LICENCIATURA EN FISICA MEDICA

BIOFISICA

CAPITULO 2

La Estática del Cuerpo Humano.

BIOFISICA

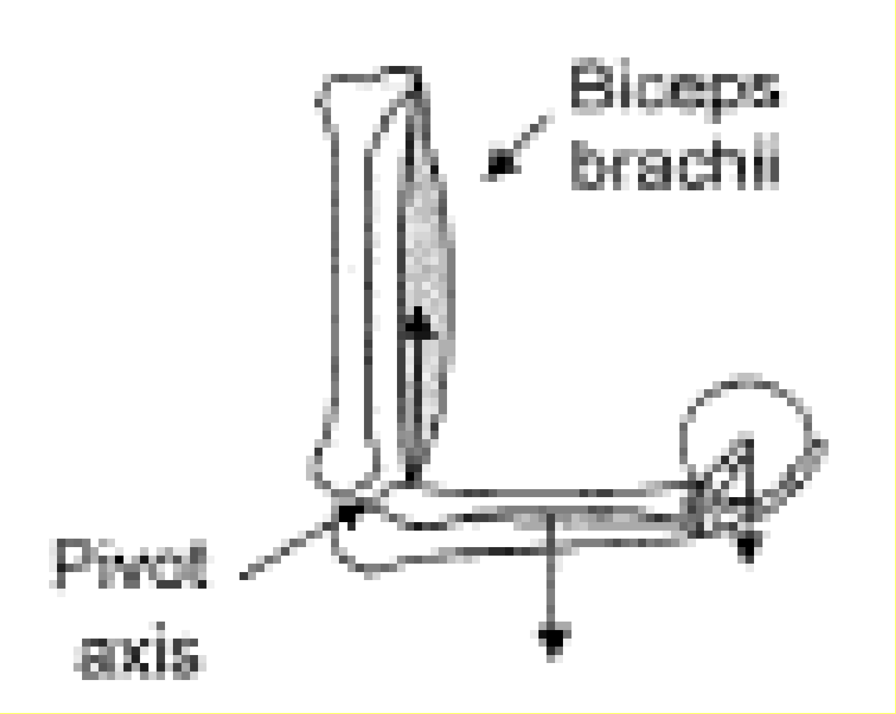
CAPITULO 2

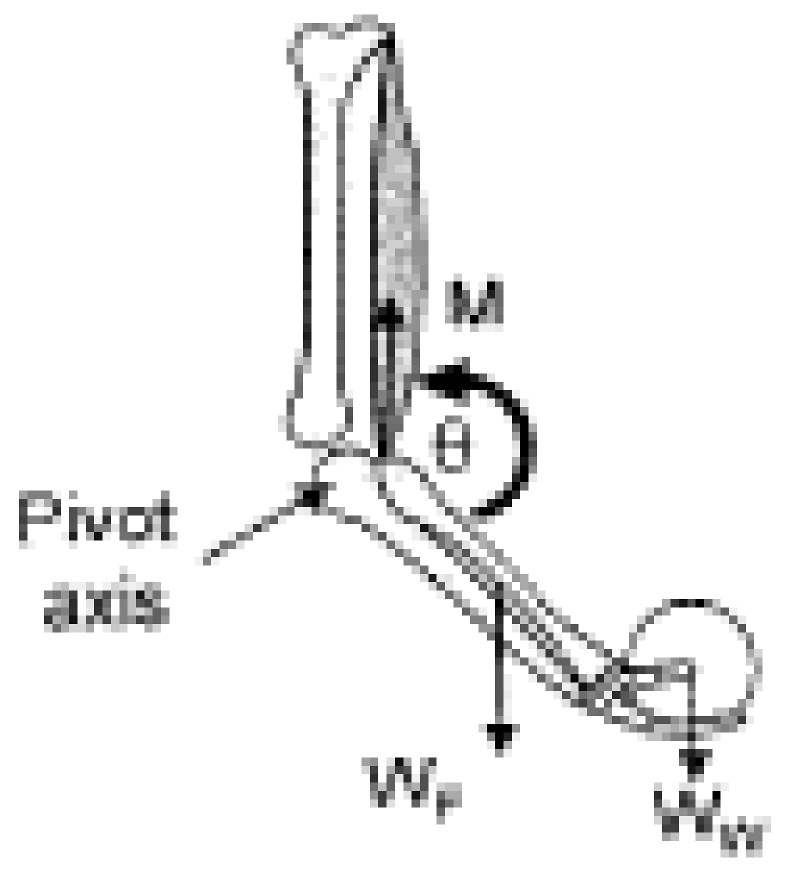
Fuerzas, Torques y Equilibrio

FUERZAS EN EQUILIBRIO

$$\sum F_x = 0, \qquad \sum F_y = 0, \qquad \sum F_z = 0.$$

TORQUES EN EQUILIBRIO I





TORQUES EN EQUILIBRIO II

$$\sum \tau_x = 0, \qquad \sum \tau_y = 0, \qquad \sum \tau_z = 0.$$

DIRECCIONES Y SIGNOS DE TORQUES

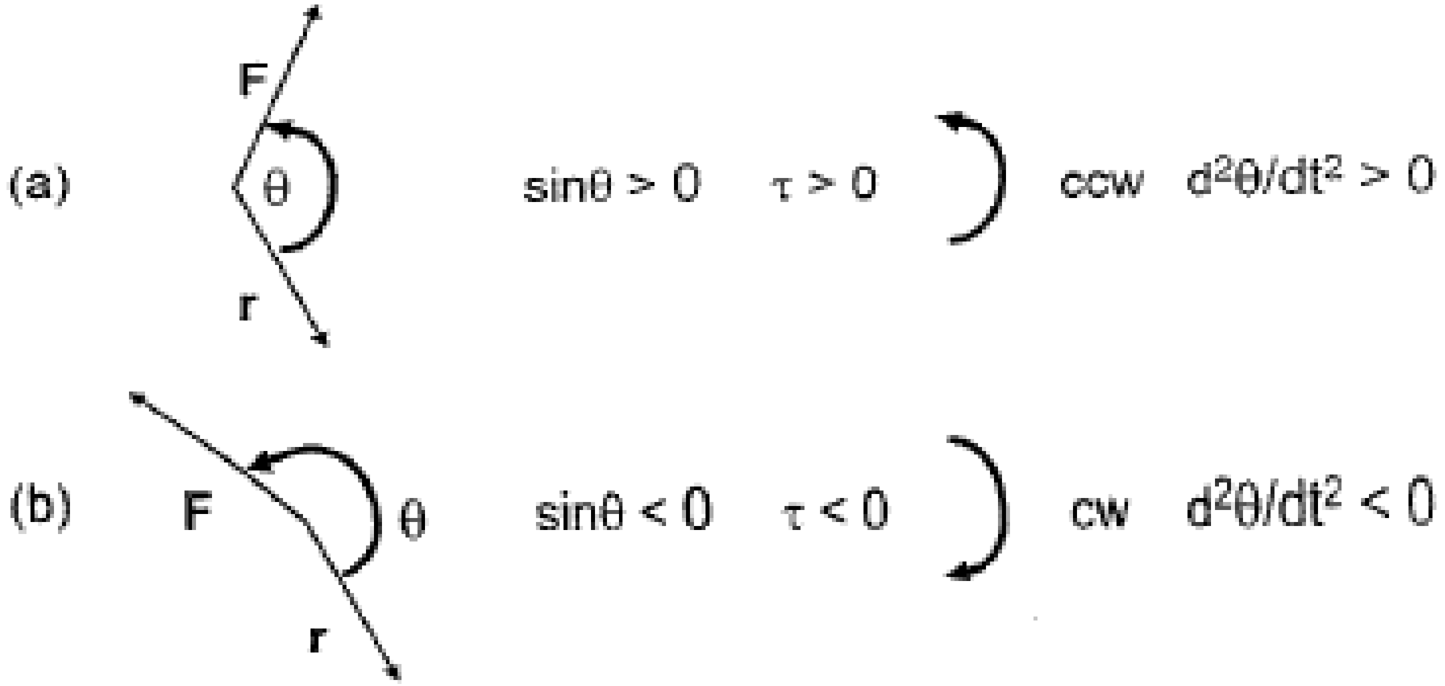
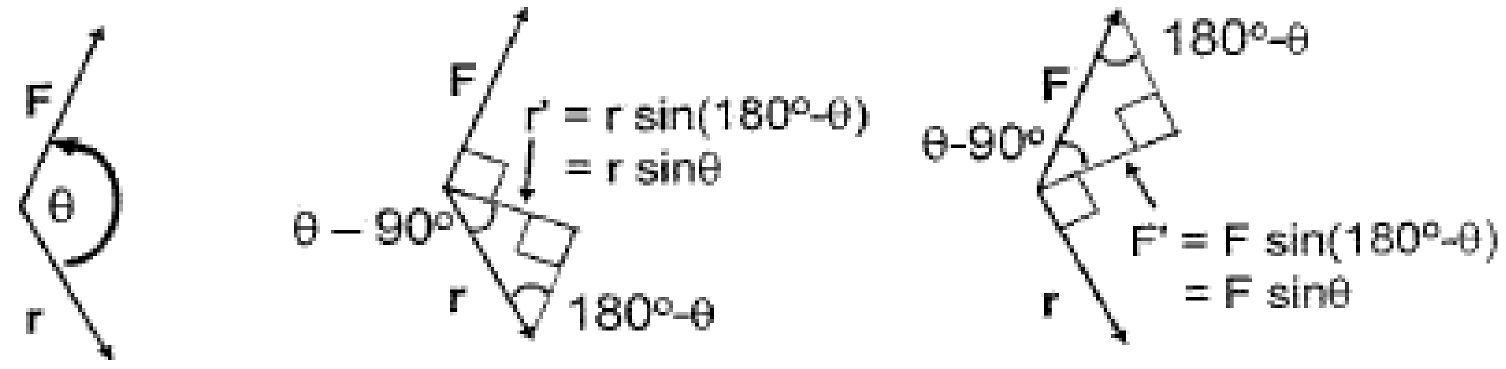


Fig. 2.2. Direction of torques, showing (a) positive and (b) negative torques

DETERMINANDO TORQUES



$$\tau = r\,F\sin\theta \quad = \quad r'F \quad = \quad rF'$$

Fig. 2.3. Determining torques from using components of the displacement and force vectors that are normal to the force and displacement vectors, respectively

FUERZA, MASA, ACELERACION Y CANTIDAD DE MOVIMIENTO LINEAL

$$\mathbf{F} = ma = m\frac{\mathrm{d}\mathrm{v}}{\mathrm{d}t} = \frac{\mathrm{d}\mathrm{p}}{\mathrm{d}t}$$

TORQUE, MOMENTO DE INERCIA, ACELERACION ANGULAR Y CANTIDAD DE MOVIMIENTO ANGULAR

$$\tau = I\frac{\mathrm{d}\Omega}{\mathrm{d}t} = \frac{\mathrm{d}L}{\mathrm{d}t}$$

LOS TRES TIPOS DE PALANCAS

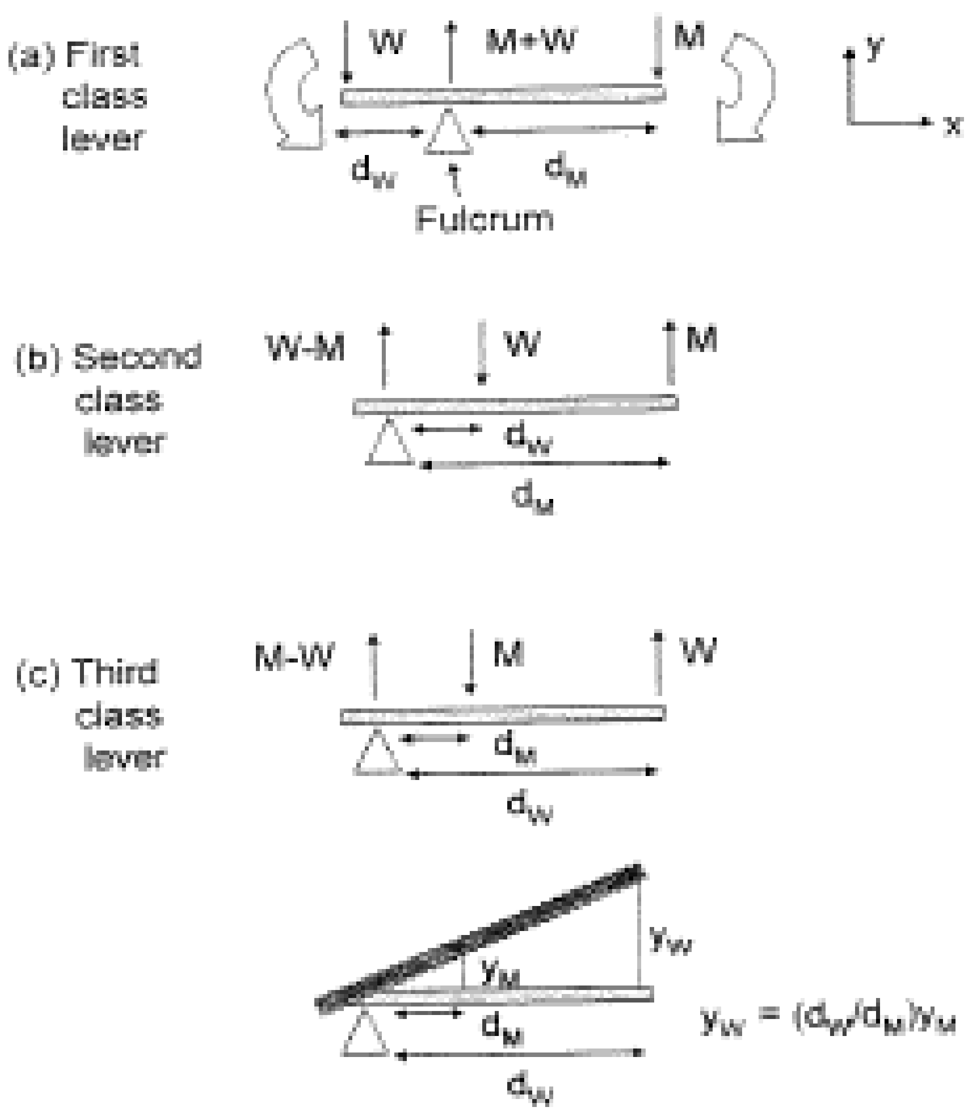


Fig. 2.4. Three types of levers, (a) first, (b) second, and (c) third class levers. The large increase in the distance the weight moves over the change in muscle length in the third class lever is also seen in part (c)

M: Fuerza muscular
W: Peso soportado

DETERMINACION DE LA FUERZA EQUILIBRANTE

$$\sum \tau_z = W d_W - M d_M = 0.$$

$$M d_M = W d_W ,$$

$$M = \boxed{\frac{d_W}{d_M}} W.$$

← Factor de Amplificación

CAMBIANDO EL EJE PARA CALCULAR EL TORQUE

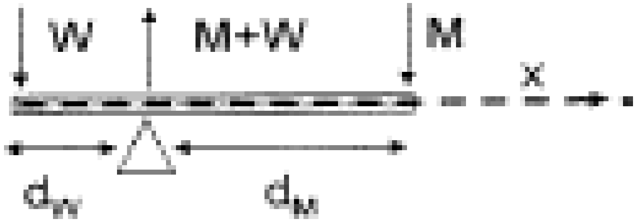
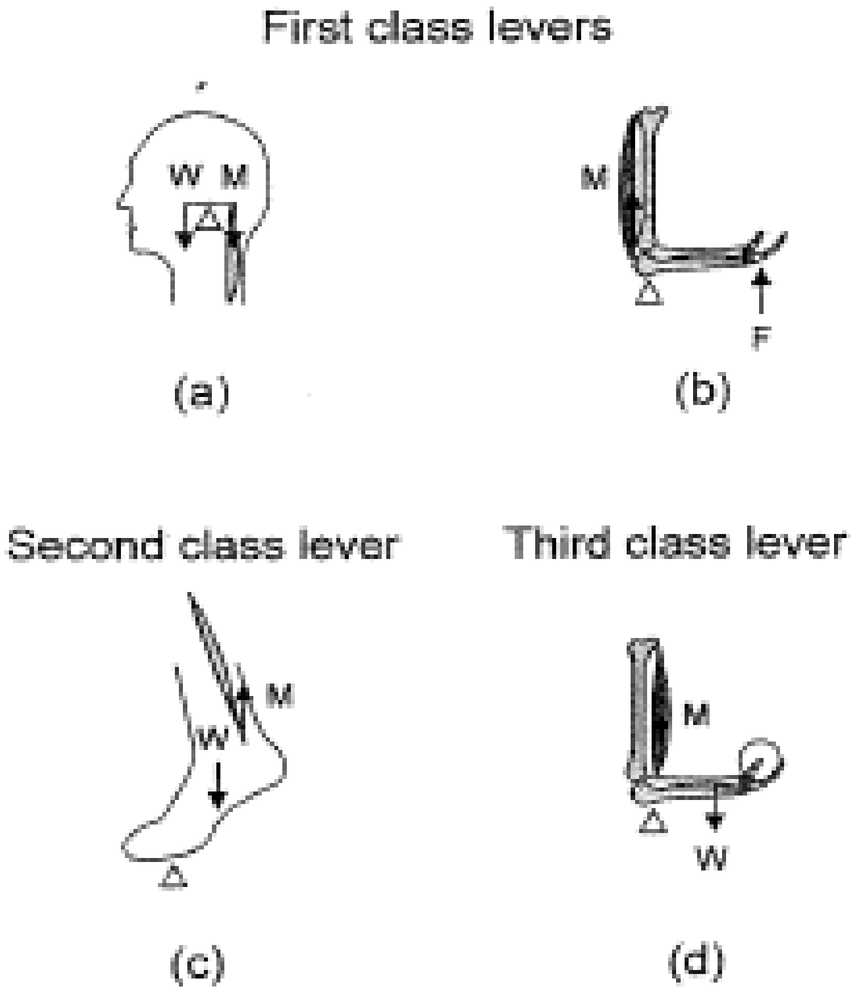


Fig. 2.5. Displacing the axis for calculating torques to the right of the weight by a distance x, as shown for a first class lever. For the axis chosen at the fulcrum $x = d_W$. The axis can be laterally displaced anywhere, to the left or right (as shown) of the lever, above or below it, or in it

$$\sum \tau_z = Wx + (W + M)(d_W - x) - M(d_W + d_M - x) = 0$$

LOS TRES TIPOS DE PALANCAS



First class levers

Second class lever

Third class lever

Fig. 2.6. Examples of first (a, b), second (c), and third (d) class levers in the body

BIOFISICA

CAPITULO 2

Análisis de Articulaciones

LA ARTICULACION DEL CODO II

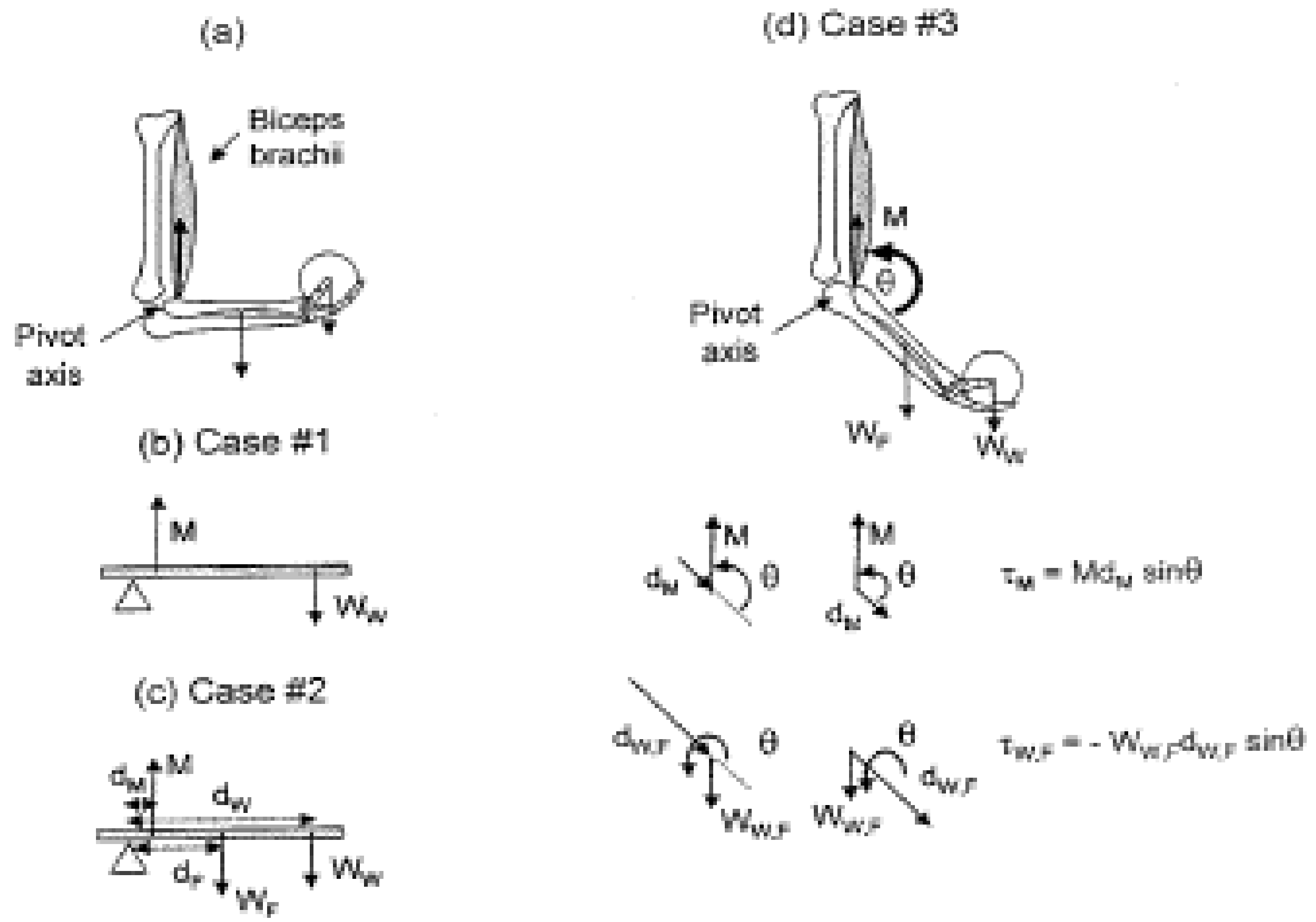
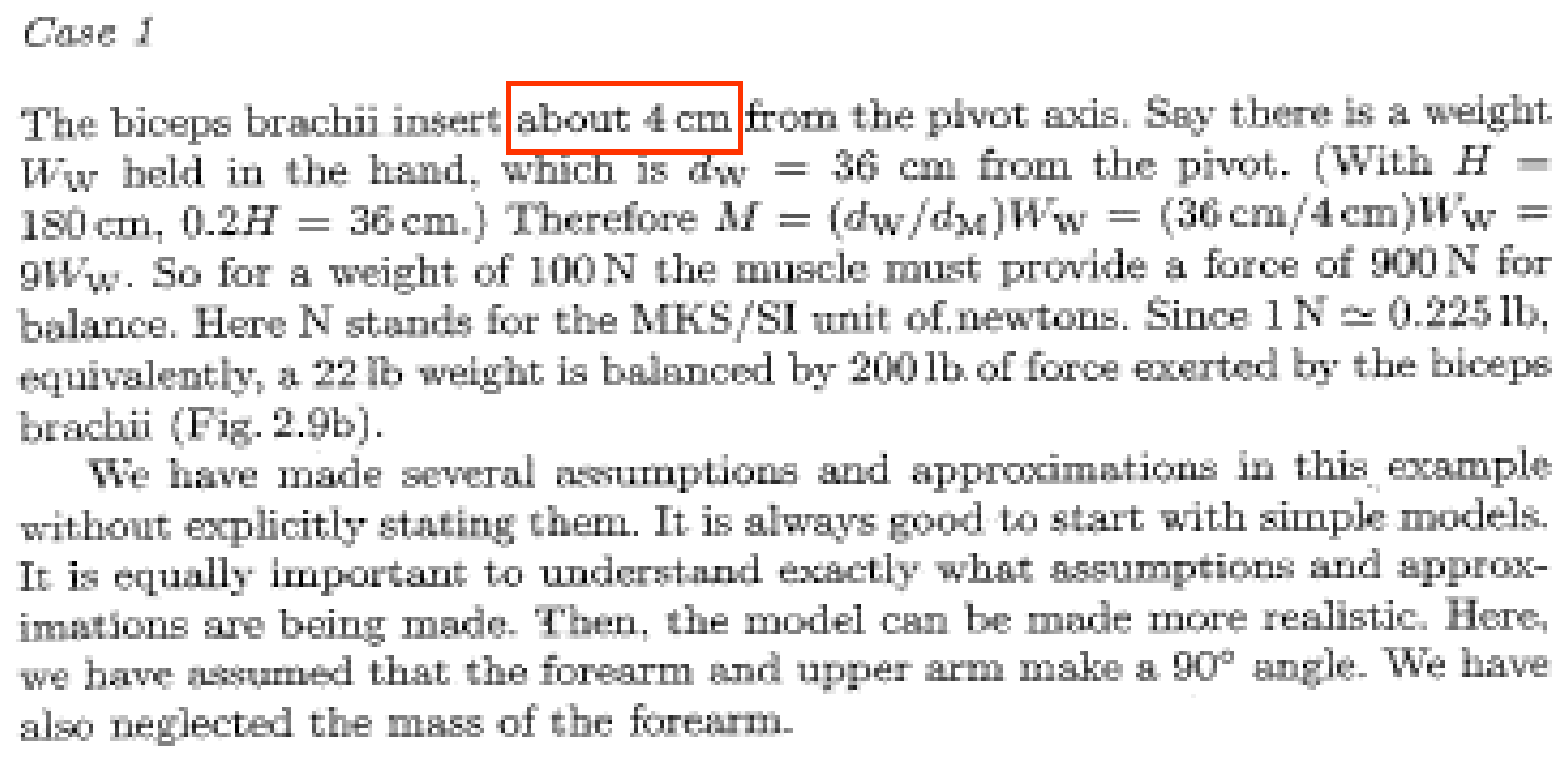


Fig. 2.9. (a) Weight held in the hand, showing the biceps brachii muscles. (b–d) Forces for the equilibrium of a weight held in the hand for Cases 1–3

LA ARTICULACION DEL CODO III



Case 1

The biceps brachii insert about 4 cm from the pivot axis. Say there is a weight W_W held in the hand, which is $d_W = 36$ cm from the pivot. (With $H = 180\,\text{cm}$, $0.2H = 36\,\text{cm}$.) Therefore $M = (d_W/d_M)W_W = (36\,\text{cm}/4\,\text{cm})W_W = 9W_W$. So for a weight of 100 N the muscle must provide a force of 900 N for balance. Here N stands for the MKS/SI unit of newtons. Since $1\,\text{N} \simeq 0.225\,\text{lb}$, equivalently, a 22 lb weight is balanced by 200 lb of force exerted by the biceps brachii (Fig. 2.9b).

We have made several assumptions and approximations in this example without explicitly stating them. It is always good to start with simple models. It is equally important to understand exactly what assumptions and approximations are being made. Then, the model can be made more realistic. Here, we have assumed that the forearm and upper arm make a 90° angle. We have also neglected the mass of the forearm.

