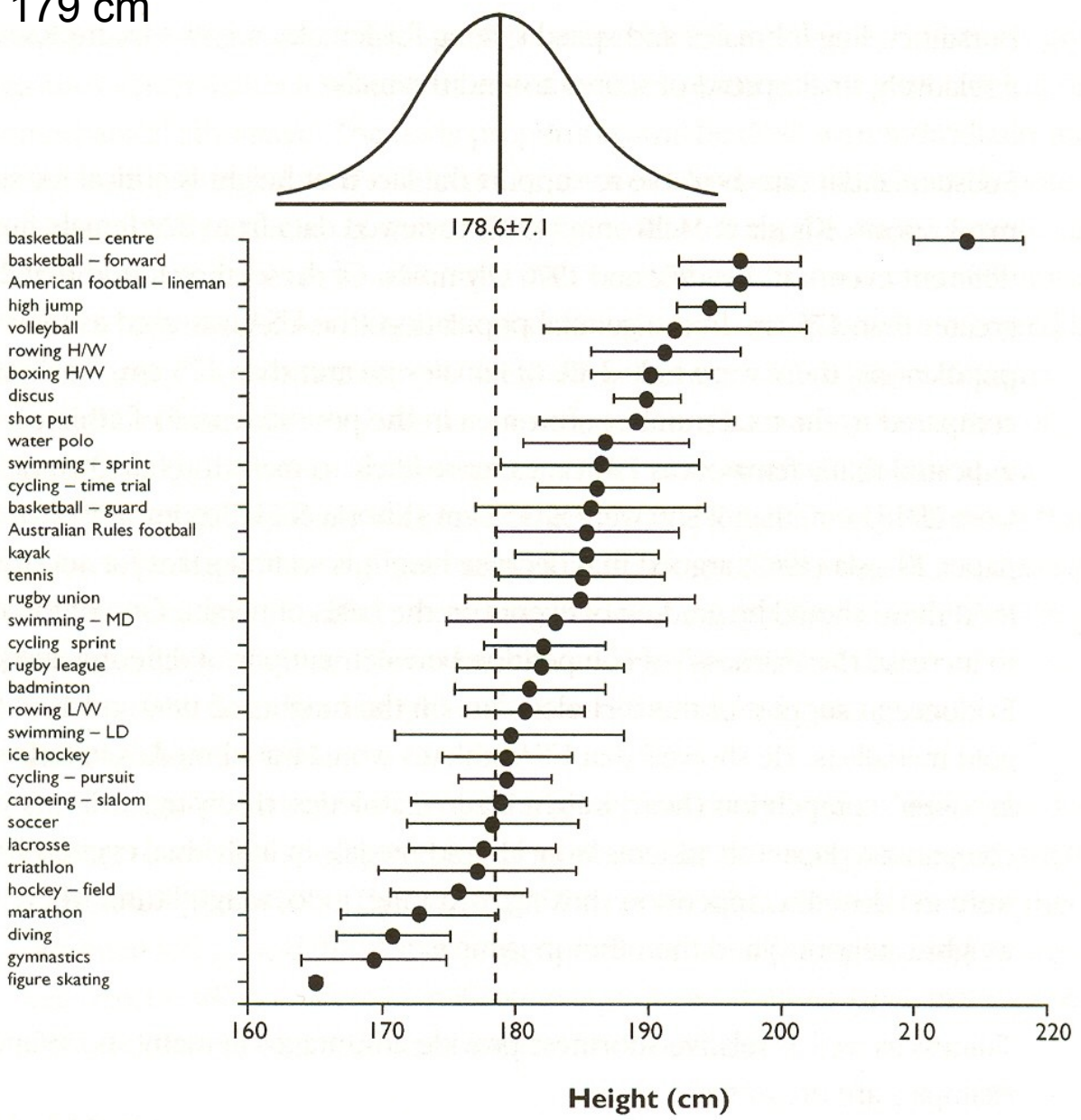



**Figure 4** Plot of mean (± SD) heights for male athletes in different sports relative to a reference population of non-athletes.

WOMEN mean CZ 166 cm

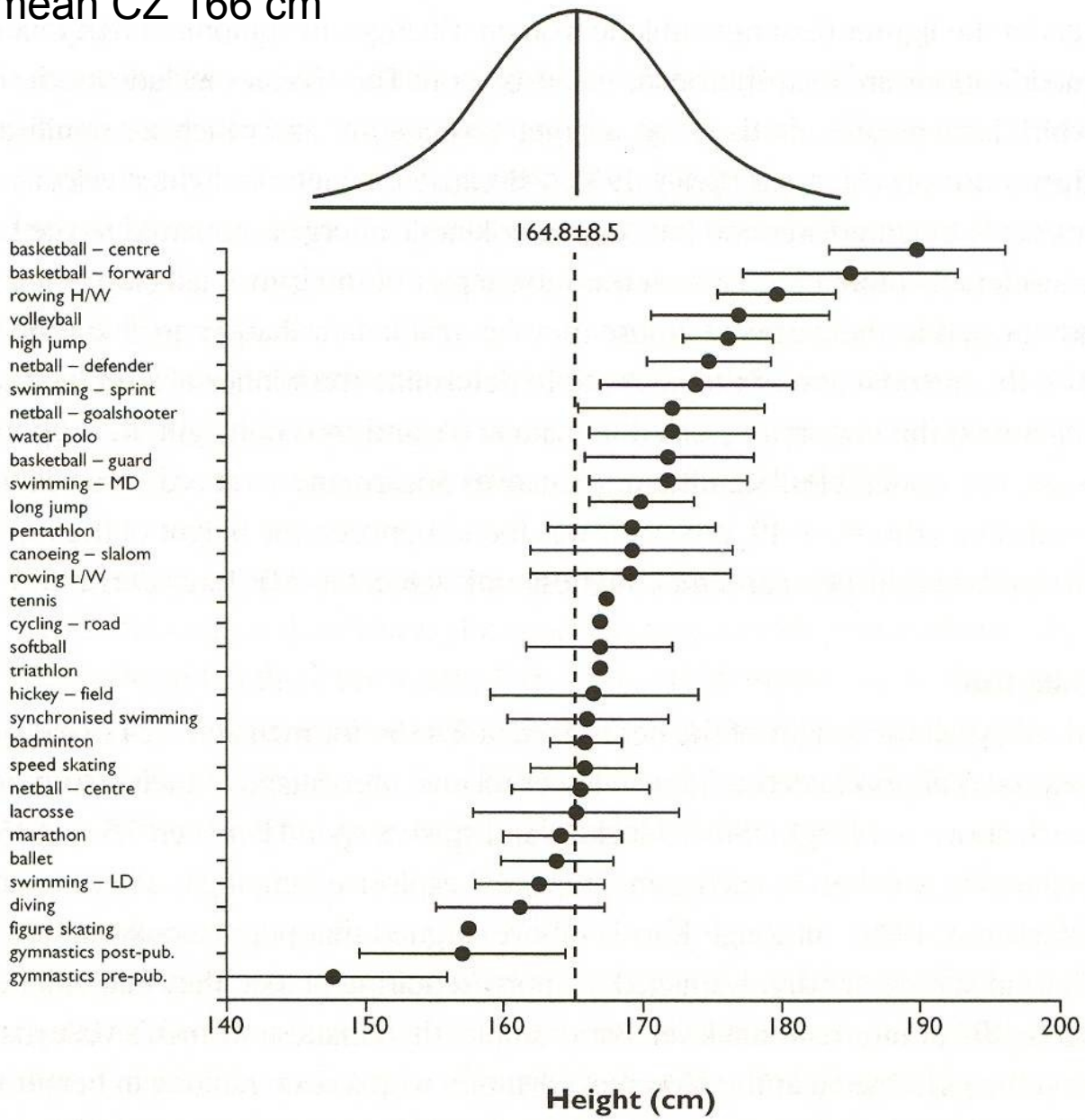



**Figure 5** Plot of mean (± SD) heights for female athletes in different sports relative to a reference population of non-athletes.

