Biomechanics of Human Motion

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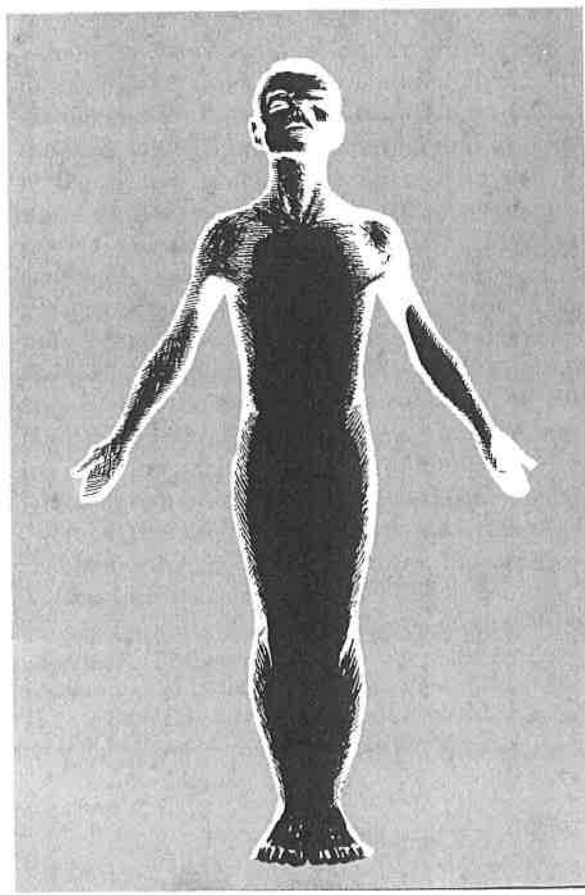

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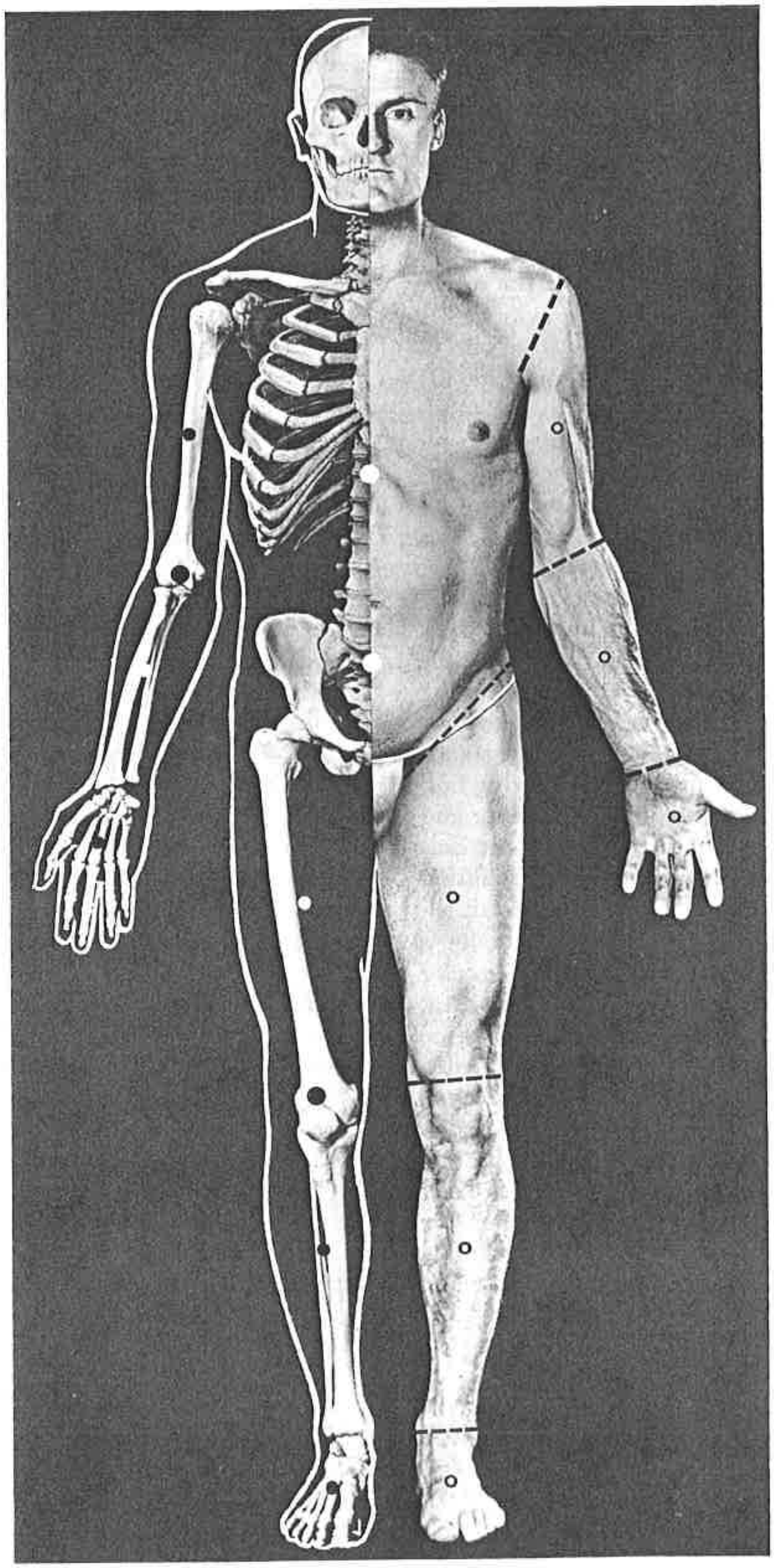