LONGITUDES DE SEGMENTOS

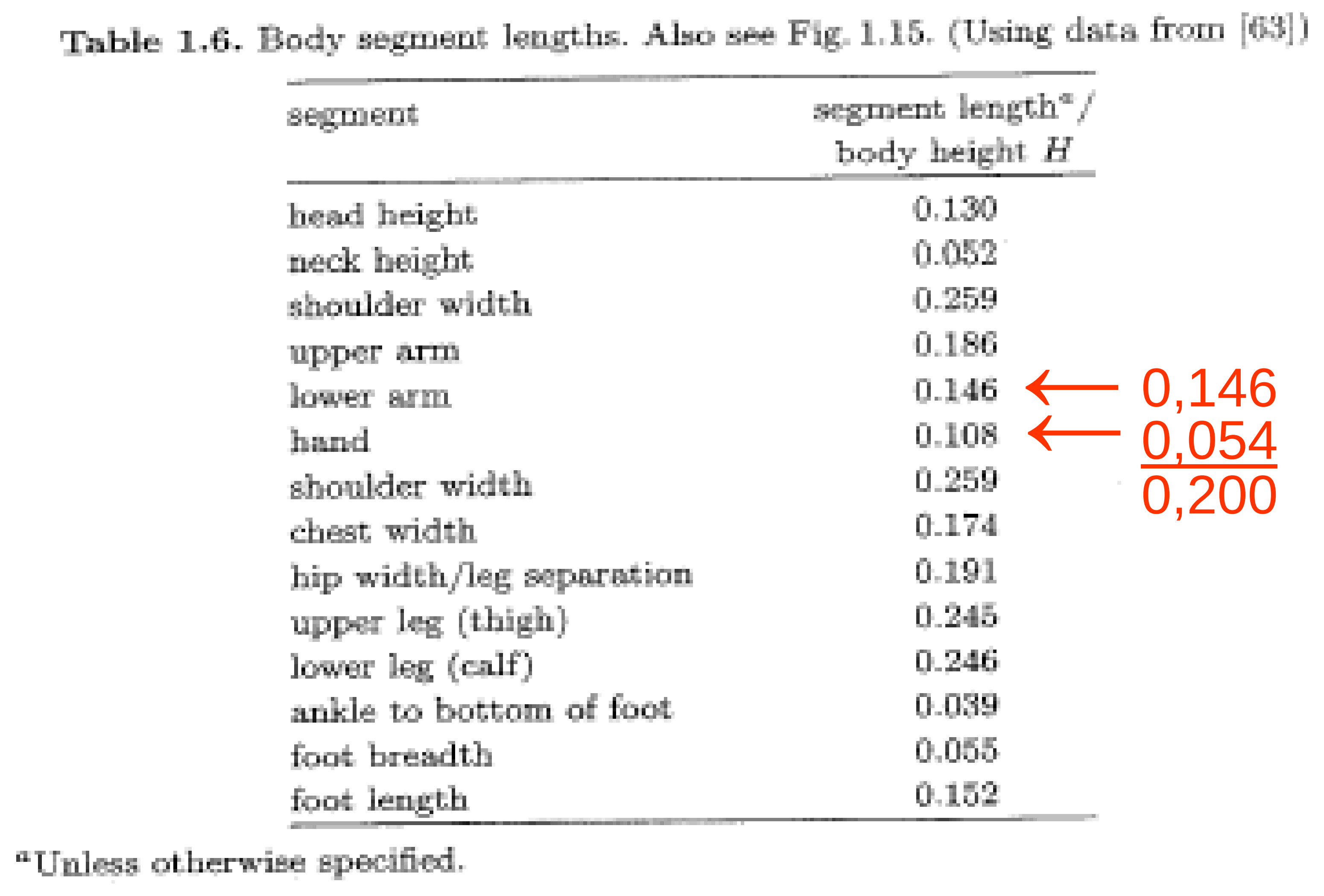


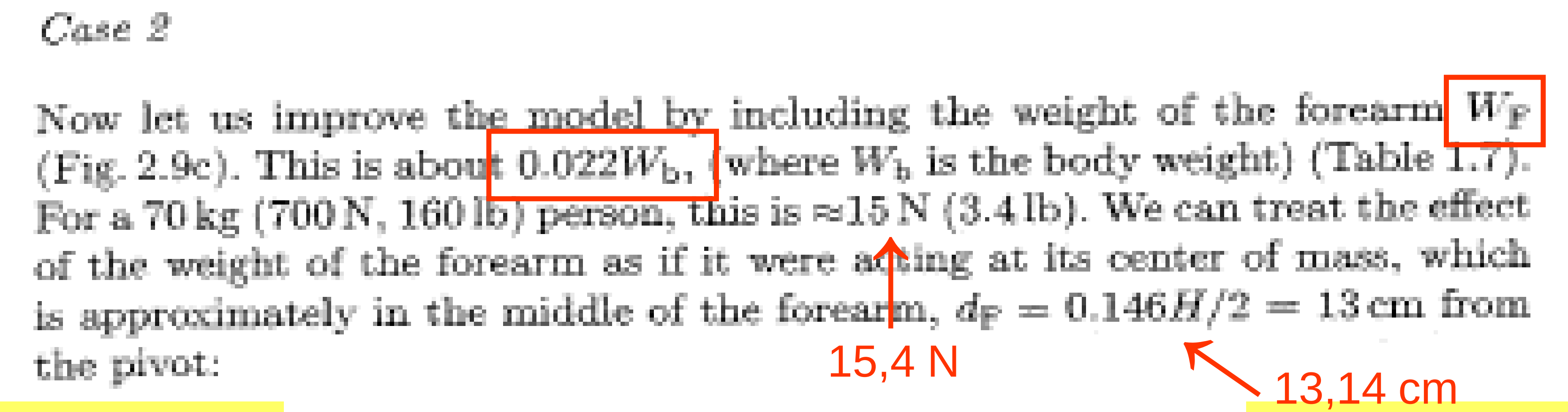
Table 1.6. Body segment lengths. Also see Fig. 1.15. (Using data from [63])

segment	segment length[a] / body height H
head height	0.130
neck height	0.052
shoulder width	0.259
upper arm	0.186
lower arm	0.146
hand	0.108
shoulder width	0.259
chest width	0.174
hip width/leg separation	0.191
upper leg (thigh)	0.245
lower leg (calf)	0.246
ankle to bottom of foot	0.039
foot breadth	0.055
foot length	0.152

[a] Unless otherwise specified.

← 0,146
← 0,054
0,200

LA ARTICULACION DEL CODO IV

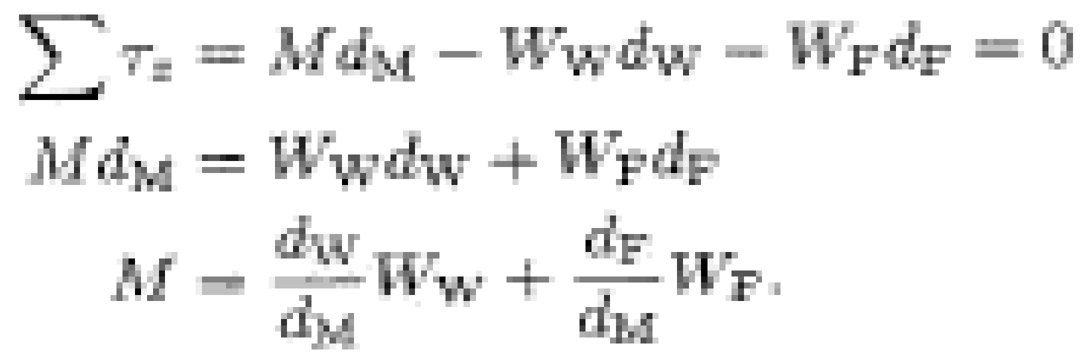


Case 2

Now let us improve the model by including the weight of the forearm $\boxed{W_F}$ (Fig. 2.9c). This is about $\boxed{0.022W_b,}$ (where W_b is the body weight) (Table 1.7). For a 70 kg (700 N, 160 lb) person, this is ≈15 N (3.4 lb). We can treat the effect of the weight of the forearm as if it were acting at its center of mass, which is approximately in the middle of the forearm, $d_F = 0.146H/2 = 13$ cm from the pivot:

15,4 N

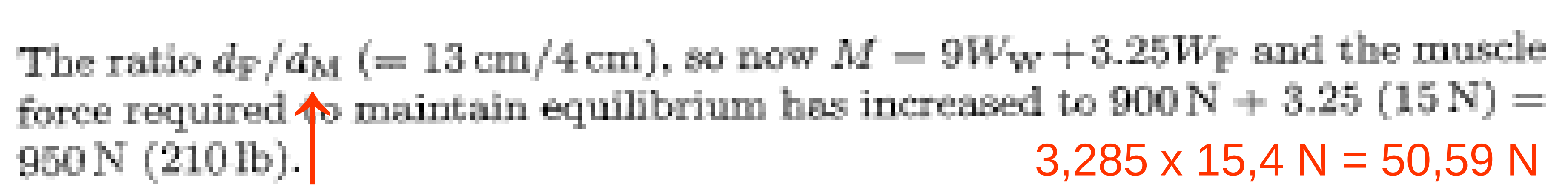
13,14 cm



$$\sum \tau_z = Md_M - W_W d_W - W_F d_F = 0$$

$$Md_M = W_W d_W + W_F d_F$$

$$M = \frac{d_W}{d_M} W_W + \frac{d_F}{d_M} W_F .$$



The ratio d_F/d_M (= 13 cm/4 cm), so now $M = 9W_W + 3.25W_F$ and the muscle force required to maintain equilibrium has increased to 900 N + 3.25 (15 N) = 950 N (210 lb).

3,285 x 15,4 N = 50,59 N

13,14 cm/<u>4cm</u> = 3,285

MASAS Y DENSIDADES
DE LOS SEGMENTOS

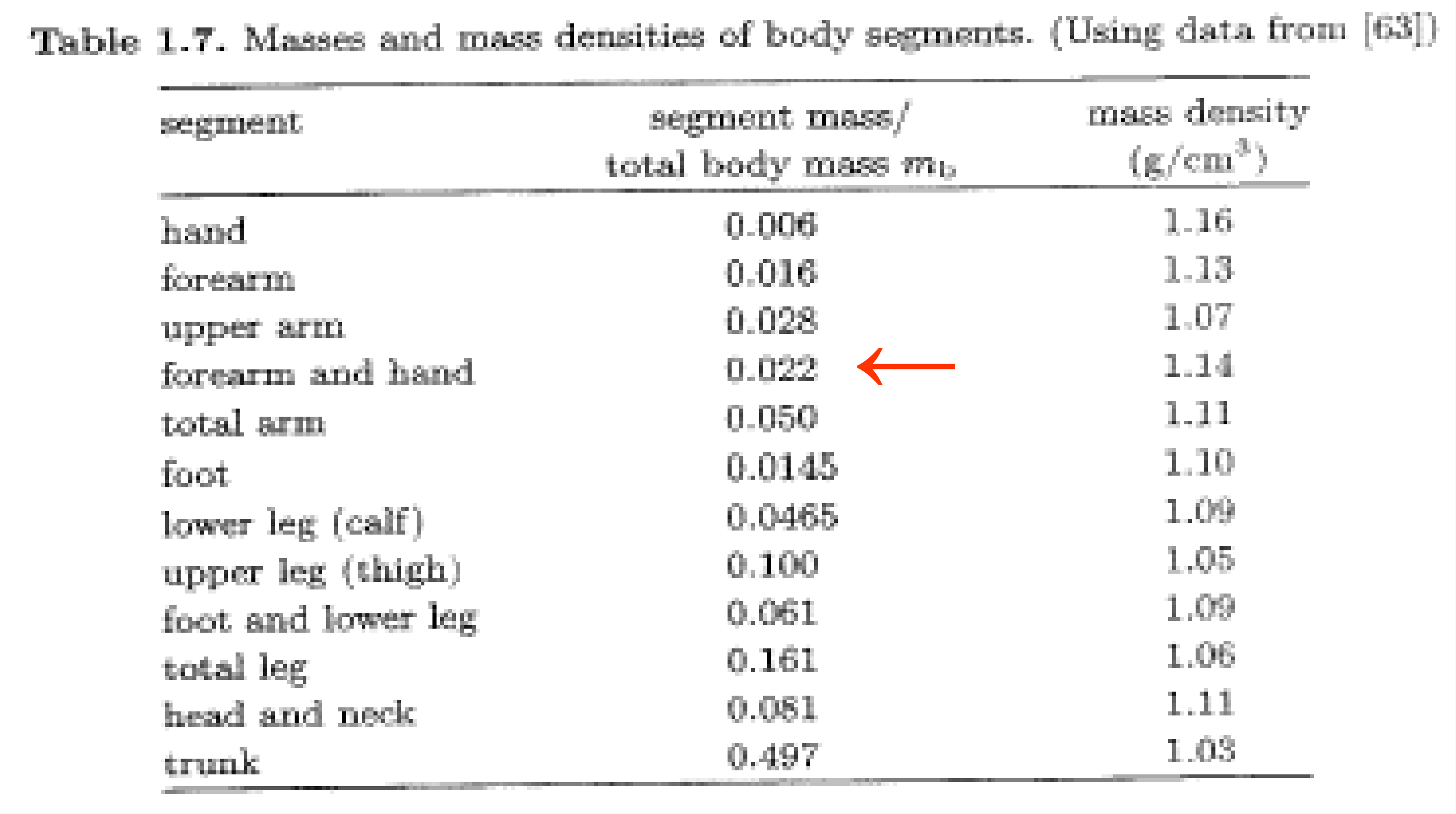
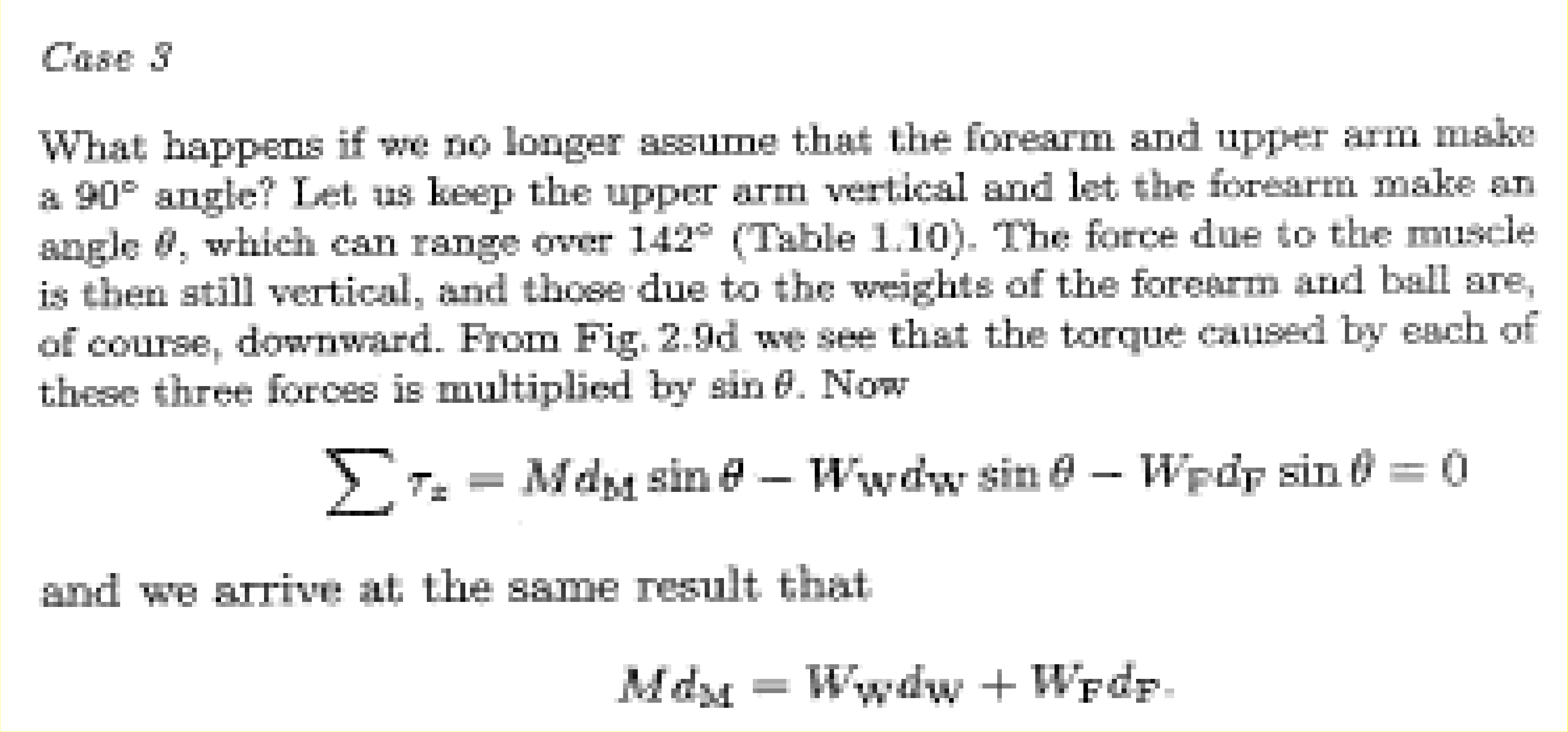


Table 1.7. Masses and mass densities of body segments. (Using data from [63])

segment	segment mass/ total body mass m_b	mass density (g/cm^3)
hand	0.006	1.16
forearm	0.016	1.13
upper arm	0.028	1.07
forearm and hand	0.022 ←	1.14
total arm	0.050	1.11
foot	0.0145	1.10
lower leg (calf)	0.0465	1.09
upper leg (thigh)	0.100	1.05
foot and lower leg	0.061	1.09
total leg	0.161	1.06
head and neck	0.081	1.11
trunk	0.497	1.03

LA ARTICULACION DEL CODO V



Case 3

What happens if we no longer assume that the forearm and upper arm make a 90° angle? Let us keep the upper arm vertical and let the forearm make an angle θ, which can range over 142° (Table 1.10). The force due to the muscle is then still vertical, and those due to the weights of the forearm and ball are, of course, downward. From Fig. 2.9d we see that the torque caused by each of these three forces is multiplied by $\sin\theta$. Now

$$\sum \tau_z = M d_{\mathrm{M}} \sin\theta - W_{\mathrm{W}} d_{\mathrm{W}} \sin\theta - W_{\mathrm{F}} d_{\mathrm{F}} \sin\theta = 0$$

and we arrive at the same result that

$$M d_{\mathrm{M}} = W_{\mathrm{W}} d_{\mathrm{W}} + W_{\mathrm{F}} d_{\mathrm{F}}.$$

LA ARTICULACION DEL CODO VI

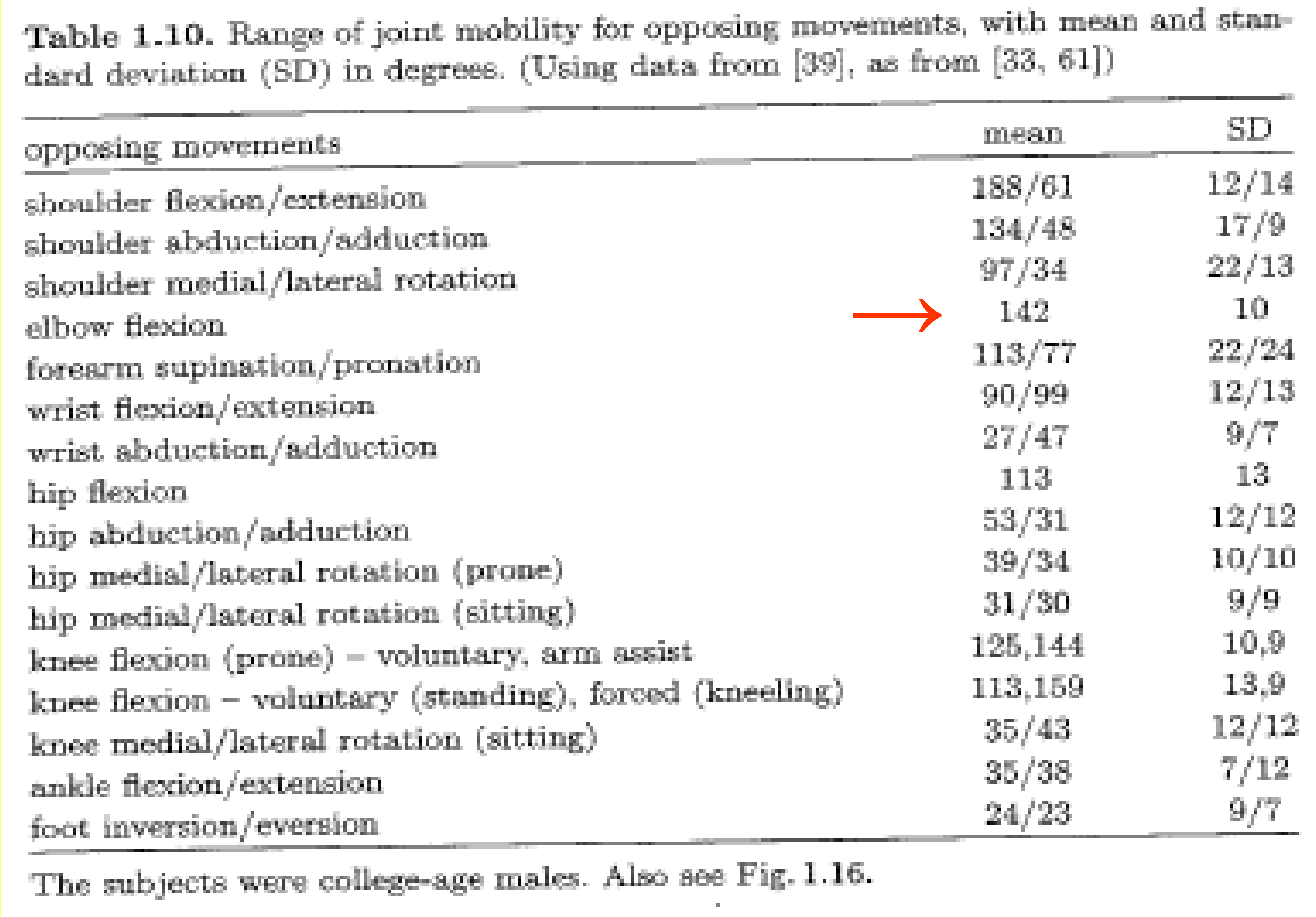


Table 1.10. Range of joint mobility for opposing movements, with mean and standard deviation (SD) in degrees. (Using data from [39], as from [33, 61])

opposing movements	mean	SD
shoulder flexion/extension	188/61	12/14
shoulder abduction/adduction	134/48	17/9
shoulder medial/lateral rotation	97/34	22/13
elbow flexion	142	10
forearm supination/pronation	113/77	22/24
wrist flexion/extension	90/99	12/13
wrist abduction/adduction	27/47	9/7
hip flexion	113	13
hip abduction/adduction	53/31	12/12
hip medial/lateral rotation (prone)	39/34	10/10
hip medial/lateral rotation (sitting)	31/30	9/9
knee flexion (prone) – voluntary, arm assist	125,144	10,9
knee flexion – voluntary (standing), forced (kneeling)	113,159	13,9
knee medial/lateral rotation (sitting)	35/43	12/12
ankle flexion/extension	35/38	7/12
foot inversion/eversion	24/23	9/7

The subjects were college-age males. Also see Fig. 1.16.