MEN mean CZ 75 kg

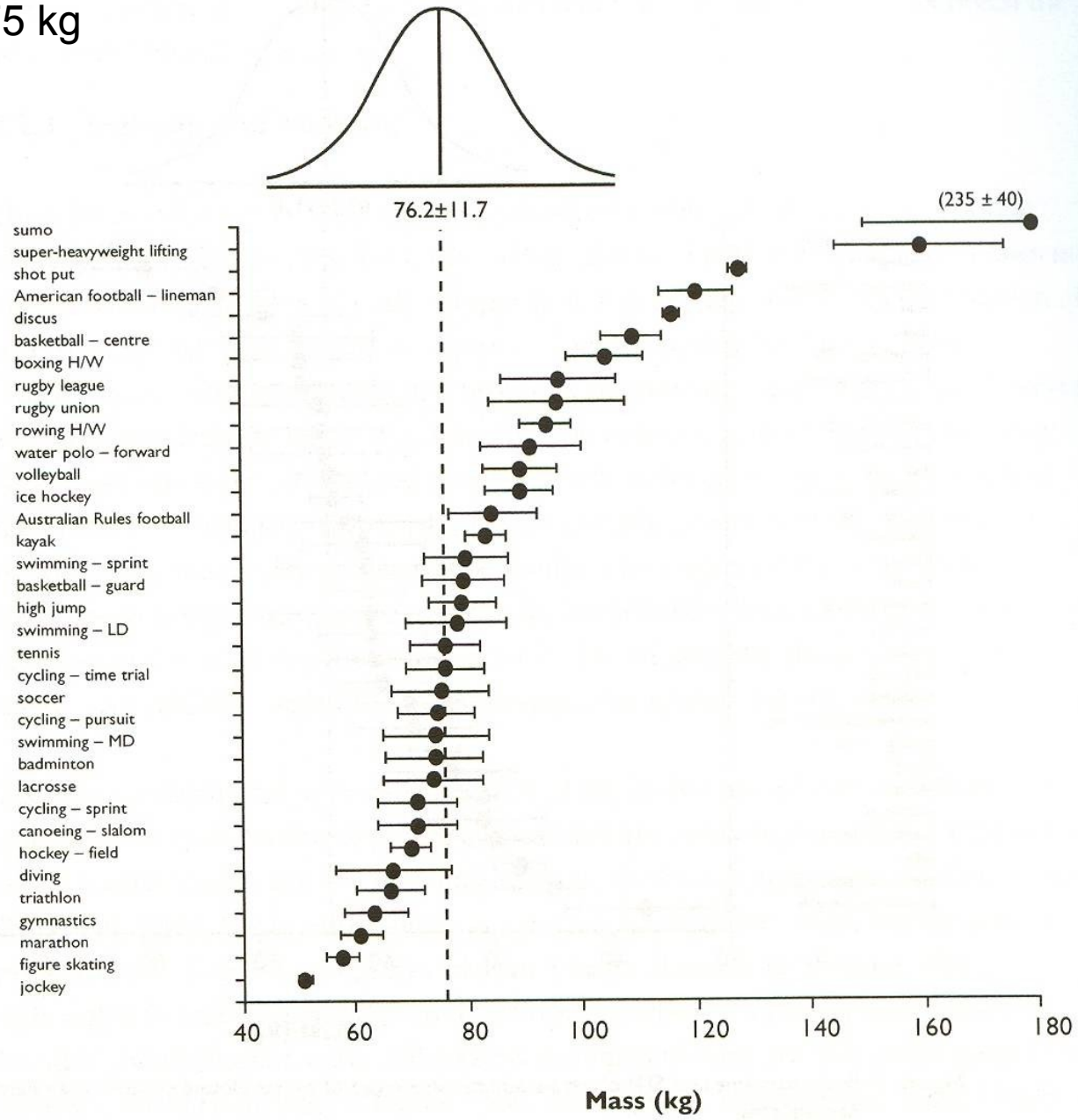



**Figure 8** Body mass (mean ± SD) of male athletes in a range of sports plotted relative to a reference group of non-athletes.

WOMEN mean CZ 60 kg

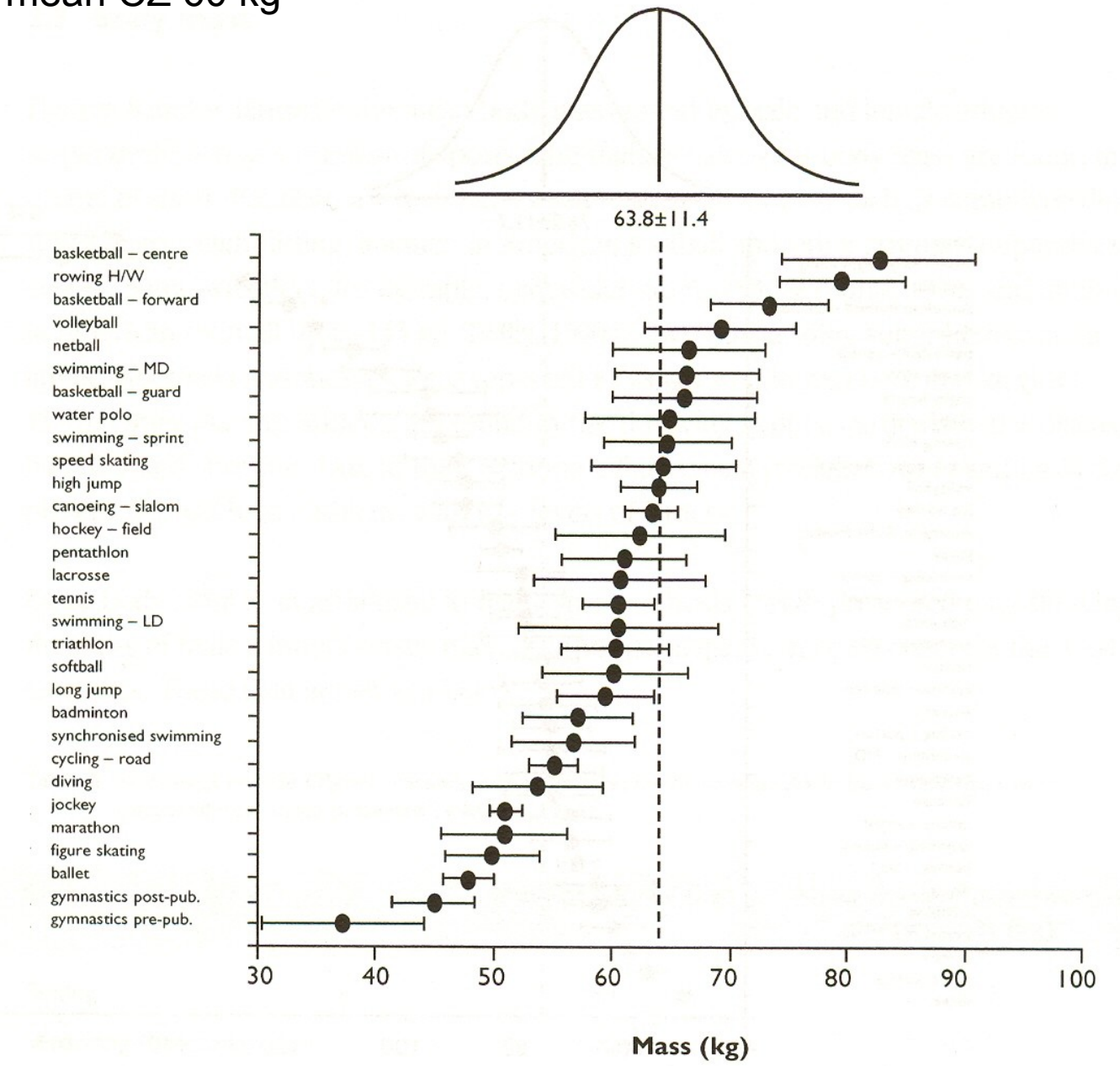



**Figure 9** Body mass (mean ± SD) of female athletes in a range of sports plotted relative to a reference group of non-athletes.