Fig. 2.11. Average weight of body segments for 150 pound man and percentage of total body weight; center of gravity loci (based on Dempster, *op. cit.,* pp. 129 to 135). Original data are on p. 135. Value for head weight was computed from Braune and Fischer's data. Center of gravity loci are from Dempster except those for entire limbs and body. (See opposite page.)

SEGMENT WEIGHTS AND PERCENTAGE OF TOTAL BODY WEIGHT FOR 150 POUND MAN.	LOCATION OF CENTERS OF GRAVITY
Head: 10.3 lb. (6.9%)	*Head.* In sphenoid sinus, 4 mm. beyond anterior inferior margin of sella. (On lateral surface, over temporal fossa on or near nasion-inion line).
Head and neck: 11.8 lb. (7.9%)	*Head and neck.* On inferior surface of basioccipital bone or within bone 23 ± 5 mm. from crest of dorsum sellae. (On lateral surface, 10 mm. anterior to supratragic notch above head of mandible.)
Head, neck and trunk: 88.5 lb. (59.0%)	*Head, neck and trunk.* Anterior to eleventh thoracic vertebra.
	UPPER LIMB. Just above elbow joint.
Arm: 4.1 lb. (2.7%)	*Arm.* In medial head of triceps, adjacent to radial groove; 5 mm. proximal to distal end of deltoid insertion.
Forearm: 2.4 lb. (1.6%)	*Forearm.* 11 mm. proximal to most distal part of pronator teres insertion; 9 mm. anterior to interosseus membrane.
Hand: 0.9 lb. (0.6%) *Upper limb:* 7.3 lb. (4.9%) *Forearm and hand:* 3.3 lb. (2.2%)	*Hand.* (in rest position). On axis of metacarpal III, usually 2 mm. deep to volar skin surface. 2 mm. proximal to proximal transverse palmar skin crease, in angle between proximal transverse and radial longitudinal crease.
	LOWER LIMB. Just above knee joint.
Thigh: 14.5 lb. (9.7%)	*Thigh.* In adductor brevis muscle (or magnus or vastus medialis) 13 mm. medial to linea aspera, deep to adductor canal. 29 mm. below apex of femoral triangle and 18 mm. proximal to most distal fibers of adductor brevis.
Leg: 6.8 lb. (4.5%)	*Leg.* 35 mm. below popliteus, at posterior part of posterior tibialis; 16 mm. above proximal end of Achilles tendon; 8 mm. posterior to interosseus membrane.
Foot: 2.1 lb. (1.4%) *Lower limb:* 23.4 lb. (15.6%) *Leg and foot:* 9.0 lb. (6.0%)	*Foot.* In plantar ligaments, or just superficial in adjacent deep foot muscles; below proximal halves of second and third cuneiform bones. On a line between ankle joint center and ball of foot in plane of metatarsal II.
	ENTIRE BODY. Anterior to second sacral vertebra.

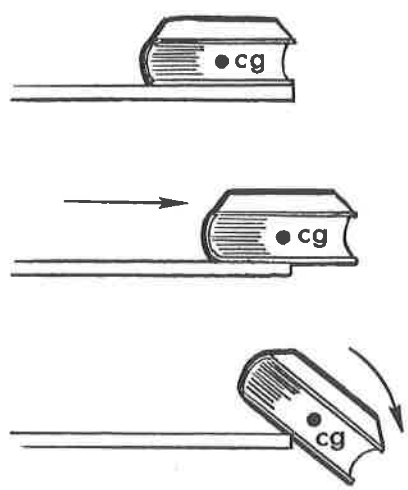

Fig. 2.12. Stability depends on relation of center of gravity to the base of support.