LA ARTICULACION DEL CODO VII

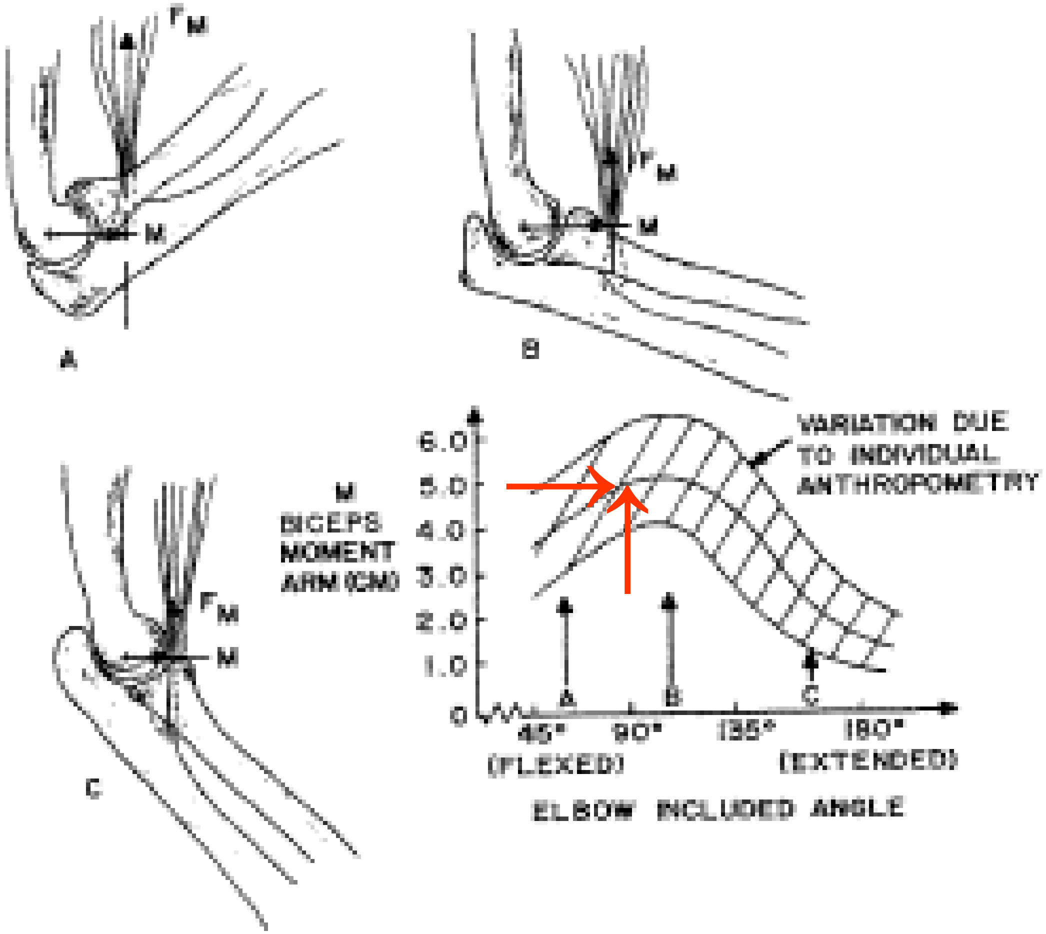
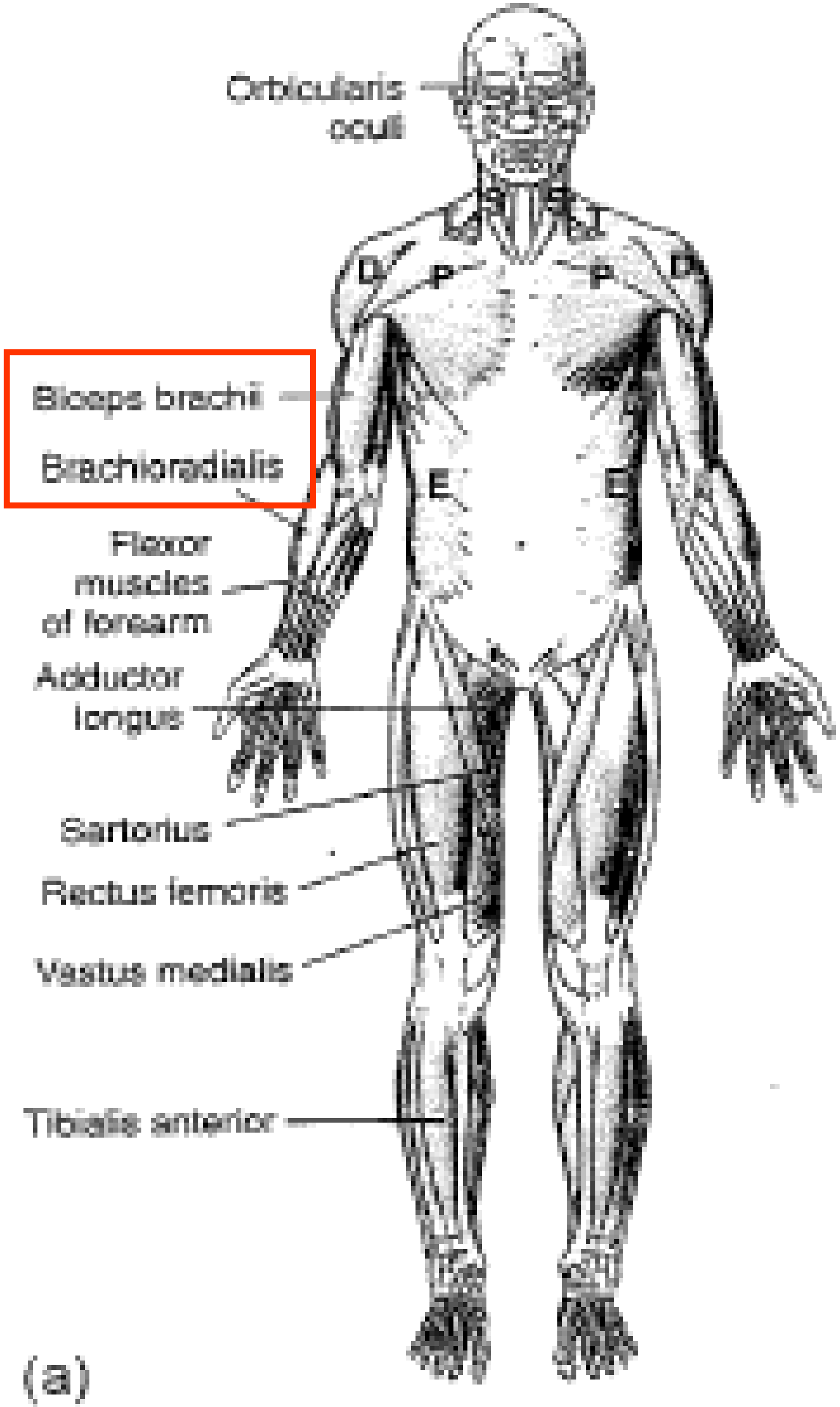


Fig. 3.42. Variation of the moment arm of biceps brachii vs. elbow angle. (From [113]. Reprinted with permission of Wiley)

(1984)



LA ARTICULACION DEL CODO VIII

LA ARTICULACION DEL CODO IX

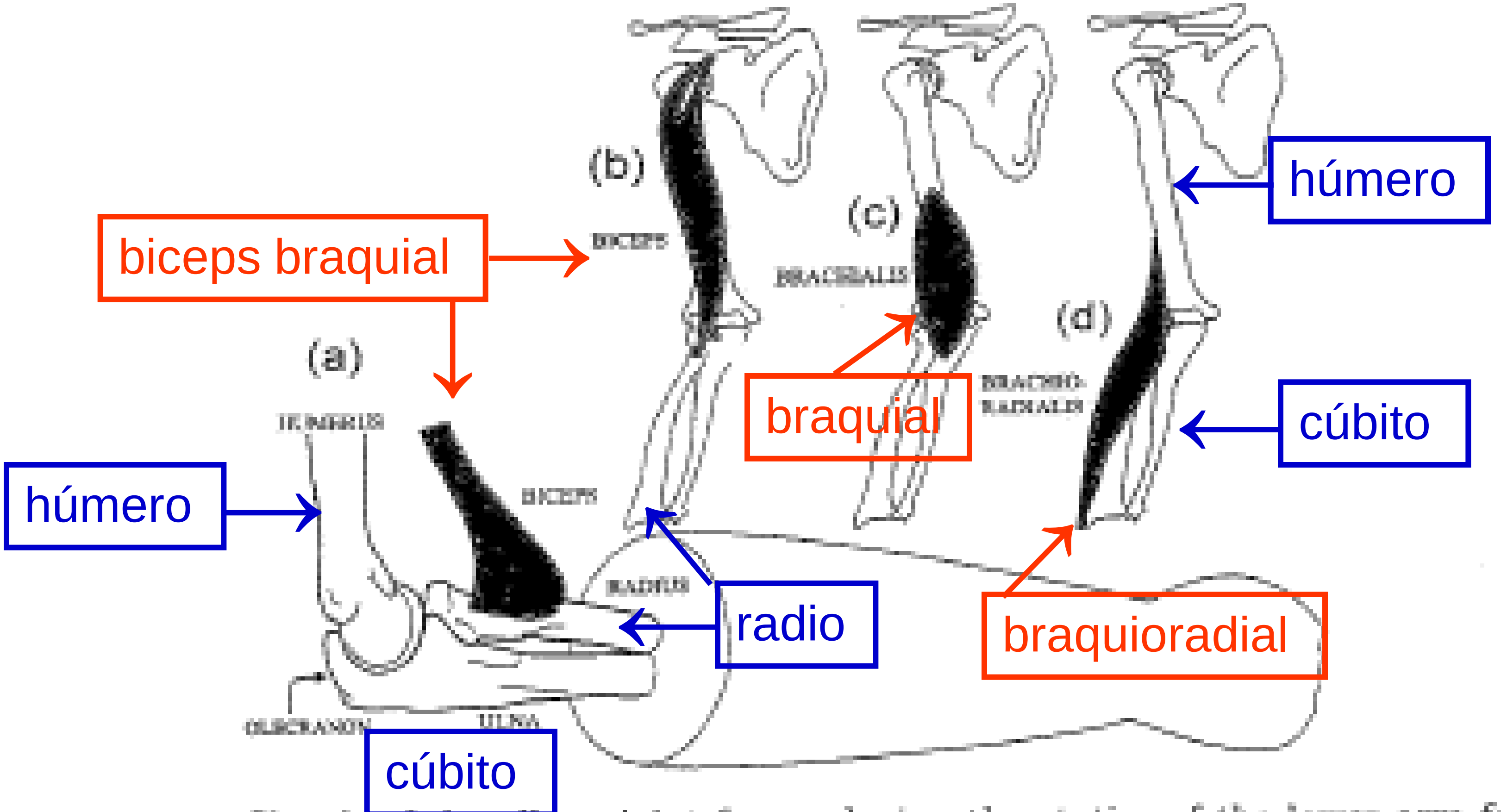
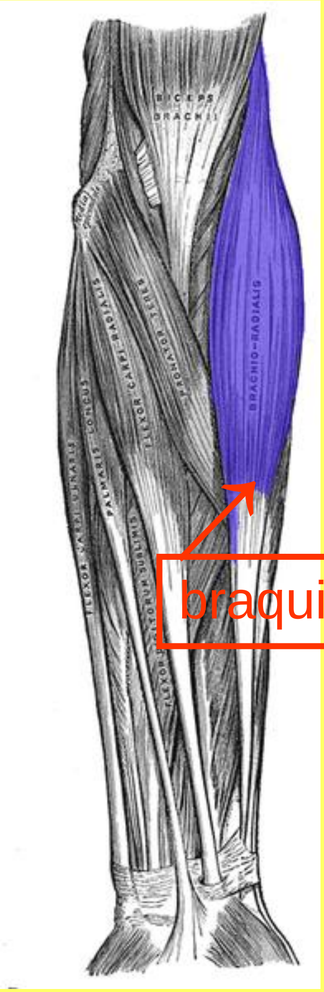
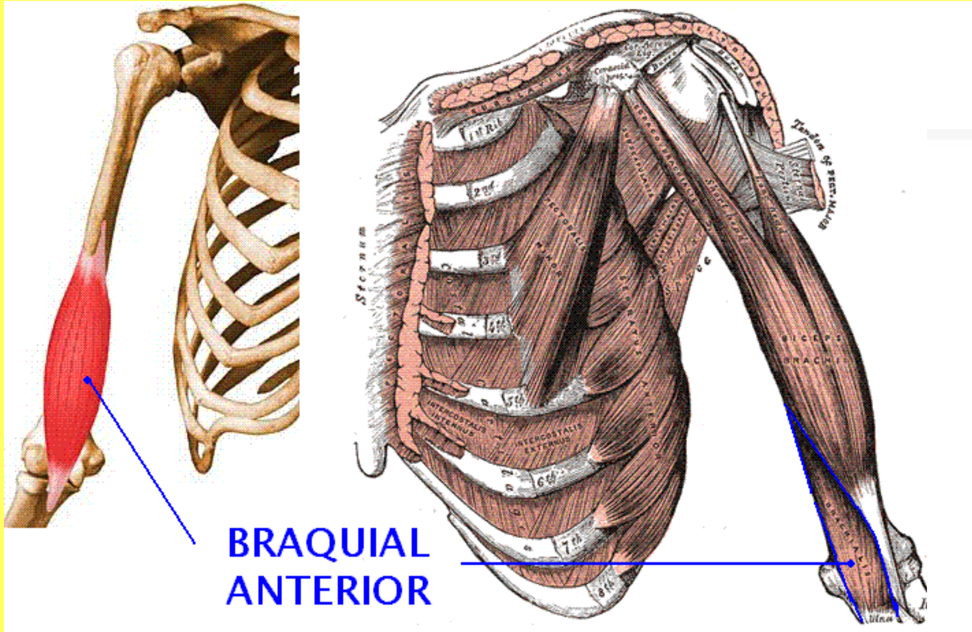


Fig. 2.10. Sketch of the elbow joint for analyzing the statics of the lower arm for Case 4, with the three muscles, the biceps (brachii), brachialis, and brachioradialis, shown in (b–d). (From [76])(1998)

LA ARTICULACION DEL CODO IX

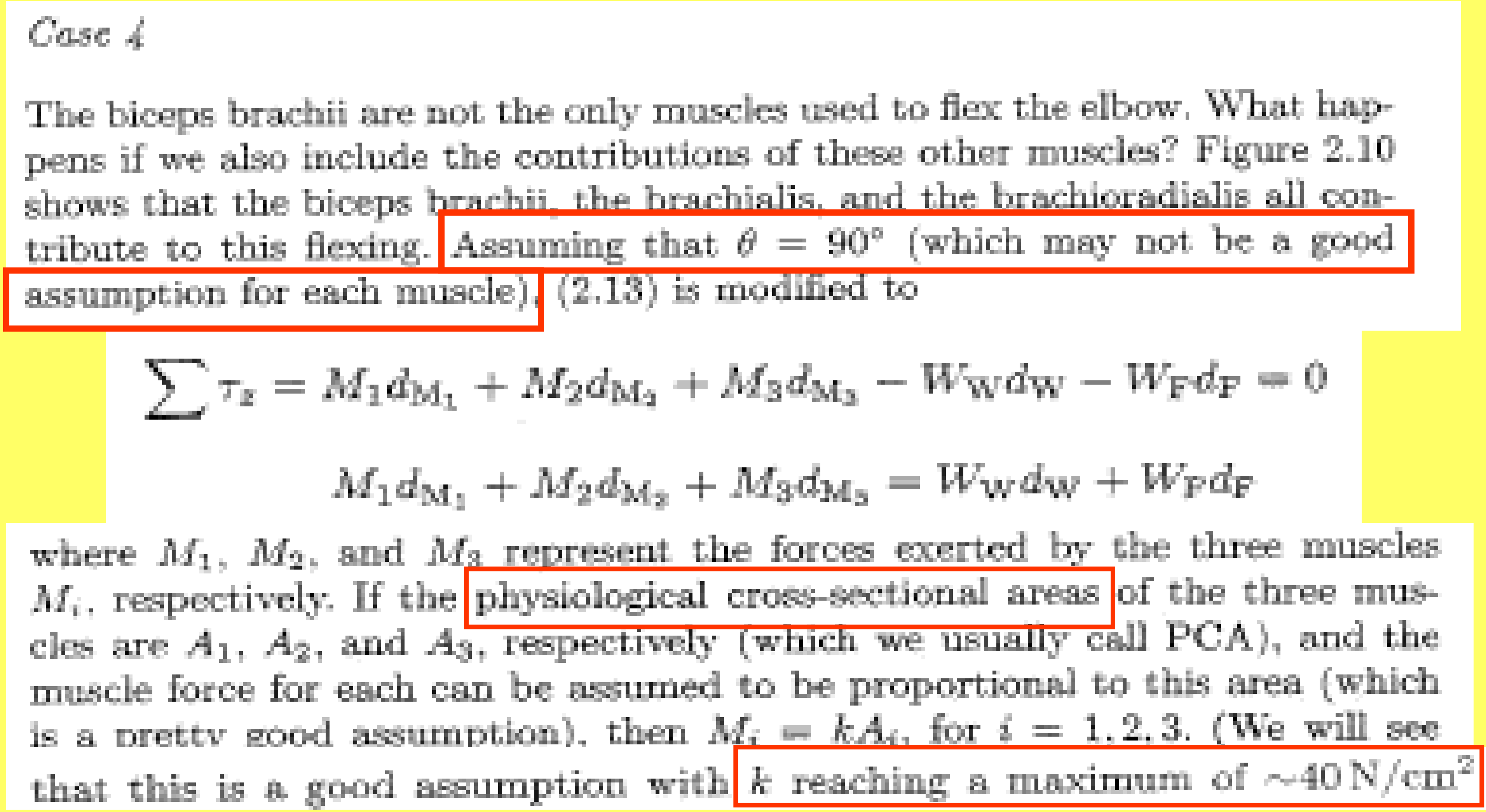


braquioradial



biceps braquial

LA ARTICULACION DEL CODO X



Case 4

The biceps brachii are not the only muscles used to flex the elbow. What happens if we also include the contributions of these other muscles? Figure 2.10 shows that the biceps brachii, the brachialis, and the brachioradialis all contribute to this flexing. Assuming that $\theta = 90°$ (which may not be a good assumption for each muscle), (2.13) is modified to

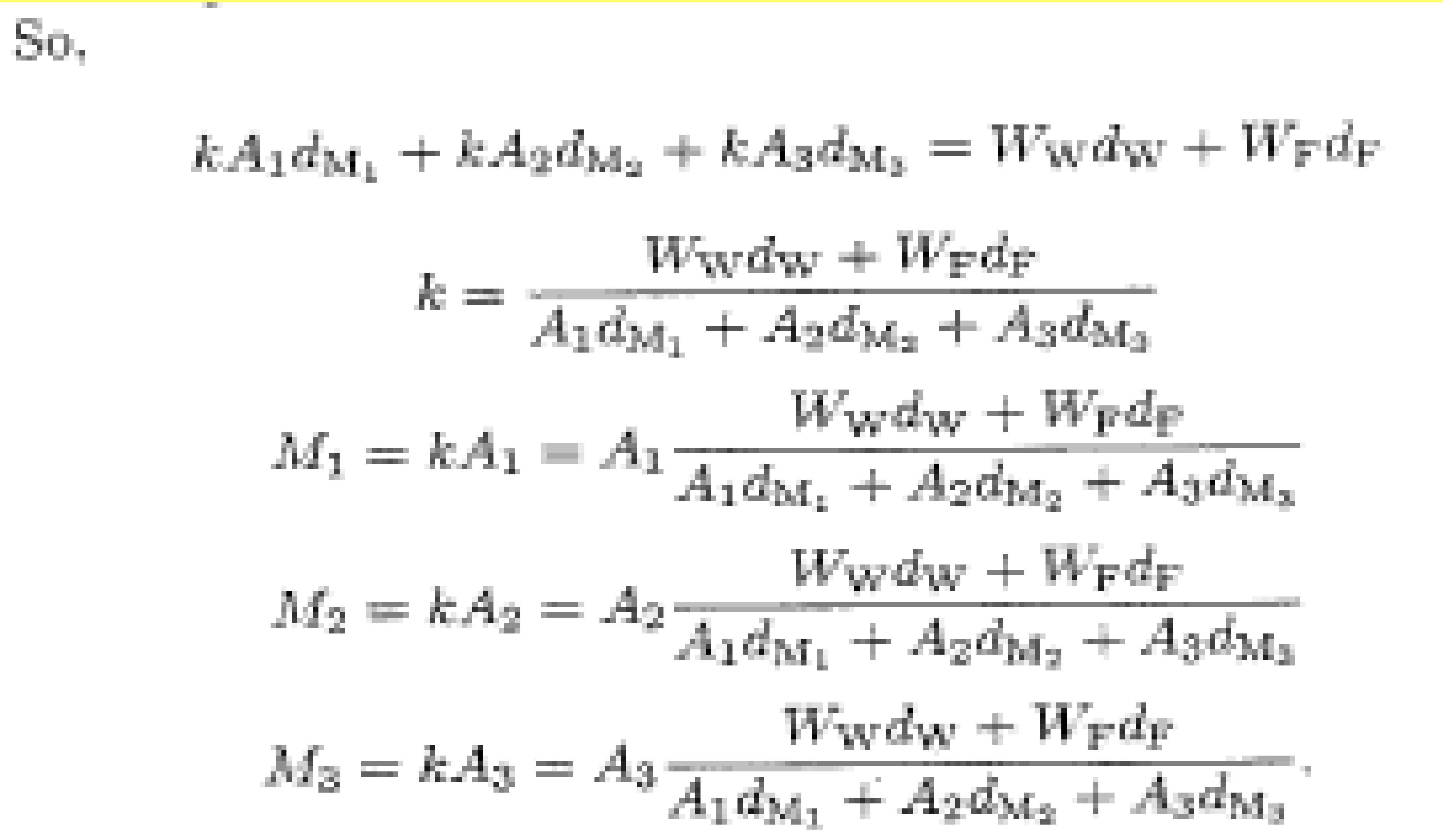
$$\sum \tau_z = M_1 d_{M_1} + M_2 d_{M_2} + M_3 d_{M_3} - W_W d_W - W_F d_F = 0$$

$$M_1 d_{M_1} + M_2 d_{M_2} + M_3 d_{M_3} = W_W d_W + W_F d_F$$

where M_1, M_2, and M_3 represent the forces exerted by the three muscles M_i, respectively. If the physiological cross-sectional areas of the three muscles are A_1, A_2, and A_3, respectively (which we usually call PCA), and the muscle force for each can be assumed to be proportional to this area (which is a pretty good assumption), then $M_i = kA_i$, for $i = 1, 2, 3$. (We will see that this is a good assumption with k reaching a maximum of $\sim 40\ \mathrm{N/cm^2}$

PCA ≡ Area de la Sección Fisiológica Muscular

LA ARTICULACION DEL CODO XI



So,

$$kA_1d_{M_1} + kA_2d_{M_2} + kA_3d_{M_3} = W_Wd_W + W_Fd_F$$

$$k = \frac{W_Wd_W + W_Fd_F}{A_1d_{M_1} + A_2d_{M_2} + A_3d_{M_3}}$$

$$M_1 = kA_1 = A_1\frac{W_Wd_W + W_Fd_F}{A_1d_{M_1} + A_2d_{M_2} + A_3d_{M_3}}$$

$$M_2 = kA_2 = A_2\frac{W_Wd_W + W_Fd_F}{A_1d_{M_1} + A_2d_{M_2} + A_3d_{M_3}}$$

$$M_3 = kA_3 = A_3\frac{W_Wd_W + W_Fd_F}{A_1d_{M_1} + A_2d_{M_2} + A_3d_{M_3}}.$$

LA ARTICULACION DEL CODO XII

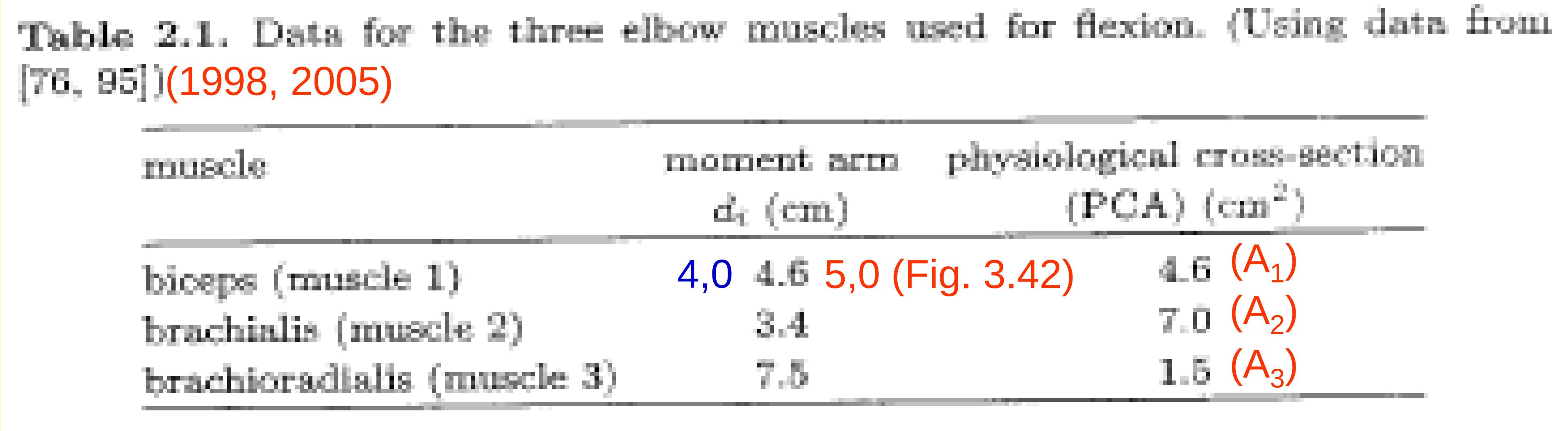
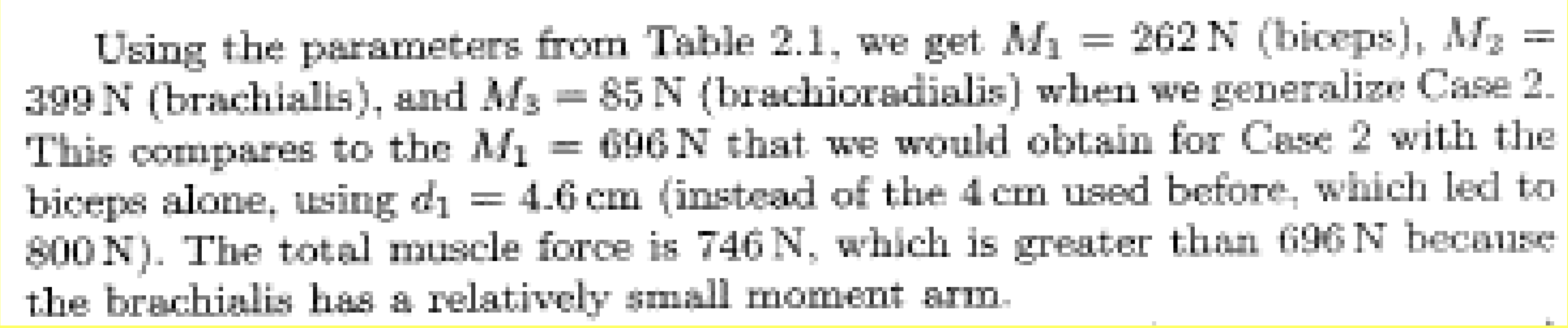


Table 2.1. Data for the three elbow muscles used for flexion. (Using data from [76, 95])(1998, 2005)

muscle	moment arm d_i (cm)	physiological cross-section (PCA) (cm^2)
biceps (muscle 1)	4,0 4.6 5,0 (Fig. 3.42)	4.6 (A_1)
brachialis (muscle 2)	3.4	7.0 (A_2)
brachioradialis (muscle 3)	7.5	1.5 (A_3)

4,0 Primera suposición
4,6 (1998, 2005)
5,0 (1984)

LA ARTICULACION DEL CODO XIII



Using the parameters from Table 2.1, we get $M_1 = 262\,\mathrm{N}$ (biceps), $M_2 = 399\,\mathrm{N}$ (brachialis), and $M_3 = 85\,\mathrm{N}$ (brachioradialis) when we generalize Case 2. This compares to the $M_1 = 696\,\mathrm{N}$ that we would obtain for Case 2 with the biceps alone, using $d_1 = 4.6\,\mathrm{cm}$ (instead of the 4 cm used before, which led to 800 N). The total muscle force is 746 N, which is greater than 696 N because the brachialis has a relatively small moment arm.