## Chart A – Determining frame size using wrist size in inches

| Frame | Men | Women |
|---|---|---|
| small | 6 inches or less | 5.5 or less |
| medium | 6.25 – 7.25 | 5.75 |
| large | 7.5 or more | 6 or more |

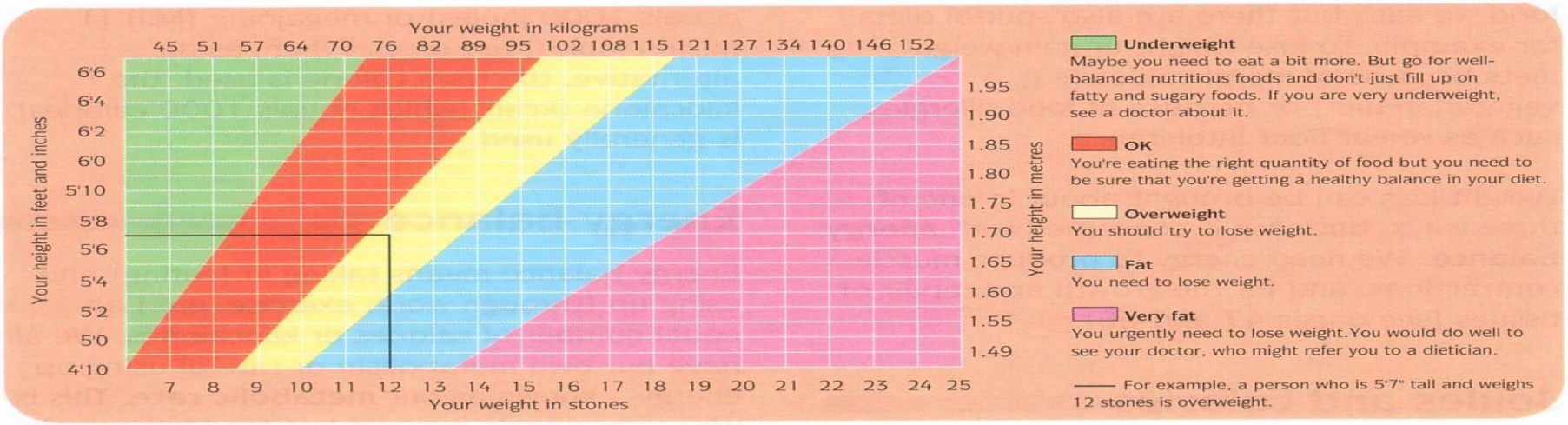
## Chart B – Desirable body weight for women (kgs)

| Height (metres) | Small frame | Medium frame | Large frame |
|---|---|---|---|
| 1·47 | 46–50 | 49–55 | 53–59 |
| 1·49 | 47–51 | 50–56 | 54–61 |
| 1·52 | 47–52 | 51–57 | 55–62 |
| 1·54 | 48–53 | 52–58 | 56–63 |
| 1·57 | 49–55 | 53–60 | 58–65 |
| 1·60 | 50–56 | 54–61 | 59–67 |
| 1·62 | 51–57 | 56–62 | 61–68 |
| 1·65 | 53–59 | 58–64 | 62–70 |
| 1·67 | 54–60 | 59–65 | 63–72 |
| 1·70 | 55–61 | 60–67 | 65–74 |
| 1·72 | 56–62 | 61–68 | 66–76 |
| 1·75 | 58–64 | 63–69 | 68–77 |
| 1·77 | 59–65 | 64–71 | 69–78 |
| 1·80 | 60–67 | 65–72 | 70–80 |
| 1·82 | 62–68 | 67–73 | 71–81 |

## Chart C – Desirable body weight for men (kgs)

| Height (metres) | Small frame | Medium frame | Large frame |
|---|---|---|---|
| 1·57 | 58–60 | 59–64 | 62–68 |
| 1·60 | 59–61 | 60–65 | 63–69 |
| 1·62 | 59–62 | 61–66 | 64–70 |
| 1·65 | 60–63 | 62–67 | 65–72 |
| 1·67 | 61–64 | 63–68 | 66–74 |
| 1·70 | 62–66 | 64–70 | 67–76 |
| 1·72 | 63–67 | 65–71 | 69–78 |
| 1·75 | 64–68 | 67–72 | 70–80 |
| 1·77 | 65–70 | 68–74 | 71–82 |
| 1·80 | 66–71 | 70–75 | 73–83 |
| 1·82 | 67–73 | 71–77 | 74–85 |
| 1·85 | 70–74 | 72–79 | 76–87 |
| 1·87 | 71–76 | 74–81 | 78–89 |
| 1·90 | 71–78 | 76–82 | 80–92 |
| 1·93 | 73–80 | 77–85 | 82–93 |

## Chart D – Height-to-weight chart for men and women




Source: Health Education Authority

## Level I Atomic

| Element | Amount (kg) | % Body Mass |
|---|---|---|
| Oxygen | 43.0 | 61.0 |
| Carbon | 16.0 | 23.0 |
| Hydrogen | 7.0 | 10.0 |
| Nitrogen | 1.8 | 2.6 |
| Calcium | 1.0 | 1.4 |
| Remainder | 1.2 | 2.0 |

## Level II Molecular

Protein | Carbohydrate | Lipid | Mineral compounds | Water

## Level III Cellular

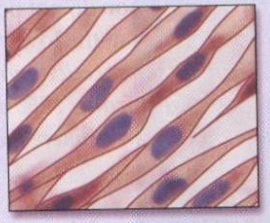
Fat cells

\+ Body cell mass (does not include storage fat) + ICF / ECF + Organic ar inorganic

