Solution:

a) Given the anatomical dimensions and masses, determine forces $\mathbf{F_L}$ and $\mathbf{F_R}$ at the gymnast's hands. Solve the problem symbolically first, then numerically, and show your work for each part.

Step 1: Write the equations of static equilibrium.

$$\sum \boldsymbol{F_x} = \boldsymbol{F}_{breeze} \cdot (body\ length) - \boldsymbol{R}_R - \boldsymbol{R}_L$$

$$\sum \boldsymbol{F_y} = -(2 \cdot \boldsymbol{m}_{leg} + \boldsymbol{m}_{torso})\, g + \boldsymbol{F}_L + \boldsymbol{F}_R = 0$$

Step 2: Write the moments about the right hand, making sure to include the contribution of the left leg due to its abduction angle.

$$\sum \boldsymbol{M_R} = -(\boldsymbol{m}_{torso} \cdot g \cdot l_{clav}) + (\boldsymbol{F}_L \cdot 2l_{clav}) - \left(\boldsymbol{m}_{leg} \cdot g\left(l_{clav} + l_{hip} + l_{knee}\sin(\mathbf{45})\right)\right) - \left(\boldsymbol{m}_{leg} \cdot g\left(l_{clav} - l_{hip}\right)\right) - \frac{1}{2}\boldsymbol{F}_{breeze} \cdot \left(l_{arm} + l_{torso} + l_{leg}\right)^2 = 0$$

Step 3: Then solve for $\boldsymbol{F}_L$.

$$\boldsymbol{F}_L = \left[(\boldsymbol{m}_{torso} \cdot g \cdot l_{clav}) + \left(\boldsymbol{m}_{leg} \cdot g\left(l_{clav} + l_{hip} + l_{knee}\sin(\mathbf{45})\right)\right) + \left(\boldsymbol{m}_{leg} \cdot g\left(l_{clav} - l_{hip}\right)\right) + \frac{1}{2}\boldsymbol{F}_{breeze} \cdot \left(l_{arm} + l_{torso} + l_{leg}\right)^2\right] / 2l_{clav}$$

With $g = 10\ m/s^2$,

$>> \boldsymbol{F_L} = \mathbf{431.18}\ \boldsymbol{N}$

With $= 9.8\ m/s^2$,

$>> \boldsymbol{F_L} = \mathbf{422.83}\ \boldsymbol{N}$

Step 4: Now, use the static equilibrium equation for force in the *y*-direction to solve for $\boldsymbol{F_R}$.

$$\sum \boldsymbol{F_y} = -(2 \cdot \boldsymbol{m}_{leg} + \boldsymbol{m}_{torso})\, g + \boldsymbol{F}_L + \boldsymbol{F}_R = 0$$

$$\boldsymbol{F}_R = (2 \cdot \boldsymbol{m}_{leg} + \boldsymbol{m}_{torso})g - \boldsymbol{F}_L$$

With $g = 10\ m/s^2$,

$>> \boldsymbol{F_R} = \mathbf{168.82}\ \boldsymbol{N}$

With $g = 9.8\ m/s^2$,

$>> \boldsymbol{F_R} = \mathbf{165.17}\ \boldsymbol{N}$