LA ARTICULACION DE LA CADERA II

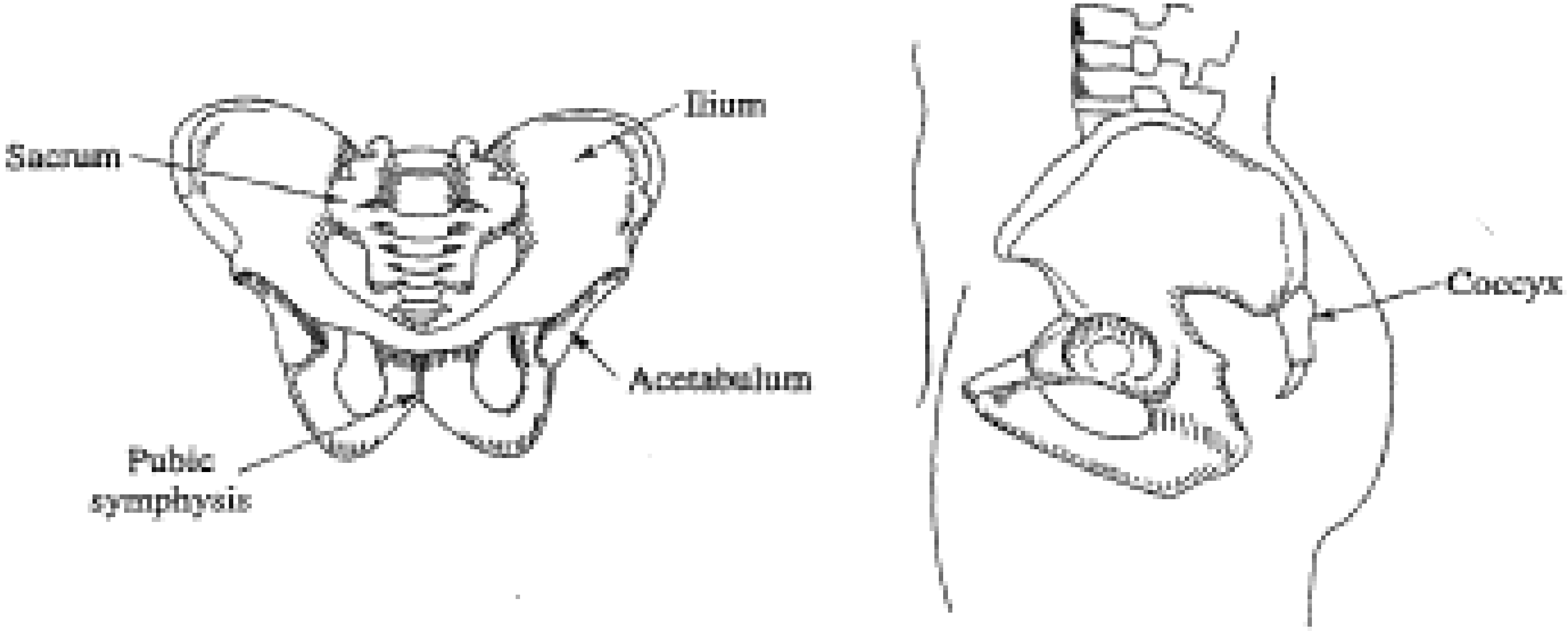


Fig. 2.12. Front and side views of the hip. (From [65])

LA ARTICULACION DE LA CADERA III

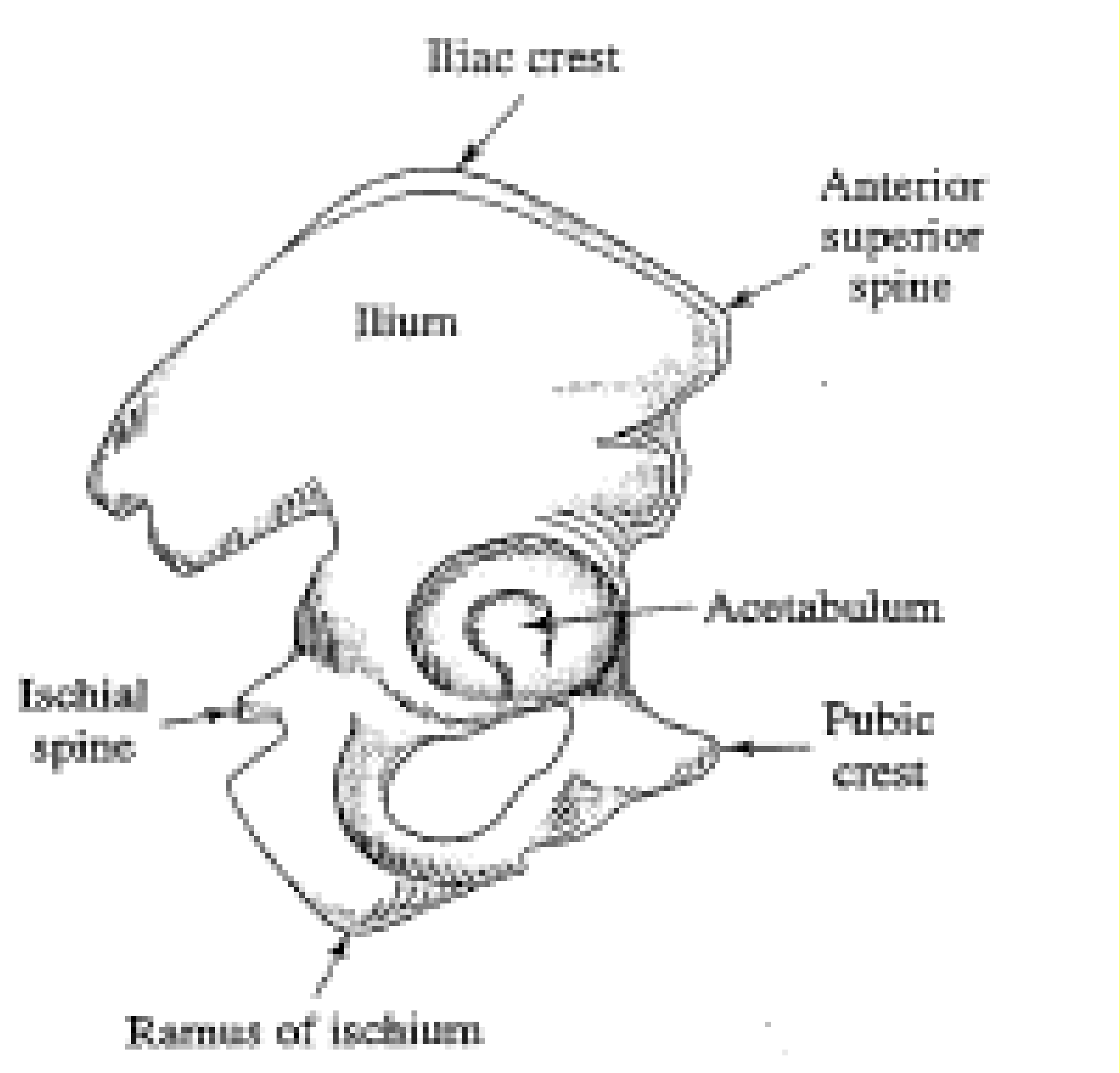


Fig. 2.11. Right hip bone in adult. (From [65])

LA ARTICULACION DE LA CADERA IV

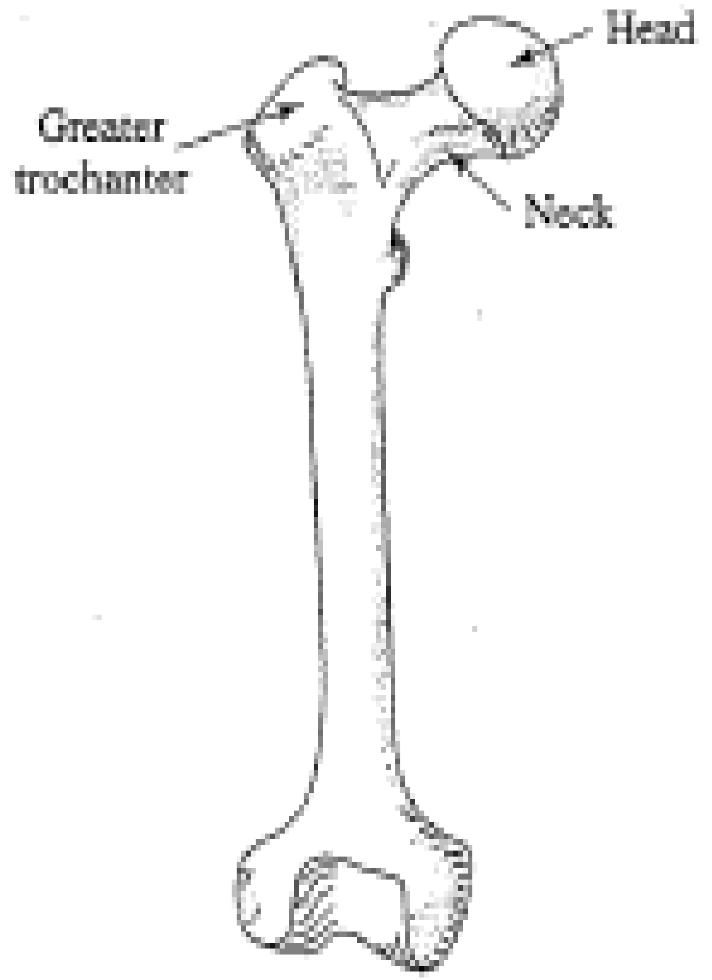
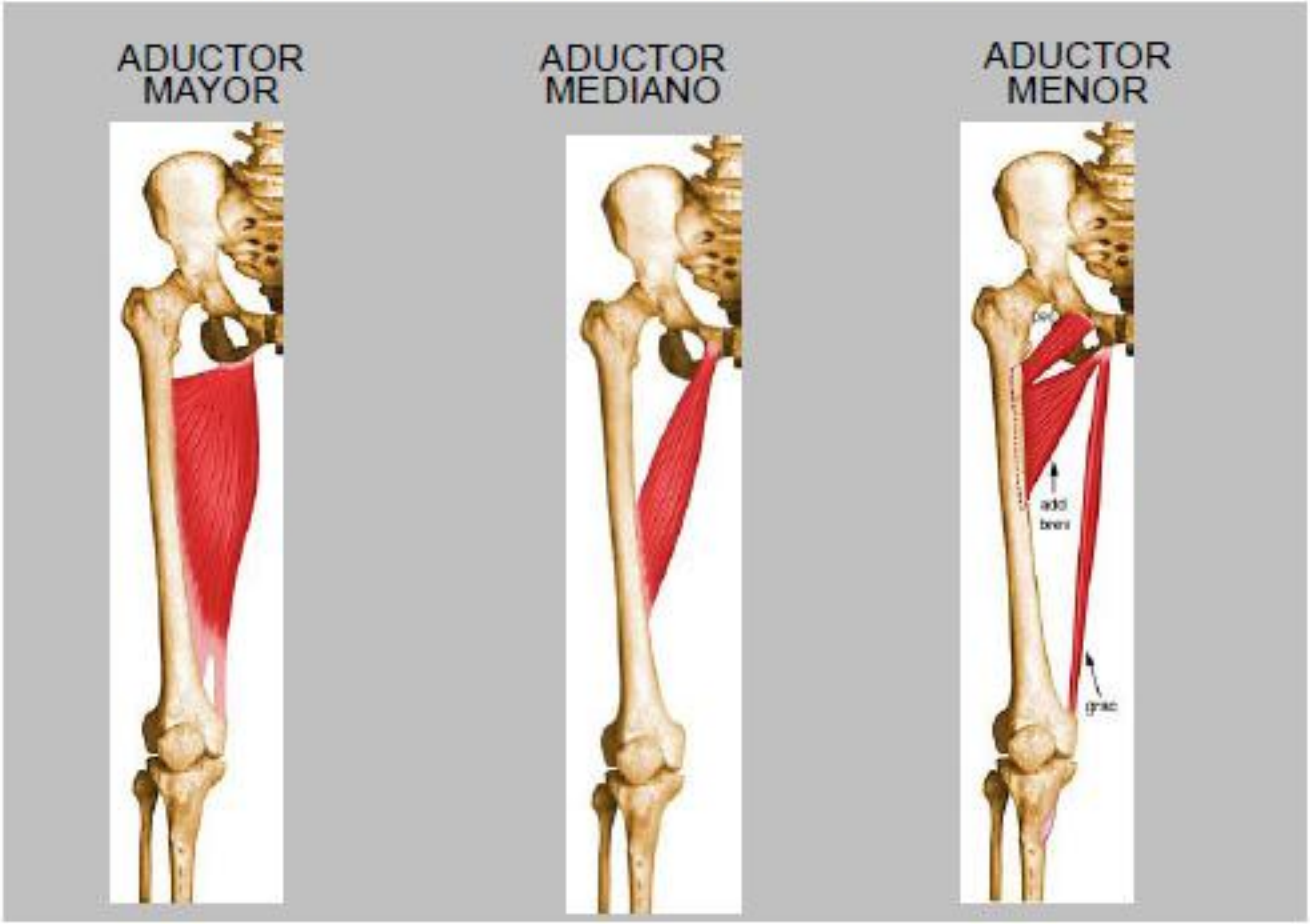
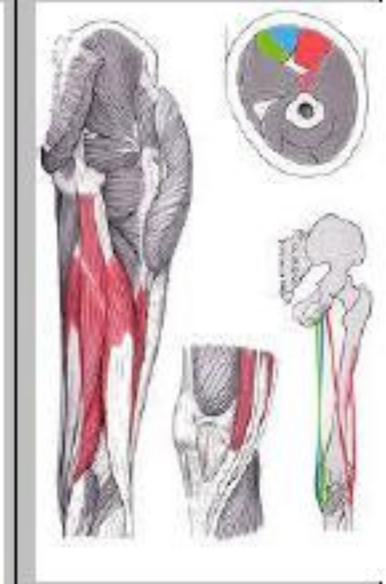


Fig. 2.13. Anterior view of right femur. (From [65])

ARTICULACIÓN DE LA CADERA
ADUCTORES (Principales)



ARTICULACIÓN DE LA CADERA
ADUCTORES (colaboradores)

PECTINEO	RECTO INTERNO	PIRAMIDAL	**GLÚTEO MAYOR**	**ISQUIOTIBIALES**
				

LA ARTICULACION DE LA CADERA V

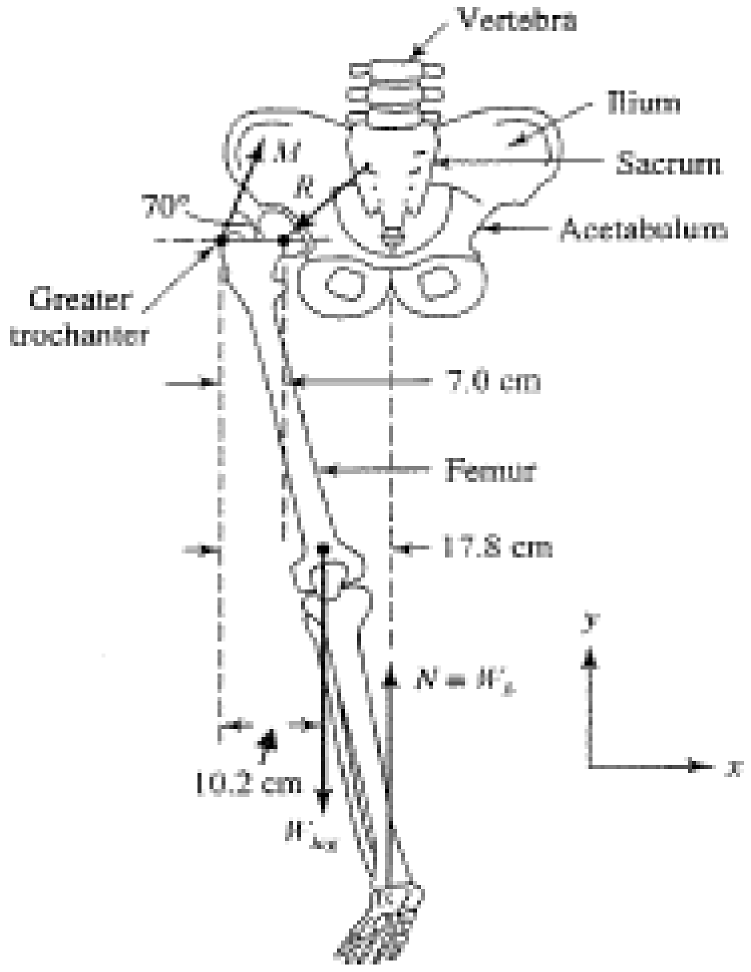


Fig. 2.16. Anatomical diagram of the leg and hip for someone standing on one leg, or during slow walking, showing the forces on them and relevant dimensions, including the force exerted on the head of the femur by the acetabulum R and the net force exerted by the hip abductor muscles. (From [65])

LA ARTICULACION DE LA CADERA VI

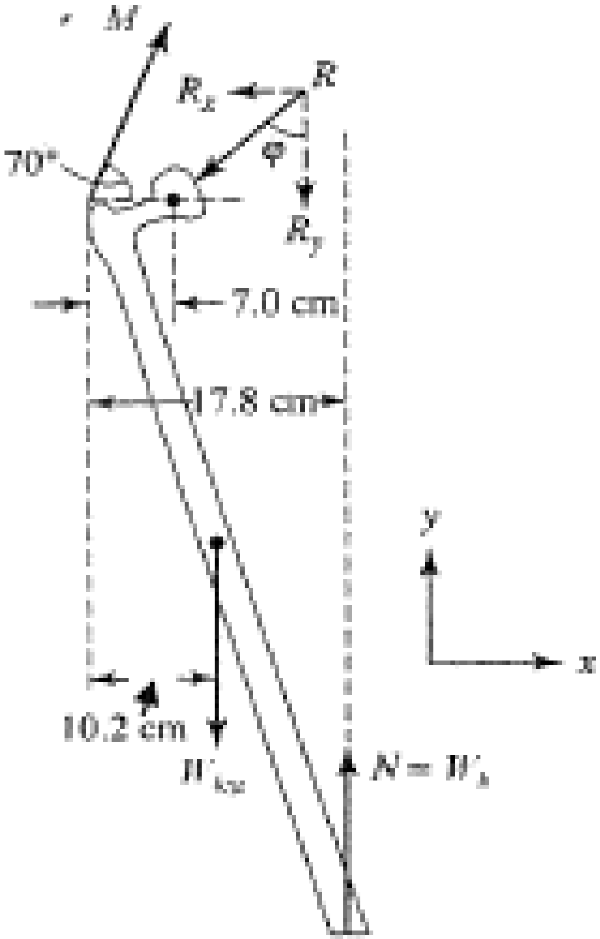


Fig. 2.17. Force diagram for a leg for someone standing on one foot, using Fig. 2.16. (From [65])

LA ARTICULACION DE LA CADERA VII

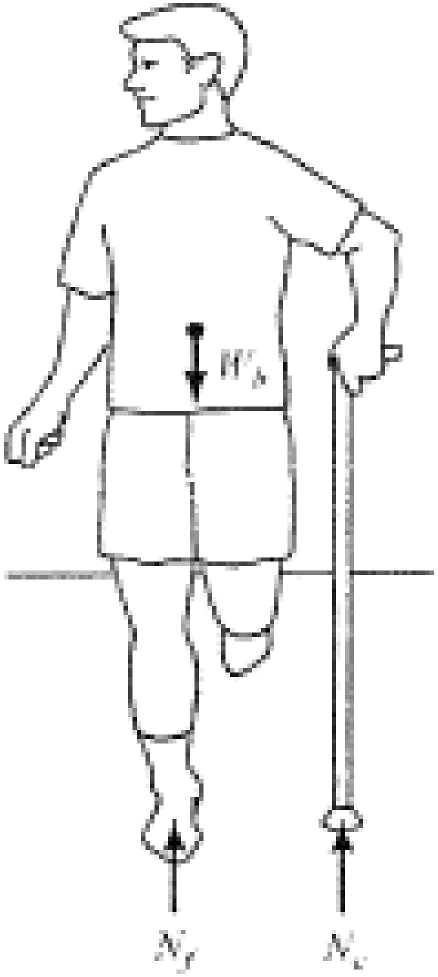


Fig. 2.18. Forces on entire person for someone walking with a cane. (From [65])

LA ARTICULACION DE LA CADERA VIII

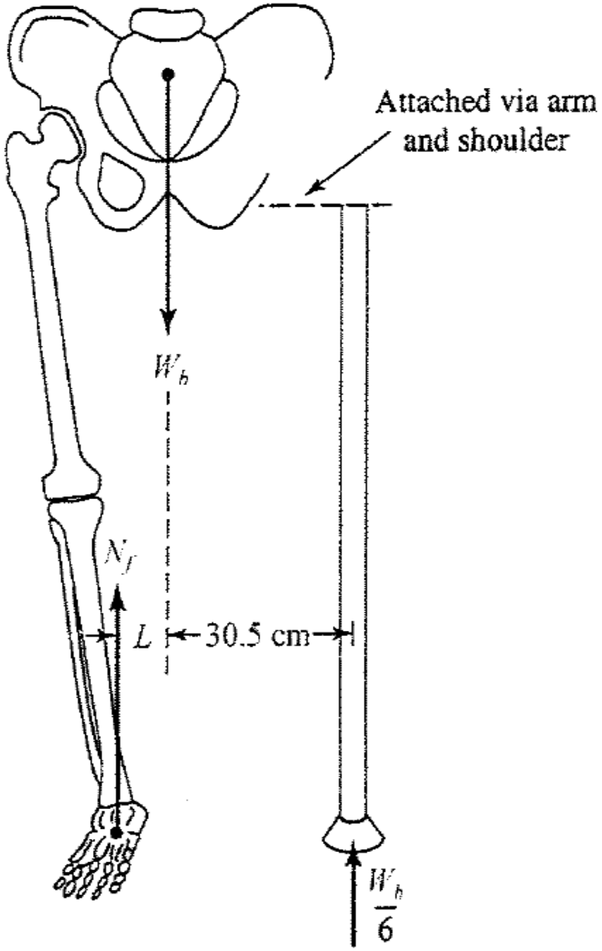


Fig. 2.19. Force diagram for a person using a cane for some support. (From [65])

LA ARTICULACION DE LA CADERA IX

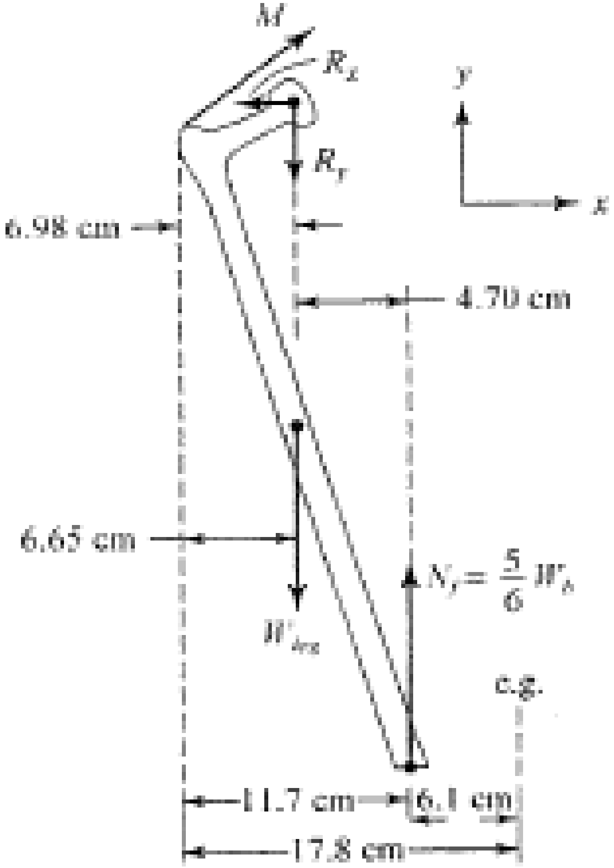
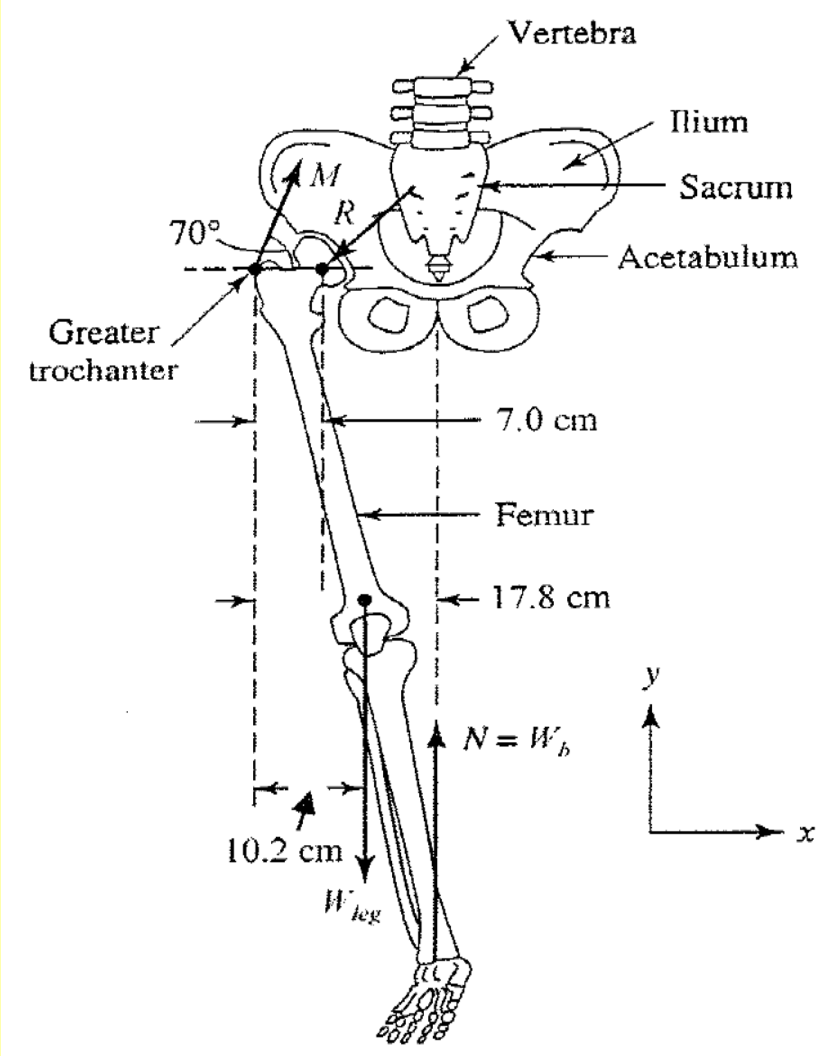
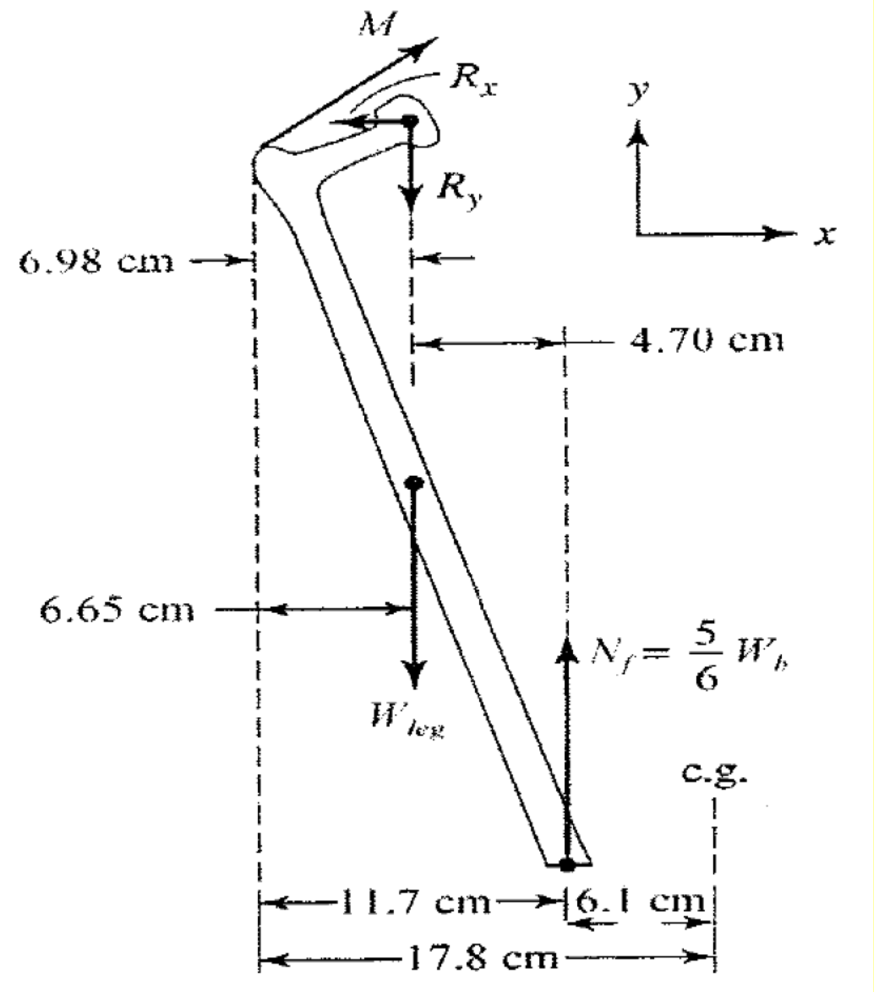


Fig. 2.20. Free-body force diagram of the leg for someone walking with a cane. Note that the center of mass of the leg is now 0.33 cm to the left of the vertical from the center of the head of the femur, whereas without the cane it was 3.2 cm to the right of the vertical. Consequently, the leg center of mass is 6.65 cm from the vertical line from the greater trochanter, whereas the center of the head of the femur is 6.98 cm from it. (From [65])

