CENTER OF GRAVİTY

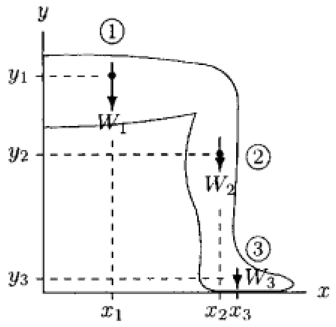


Fig. 4.47 *Locating the center of gravity of a flexed leg*

$$x_{cg} = \frac{x_1 W_1 + x_2 W_2 + x_3 W_3}{W_1 + W_2 + W_3}$$

$$x_{cg} = \frac{(17.3)(0.106W) + (42.5)(0.046W) + (45)(0.017W)}{0.106W + 0.046W + 0.017W}$$

$$x_{cg} = 26.9 \text{ cm}$$

$$y_{cg} = \frac{y_1 W_1 + y_2 W_2 + y_3 W_3}{W_1 + W_2 + W_3}$$

$$y_{cg} = \frac{(51.3)(0.106W) + (32.8)(0.046W) + (3.3)(0.017W)}{0.106W + 0.046W + 0.017W}$$

$$y_{cg} = 41.4 \text{ cm}$$

Table 4.2 *Example 4.8*

Part	x (cm)	y (cm)	% W
1	17.3	51.3	10.6
2	42.5	32.8	4.6
3	45.0	3.3	1.7

Mechanics of Bodypart

1) LOWER ARM

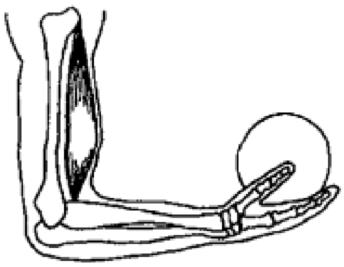


Fig. 5.4 *Example 5.1*

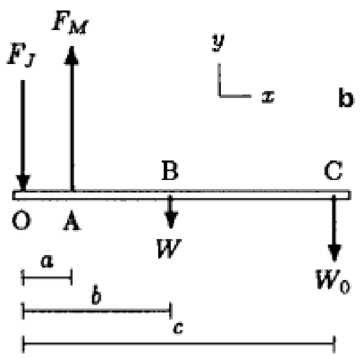
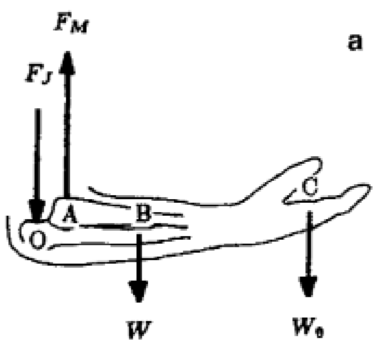


Fig. 5.5 *Forces acting on the lower arm*



$$\sum M_O = 0$$

That is, $cW_O + bW - aF_M = 0$

Then $F_M = \frac{1}{a}(bW + cW_O)$

For the translational equilibrium of the forearm y direction:

