Body Composition

Chapter 6
The Spectrum of Body Size, Shape and Composition
We All Change in Many Ways
What are the different ways to look at human body composition?

- Medical (health)
- Anthropological
- Performance
- Appearance
Why is knowledge of body composition so important?

- Health and Disease
- Performance
- Appearance
- Longevity
What Is Body Composition?

- Body composition = the body’s relative amounts of fat mass and fat-free mass (bone, water, muscle, connective and organ tissues, teeth)
- Essential fat = crucial for normal body functioning
  - 3–5% of total body weight in males
  - 8–12% of total body weight in females
- Nonessential fat = adipose tissue
Typical Body Composition

- **Muscle**
  - Male: 45%
  - Female: 36%
- **Essential fat**
  - Male: 3%
  - Female: 12%
- **Nonessential (storage) fat**
  - Male: 12%
  - Female: 15%
- **Bone**
  - Male: 15%
  - Female: 12%
- **Other**
  - Male: 25%
  - Female: 25%

Fahey/Insel/Roth, *Fit & Well: Core Concepts and Labs in Physical Fitness and Wellness*, Chapter 6
Genetics and Body Composition

- Percent Body Fat and Fat Mass
  - Genetic (25%)
  - Cultural transmission (30%)
  - Nontransmissible (45%)
Different Levels of BC Measurement

**Level II** Molecular
- Protein
- Carbohydrate
- Lipid
- Mineral compounds
- Water

**Level III** Cellular
- Fat cells
- Body cell mass (does not include storage fat)
- ICF
- ECF
- Extracellular solids

**Level IV** Tissue
- Adipose tissue
- Skeletal muscle
- Bone
- Blood

**Level V** Whole body
- Skinfolds
- Girths
- Densitometry
- Segment volume
Reference Female

Reference woman
Age: 20-24 y
Stature: 163.8 cm (64.5 in)

Body mass component (kg)

- Body mass: 56.7 kg (85.0%)
- Lean body mass: 48.2 kg (36.0%)
- Muscle: 20.4 kg (12.0%)
- Bone: 6.8 kg (15.0%)

Body fat
- Total: 15.3 kg (27.0%)
- Storage: 8.5 kg (15.0%)
- Essential: 6.8 kg (12.0%)
Reference Male

Reference man
Age: 20-24 y
Stature: 174.0 cm (68.5 in)

Body mass component (kg)

<table>
<thead>
<tr>
<th>Component</th>
<th>Mass (kg)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body mass</td>
<td>70.0</td>
<td></td>
</tr>
<tr>
<td>Lean body mass</td>
<td>61.7</td>
<td>88.1%</td>
</tr>
<tr>
<td>Muscle</td>
<td>31.3</td>
<td>44.7%</td>
</tr>
<tr>
<td>Bone</td>
<td>10.4</td>
<td>14.9%</td>
</tr>
<tr>
<td>Total Body Fat</td>
<td>10.5</td>
<td>15.0%</td>
</tr>
<tr>
<td>Storage</td>
<td>8.4</td>
<td>12.0%</td>
</tr>
<tr>
<td>Essential Fat</td>
<td>2.1</td>
<td>3.0%</td>
</tr>
</tbody>
</table>
Male vs Female

Reference man
Age: 20-24 y
Stature: 174.0 cm (68.5 in)

Body mass component (kg)
- Body mass: 70.0
- Lean body mass: 61.7 (88.1%)
- Muscle: 31.3 (44.7%)
- Bone: 10.4 (14.9%)
- Total Body fat: 10.5 (15.0%)
- Storage Body fat: 8.4 (12.0%)
- Essential Body fat: 2.1 (3.0%)

Reference woman
Age: 20-24 y
Stature: 163.8 cm (64.5 in)

Body mass component (kg)
- Body mass: 56.7
- Lean body mass: 48.2 (85.0%)
- Muscle: 20.4 (36.0%)
- Bone: 6.8 (12.0%)
- Total Body fat: 15.3 (27.0%)
- Storage Body fat: 8.5 (15.0%)
- Essential Body fat: 6.8 (12.0%)

(note differences in fat and muscle content)
What is Essential Fat?