LA ARTICULACION DE LA CADERA V/IX





LA ARTICULACION DE LA CADERA X

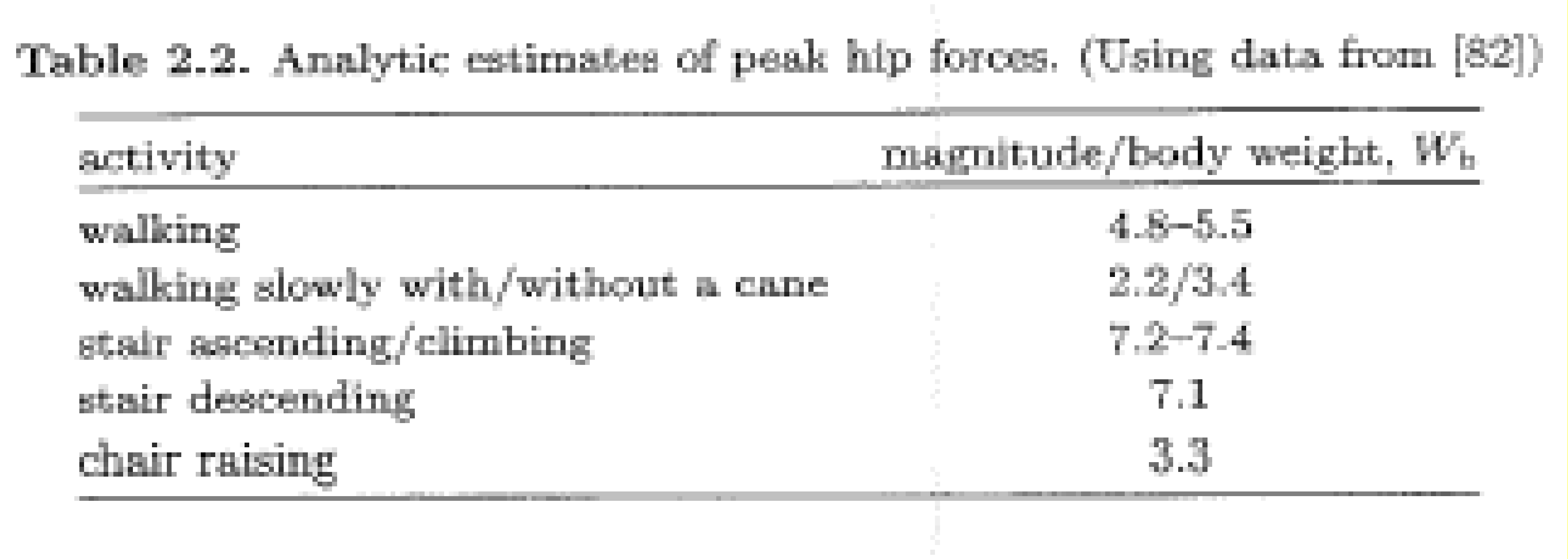


Table 2.2. Analytic estimates of peak hip forces. (Using data from [82])

activity	magnitude/body weight, W_b
walking	4.8–5.5
walking slowly with/without a cane	2.2/3.4
stair ascending/climbing	7.2–7.4
stair descending	7.1
chair raising	3.3

LA ARTICULACION DE LA CADERA XI

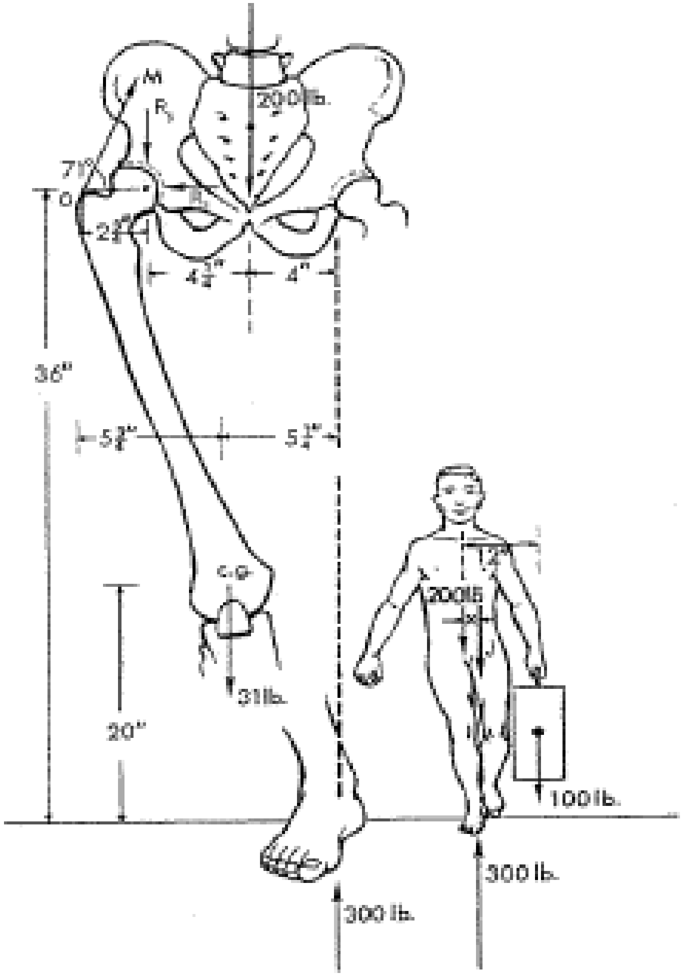


Fig. 2.50. Forces on hip and femoral head while standing on one leg and lifting a weight with the opposite hand. (Reprinted from [75]. Used with permission of Elsevier.) For Problem 2.8

LA ARTICULACION DE LA CADERA XII

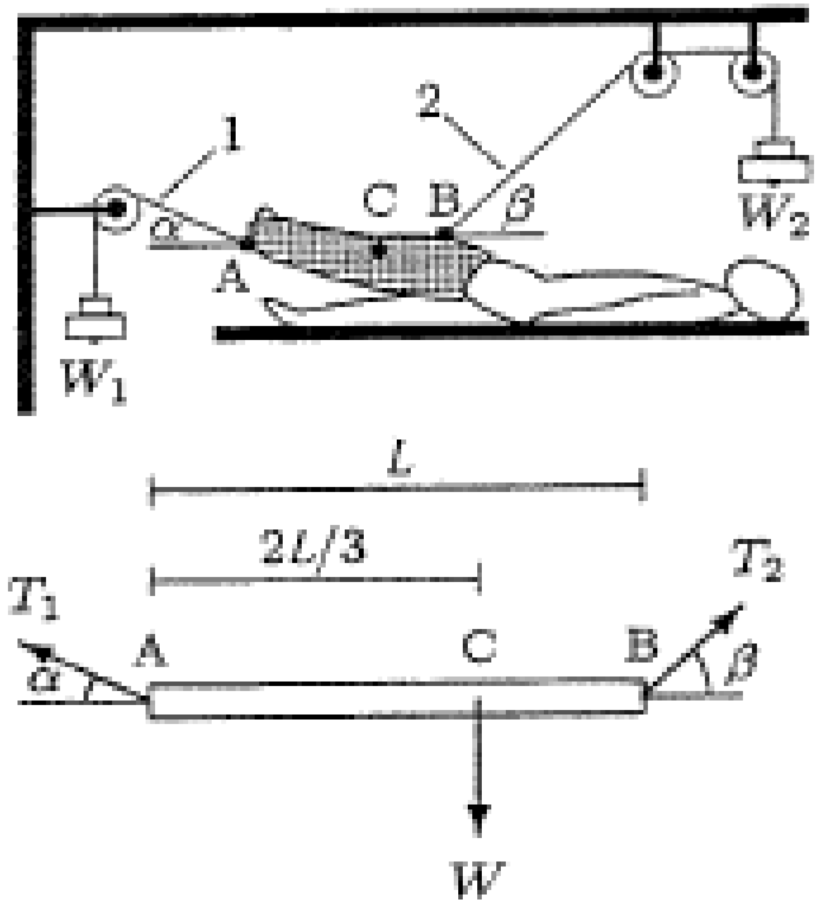


Fig. 2.51. The split Russel traction device. (From [86].) For Problem 2.14

LA ARTICULACION DEL HOMBRO I

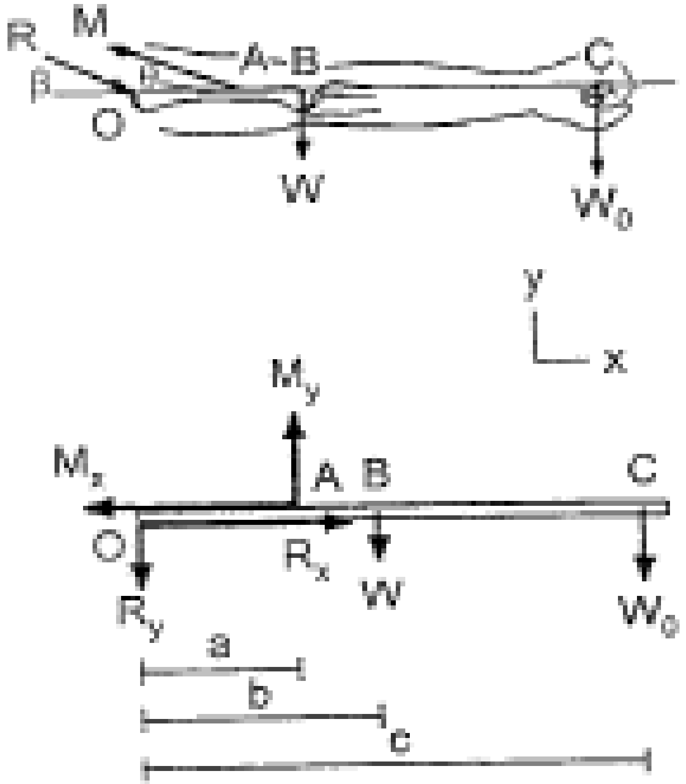


Fig. 2.21. Forces on the arm and shoulder, when the arm is abducted to the horizontal position and the hand holds a weight, along with the force diagram. (From [86])

LA ARTICULACION DEL HOMBRO II

Fig. 2.52. Deltoid muscle during lifting with an outstretched arm. (From [65].) For Problem 2.15

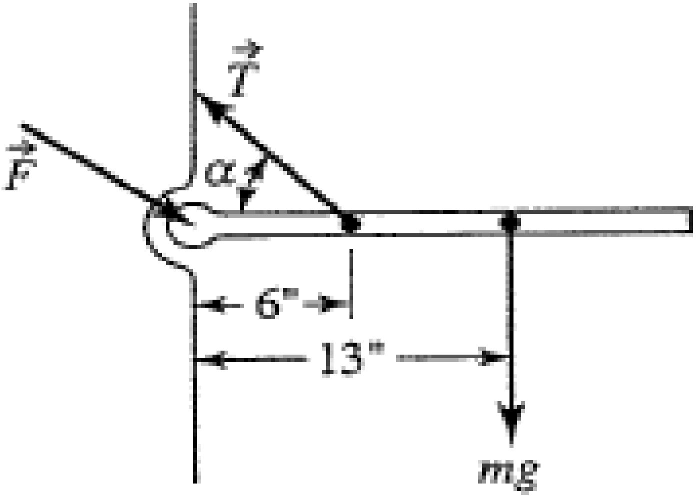
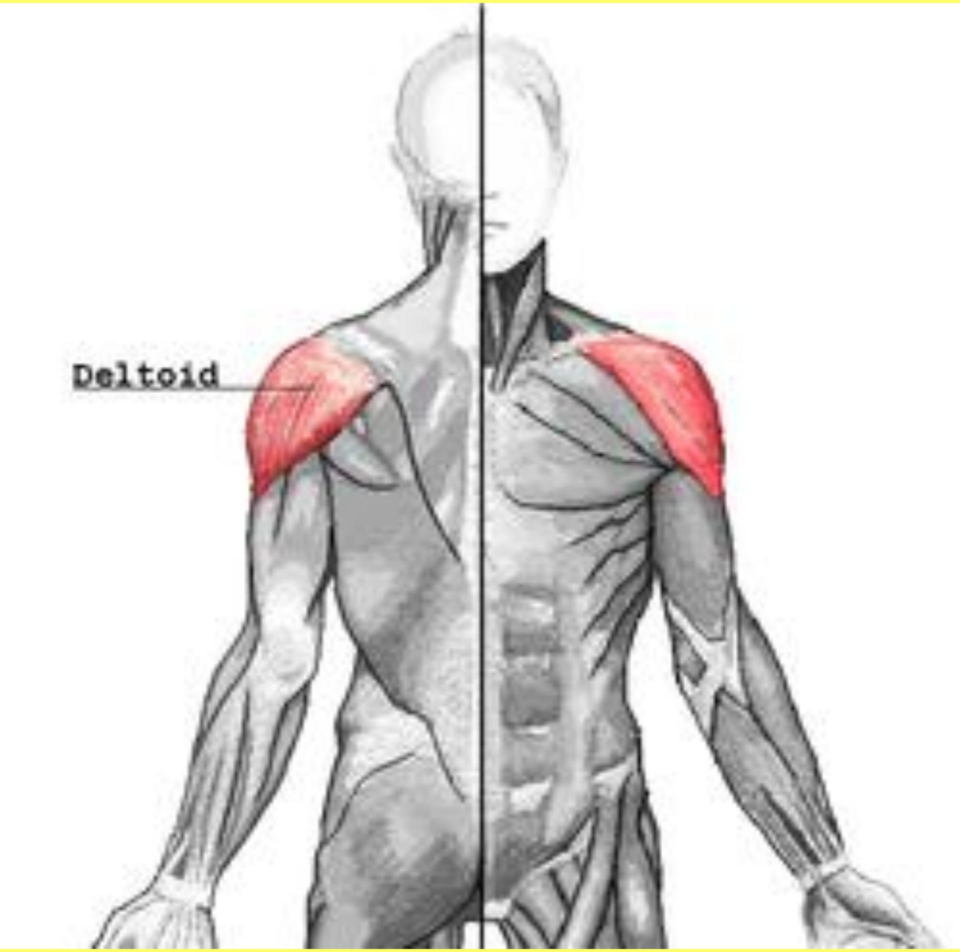
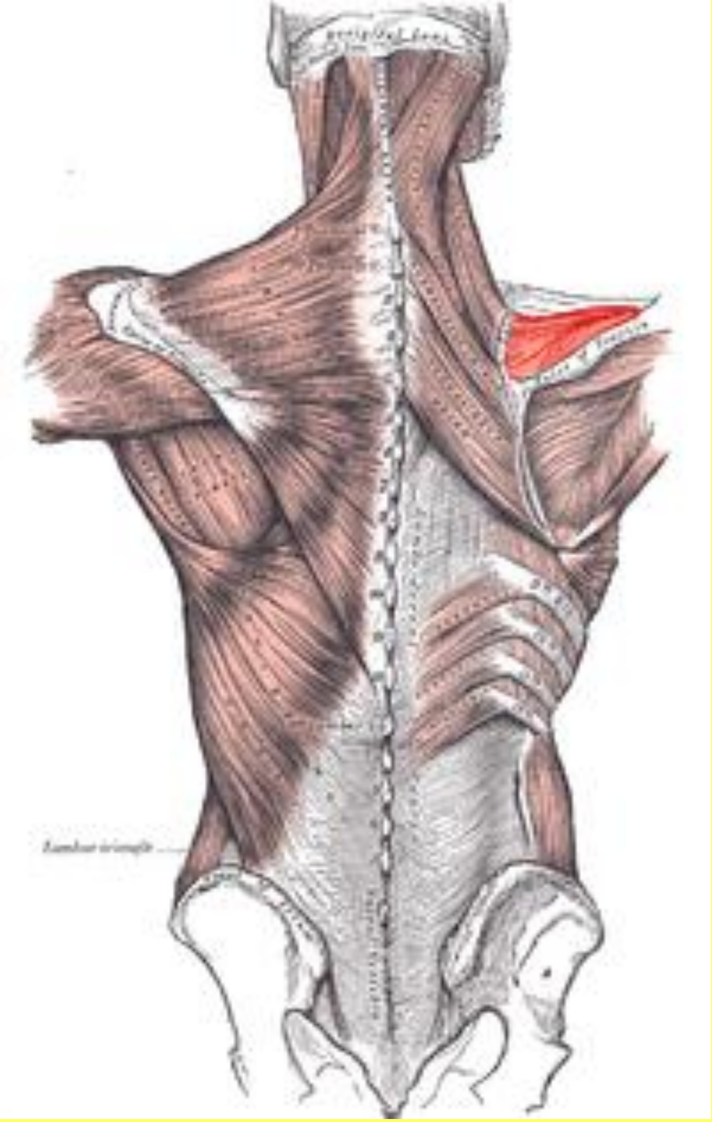


Fig. 2.53. Force diagram for the deltoid muscle and reaction forces during lifting with an outstretched arm. (This is a simpler version of Fig. 2.21.) (From [65].) For Problem 2.15


Deltoid


Occipital bone
Lumbar triangle

LA ARTICULACION DE LA RODILLA I

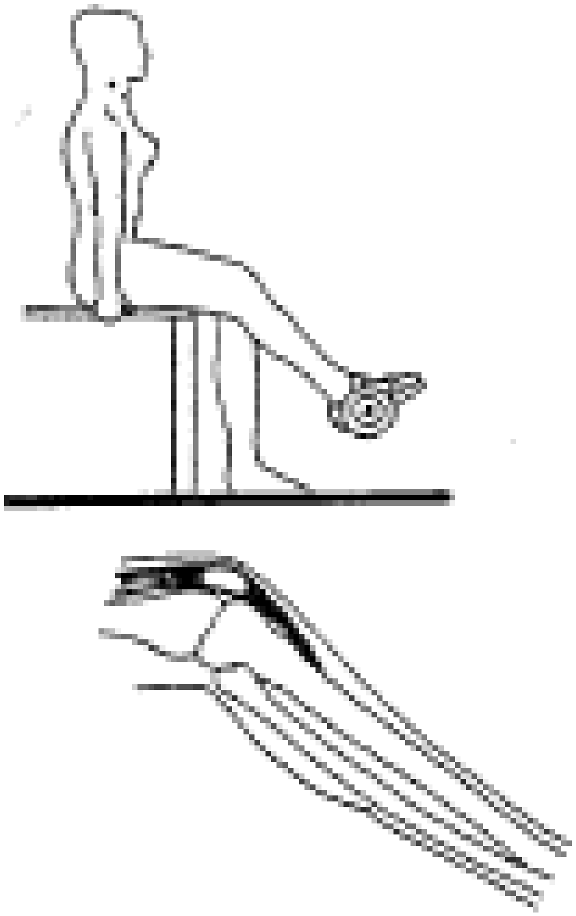


Fig. 2.22. Exercising muscles near and at the knee. (From [86])

LA ARTICULACION DE LA RODILLA II

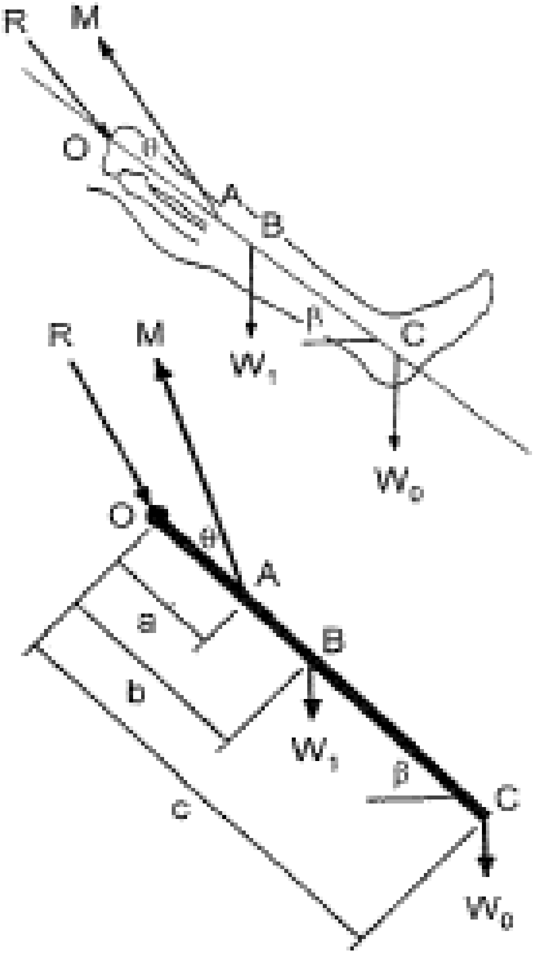


Fig. 2.23. Forces on the lower leg, while exercising the muscle around the knee. (From [86])

LA ARTICULACION DE LA RODILLA III

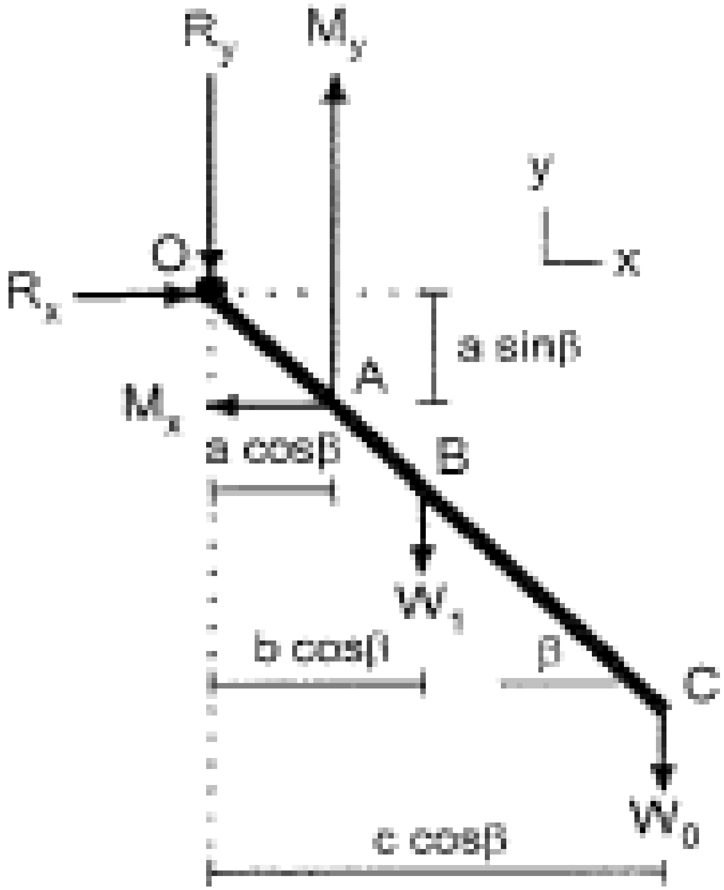
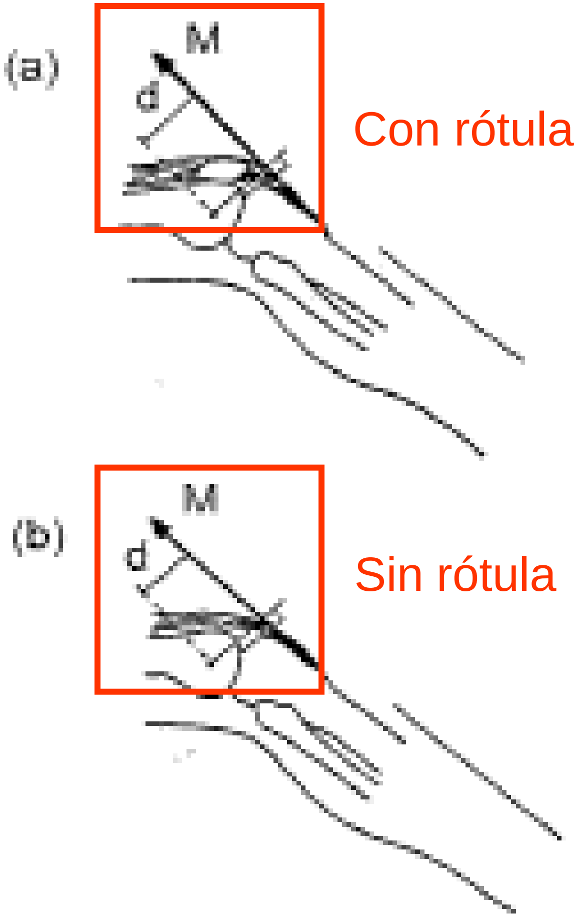


Fig. 2.24. Resolution of the forces on the lower leg in Fig. 2.23. (From [86])

LA ARTICULACION DE LA RODILLA IV



Con rótula

Sin rótula

Fig. 2.25. The presence of the kneecap (patella) increases the moment arm in the lever. (From [86])

LA ARTICULACION DE LA RODILLA V

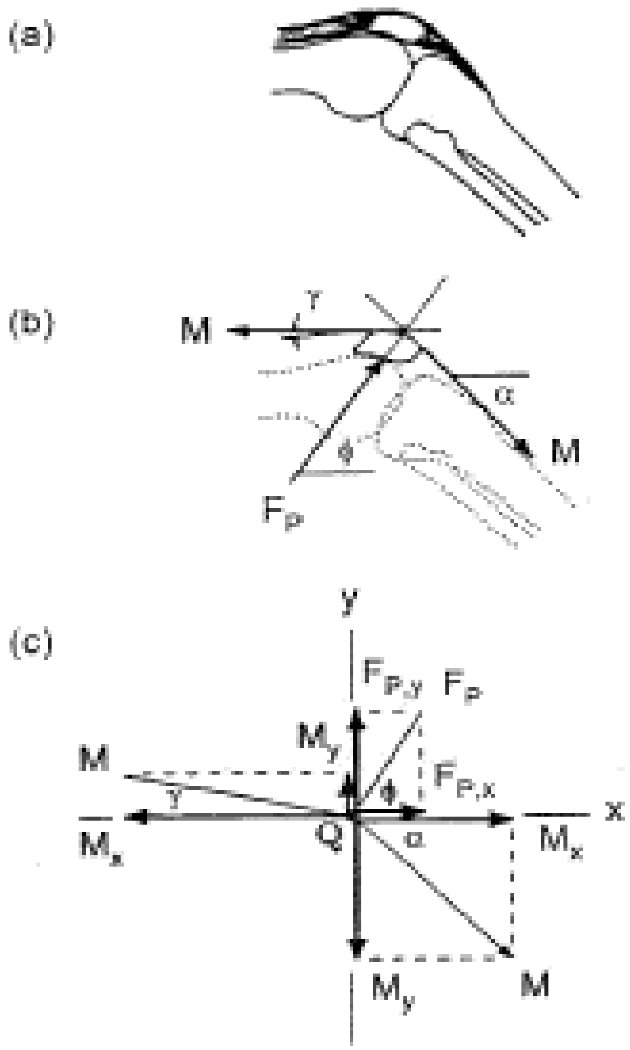


Fig. 2.26. Force diagram of the kneecap (patella) in equilibrium. (From [86])

