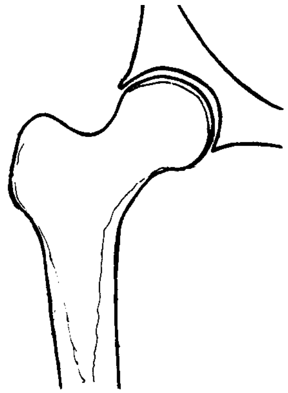
Surface joint Motion – Normal pattern is that femora head slides (glides) across the acetabulum in movements in all 3 planes.



ICR has been found to lie within femoral head for simple one plane motions (flex/ext) (or ab/adduction). However, in certain circumstances, this normal sliding motion can be disrupted – causing compression or distraction.

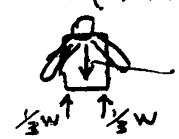
For true 3D motions, a single ICR point is ________. Rather, recent studies have attempted to define the ___ ______ ______ ___ orientation and position within various joints. This axis represents (at any given instant) that line about which the body segment is rotating and along which the body segment is translating all at once. (relative to its adjacent segment)

Kinetics – Large forces are applied to the hip joint area during everyday activities. It is important to understand the factors which influence these forces – especially for rehab choices for patients with hip pathology.

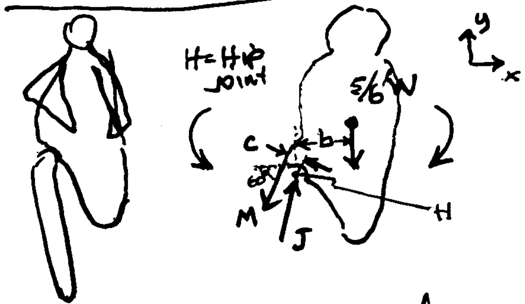
"__________________" (First example)

very little muscular activity is need here. Joint is very stable from joint capsule and the capsular ligaments surrounding the joint. Joint force is mainly a result of compression from weight of the body above the hip. ("superincumbent body weight", SBW)

For symmetrical standing each hip supports $\frac{1}{2}$ of this SBW (see Wiktorin? Nordin Table A-1 for relative weights of body segments) Total body weight = W Each leg ≈ $\frac{1}{6}$W Two legs ~ $\frac{1}{3}$W, Head + arms + trunk (HAT = $\frac{2}{3}$W)



– force analysis



____ Diagram FBD of ________ ______

b = moment arm of 5/6 W force

c = moment arm of abductor muscle force M

Alternatively

you could use a FBD of stance leg

see problem 7.3

$\circlearrowleft + \quad \Sigma M_H = 0$

$M \cdot c - \frac{5}{6} W \cdot b = 0$

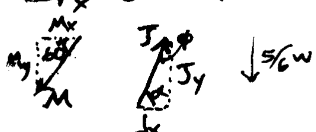
$=$

$M = \frac{5}{6} W \left(\frac{b}{c}\right)$ ____________

if, say $\frac{b}{c} = \frac{12}{5}$ then $M =$ $\qquad =$

$\xrightarrow{+} \quad \Sigma F_x = 0 \Rightarrow -M_x + J_x = 0$

$J_x = M_x =$ $\qquad =$



$+\uparrow \quad \Sigma F_y = 0 \Rightarrow -M_y + J_y - \frac{5}{6} W = 0$

$J_y = M_y + \frac{5}{6} W =$

$\cong \qquad \cong$

$J = \sqrt{\qquad} \cong$

$\alpha = \tan^{-1}(\qquad) \approx 69°$ check these numbers $\phi = 90° - \alpha = 21°$

Effect of $\frac{c}{b}$ ratio on forces in hip joint

see Fig

________ tends to reduce muscle moment arm c. This tends to increase J.

Artificially changing moment arms c and/or b:

Examples:

1. Total hip replacement – if you moved the greater trochanter ______ this would tend to increase muscle moment arm c. –or–
2. Inserting a prosthetic cup deeper into acetabulum moves center of joint closer to the midline, thus decreasing the ______ ______ (b) of the SBW.