Another type of motor disability in which body balance plays a critical role is muscular dystrophy. In the absence of strength in trunk muscles, the patient arches his spine in an exaggerated lordosis and balances in the upright position. Since the slightest touch may disturb his precarious position, it may be best for the therapist not to attempt to assist him. Walking is slow, requiring a new delicately centered position of balance over each supporting foot after it has swung forward. Here the patient often holds the therapist's arm for support.[8]

Speed of movement is closely associated with requirements for balance. It is easier to balance on a bicycle when it is moving fast than when it is traveling slowly. In the same fashion, patients with a precarious sense of balance may

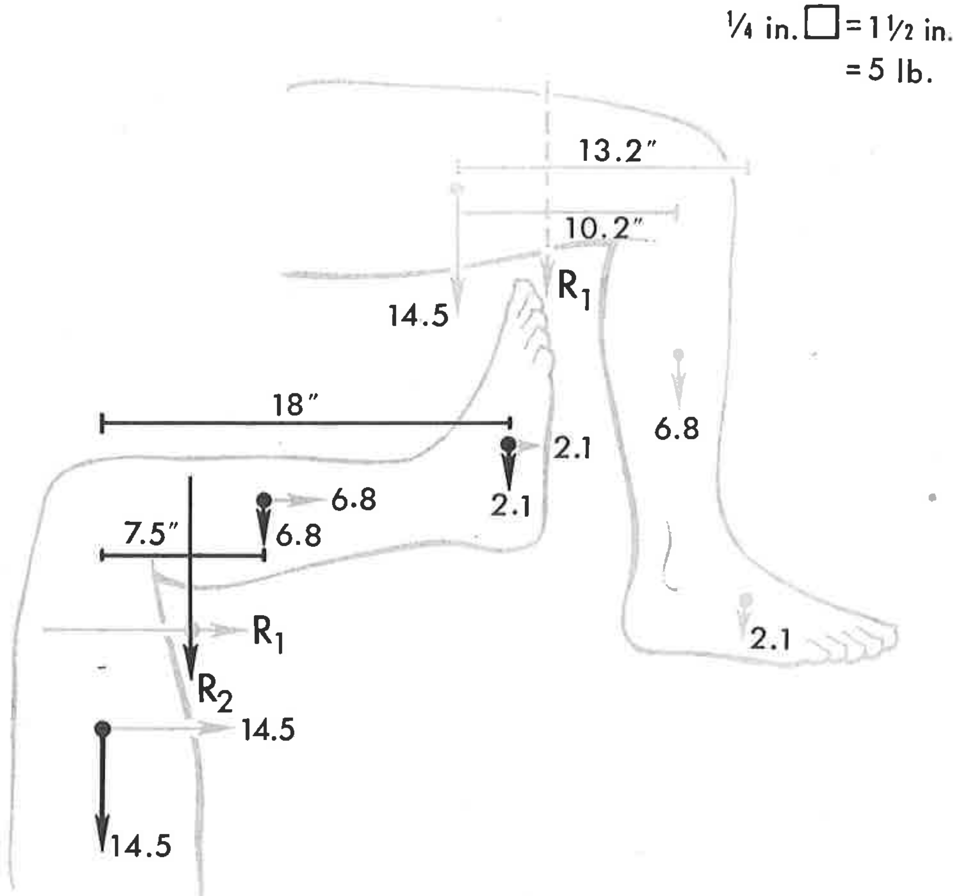

Fig. 5.35. Locating the center of gravity of the lower limb flexed to 90 degrees.

Table 5.1. LOCATING THE CENTER OF GRAVITY OF A FLEXED LOWER LIMB

		R_1		R_2	
SEGMENT	WEIGHT (LB.)	DISTANCE (IN.)	MOMENT (IN.-LB.)	DISTANCE (IN.)	MOMENT (IN.-LB.)
Thigh	14.5	0	0	0	0
Leg	6.8	10.2	69.4	7.5	51.0
Foot	2.1	13.2	27.7	18.0	37.8
	23.4		97.1		88.8

$R_1X = 97.1$ $\quad$ $R_2X = 88.8$
$23.4X = 97.1$ $\quad$ $23.4X = 88.8$
$X = 4.1$ in. $\quad$ $X = 3.8$ in.

3. Problem

Mr. X is seated with both arms flexed to 90 degrees (Fig. 5.36).

QUESTION. Find the center of gravity of the entire body when it is in this posture.