- Consists of fat stored in major organs, muscles, and central nervous system.

- Important for childbearing and hormone-related functions.

- Required for normal physiological functioning: reducing essential fat below some minimal amount can impair overall health. Extremes in dieting (and exercise) can reduce essential fat stores.
Sex Differences in Essential Fat

Men
3%

Women
12%
Of this amount, 5 to 9% is called sex-specific, reserve storage fat contained in breast and genital regions, lower body subcutaneous fat, and intramuscular depots.
Sex Differences in Storage Fat

Storage fat accumulates mainly in adipose tissues. This fat depot includes visceral fatty tissues and adipose tissue deposited beneath the skin’s surface called subcutaneous fat.

Women: 15%
Men: 12%
Distribution of Adipose Tissue

- Upper trunks
- Upper arms
- Lower arms
- Calves
- Thighs
- Lower trunk
Fat-Free Body Mass (FFM)

Defined as body mass devoid of all extractable fat

Body mass = 75.1 kg  Body fat = 23.6%

Fat mass = Body mass * % body fat

FFM = Body mass - fat mass

What is the FFM for this person?

Answer: 57.4 kg
Lean Body Mass (LBM)

In men, FFM includes 3% essential fat
In females, FFM includes 12% essential fat

When you compute LBM (body mass minus fat mass), the LBM component includes the “lipid-rich” essential fat stores in bone marrow, brain, spinal cord, and internal organs. LBM and FFM yield the same result, but the interpretation of their tissue composition distinguishes between the two concepts.
The Concept of Minimal Weight

Lowest you can weigh before compromising FFM stores

Males:

Females: Includes about 4%-7% essential fat + sex-specific fat (5%-9%) = 12%
[probably around 48.5 kg (105 lbs) for reference female]
How Lean is Too Lean?

In males, the lower limit of leanness equals about about 3% body fat. Long distance runners typically have such low values. This level of fatness is compatible with efficient heat dissipation during intense prolonged aerobic exercise.

In females, the lowest values for body fat correspond to the essential fat content (about 12%). This level of fatness is extremely low—in fact, females rarely go below this amount and still remain in "good" health. A woman who appears "skinny" or thin does not necessarily mean she has a low body fat content.
Leanness, Exercise, and Menstrual Irregularity

Society places an extreme focus on body weight and need for weight loss through dieting. The effects are felt in the general adult population, many athletic endeavors, and unfortunately in grade school. For example, 55% of 8th grade girls and 28% of 8th grade boys believed they were too fat and required dieting. The facts revealed the contrary. Only 13% of both populations needed to reduce. Sadly, 50% of the 8th grade girls and 15% of the boys had already begun dieting regimens.
Health Consequences of “Thinness”

- Ammenorrhea (completion cessation of menses) occurs in 2 to 5% of women of reproductive age, and 40% of female athletic groups such as dancers, skaters, cheerleaders, gymnasts, cross-country runners.

- Oligomenorrhea (irregular menstrual cycles) or amenorrhea increases the risk of bone loss and musculoskeletal injury in premenopausal women.
Overweight and Obesity

- The most important consideration in evaluating body weight and composition is the proportion of total body weight that is fat (percent body fat).
- Overweight = total body weight above a recommended range for good health.
- Obesity = severely overweight and overfat; characterized by excessive accumulation of body fat.
Prevalence of Overweight and Obesity

Fahey/Insel/Roth, *Fit & Well: Core Concepts and Labs in Physical Fitness and Wellness*, Chapter 6
Obesity Trends* Among U.S. Adults

1990

(*BMI ≥30, or ~ 30 lbs overweight for 5’ 4” woman)