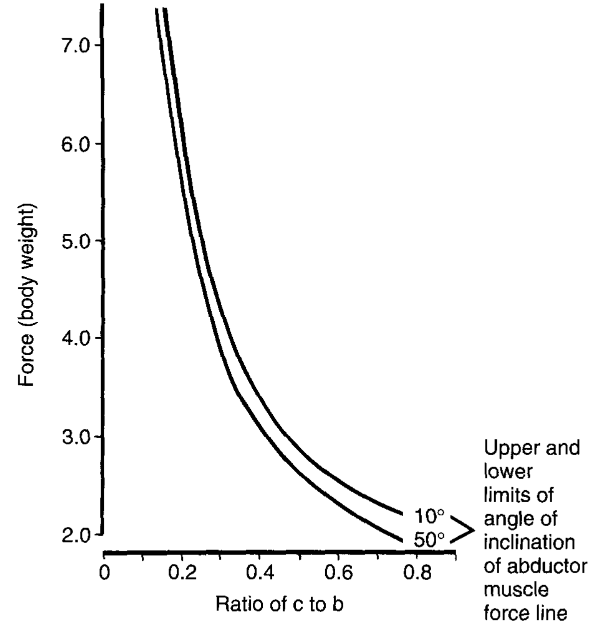


FIG. 8-11

The value of the ratio of the abductor muscle force lever arm (*c*) to the gravitational force lever arm (*b*) is plotted against the joint reaction force on the femoral head in units of body weight. Because the line of application of the abductor muscle force (its angle of inclination in the frontal plane) has finite upper and lower limits (10 and 50°), the force envelope is plotted. The curve can be utilized to determine the minimal force acting on the femoral head during a one-leg stance if the ratio of c to b is known. *Adapted from Frankel, V.H. (1960). In* The Femoral Neck: Function, Fracture Mechanisms, Internal Fixation. *Springfield: Charles C. Thomas.*

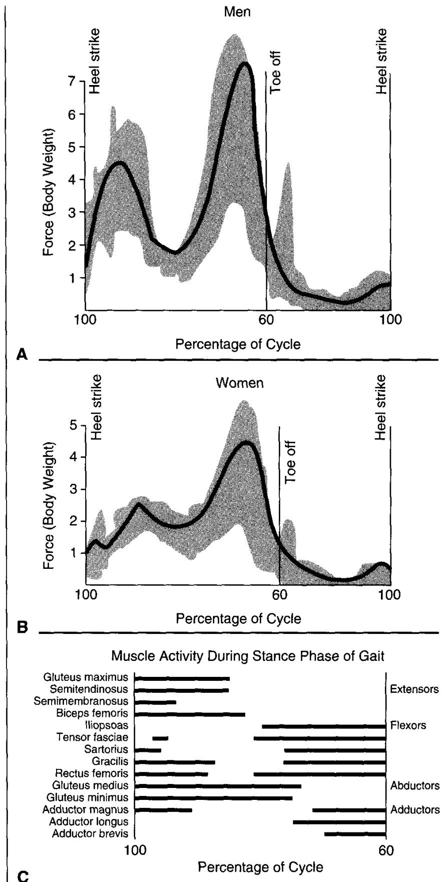


FIG. 8-12

Hip joint reaction force in units of body weight during walking, one gait cycle. The *shaded area* indicates variations among subjects. **A,** Force pattern for normal men. **B,** Force pattern for normal women. *Adapted from Paul, J.P. (1967).* Forces at the human hip joint. *Unpublished doctoral thesis, University of Chicago.* **C,** Muscle activity during stance phase of gait. The first peak corresponds mainly for the extensor and abductor muscles. The last peak is for the flexors and adductor muscles. *Adapted from the University of California. (1953). The pattern of muscular activity in the lower extremity during walking.* Univ Cal Prosthet Dev Res Rep, 2(25), 1–41.