LA ARTICULACION DE LA RODILLA VI

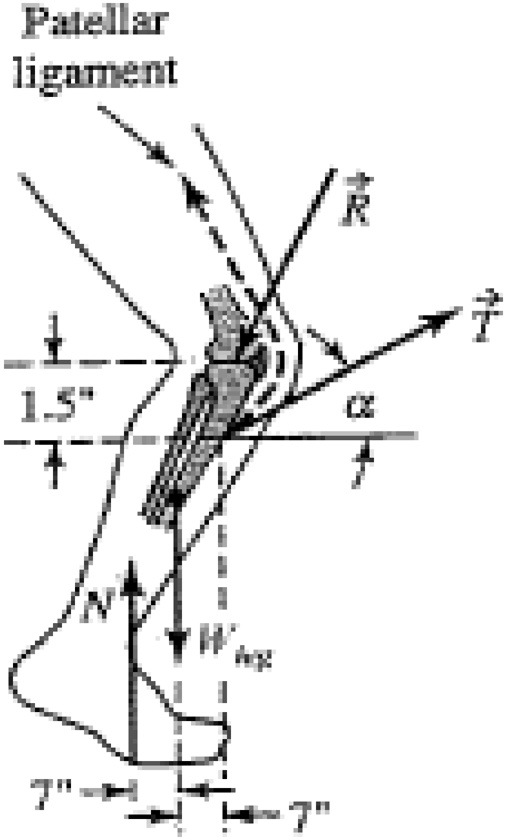
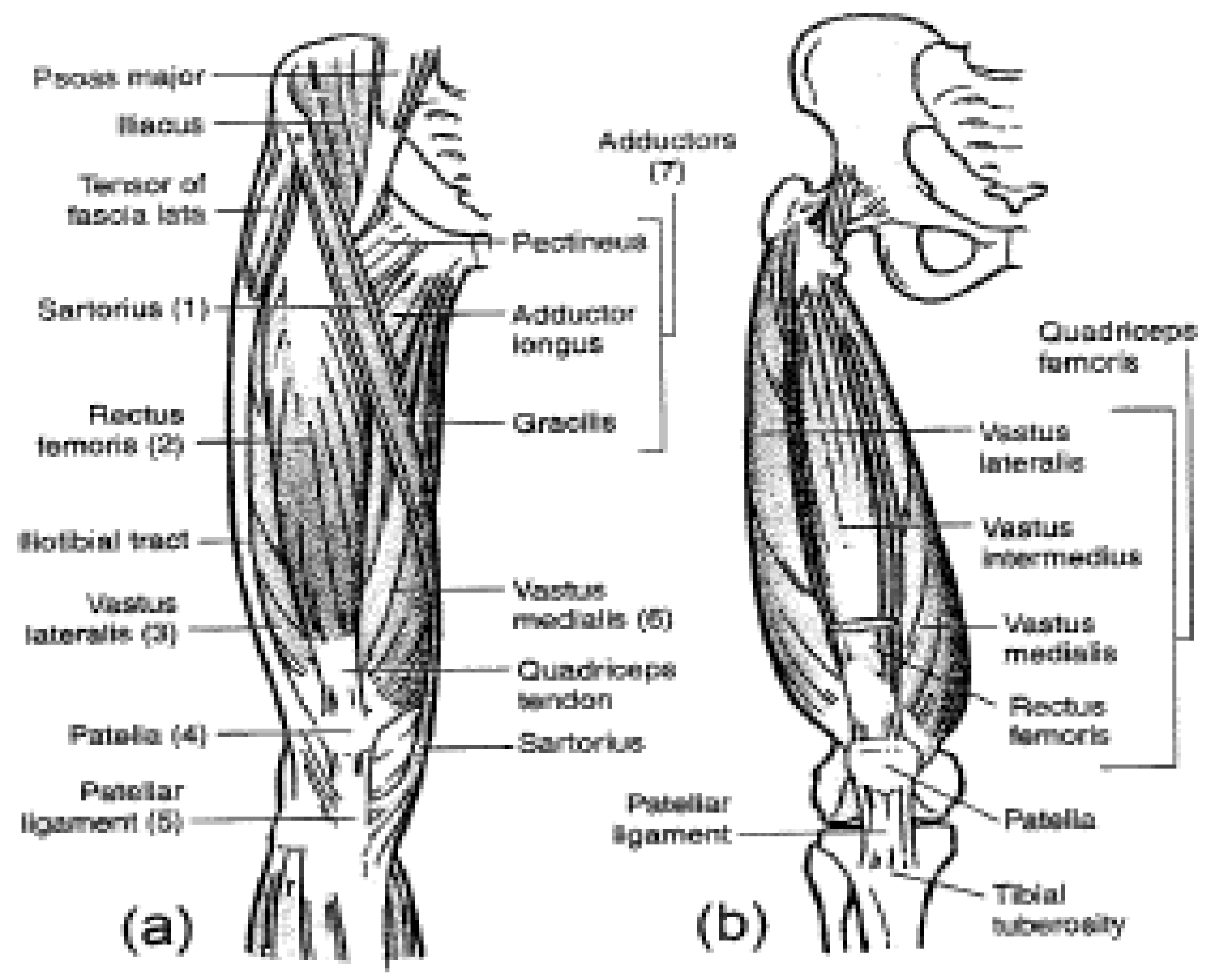
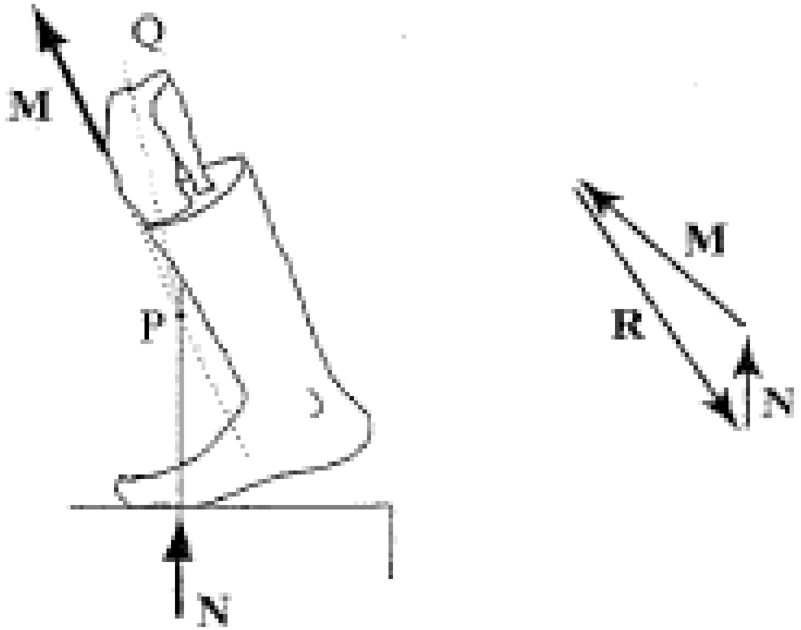


Fig. 2.55. Forces on the lower leg during crouching. (From [65].) For Problem 2.24

LA ARTICULACION DE LA RODILLA VIII



LA ARTICULACION DE LA RODILLA IX



(a) (b)

Fig. 2.46. (a) Illustrating the three-force rule on the free lower leg, with reaction force **N**, patellar tendon force **M**, point where these extended vector lines meet P, and the point where the joint force acts on the tibia Q. (b) Vector diagram of three-force rule with **R** being the joint reaction force at Q. (From [76])

LA ARTICULACION DEL TOBILLO I

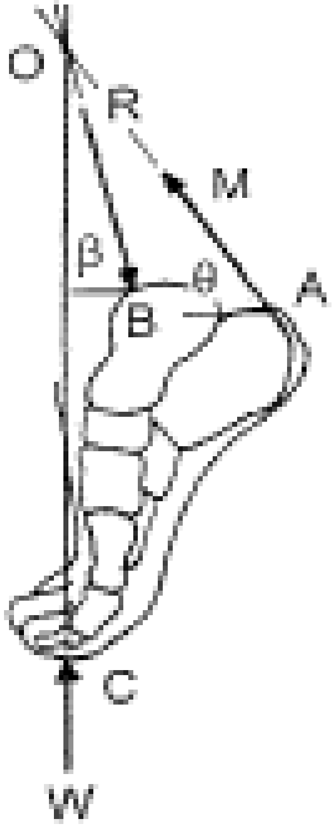


Fig. 2.27. Force diagram of the foot on tiptoe, showing that they form a concurrent system. (From [86])

LA ARTICULACION DEL TOBILLO II

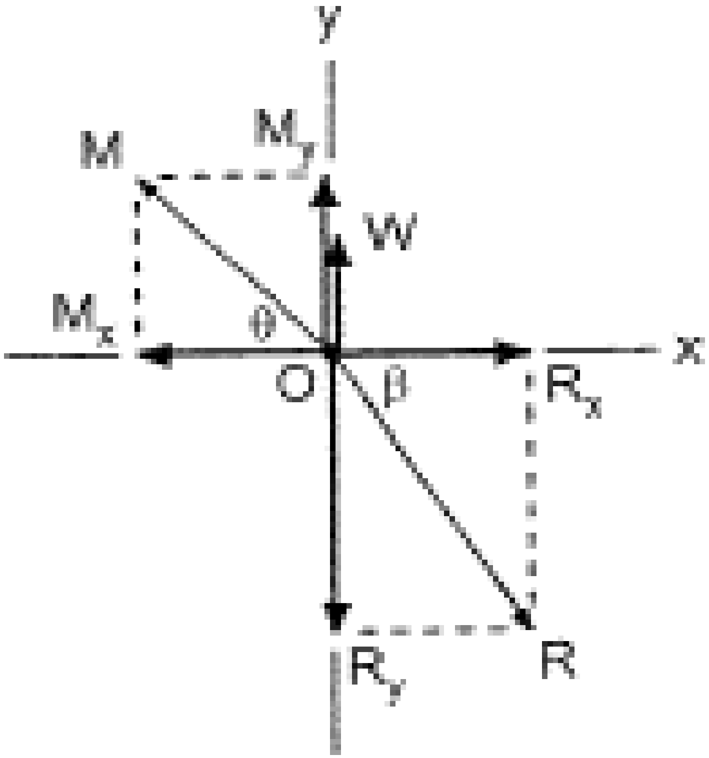


Fig. 2.28. Components of the forces acting on a foot on tiptoe. (From [86])

LA ARTICULACION DEL TOBILLO III

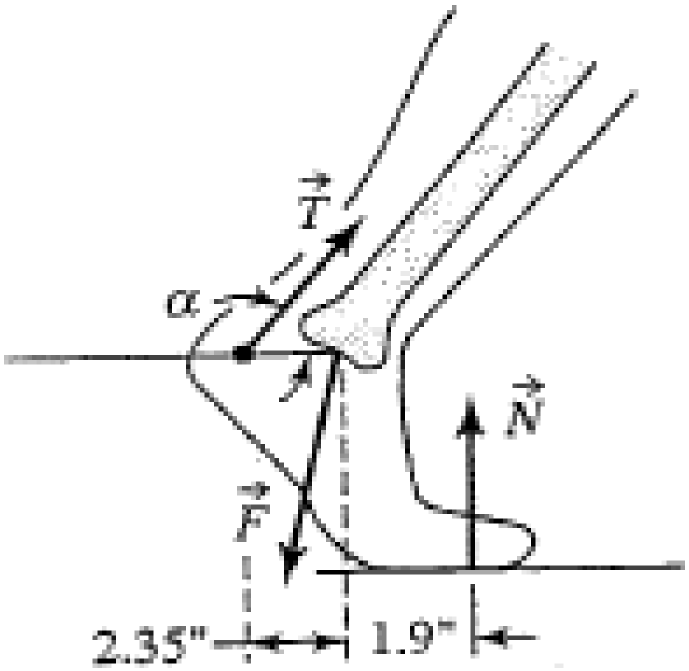
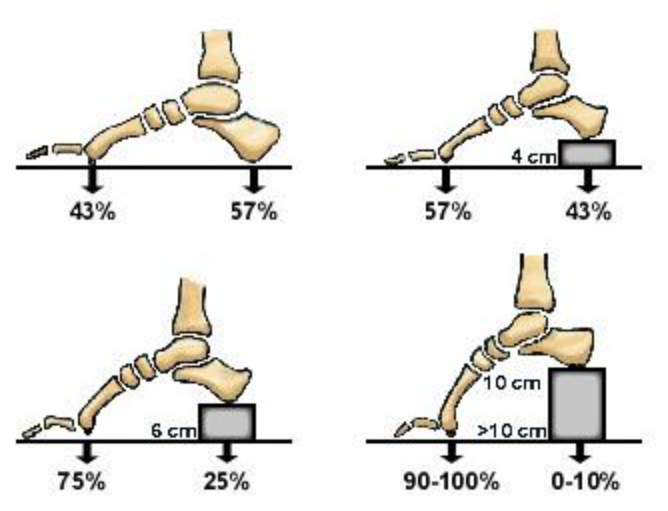


Fig. 2.54. Forces on the foot during crouching. (From [65].) For Problem 2.21

CAMINAR CON TACOS



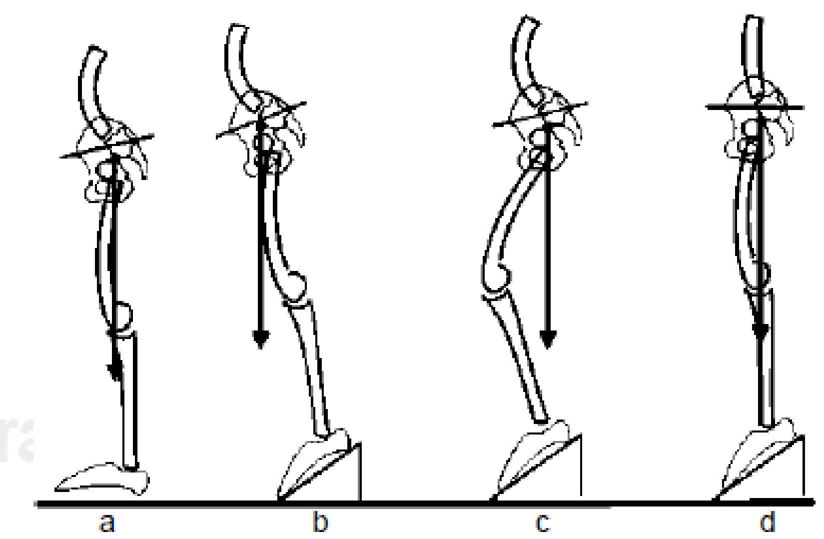
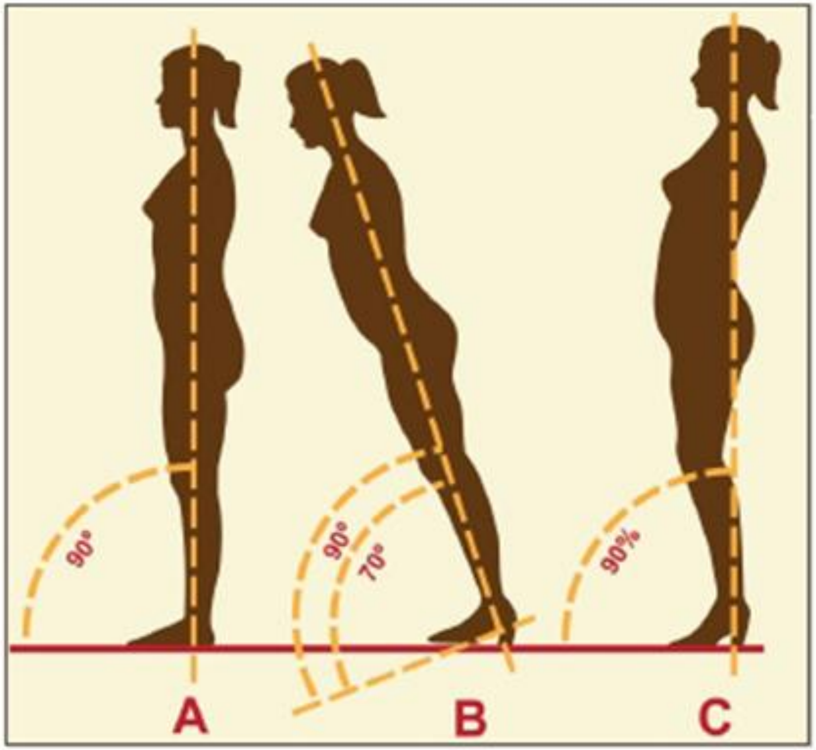


Figura 3. Esquema del efecto que el uso de tacones tiene sobre la postura en el plano sagital. En el dibujo "a" se observa la posición basal. La flecha representa la línea de gravedad.



LA COLUMNA VERTEBRAL I

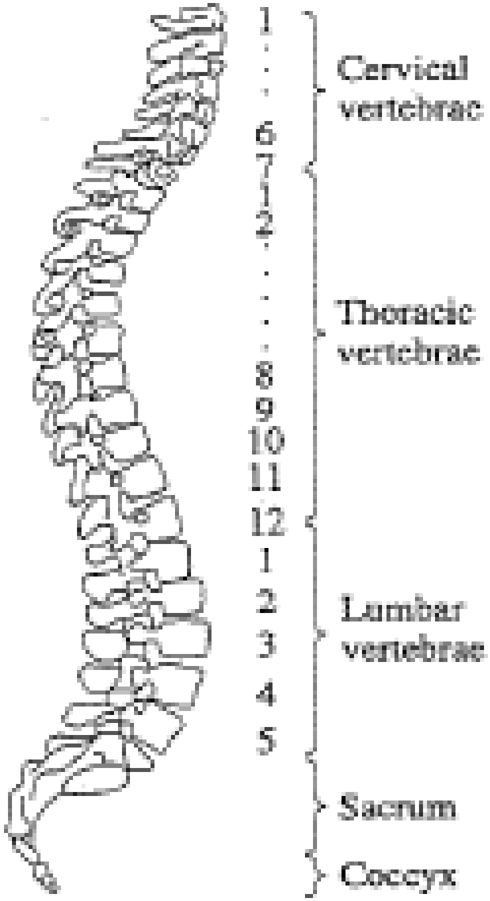


Fig. 2.33. The vertebral column (spine). (From [65].) The thoracic and sacral curves are primary curves, while the cervical and lumbar curves are secondary curves

LA COLUMNA VERTEBRAL II

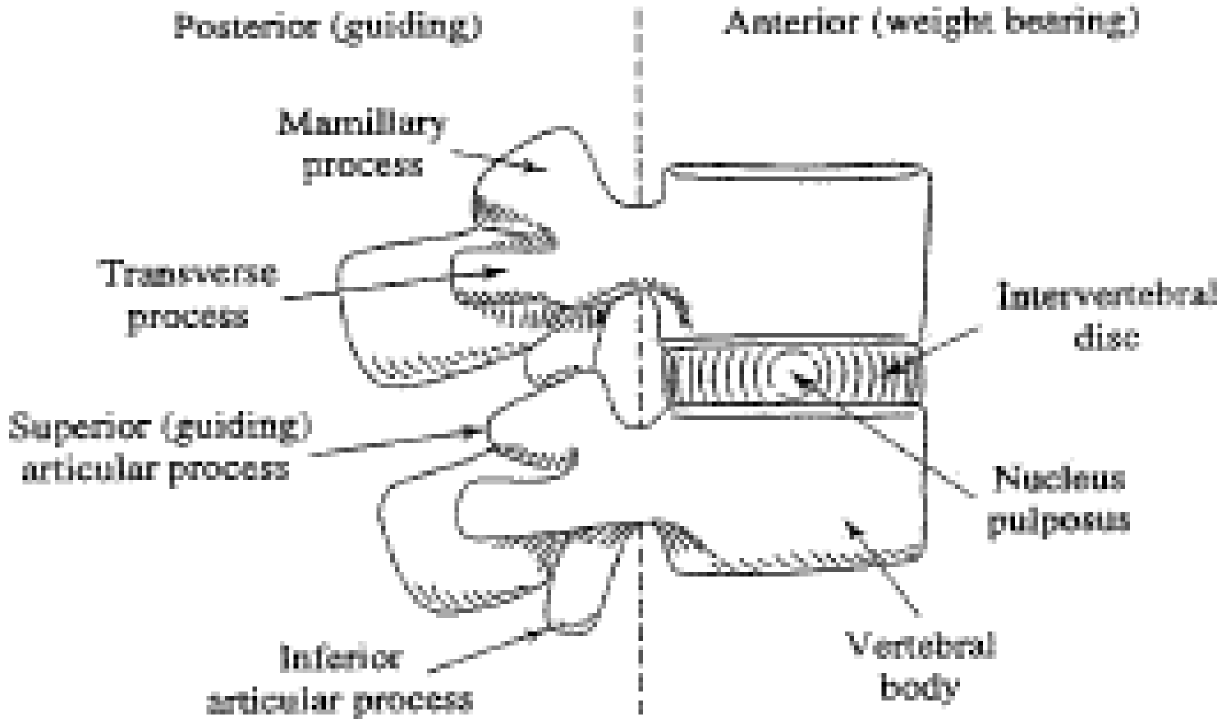


Fig. 2.34. Side view of two vertebrae separated by a vertebral disc. (From [65])

LA COLUMNA VERTEBRAL III

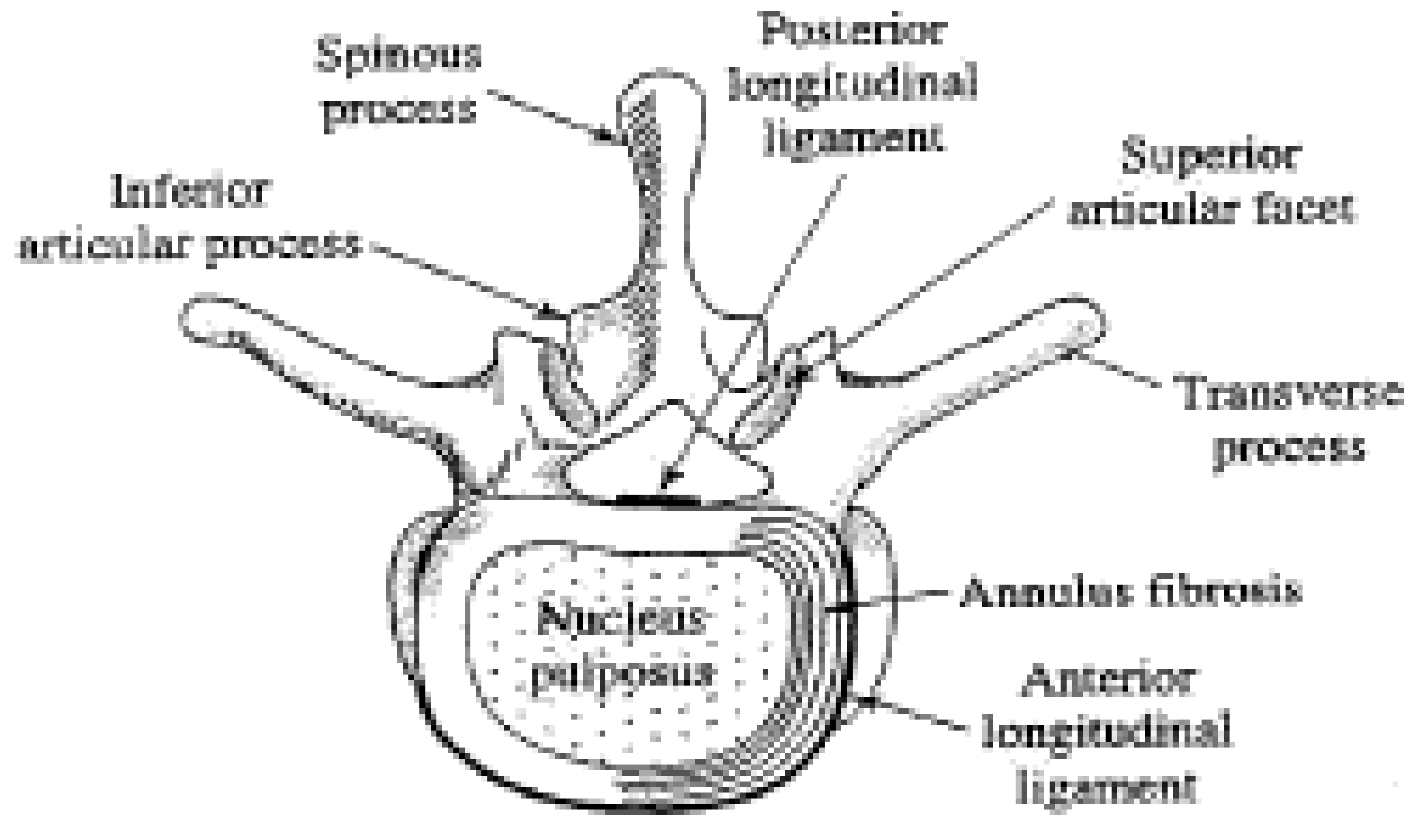


Fig. 2.35. Vertebra viewed from above. (From [65])

LA COLUMNA VERTEBRAL IV

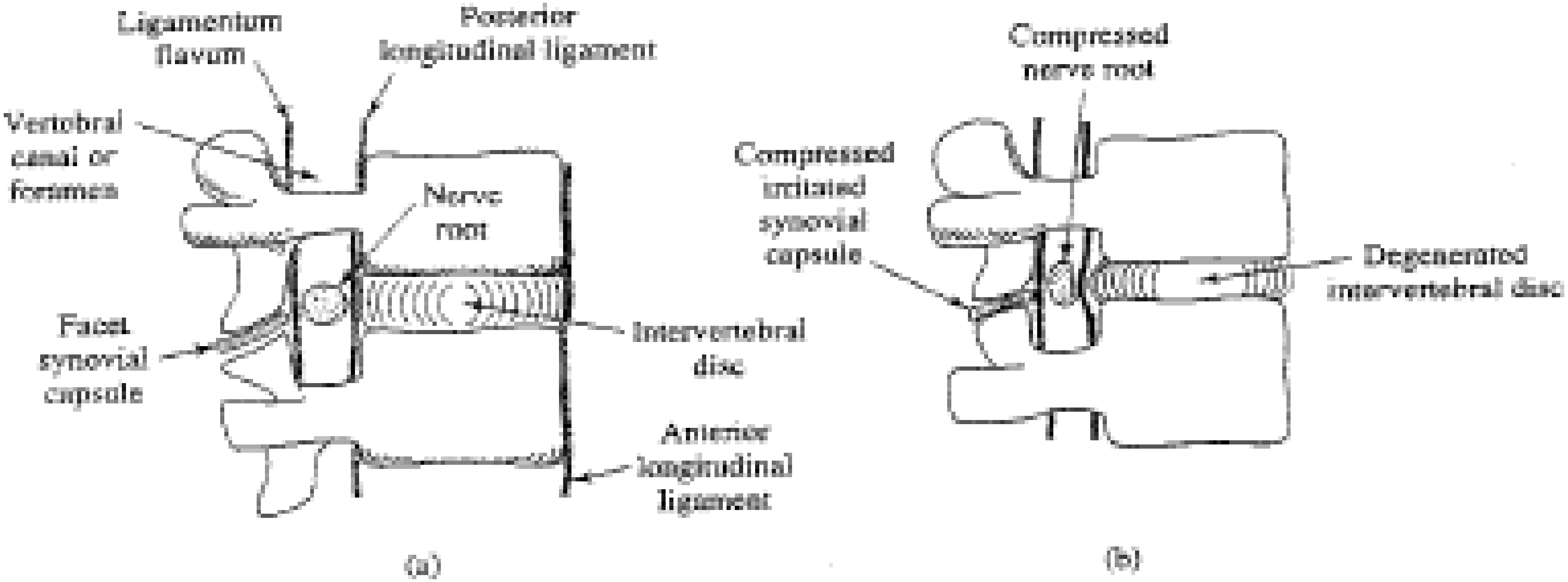
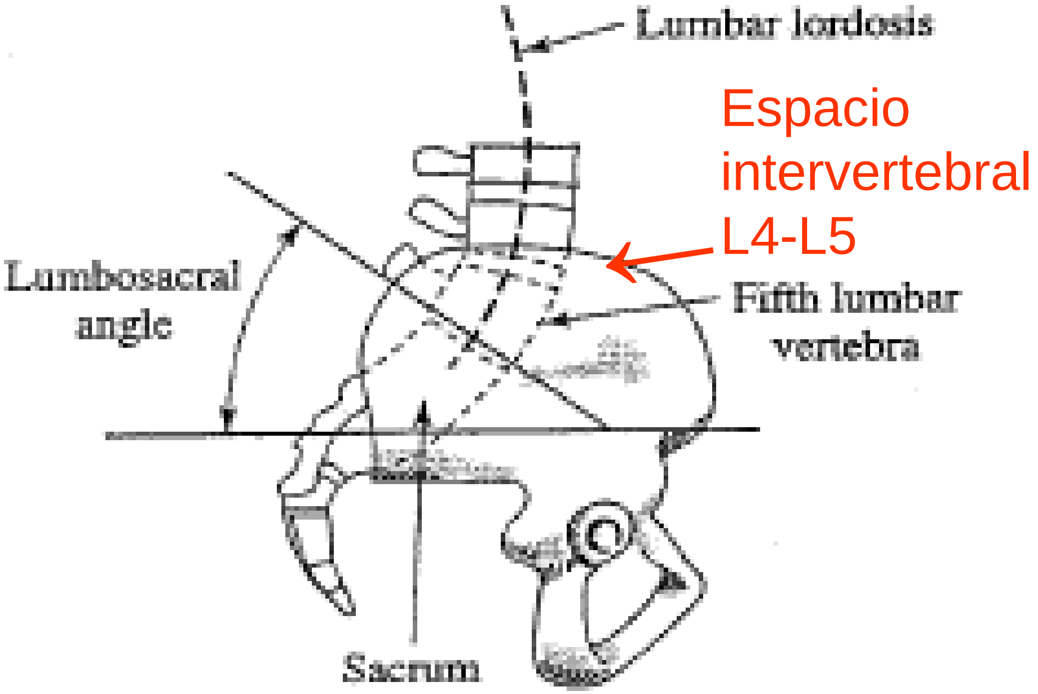