$$\sum F_y = 0$$

That is: $-F_J + F_M - W - W_O = 0$

Then $F_J = F_M - W - W_O$

2) Biseps

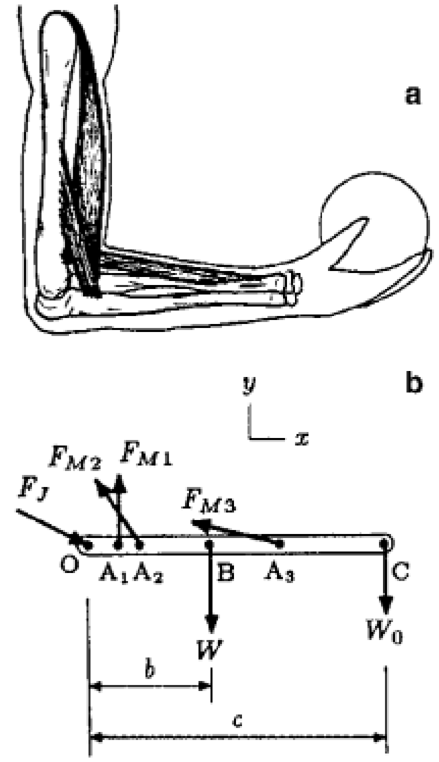


Fig. 5.8 *Three-muscle system*

$$\sum M_O = 0: \quad a_1 F_{M1} + a_2 F_{M2} + a_3 F_{M3} = bW + cW_O$$

$$\sum F_x = 0: \quad F_{Jx} = F_{M1x} + F_{M2x} + F_{M3x}$$

$$\sum F_y = 0: \quad F_{Jy} = F_{M1y} + F_{M2y} + F_{M3y} - W - W_O$$

$$F_{M1} = \frac{bW + cW_O}{a_1 + a_2 k_{21} + a_3 k_{31}}$$

3) Horizantal Arm

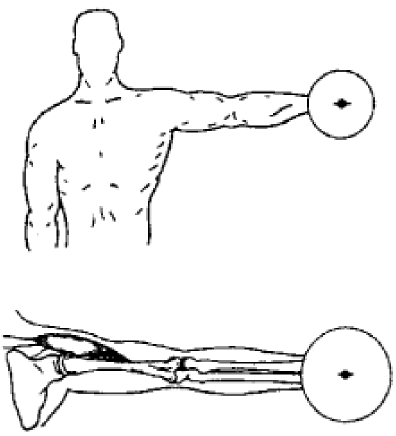


Fig. 5.11 *The arm is abducted to horizontal*

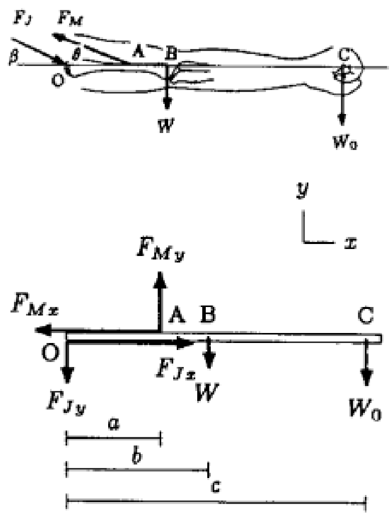


Fig. 5.12 *Forces acting on the arm and a mechanical model representing the arm*

$$\sum M_O = 0: \quad aF_{My} - bW - cW_O = 0$$

$$F_{My} = \frac{1}{a}(bW + cW_O)$$

4) Skull

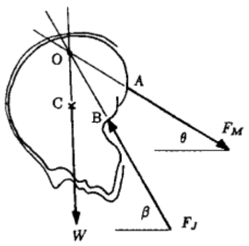


Fig. 5.15 *Forces on the skull form a concurrent system*

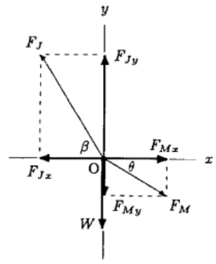


Fig. 5.16 *Components of the forces acting on the head*

$$F_M = \frac{W}{\cos\theta\tan\beta - \sin\theta}$$

$$\tan\beta = \frac{W + F_M \sin\theta}{F_M \cos\theta}$$

5) Lower Body (halter)

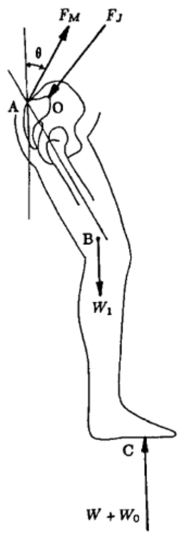


Fig. 5.19 *Forces acting on the lower body of the athlete*

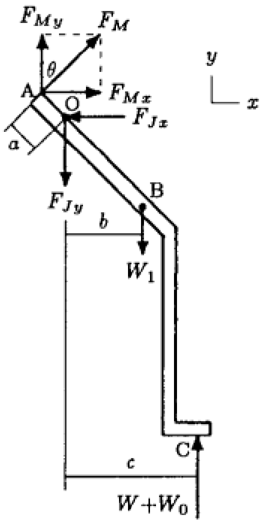


Fig. 5.20 *Free-body diagram*

$$F_M = \frac{c(W + W_0) - bW_1}{a}$$

$$\sum M_o = 0: \quad aF_M + bW_1 - c(W + W_0) = 0$$

6) Foot Concurrent

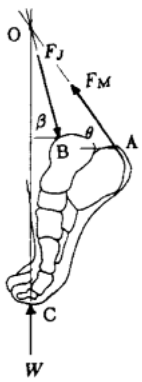


Fig. 5.45 *Forces acting on the foot form a concurrent system of forces*

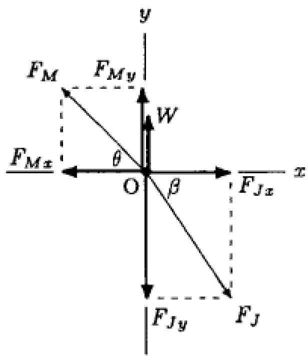


Fig. 5.46 *Components of the forces acting on the foot*

$$F_{Mx} = F_M \cos\theta$$
$$F_{My} = F_M \sin\theta$$
$$F_{Jx} = F_J \cos\beta$$
$$F_{Jy} = F_J \sin\beta$$