Body fluids

Extracellula solids

## Level IV Tissue



Adipose tissue

\+

Skeletal muscle

\+

Bone

\+

Blood

## Level V Whole body

Skinfolds

Girths

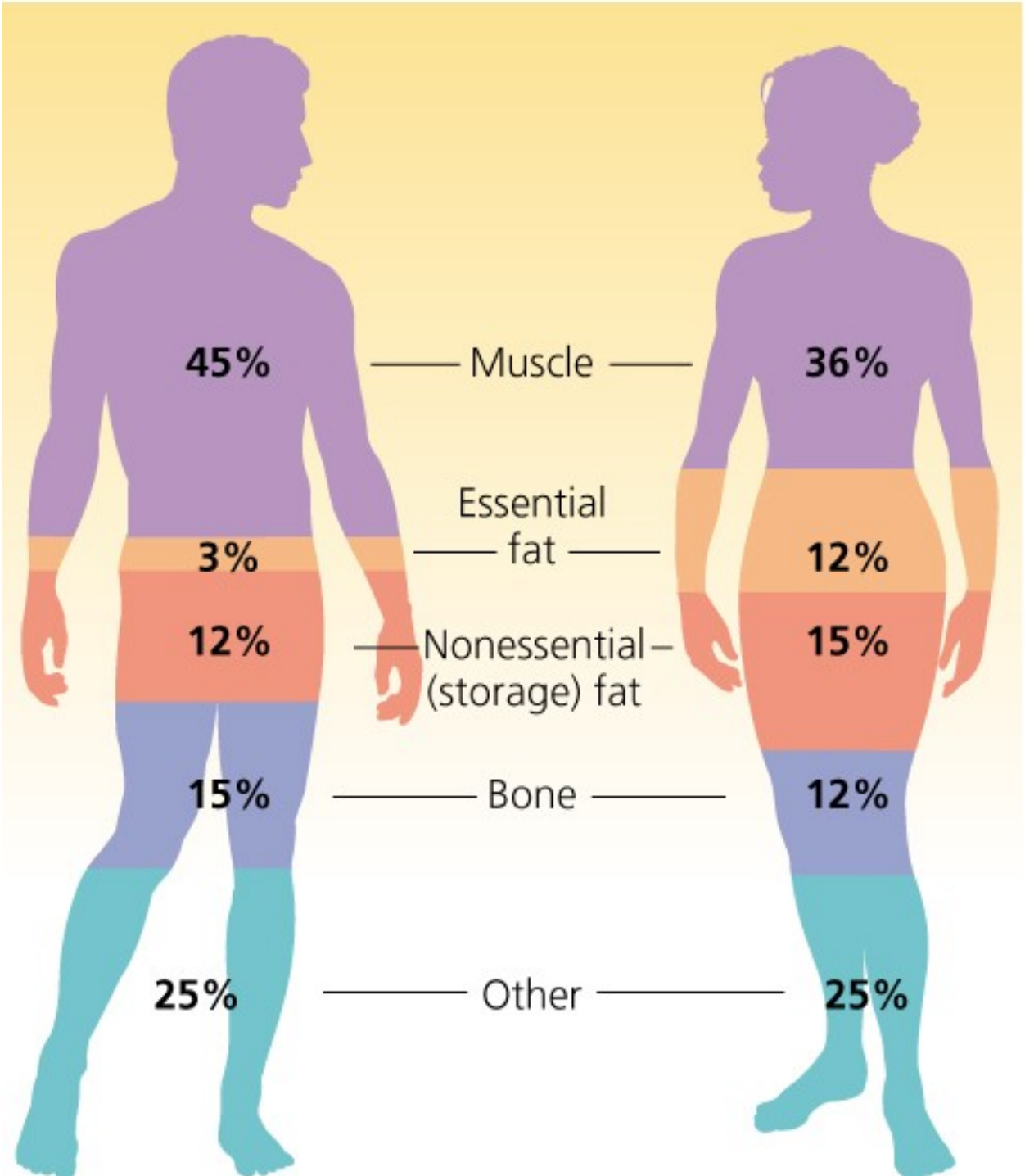
Densitometry

Segment volu

# Body Composition
# Matiegka Method

4 components:

- Skeletal mass (bones)
- Fat body mass (fat)
- Muscle mass (muscles)
- Other


45%
Muscle
36%
Essential
fat
3%
12%
12%
Nonessential–
(storage) fat
15%
15%
Bone
12%
25%
Other
25%

# BREADTHS

- biepicondylar humerus
- bistyloideus
- biepicondylar femur
- bimalleolar

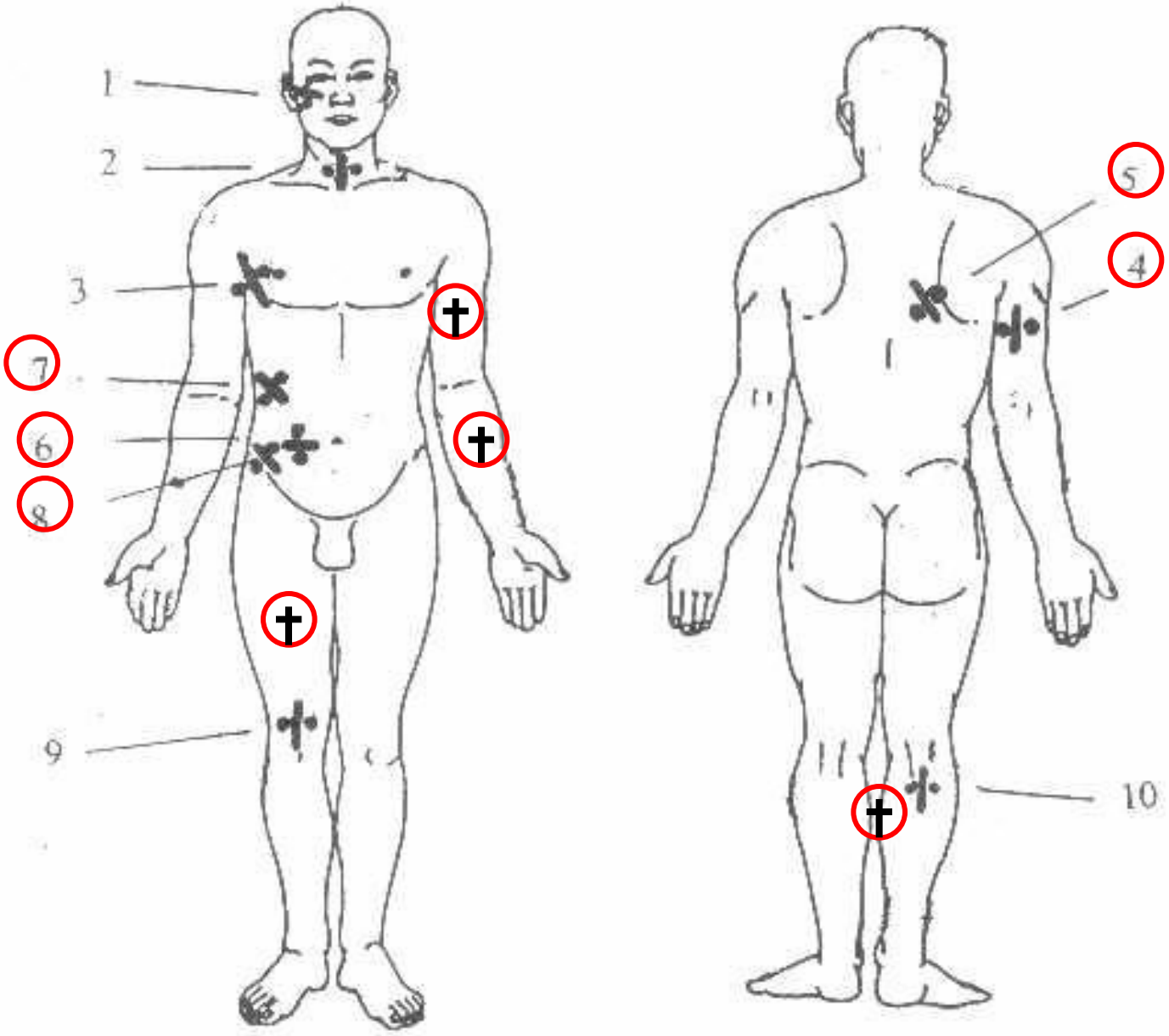
# GIRTHS

- relax arm
- flexed arm
- forearm girth
- thigh girth
- calf girth

# SKINFOLD MEASUREMENTS

- triceps
- subscapular
- chest 2
- abdomen
- supraspinal

- biceps
- forearm
- mid-thigh
- medial calf




Standardní místa snímání tloušťky kožních řas pro stanovení relativní hmotnosti depotní tukové tkáně kaliperem.

| | MEN | WOMEN |
|---|---|---|
| Skeletal mass: | 17% | 16% |
| Muscle mass: | 46% | 41% |
| Fat body mass: | 14% | 22% |
| Other: | 23% | 21% |


35%
8%
45%
15%

# BIOELETRIC IMPEDANCE ANALYSIS (BIA)

DEVICE:

- Omron
- Tanita
- Body stat
- In-Body

# BIOELETRIC IMPEDANCE ANALYSIS (BIA)

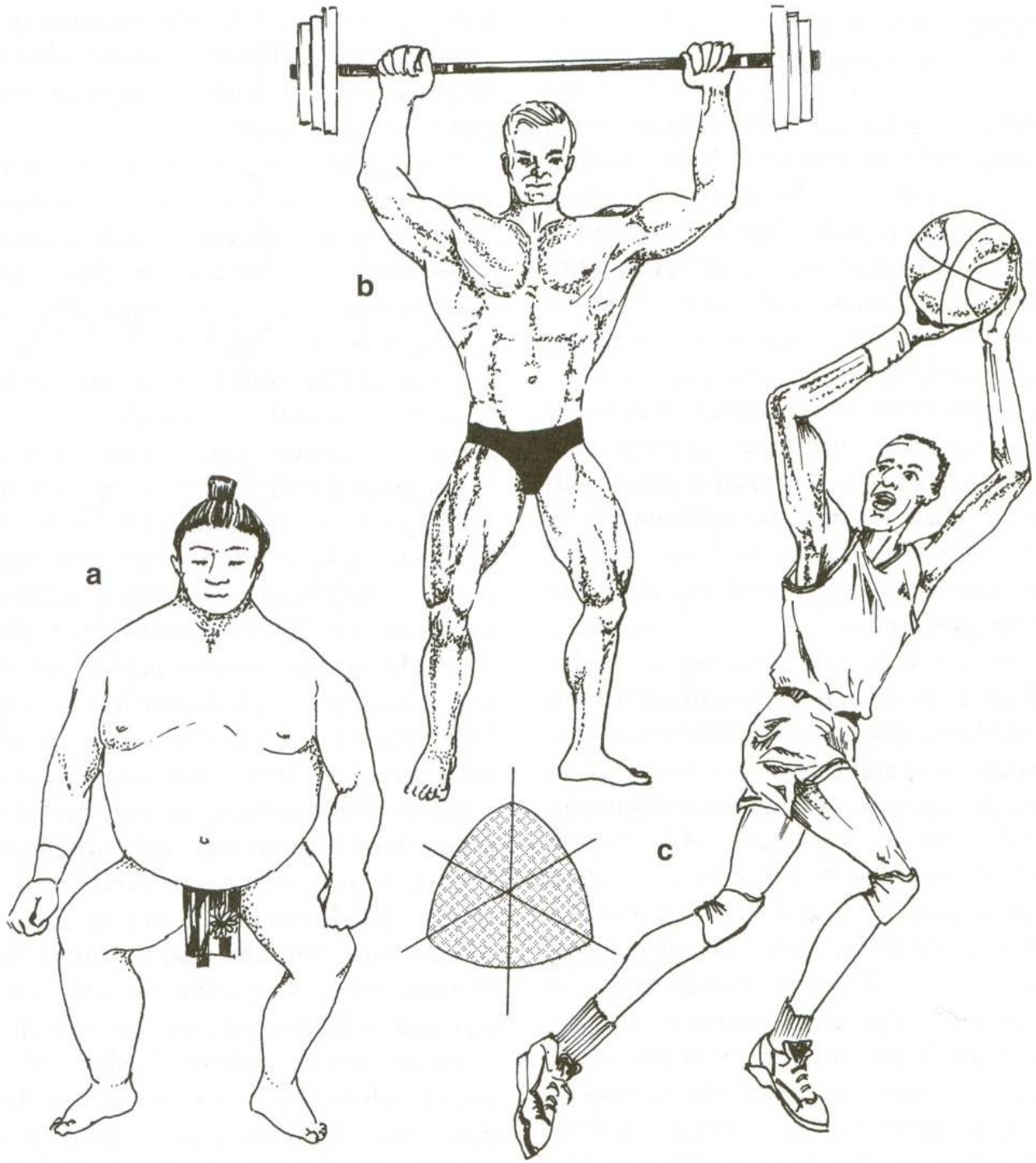
- Body fat scales use the Bioelectrical Impedance Analysis (BIA) technique.
- This method measures body composition by sending a low, safe electrical current through the body.
- The current passes freely through the fluids contained in muscle tissue, but encounters difficulty/resistance when it passes through fat tissue.
- This resistance of the fat tissue to the current is termed 'bioelectrical impedance', and is accurately measured by body fat scales.
- When set against a person's height, gender and weight, the scales can then compute their body fat percentage.

# SOMATOTYPING

# The Heat-Carter Somatotype method

# SOMATOTYPE

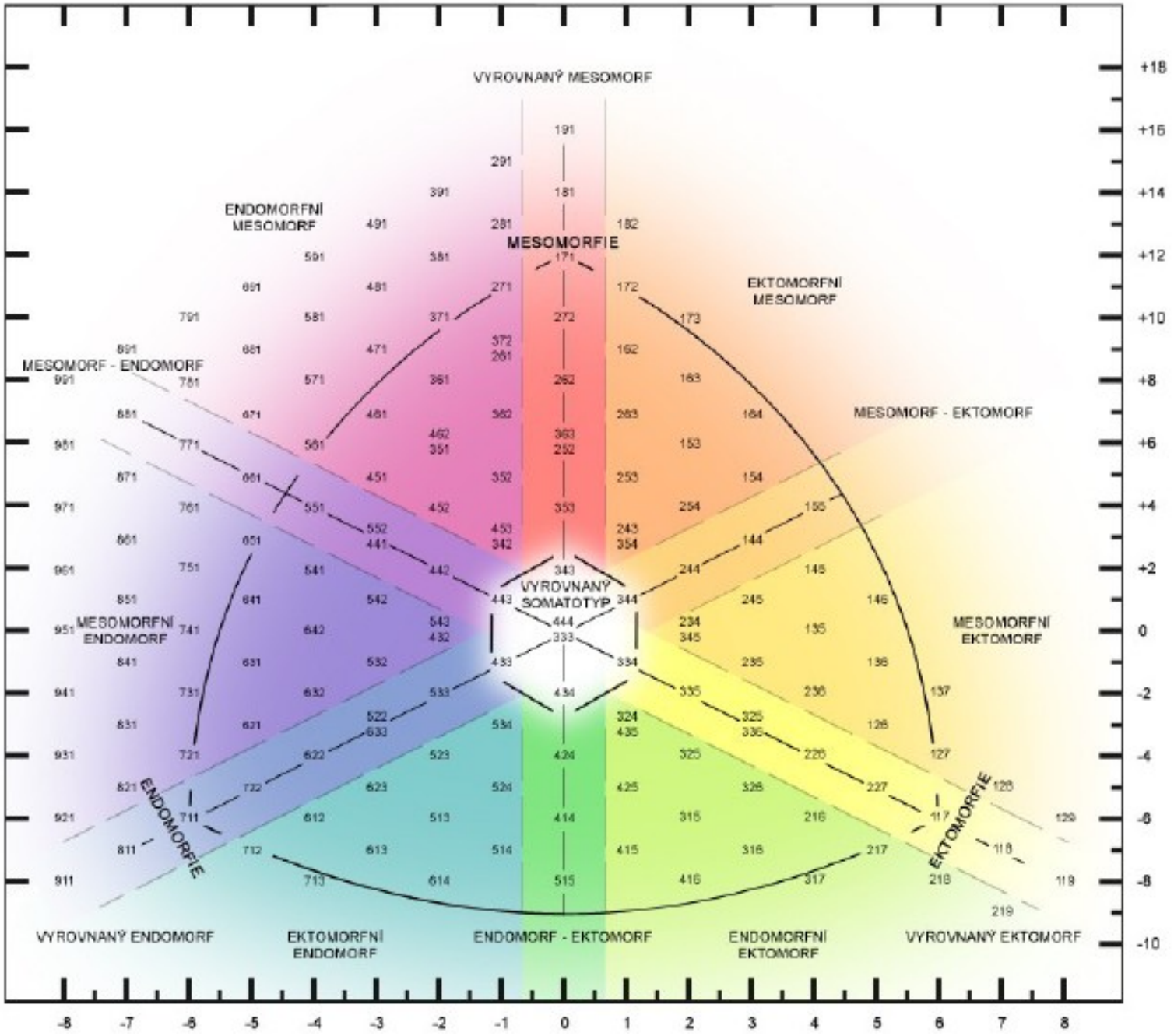
| | |
|---|---|
| **ENDOMORPHY** | **describes the relative degree of adiposity of body (fat mass)** |
| **MESOMORPHY** | **describes the realtive muscle-skeletal development of the body (apparent robustness - muscle, bone)** |
| **ECTOMORPHY** | **describes the relative slenderness of the body (fragilitx of the limbs** |