Source: Behavioral Risk Factor Surveillance System, CDC

Fahey/Insel/Roth, Fit & Well: Core Concepts and Labs in Physical Fitness and Wellness, Chapter 6
Obesity Trends* Among U.S. Adults 2002

(*BMI ≥30, or ~ 30 lbs overweight for 5’ 4” woman)

Source: Behavioral Risk Factor Surveillance System, CDC

Fahey/Insle/Roth, *Fit & Well: Core Concepts and Labs in Physical Fitness and Wellness*, Chapter 6
Excess Body Fat and Wellness

- Increased risk of chronic disease and premature death; associated health problems include:
  - Unhealthy blood fat levels
  - Impaired heart function
  - Heart disease and hypertension
  - Cancer
  - Impaired immune function
  - Gallbladder disease
  - Kidney disease
  - Skin problems
  - Sleeping problems
Body Composition and Cancer Mortality

Fahey/Insel/Roth, *Fit & Well: Core Concepts and Labs in Physical Fitness and Wellness*, Chapter 6
Body Composition and Diabetes

- Obese people are more than three times as likely as nonobese people to develop diabetes
- Excess body fat is a key risk factor for the most common type of diabetes
Diabetes

- Diabetes mellitus = disruption of normal glucose metabolism
  - Type 1 diabetes = the pancreas produces little or no insulin
  - Type 2 diabetes = the pancreas doesn’t produce enough insulin, cells are resistant to insulin, or both
  - Gestational diabetes = develops in 2–5% of pregnant women
  - Pre-diabetes = elevated blood glucose levels
Diabetes

**Normal:**
Insulin binds to receptors on the surface of a cell and signals special transporters in the cell to transport glucose inside.

**Type 1 diabetes:**
The pancreas produces little or no insulin. Thus, no signal is sent instructing the cell to transport glucose, and glucose builds up in the bloodstream.

**Type 2 diabetes:**
The pancreas produces too little insulin and/or the body’s cells are resistant to it. Some insulin binds to receptors on the cell’s surface, but the signal to transport glucose is blocked. Glucose builds up in the bloodstream.
Diabetes: Symptoms

Symptoms of diabetes:
- Frequent urination
- Extreme thirst and hunger
- Unexplained weight loss
- Extreme fatigue
- Blurred vision
- Frequent infections
- Slow wound healing
- Tingling or numbness in hands and feet
- Dry, itchy skin
Diabetes: Prevention

- Regular physical activity including endurance exercise and weight training
- Moderate diet rich in whole grains, fruits, vegetables, legumes, fish, and poultry
- Modest weight loss
- For people with pre-diabetes, lifestyle changes are more effective than medication in preventing diabetes
Diabetes: Treatment

- Keep blood sugar levels within safe limits through diet, exercise, and, if needed, medication
- Monitor blood sugar levels with a home test
- Lose weight if overweight
Body Fat Distribution and Chronic Disease

- Location of fat is important to health
  - People who gain weight in the abdominal area = “apples;” this group has an increased risk of coronary heart disease, high blood pressure, diabetes, and stroke
  - People who gain weight in the hip area = “pears”
Physical Activity, Overweight, and Risk of Death

![Graph showing relative risk of death for active and inactive individuals, with overweight and not overweight categories.]

Fahey/Insel/Roth, *Fit & Well: Core Concepts and Labs in Physical Fitness and Wellness*, Chapter 6
Body Composition and Wellness

- Excess body fat decreases the ability to perform physical activities
- Unrealistic expectations about body composition can hurt self-image; exercise improves body image
- Set a realistic goal and maintain a wellness lifestyle to develop a healthy body composition
Problems Associated with Very Low Levels of Body Fat

- Too little body fat is associated with reproductive, circulatory, and immune system disorders
  - Less than 10–12% for women
  - Less than 5% for men
Female Athlete Triad