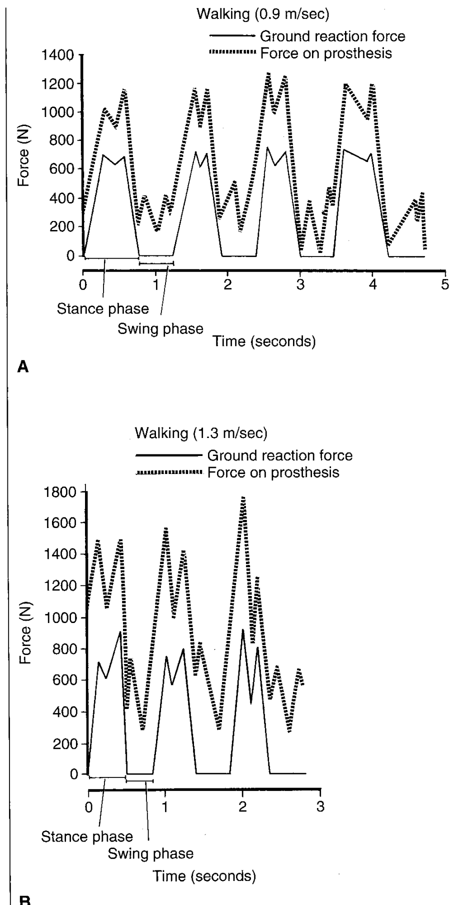


FIG. 8-13

Forces on an instrumented hip prosthesis during walking. The *broken line* represents the force on the prosthesis, and the *solid line* represents the ground reaction force. **A,** Walking speed 0.9 m per second. **B,** Walking speed 1.3 m per second. An increase in muscle activity at the faster cadence resulted in higher forces on the prosthesis. *Adapted from Rydell, N. (1965). Forces in the hip-joint. Part II: Intravital measurements. In R.M. Kenedi (Ed.),* Biomechanics and Related Bio-Engineering Topics *(pp. 351–357). Oxford: Pergamon Press.*

TABLE 8-2

Range of Typical Reported Peak Hip Joint Forces From Selected Studies

Activity	Reported Peak Force BW	Instrumentation	Reference
Walking		Instrumented implants	Bergmann et al., 1993, 1995
			Kotzar et al., 1991
			English et al., 1979
			Rydell et al., 1966
Walking		EMG /force plate	Paul, 1967
			Crowninshield et al., 1978
			Rohrle et al., 1984
		accelerometers	van den Bogert et al., 1999

BW, body weight; EMG, electromyography

7.7. Hip Joint Loading during Symmetrical and Asymmetrical Lifting

Moment Equilibrium; Force Equilibrium

This example illustrates the effect of the distribution of a burden on hip joint loading. The loading of the hip joint when a suitcase is carried in one hand is compared with the loading when the same type of suitcase is carried in each hand (in other words, when the burden is twice as heavy).

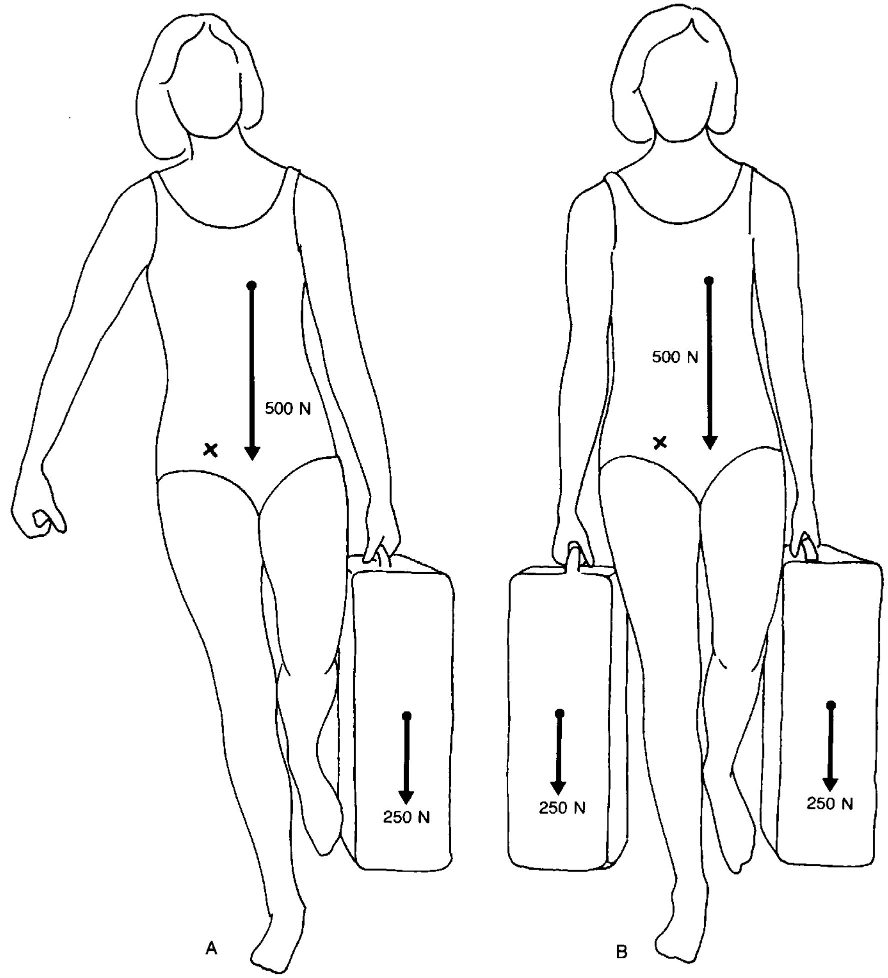


Figure 7.7. A person is standing on one leg while carrying a 25-kg suitcase in the hand on the side opposite the standing leg (Figure A) and a 25-kg suitcase in each hand (Figure B). The body weight excluding the weight of the standing leg is 500 N. The center of rotation of the hip joint is marked with an X.