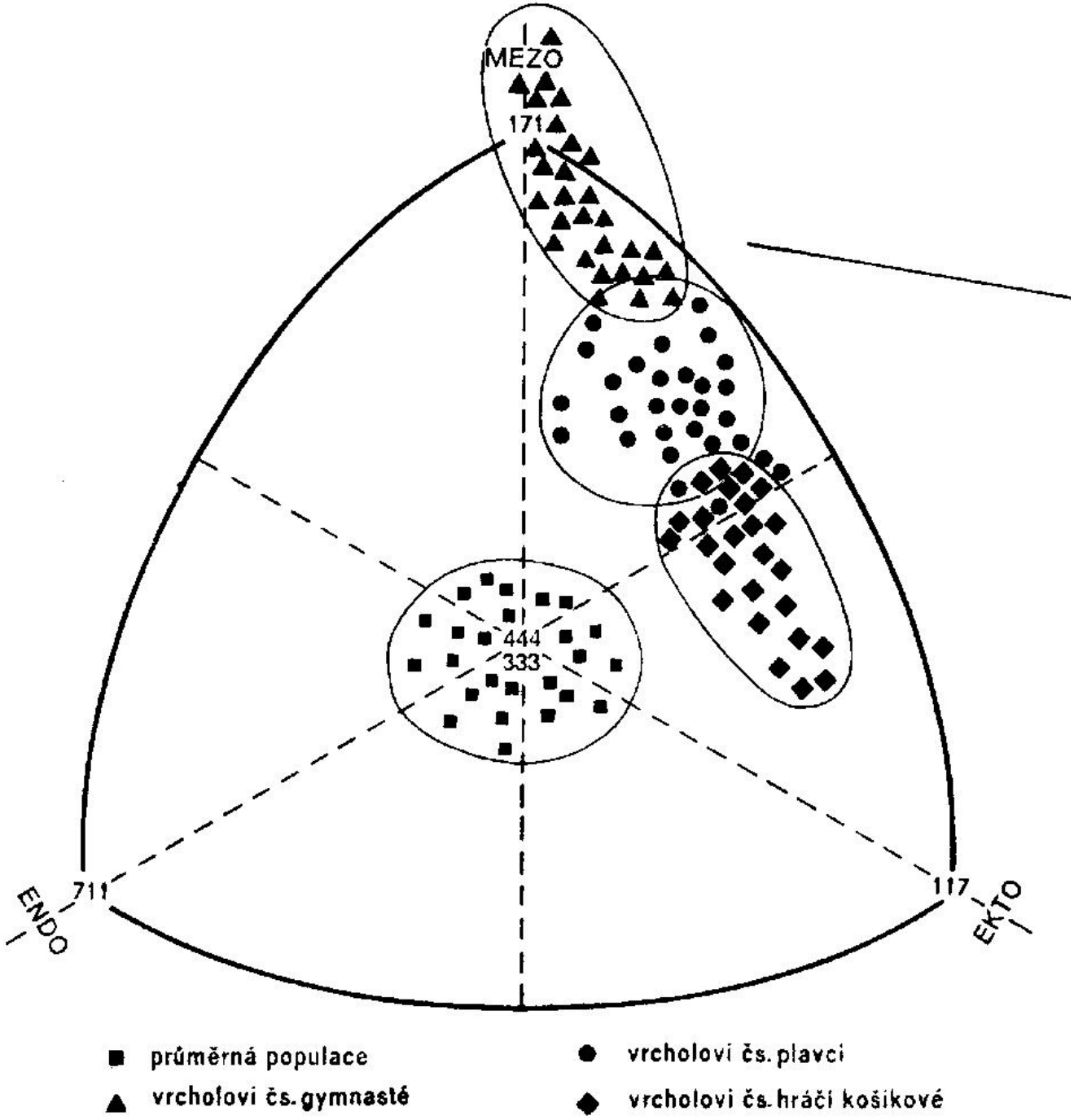

a
b
c

# Somatotype categories:

| | |
|---|---|
| Balance endomorph (balance mesomorph, balance ectomorph) | 1 component predominantes, 2 and 3 are balanced |
| Mesomorphic endomoph (ectomorphic endomorph, endomorphic mesomorph, atd.) | 1 component predominantes, 2. is upper than 3. |
| endomorph - mesomorph (endomorph - ectomorph, ectomorph - mesomorph) | 1 component is below 3, 2. and 3. are balanced |
| Central type | All components are 3, 4 |

X = EKTOMORFIE - ENDOMORFIE
Y = 2 x MESOMORFIE - (ENDOMORFIE + EKTOMORFIE)




MEZO
171
444
333
ENDO
711
117
EKTO
průměrná populace
vrcholoví čs. gymnasté
vrcholoví čs. plavci
vrcholoví čs. hráči košíkové

Name A. Medhurst | Age 20yr 5 mo | Sex (M) F | No A

Occupation Designer | Ethnic Group Black | Date 1 Jan 1996

Project Track Sprinter | Measured by TSO

| Skinfolds mm | |
|---|---|
| Triceps | = 6.4 |
| Subscapular | = 7.1 |
| Supraspinale | = 4.6 |
| Sum 3 Skinfolds | = 18.1 |
| Calf | = 5.2 |

Sum 3 Skinfolds (mm)

| | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Upper Limit | 10.9 | 14.9 | 18.9 | 22.9 | 26.9 | 31.2 | 35.8 | 40.7 | 46.2 | 52.2 | 58.7 | 65.7 | 73.2 | 81.2 | 89.7 | 98.9 | 108.9 | 119.7 | 131.2 | 143.7 | 157.2 | 171.9 | 187.9 | 204.0 |
| Mid-point | 9.0 | 13.0 | (17.0) | 21.0 | 25.0 | 29.0 | 33.5 | 38.0 | 43.5 | 49.0 | 55.5 | 62.0 | 69.5 | 77.0 | 85.5 | 94.0 | 104.0 | 114.0 | 125.5 | 137.0 | 150.5 | 164.0 | 180.0 | 196.0 |
| Lower Limit | 7.0 | 11.0 | 15.0 | 19.0 | 23.0 | 27.0 | 31.3 | 35.9 | 40.8 | 46.3 | 52.3 | 58.8 | 65.8 | 73.3 | 81.3 | 89.8 | 99.0 | 109.0 | 119.8 | 131.3 | 143.8 | 157.3 | 172.0 | 188.0 |

$\times\left(_{ht} = \frac{170.18}{178.3}\right) = 17.3$ (height corrected skinfolds)