For the translational equilibrium of the foot in the horizontal and vertical directions:

$$\sum F_x = 0: \quad F_{Jx} = F_{Mx}, \text{ that is } F_J \cos\beta = F_M \cos\theta$$
$$\sum F_y = 0: \quad F_{Jy} = F_{My} + W, \text{ that is } F_J \sin\beta = F_M \sin\theta + W$$

Simultaneous solutions of these equations will yield:

$$F_M = \frac{W\cos\beta}{\cos\theta\sin\beta - \sin\theta\cos\beta}, \text{ that is: } F_M = \frac{W\cos\beta}{\sin(\beta - \theta)}$$
$$F_J = \frac{W\cos\theta}{\cos\theta\sin\beta - \sin\theta\cos\beta}, \text{ that is: } F_J = \frac{W\cos\theta}{\sin(\beta - \theta)}$$

7) Pelvis

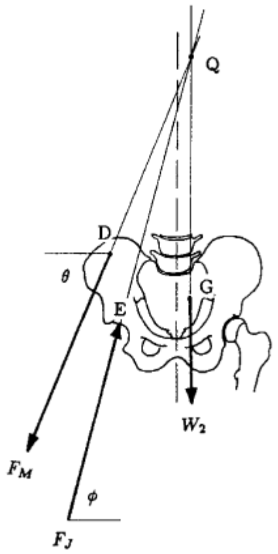


Fig. 5.27 *Forces involved form a concurrent system*

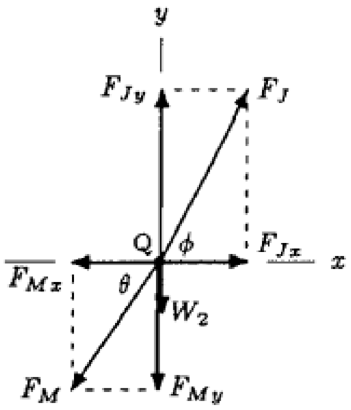


Fig. 5.28 *Resolution of the forces into their components*

$$F_J = \frac{F_M \cos\theta}{\cos\varphi}$$

$$F_J = \frac{\cos\theta W_2}{\sin(\varphi - \theta)}$$

8) Lower Leg

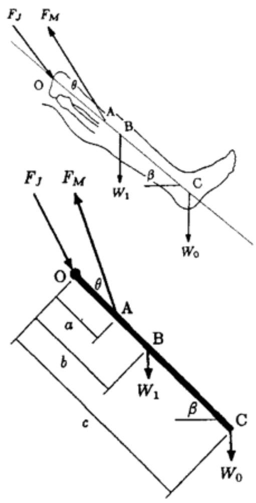


Fig. 5.38 *Forces acting on the lower leg*

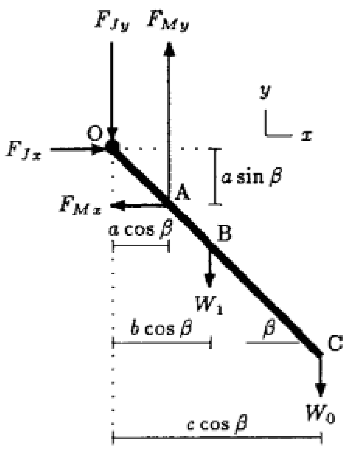


Fig. 5.39 *Force components, and their lever arms*

$$F_M = \frac{(bW_1 + cW_0)\cos\beta}{a[\cos\beta\sin(\theta+\beta) - \sin\beta\cos(\theta+\beta)]} \qquad \text{(iii)}$$

Note that this equation can be simplified by considering that $[\cos\beta\sin(\theta+\beta) - \sin\beta\cos(\theta+\beta)] = \sin\theta$, that is:

$$F_M = \frac{(bW_1 + cW_0)\cos\beta}{a\sin\theta}$$

$$\sum F_x = 0: \quad F_{Jx} = F_{Mx} = F_M\cos(\theta+\beta)$$

$$\sum F_y = 0: \quad F_{Jy} = F_{My} - W_0 - W_1$$

$$F_{Jy} = F_M\sin(\theta+\beta) - W_0 - W_1$$

$$\sum M_O = 0: \quad (a\cos\beta)F_{My} - (a\sin\beta)F_{Mx} - (b\cos\beta)W_1 - (c\cos\beta)W_0 = 0$$