7.7A. How large is the joint reaction force (R) in the right hip when a person stands on the right leg while carrying a 25-kg suitcase in the left hand (Figure 7.7A)? Use the following data:

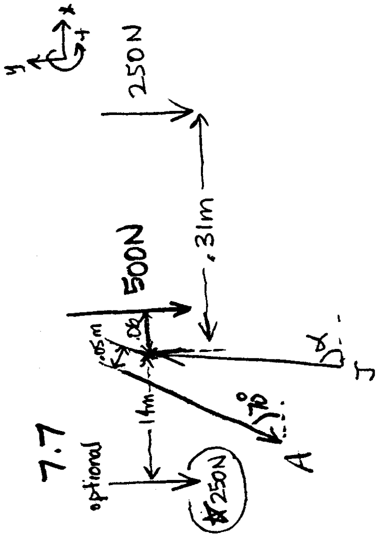
Body weight	600 N
Weight of the standing leg	100 N
Moment arm of the weight of the suitcase	0.31 m
Moment arm of the abductor muscle force	0.05 m
Moment arm of of the body weight excluding the weight of the standing leg	0.06 m

The abductor muscle force (A) acts at a 70° angle to the transverse plane.

7.7B. How large is the joint reaction force (R) on the right hip joint when a person stands on the right leg while carrying a 25-kg suitcase in each hand (Figure 7.7B)?

The moment arm for the weight of the suitcase in the right hand is 0.14 m, and for the weight of the suitcase in the left hand, 0.31 m. The moment arms of the body weight and of the abductor muscle force are assumed to be the same as in problem 7.7A.

7.7



A. $\Sigma M_H = 0 \Rightarrow A(.05) - 500(.06) - 250(.31) = 0$

$A = \frac{500(.06) + 250(.31)}{.05} =$ ____

$\Sigma F_x = 0 \Rightarrow J_x - A_x = 0 \Rightarrow J_x = A_x = 2150\cos 70° =$ ____

$\Sigma F_y = 0 \Rightarrow J_y - A_y - 500 - 250 = 0$

$J_y = A_y + 750 = 2150\sin 70° + 750 =$ ____

$J = \sqrt{J_x^2 + J_y^2} =$ [ ] $\alpha = \tan^{-1}\left(\frac{J_y}{J_x}\right) =$ [ ] (angle is optional)

★ suitcase in right hand for part B only

B. $\Sigma M_H = 0 \Rightarrow A(.05) - 500(.06) - 250(.31) + 250(.14) = 0$

$A = \frac{500(.06) + 250(.31) - 250(.14)}{.05} =$ ____

$\Sigma F_x = 0 \Rightarrow J_x - A_x = 0 \Rightarrow J_x = A_x = 1450\cos 70° =$ ____

$\Sigma F_y = 0 \Rightarrow J_y - A_y - 500 - 250 - 250 = 0 \Rightarrow J_y = A_y + 1000 = 1450\sin 70° + 1000$

$J_y =$ ____

$J = \sqrt{J_x^2 + J_y^2} =$ [ ] $\alpha = \tan^{-1}\left(\frac{J_y}{J_x}\right) =$ [ ] (angle is optional)

One legged stance examples: (see problem 7-7)

<u>Carrying one suitcase vs 2 suitcases</u> —
______ ________ in hip is reduced when you carry 2 suitcases — one in each hand — compared to one suitcase. This is true even if the total weight carried is more with 2 suitcases than one. Better yet — split up one big suitcase into 2 smaller ones — one in each hand.

<u>Using a cane</u>: (see problem 7-6)
Cane should be used on the ______ side of the painful hip. This will tend to assist the ______ ______ muscle in balancing the moment of the SBW about the hip joint. This reduces the ______ muscle force and hence reduces the ______ force at the hip.