Endomorphy: 1 | (1½) | 2 | 2½ | 3 | 3½ | 4 | 4½ | 5 | 5½ | 6 | 6½ | 7 | 7½ | 8 | 8½ | 9 | 9½ | 10 | 10½ | 11 | 11½ | 12

| | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Height (cm) = 178.3 | 139.3 | 143.5 | 147.3 | 151.1 | 154.9 | 158.8 | 162.6 | 166.4 | 170.2 | 174.0 | (177.8) | 181.6 | 185.4 | 189.2 | 193.0 | 196.9 | 200.3 | 204.5 | 208.3 | 212.1 | 215.9 | 219.7 | 223.5 | 227.3 |
| Humerus width (cm) = 7.20 | 5.19 | 5.34 | 5.49 | 5.64 | 5.78 | 5.93 | 6.07 | 6.22 | 6.37 | 6.51 | 6.65 | 6.80 | 6.95 | 7.09 | (7.24) | 7.38 | 7.53 | 7.67 | 7.82 | 7.97 | 8.11 | 8.25 | 8.40 | 8.55 |
| Femur with (cm) = 9.75 | 7.41 | 7.62 | 7.83 | 8.04 | 8.24 | 8.45 | 8.66 | 8.87 | 9.08 | 9.28 | 9.49 | (9.70) | 9.91 | 10.12 | 10.33 | 10.53 | 10.74 | 10.95 | 11.16 | 11.36 | 11.57 | 11.78 | 11.99 | 12.21 |
| Biceps girth (cm) = 33.9 | | | | | | | | | | | | | | | | | | | | | | | | |
| -- triceps skinfolds (cm) = 0.6 | | | | | | | | | | | | | | | | | | | | | | | | |
| 33.3 | 23.7 | 24.4 | 25.0 | 25.7 | 26.3 | 27.0 | 27.7 | 28.3 | 29.0 | 29.7 | 30.3 | 31.0 | 31.6 | 32.2 | (33.0) | 33.6 | 34.3 | 35.0 | 35.6 | 36.3 | 37.0 | 37.6 | 38.3 | 39.0 |
| Calf girth (cm) = 37.6 | | | | | | | | | | | | | | | | | | | | | | | | |
| -- calf skinfold (cm) = 0.5 | | | | | | | | | | | | | | | | | | | | | | | | |
| 37.1 | 27.7 | 28.5 | 29.3 | 30.1 | 30.8 | 31.6 | 32.4 | 33.2 | 33.9 | 34.7 | 35.5 | 36.3 | (37.1) | 37.8 | 38.6 | 39.4 | 40.2 | 41.0 | 41.7 | 42.5 | 43.3 | 44.1 | 44.9 | 45.6 |

Mesomorphy: ½ | 1 | 1½ | 2 | 2½ | 3 | 3½ | 4 | 4½ | 5 | (5½) | 6 | 6½ | 7 | 7½ | 8 | 8½ | 9

| Weight (kg) = 69.2 | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ht/∛Wt = 43.4 | | | | | | | | | | | | | | | | | | |
| Upper Limit | 39.65 | 40.74 | 41.43 | 42.13 | 42.82 | (43.48) | 44.18 | 44.84 | 45.53 | 46.23 | 46.92 | 47.58 | 48.25 | 48.94 | 49.63 | 50.33 | 50.99 | 51.68 |
| Mid-point | and | 40.20 | 41.09 | 41.79 | 42.48 | 43.14 | 43.84 | 44.50 | 45.19 | 45.89 | 46.32 | 47.24 | 47.94 | 48.60 | 49.29 | 49.99 | 50.68 | 51.34 |
| Lower Limit | below | 39.66 | 40.75 | 41.44 | 42.14 | 42.83 | 43.49 | 44.19 | 44.85 | 45.54 | 46.24 | 46.93 | 47.59 | 48.26 | 48.95 | 49.64 | 50.34 | 51.00 |

Ectomorphy: ½ | 1 | 1½ | 2 | 2½ | (3) | 3½ | 4 | 4½ | 5 | 5½ | 6 | 6½ | 7 | 7½ | 8 | 8½ | 9

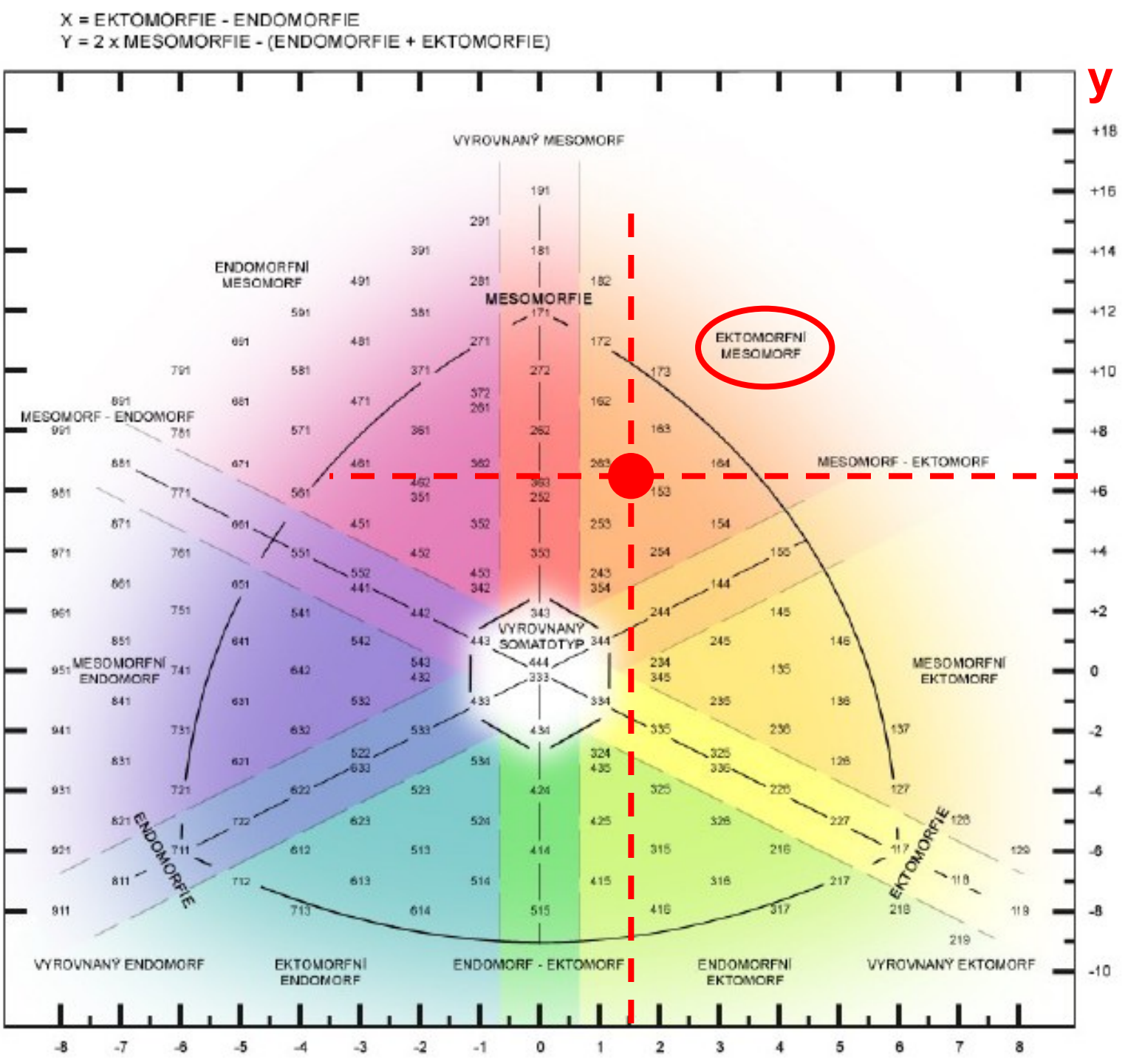
| | ENDOMORPHY | MESOMORPHY | ECTOMORPHY | |
|---|---|---|---|---|
| Anthropometric Somatotype | 1½ | 5½ | 3 | BY: TSO |
| Anthropometric plus Photoscopic Somatotype | | | | RATER: |

Biceps girth in cm corrected for fat by subtracting triceps skinfold value expressed in cm.
Calf girth in cm corrected for fat by subtracting medial calf skinfold value expressed in cm.