- A condition consisting of three interrelated disorders
Body Mass Index

- A rough assessment based on the concept that a person’s weight should be proportional to height
- Body weight in kilograms is divided by the square of height in meters
- Elevated BMI is linked to increased risk of disease, especially if associated with large waist circumference
## Body Mass Index

<table>
<thead>
<tr>
<th>BMI</th>
<th>Underweight</th>
<th>Normal</th>
<th>Overweight</th>
<th>Obesity (Class I)</th>
<th>Obesity (Class II)</th>
<th>Extreme obesity</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;18.5</td>
<td>17 18</td>
<td>19 20</td>
<td>22 23 24</td>
<td>30 32 33 34</td>
<td>35 36 37 38 39</td>
<td>40</td>
</tr>
<tr>
<td>Height</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4' 10&quot;</td>
<td>81 86</td>
<td>91 96</td>
<td>101 105 110 115</td>
<td>120 124 129 134 139</td>
<td>144 148 153 158 163</td>
<td>168 172 177 182 187 192</td>
</tr>
<tr>
<td>4' 11&quot;</td>
<td>84 89</td>
<td>94 99</td>
<td>104 109 114 119</td>
<td>124 129 134 139 144</td>
<td>149 154 159 163 168</td>
<td>173 178 183 188 193 198</td>
</tr>
<tr>
<td>5'</td>
<td>87 92</td>
<td>97 102</td>
<td>108 113 118 123</td>
<td>128 133 138 143 149</td>
<td>154 159 164 169 174</td>
<td>179 184 190 195 200 205</td>
</tr>
<tr>
<td>5' 1&quot;</td>
<td>90 95</td>
<td>101 106</td>
<td>111 117 122 127</td>
<td>132 138 143 148 154</td>
<td>159 164 169 175 180</td>
<td>185 191 196 201 207 212</td>
</tr>
<tr>
<td>5' 2&quot;</td>
<td>93 98</td>
<td>104 109</td>
<td>115 120 126 131</td>
<td>137 142 148 153 159</td>
<td>164 170 175 181 186</td>
<td>191 197 202 208 213 219</td>
</tr>
<tr>
<td>5' 3&quot;</td>
<td>96 102</td>
<td>107 113</td>
<td>119 124 130 136</td>
<td>141 147 153 158 164</td>
<td>169 175 181 186 192</td>
<td>198 203 209 215 220 226</td>
</tr>
<tr>
<td>5' 4&quot;</td>
<td>99 105</td>
<td>111 117</td>
<td>122 128 134 140</td>
<td>146 152 157 163 169</td>
<td>175 181 187 192 198</td>
<td>204 210 216 222 227 233</td>
</tr>
<tr>
<td>5' 5&quot;</td>
<td>102 108</td>
<td>114 120</td>
<td>126 132 138 144</td>
<td>150 156 162 168 174</td>
<td>180 186 192 198 204</td>
<td>210 216 222 229 235 241</td>
</tr>
<tr>
<td>5' 6&quot;</td>
<td>105 112</td>
<td>118 124</td>
<td>130 136 143 149</td>
<td>155 161 167 174 180</td>
<td>186 192 198 205 211</td>
<td>217 223 229 236 242 248</td>
</tr>
<tr>
<td>5' 7&quot;</td>
<td>109 115</td>
<td>121 128</td>
<td>134 141 147 153</td>
<td>160 166 173 179 185</td>
<td>192 198 204 211 217</td>
<td>224 230 236 243 249 256</td>
</tr>
<tr>
<td>5' 8&quot;</td>
<td>112 118</td>
<td>125 132</td>
<td>138 145 151 158</td>
<td>165 171 178 184 191</td>
<td>197 204 211 217 224</td>
<td>230 237 244 250 257 263</td>
</tr>
<tr>
<td>5' 9&quot;</td>
<td>115 122</td>
<td>129 136</td>
<td>142 149 156 163</td>
<td>169 176 183 190 197</td>
<td>203 210 217 224 230</td>
<td>237 244 251 258 264 271</td>
</tr>
<tr>
<td>5' 10&quot;</td>
<td>119 126</td>
<td>133 139</td>
<td>146 153 160 167</td>
<td>174 181 188 195 202</td>
<td>209 216 223 230 237</td>
<td>244 251 258 265 272 279</td>
</tr>
<tr>
<td>5' 11&quot;</td>
<td>122 129</td>
<td>136 143</td>
<td>151 158 165 172</td>
<td>179 187 194 201 208</td>
<td>215 222 230 237 244</td>
<td>251 258 265 273 280 287</td>
</tr>
<tr>
<td>6'</td>
<td>125 133</td>
<td>140 148</td>
<td>155 162 170 177</td>
<td>184 192 199 207 214</td>
<td>221 229 236 243 251</td>
<td>258 266 273 280 288 295</td>
</tr>
<tr>
<td>6' 1&quot;</td>
<td>129 137</td>
<td>144 152</td>
<td>159 167 174 182</td>
<td>190 197 205 212 220</td>
<td>228 235 243 250 258</td>
<td>265 273 281 288 296 303</td>
</tr>
<tr>
<td>6' 2&quot;</td>
<td>132 140</td>
<td>148 156</td>
<td>164 171 179 187</td>
<td>195 203 210 218 226</td>
<td>234 242 249 257 265</td>
<td>273 281 288 296 304 312</td>
</tr>
<tr>
<td>6' 3&quot;</td>
<td>136 144</td>
<td>152 160</td>
<td>168 176 184 192</td>
<td>200 208 216 224 232</td>
<td>240 248 256 264 272</td>
<td>280 288 296 304 312 320</td>
</tr>
<tr>
<td>6' 4&quot;</td>
<td>140 148</td>
<td>156 164</td>
<td>173 181 189 197</td>
<td>206 214 222 230 238</td>
<td>247 255 263 271 280</td>
<td>288 296 304 312 321 329</td>
</tr>
</tbody>
</table>