SOLUTION. Table 5.2 gives weights, distances, and tabulation of data in the solution of the problem. Our subject weighs 160 lb. Segment weights are shown in Figure 5.36. Since we

Table 5.2. LOCATING THE CENTER OF GRAVITY OF A SEATED SUBJECT

		R_1		R_2	
SEGMENT	WEIGHT (LB.)	DISTANCE (IN.)	MOMENT (IN.-LB.)	DISTANCE (IN.)	MOMENT (IN.-LB.)
Head and Trunk	98.4	0	0	0	0
Arm	8.6	6.7	57.6	−6.5	−55.9
Forearm	5.2	19.5	101.4	−8.0	−41.6
Hand	1.9	28.5	54.1	−9.0	−17.1
Lower Limb	45.9	13.0	596.7	+18.2	+835.4
	160.0		809.8		720.8

$R_1X = 809.8$ $\quad$ $R_2X = 720.8$
$160X = 809.8$ $\quad$ $160X = 720.8$
$X = 5.1$ in. $\quad$ $X = 4.5$ in.

are dealing with two limbs, we have doubled the weights. Drawing the figure on ¼ in. graph paper will help to give us the necessary distances to solve the problem. In the previous problem we determined a single center of gravity point for the lower limb in flexion, so we can make use of this point now. Remaining centers are for the three upper limb segments, and the head and trunk.

The student should experiment for himself with center of gravity determinations of the body and its segments.

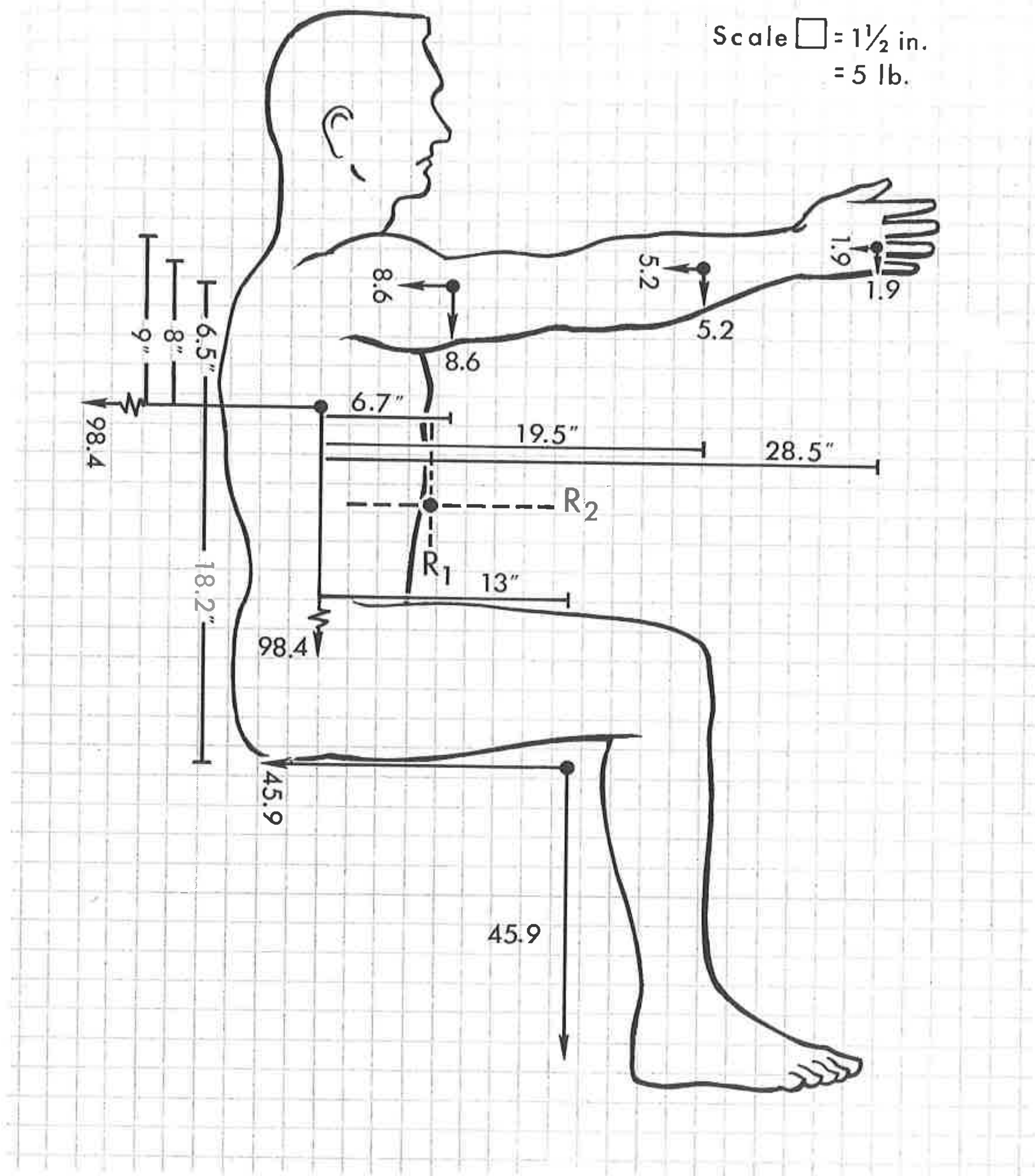

Fig. 5.36. Locating the center of gravity of a seated figure with arms flexed to horizontal.