**Figure 1** Calculations of the anthropometric somatotype for subject A using the rating form.

**Příklad 1:**

**Endo 1,5**
**Mezo 5,5**
**Ekto 3**



1 Basketball (3.7–4.0–2.9)
2 Hockey (3.7–4.5–2.2)
3 Netball (3.0–3.8–3.3)
4 Soccer (4.2–4.6–2.2)
5 Softball (3.8–4.3–2.7)
6 Squash (3.4–4.0–2.8)
7 Volleyball (3.0–3.5–3.5)
8 Badminton (4.1–4.4–2.5)
9 Lacrosse (4.1–4.5–2.4)
10 Cricket (4.9–4.4–2.0)

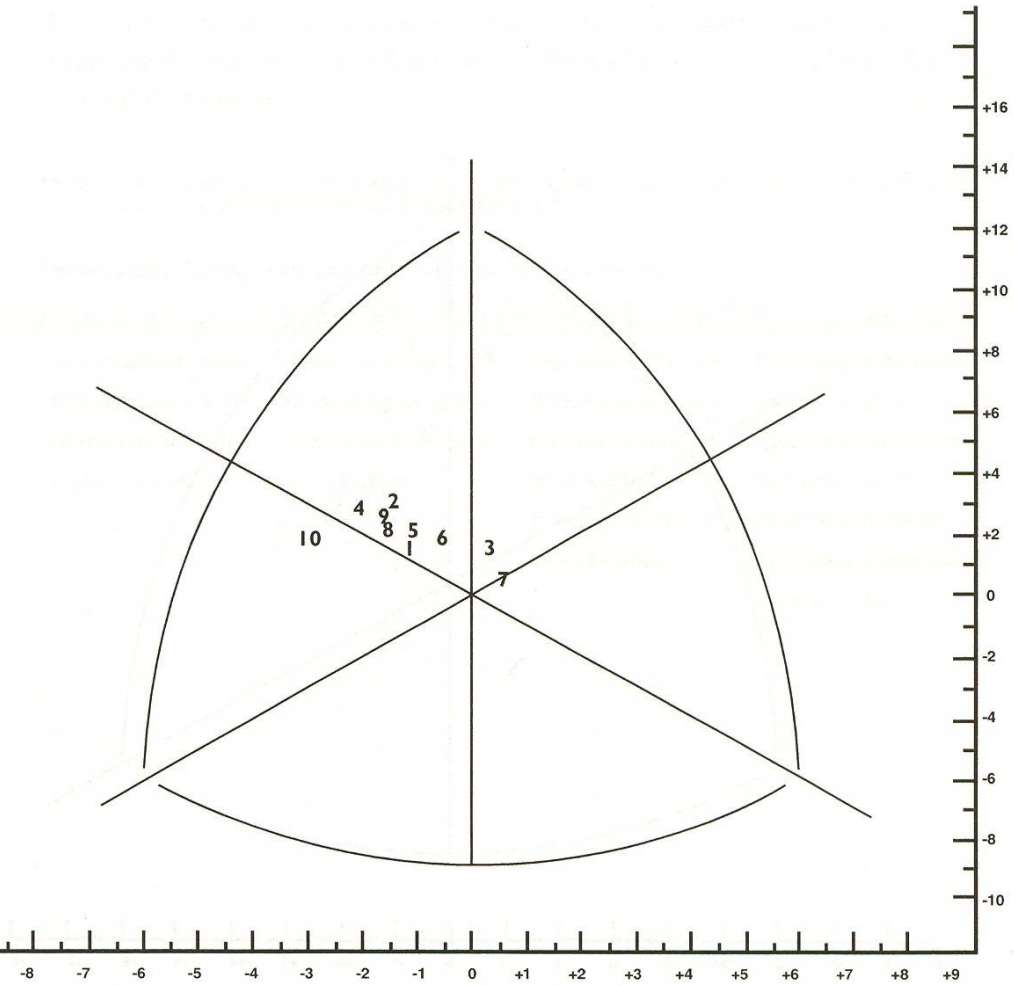



**Figure 7** Somatochart showing the somatoplots for Australian female athletes. The mean values are shown after each sport. (Data from Withers, et al., 1987).

Australian Rules (2.1–5.7–2.5)
Basketball (2.1–4.5–3.5)
Gymnastics (1.9–6.1–2.5)
Hockey (2.4–5.4–2.6)
Hurdles (1.8–4.1–3.9)
6 Powerlifting (2.7–7.9–0.6)
7 Heavyweight rowing (2.0–5.2–3.0)
8 Rugby Union (2.7–6.0–2.0)
9 Distance running (1.8–4.4–3.7)
10 Squash (2.5–5.2–2.8)

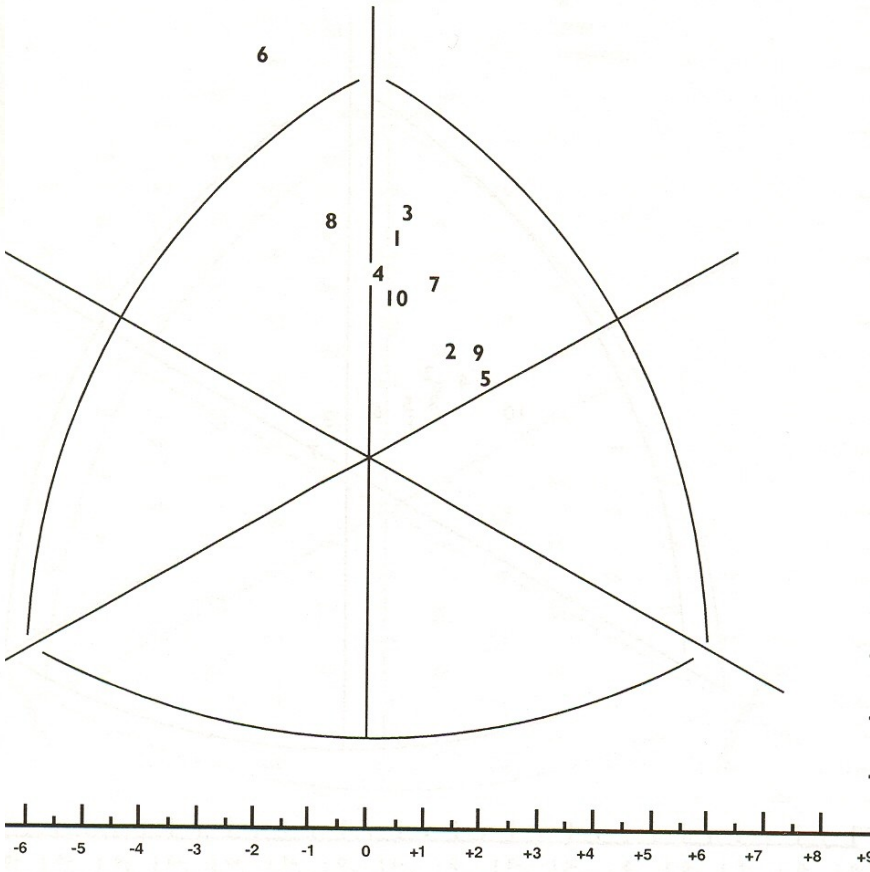



**Figure 8** Somatochart showing the somatoplots for Australian male athletes. The mean values are shown after each sport. (Data mainly from Withers, et al., 1986).