Fig. 2.36. Cross-section of two vertebrae and a vertebral disc with nerve for (a) a normal intervertebral disc and (b) one that has degenerated and is compressing the nerve root. (From [65])

LA COLUMNA VERTEBRAL V



Espacio intervertebral L4-L5

Fig. 2.37. The lumbosacral angle is defined as that between the horizontal and the top surface of the sacrum. (From [65])

LA COLUMNA VERTEBRAL VI

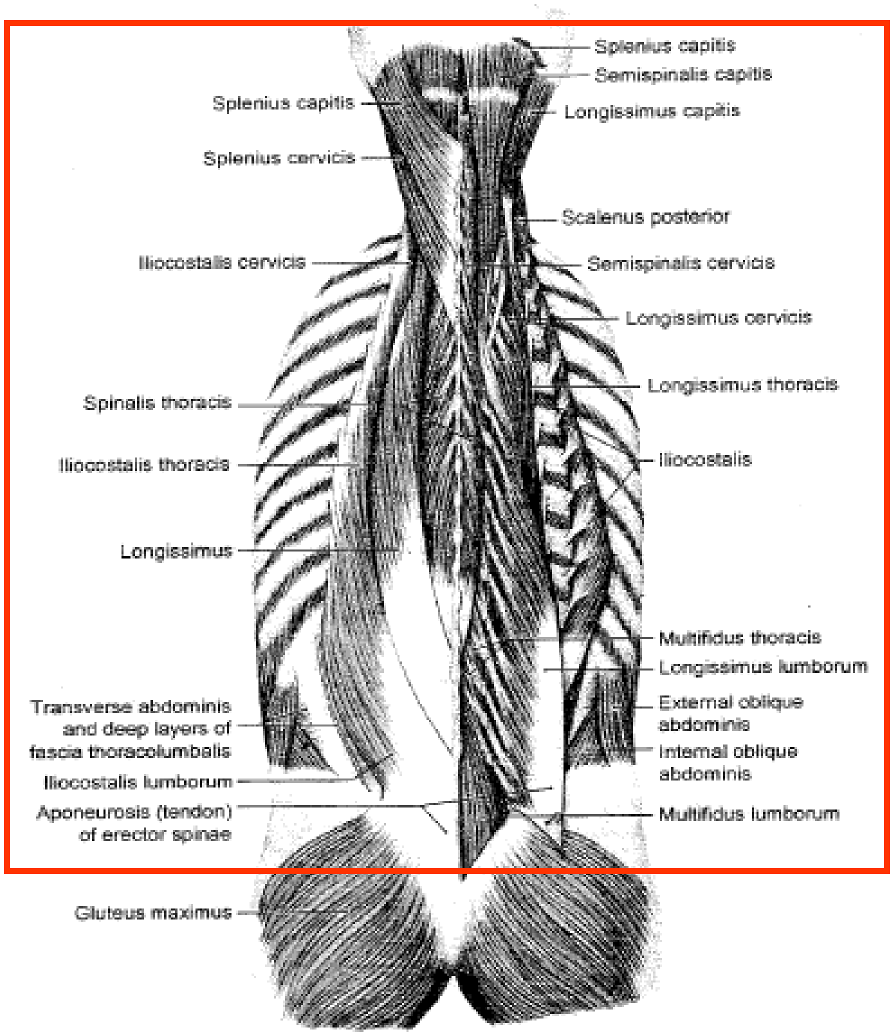


Fig. 2.38. Intermediate (*left*) and deep (*right*) layers of back muscles – showing the erector spinae muscles. The erector spinae consists of lateral columns (the iliocostalis lumborum, thoracis, and cervicis muscles), intermediate columns (the longissimus thoracis, cervicis, and capitis muscles), and a medial column (spinalis thoracis). (From [93])

LA COLUMNA VERTEBRAL VII

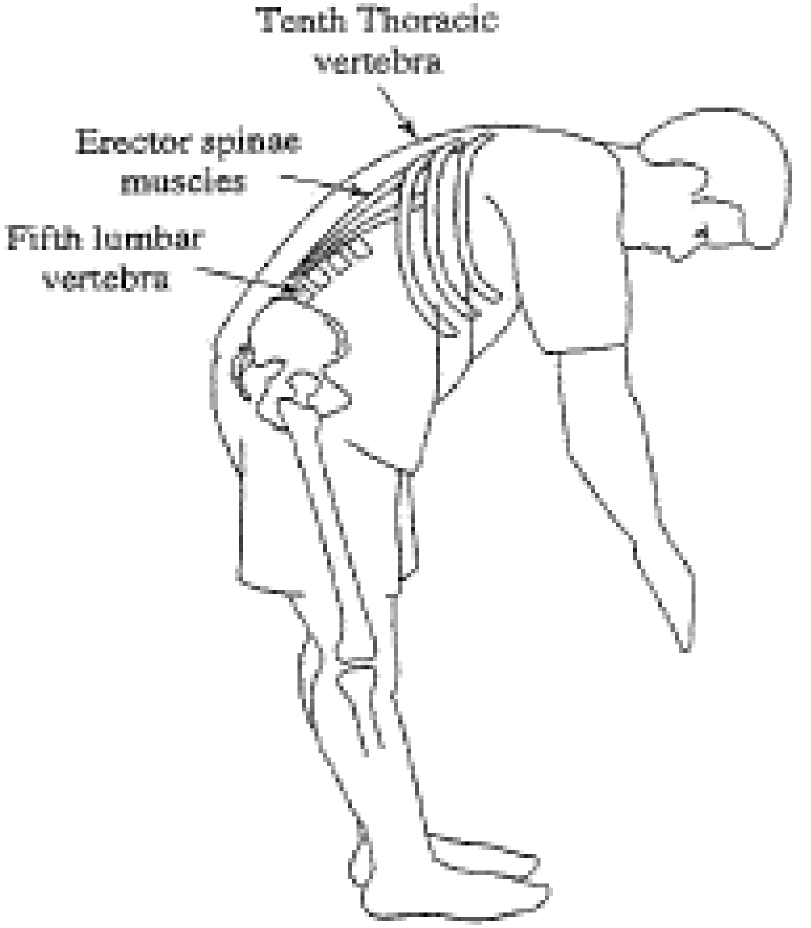


Fig. 2.39. Diagram of the erector spinae muscles used to control the trunk when bending. (From [65])

LA COLUMNA VERTEBRAL VIII

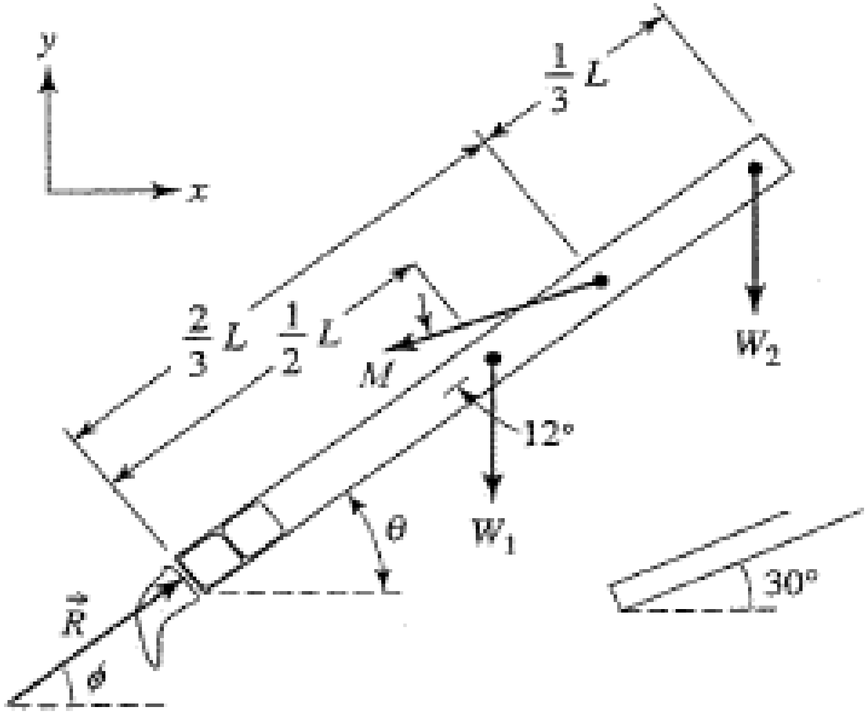


Fig. 2.40. Free-body diagram of the vertebral column while bending, with the spine modeled as a straight bar at an angle θ to the horizontal, which we will take to be ~30° – a bit steeper bend than is depicted here and shown in the inset. The angle of $\mathbf{R}$ to the horizontal is φ. With nothing being lifted, we will take $W_1 = 0.4W_b$ and $W_2 = 0.2W_b$. (From [65])

LA COLUMNA VERTEBRAL IX

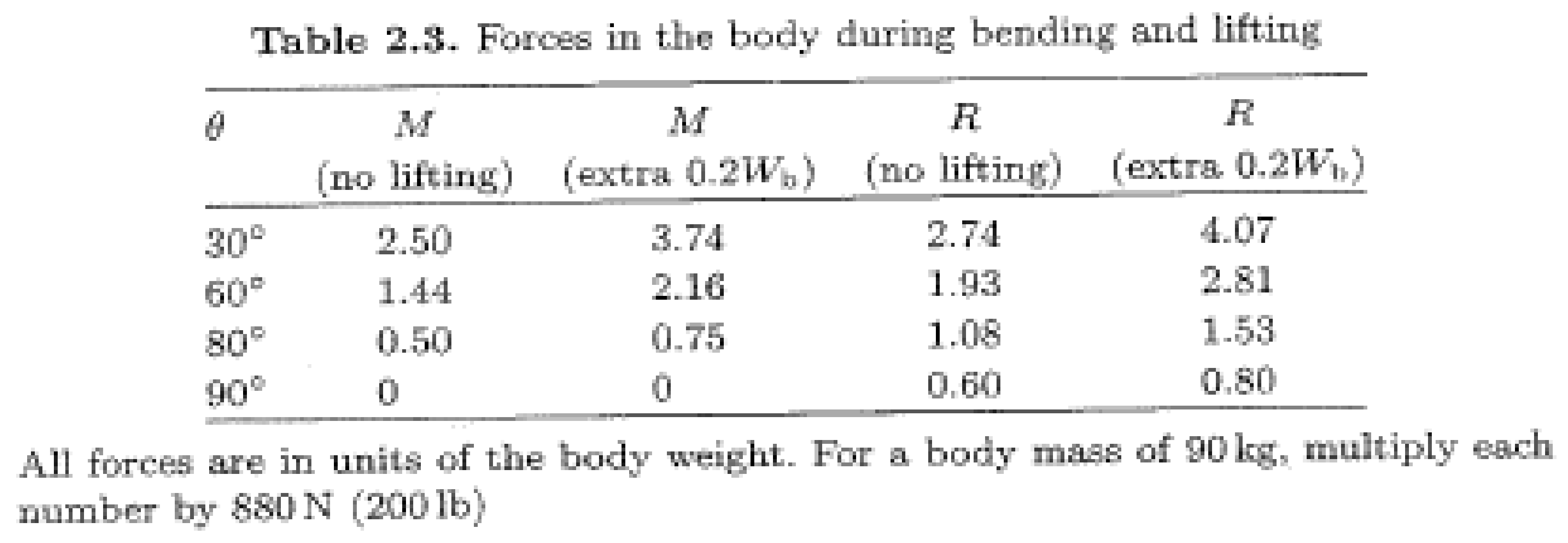


Table 2.3. Forces in the body during bending and lifting

θ	M (no lifting)	M (extra $0.2W_b$)	R (no lifting)	R (extra $0.2W_b$)
30°	2.50	3.74	2.74	4.07
60°	1.44	2.16	1.93	2.81
80°	0.50	0.75	1.08	1.53
90°	0	0	0.60	0.80

All forces are in units of the body weight. For a body mass of 90 kg, multiply each number by 880 N (200 lb)

LA COLUMNA VERTEBRAL X

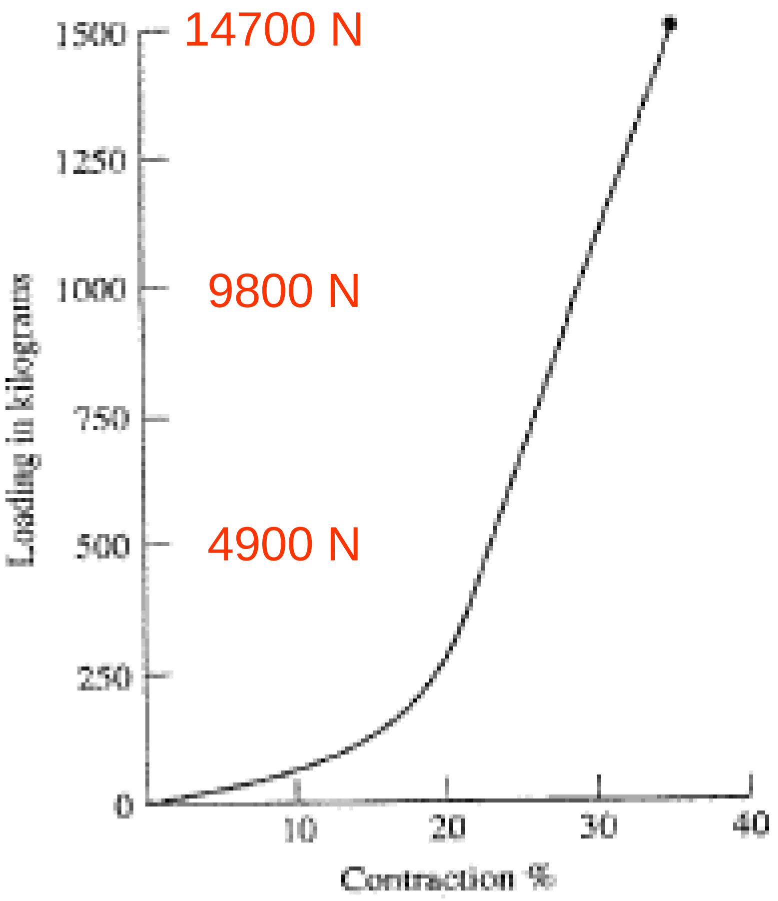
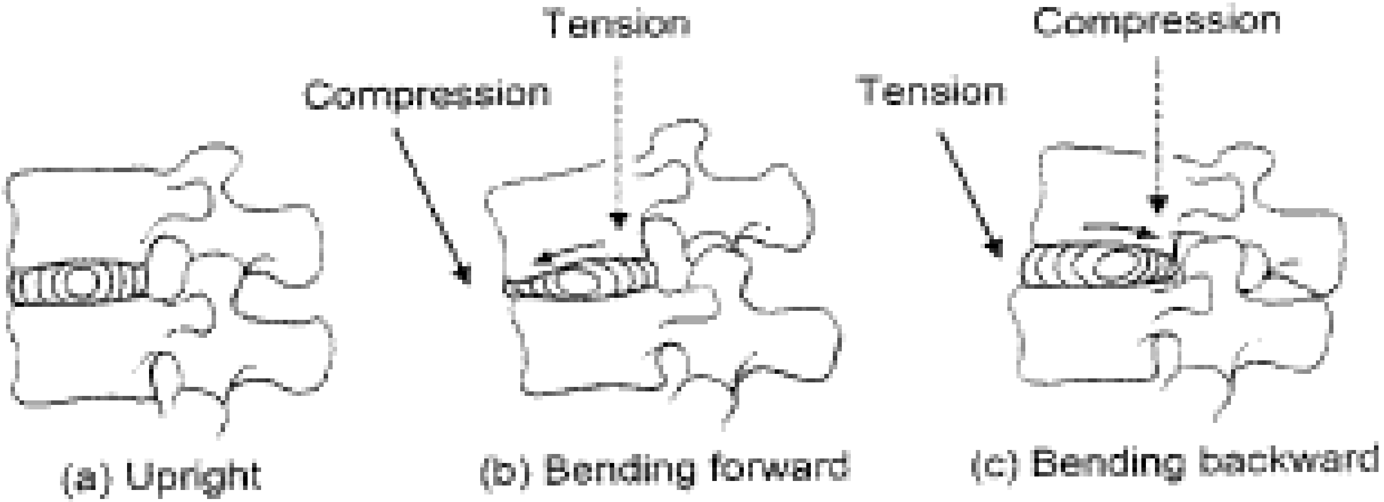


Fig. 2.41. Loading of wet lumbar vertebral discs of persons 40–59 years of age vs. percent compression. For the loading in N, the ordinate scale needs to be multiplied by 9.8. (From [65]. Based on [96])

LA COLUMNA VERTEBRAL XI



(a) Upright (b) Bending forward (c) Bending backward

Fig. 2.42. Disc compression for a person who is (**a**) vertical, (**b**) bending forward, and (**c**) bending backward. Bending forward leads to disc compression anteriorly and tension posteriorly, bulging on the compressive side, and the shifting of the disc nucleus posteriorly. (From [88])

LA COLUMNA VERTEBRAL XII

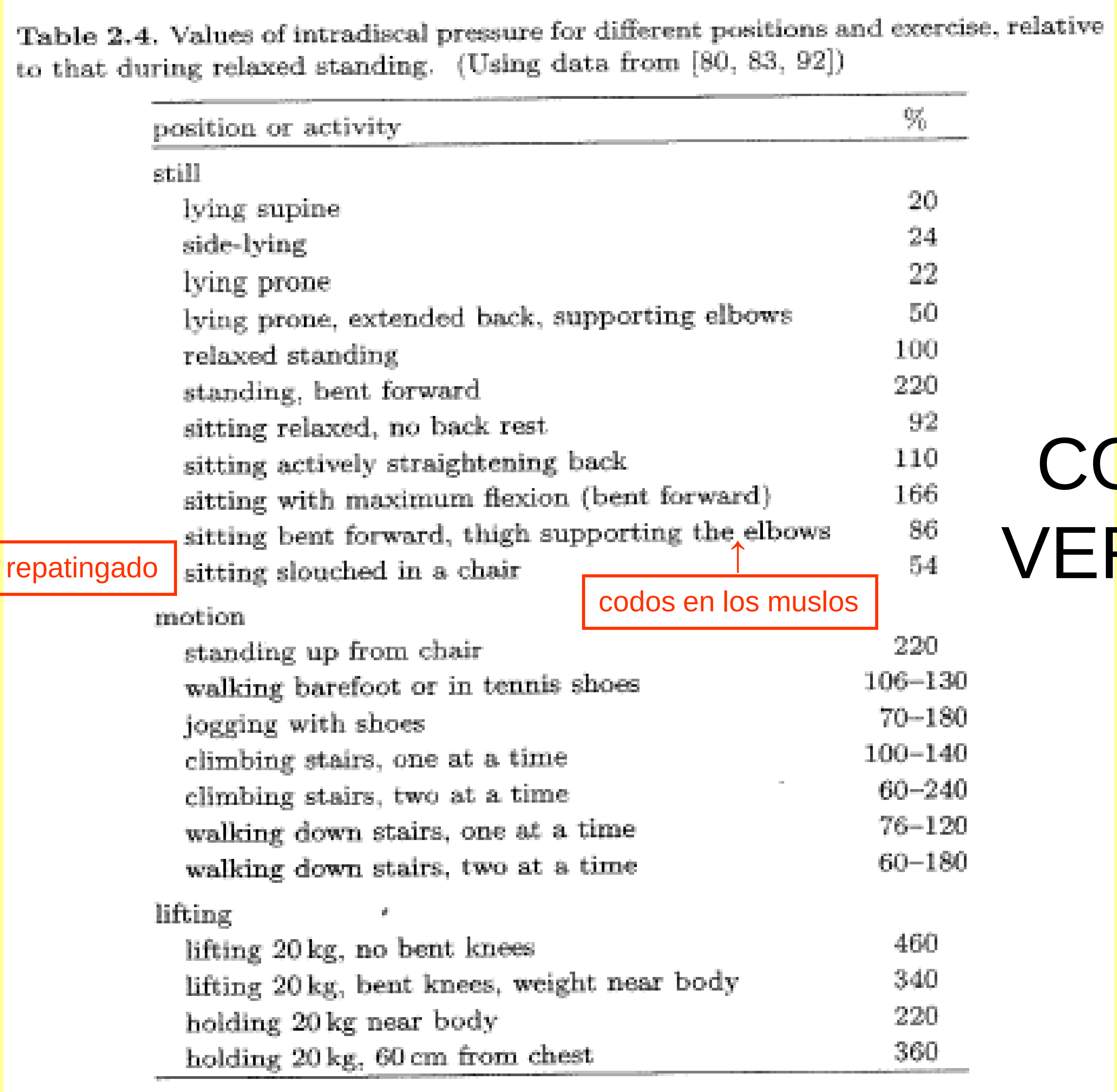


Table 2.4. Values of intradiscal pressure for different positions and exercise, relative to that during relaxed standing. (Using data from [80, 83, 92])

position or activity	%
still	
lying supine	20
side-lying	24
lying prone	22
lying prone, extended back, supporting elbows	50
relaxed standing	100
standing, bent forward	220
sitting relaxed, no back rest	92
sitting actively straightening back	110
sitting with maximum flexion (bent forward)	166
sitting bent forward, thigh supporting the elbows	86
sitting slouched in a chair	54
motion	
standing up from chair	220
walking barefoot or in tennis shoes	106–130
jogging with shoes	70–180
climbing stairs, one at a time	100–140
climbing stairs, two at a time	60–240
walking down stairs, one at a time	76–120
walking down stairs, two at a time	60–180
lifting	
lifting 20 kg, no bent knees	460
lifting 20 kg, bent knees, weight near body	340
holding 20 kg near body	220
holding 20 kg, 60 cm from chest	360

repatingado

↑ codos en los muslos

LA COLUMNA VERTEBRAL XIII

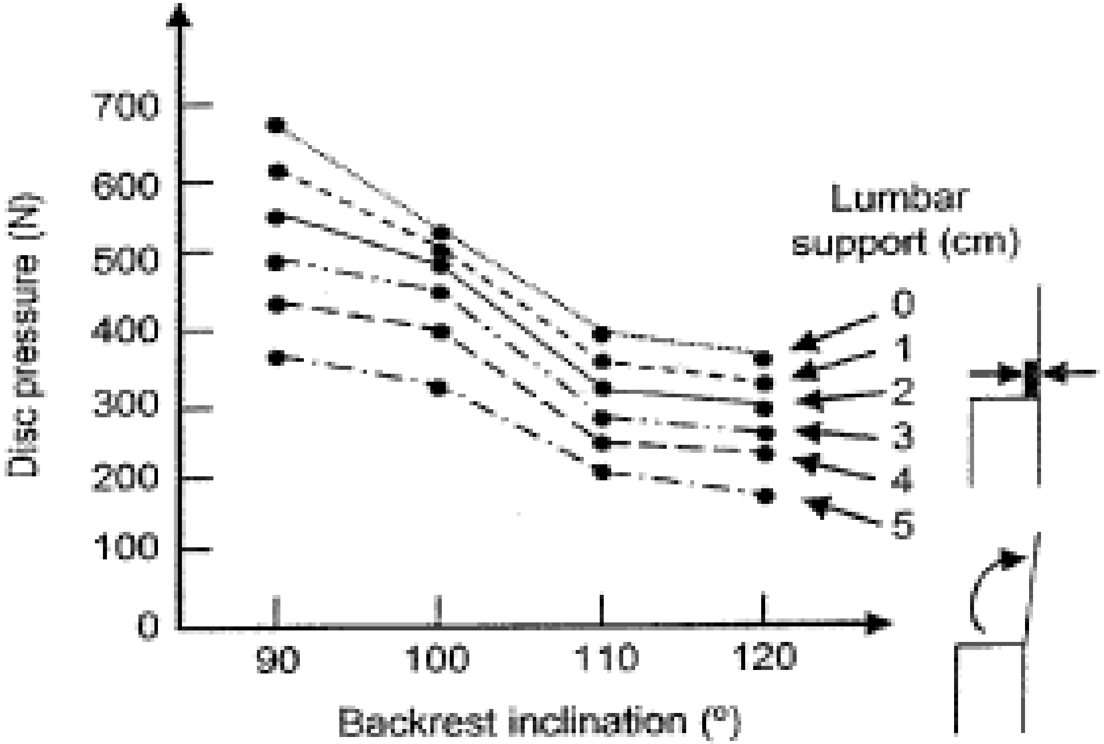


Fig. 2.44. The pressure on the third lumbar disc is decreased with backward backrest inclination and with lumbar support. Also, it is increased with support in the thoracic region, which is not shown here. Chairs with some backward inclination and lumbar support provide needed support, while those with an upright flat back or that curve toward the body can cause painful pressure. (Based on [64, 69])