Fahey/Insel/Roth, *Fit & Well: Core Concepts and Labs in Physical Fitness and Wellness*, Chapter 6
Body Mass Index and Risk of Type 2 Diabetes

Fahey/Insel/Roth, *Fit & Well: Core Concepts and Labs in Physical Fitness and Wellness*, Chapter 6
Estimating Percent Body Fat

- Skinfold measurements: Folds of skin are measured with a caliper. The measurements are used in equations that link the thickness of skinfolds to percent body fat calculations made from more precise experiments.
Estimating Percent Body Fat

- Underwater weighing: An individual is submerged and weighed under water. Percentages of fat and fat-free weight are calculated from body density.
- The Bod Pod: The amount of air displaced by a person in a small chamber is measured by computerized sensors.
- Bioelectrical impedance analysis (BIA): A small electrical current is sent through the body, and the resistance of the body to it is recorded. The resulting estimates of how much water is in the body can be used to determine body composition.
Assessing Body Fat Distribution

- Disease risk increases with total waist measurement of more than
  - 40 inches for men
  - 35 inches for women
- Disease risk increases with total waist-to-hip measurement above
  - 0.94 for young men
  - 0.82 for young women
Setting Body Composition Goals

- If fat loss would benefit your health, set a **realistic** goal in terms of percent body fat or BMI.
- If you have underlying health issues, check with your physician before setting a goal.
- A little weight loss at a time can be very beneficial; focus on a healthy lifestyle including proper diet and exercise.
Making Changes in Body Composition

- Lifestyle should focus on:
  - Regular physical activity, endurance exercise, and strength training

Before training

After training

Fahey/Insel/Roth, *Fit & Well: Core Concepts and Labs in Physical Fitness and Wellness*, Chapter 6
Making Changes in Body Composition

- Lifestyle should focus on:
  - Moderate energy intake
  - Physical activity is the key to long-term success