LA COLUMNA VERTEBRAL XIV

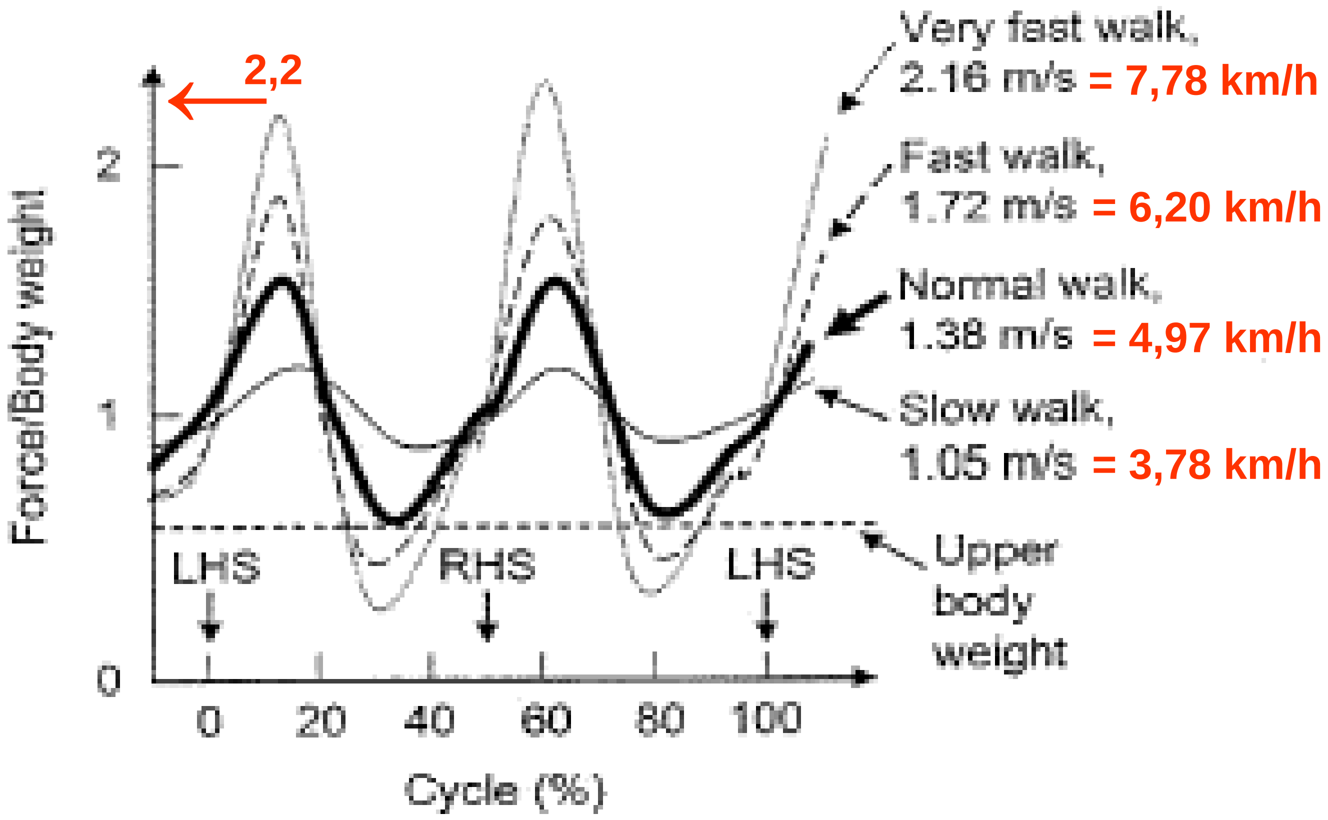


Fig. 2.43. Axial load on the disc between the L3 and L4 vertebra while walking at different speeds. LHS and RHS are left and right heel strike, respectively. (Based on [68, 83])

1 cuadra/minuto = 120 m/minuto = 120 m/ 60 s = 2 m/s = 7,20 km/h

LA COLUMNA VERTEBRAL XV

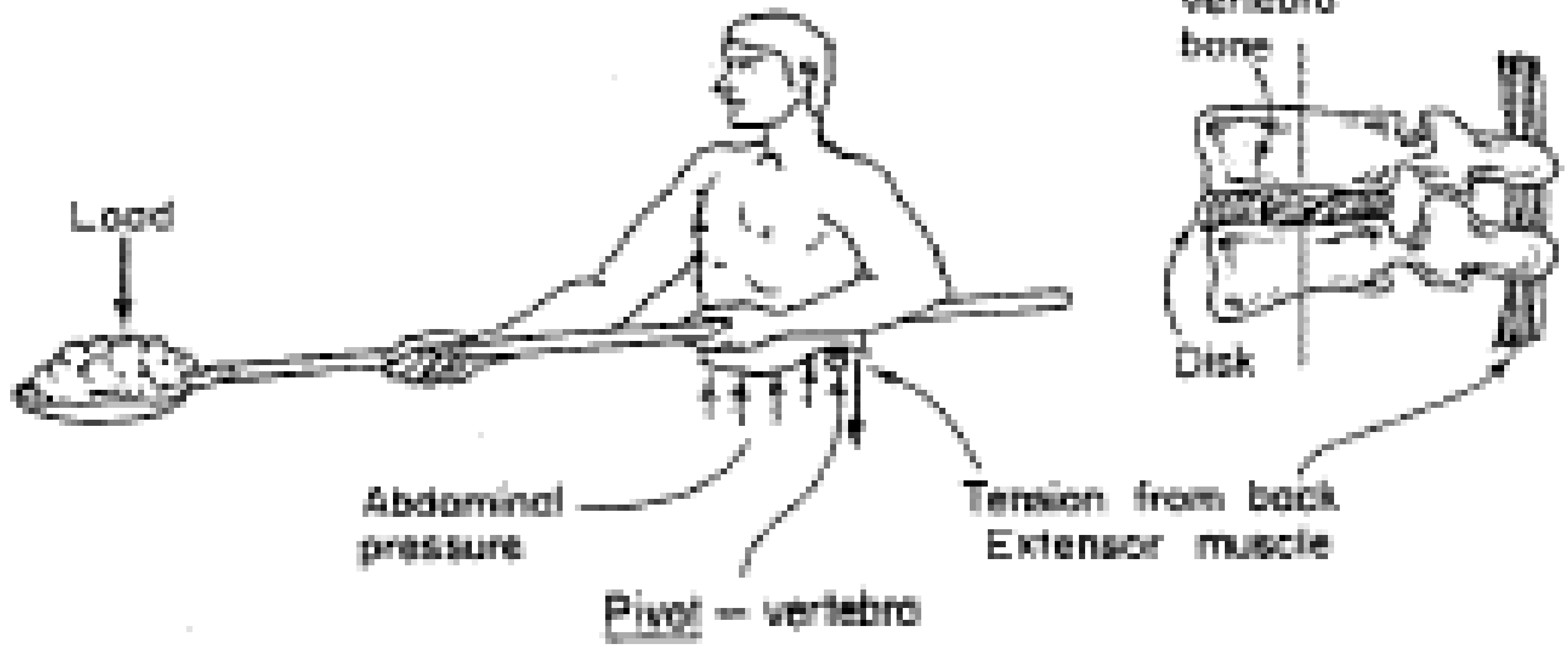


Fig. 2.56. Shoveling. (From [71].) For Problem 2.36

LA COLUMNA VERTEBRAL XVI

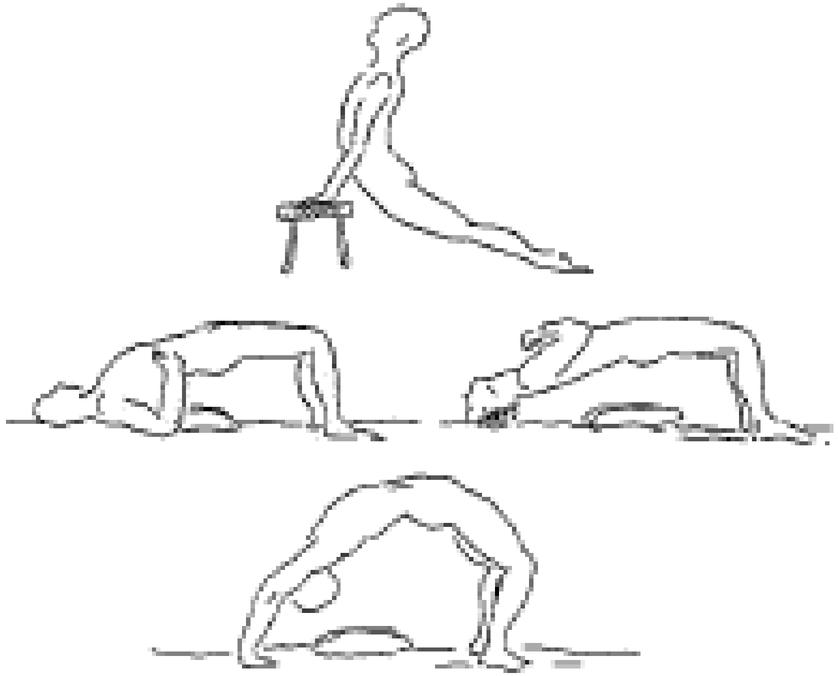


Fig. 2.45. Hyperextension exercises recommended (at the Tientzin Hospital in China) to strengthen the back of lumbago patients (i.e., those with mild to severe pain or discomfort in the lower back); each is performed with the patient's back kept hollow. Several other exercises are also recommended for those with lower back pain. If you have lower back pain, please consult your physician before attempting any of these exercises. (From [70])

BIOFISICA

CAPITULO 2

Modelado de las Articulaciones por Segmentos

MODELO DE SEGMENTOS I

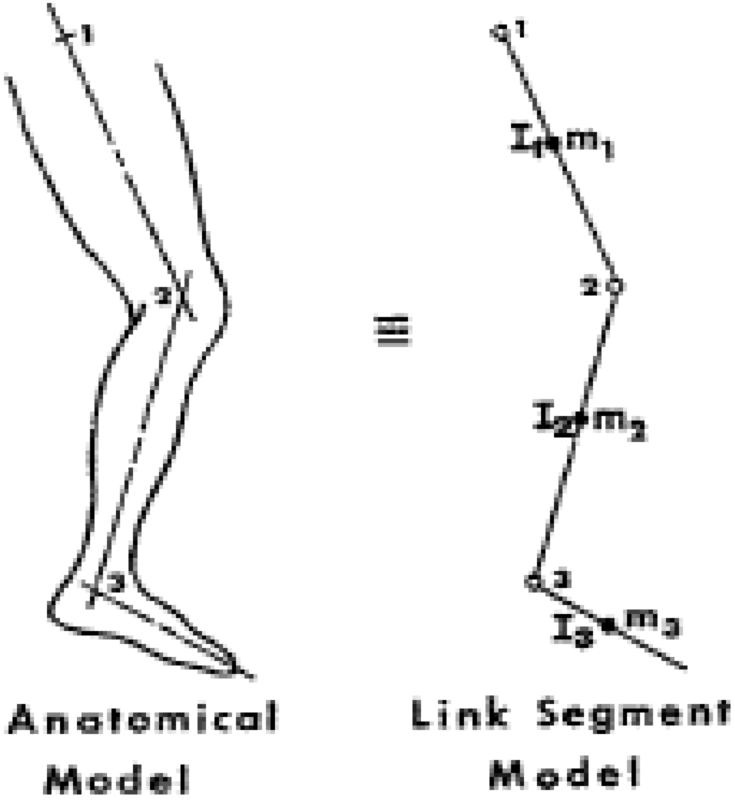


Fig. 2.47. Relationship between an anatomical model of the leg and a link segment model of the upper leg, lower leg, and foot. (From [95]. Reprinted with permission of Wiley)

MODELO DE SEGMENTOS II

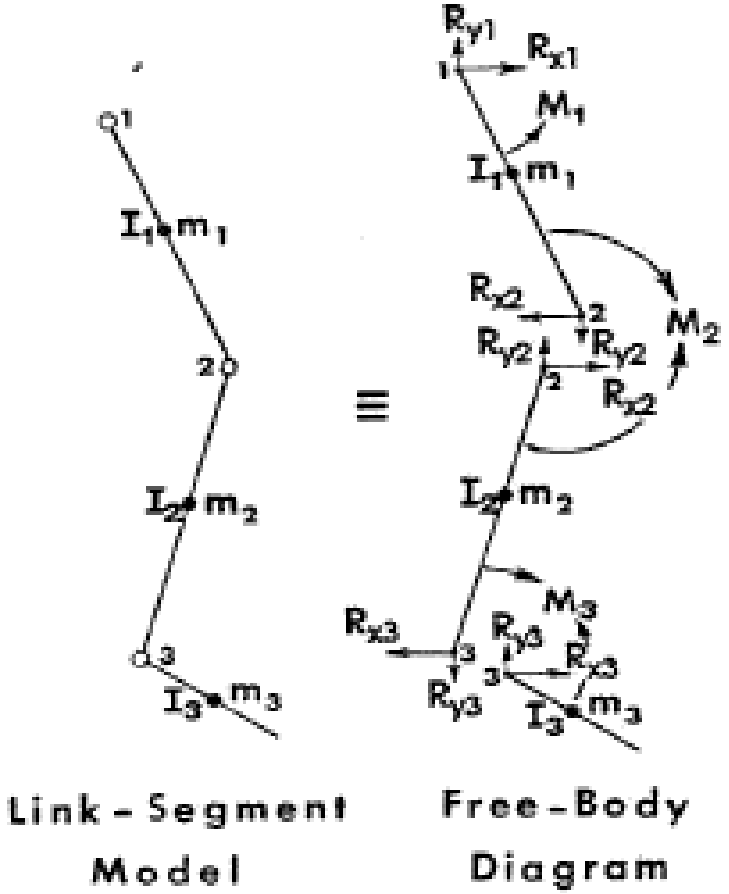


Fig. 2.48. Relationship between the link segment of the leg with a free-body diagram, with individual upper leg, lower leg, and foot. (From [95]. Reprinted with permission of Wiley)

MODELO DE SEGMENTOS III

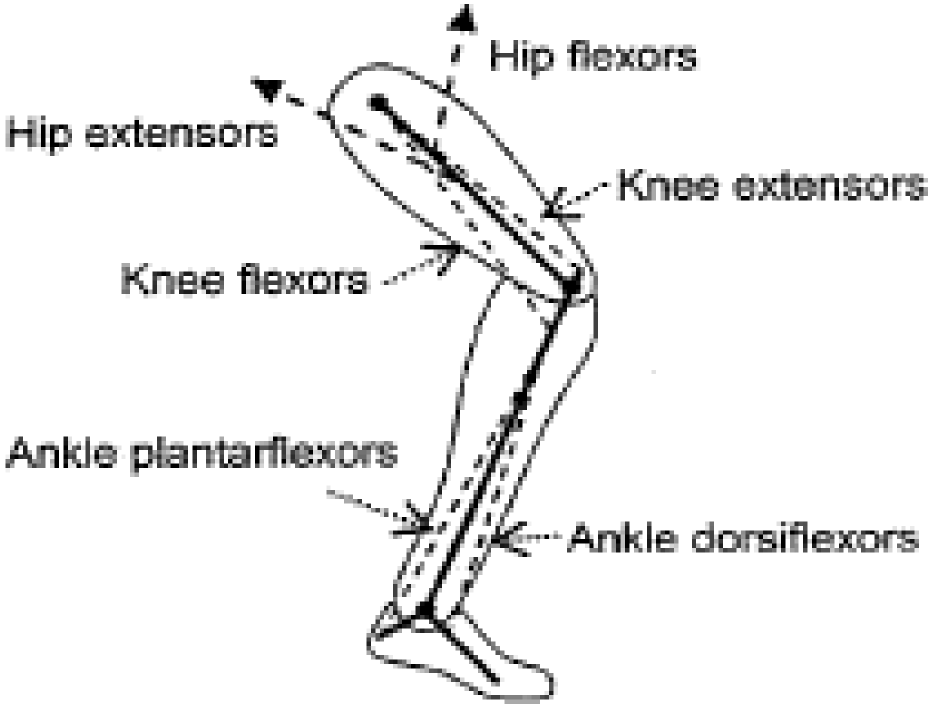


Fig. 2.57. Idealized resultant forces for six muscle groups in the leg. (Based on [77].) For Problem 2.37

BIOFISICA

CAPITULO 2

La Articulación Temporo-mandibular. Evolución, Filogenia y Ontogenia. Dentición y Ortodoncia.

LA ARTICULACION TEMPORO-MANDIBULAR I

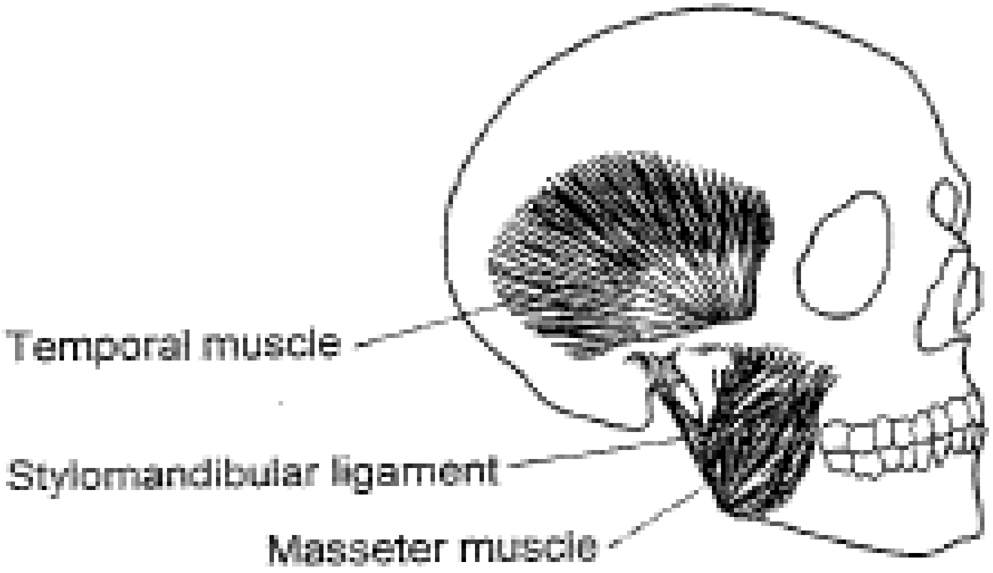
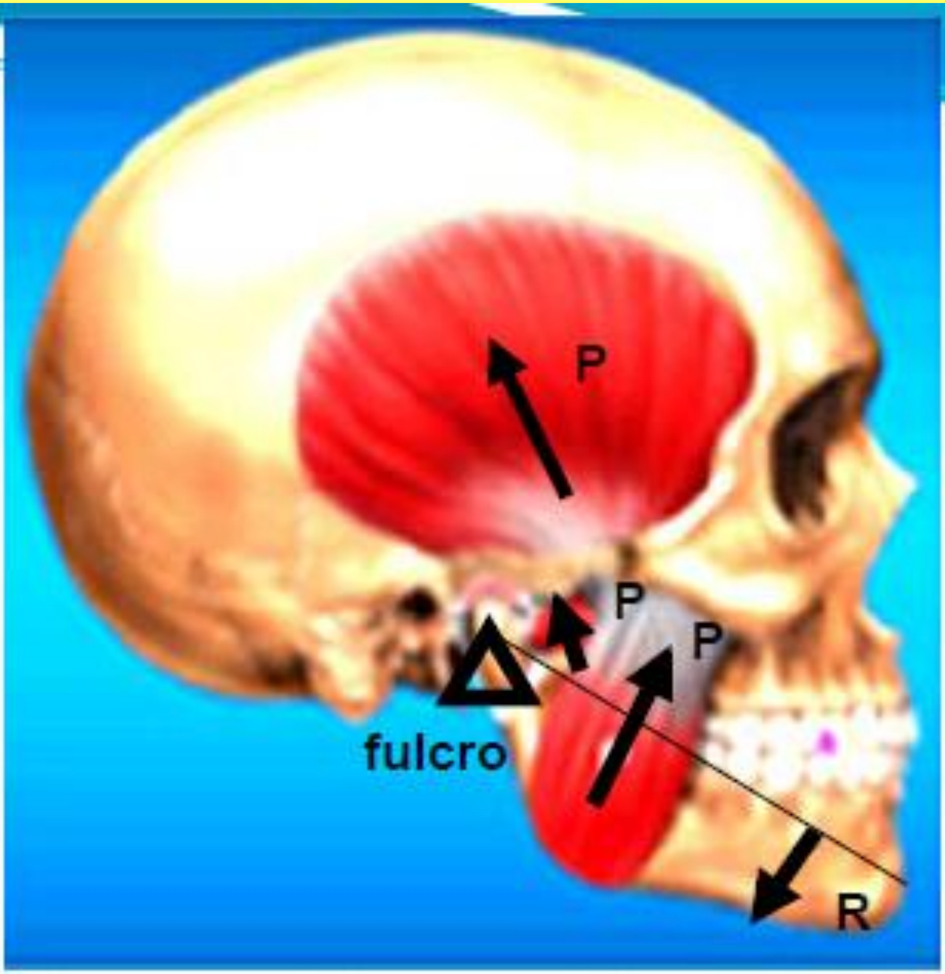


Fig. 2.29. The masseter and temporal muscles in the jaw, about the temporomandibular joint. (From [88])



En el **sistema estomatognático** la palanca es de **3er género**.

Potencias: (músculos temporal, masetero y pterigoideos interno y externo)
Fulcro: (articulación temporomandibular - ATM)
Resistencia: (maxilar inferior)

FUERZAS Y TORQUES I

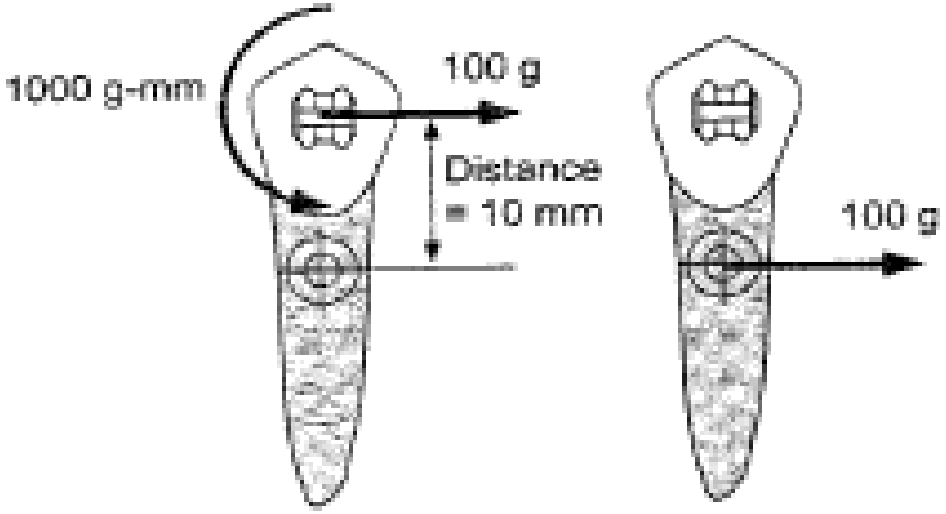
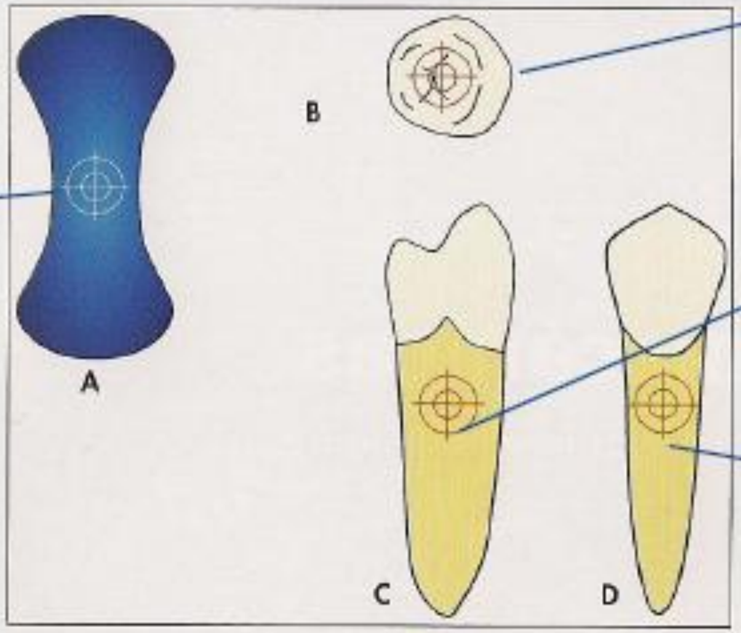


Fig. 2.30. In orthodontics forces and torques are applied to the crown (*left*), leading to forces (and in this case no torques) about the center of resistance. (Reprinted from [81]. Used with permission of Elsevier)

Centro de Resistencia de un elemento dentario individual



Cm en un cuerpo genérico

Vista frontal

Vista oclusal

Vista mesial

Fig. 1-1 Centro de resistencia. **A** Centro de masa de un cuerpo libre. **B** Frontal **C** Oclusal y **D** Vistas mesiales del centro de resistencia de un diente individual.

Cm o C R en cada elemento

Depende de:

- LONGITUD de la raíz
- MORFOLOGÍA: Nº de raíces y nivel o altura del apoyo óseo alveolar

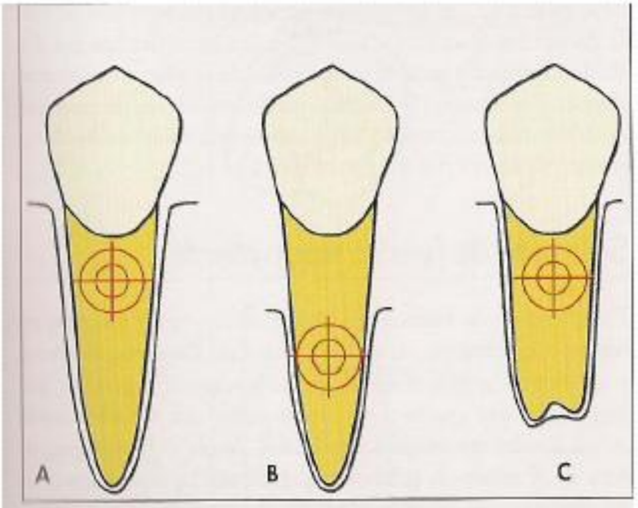
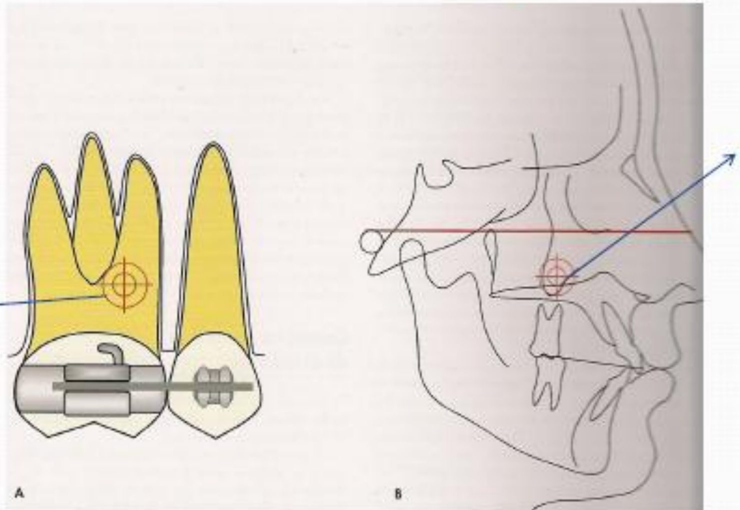


Fig. 1-3 La localización del centro de resistencia depende de la altura del hueso alveolar y la longitud de la raíz. **B** Localización del centro de resistencia con pérdida de hueso alveolar y **C** Con una raíz reducida.

Cm o C R en dos elementos y en un maxilar

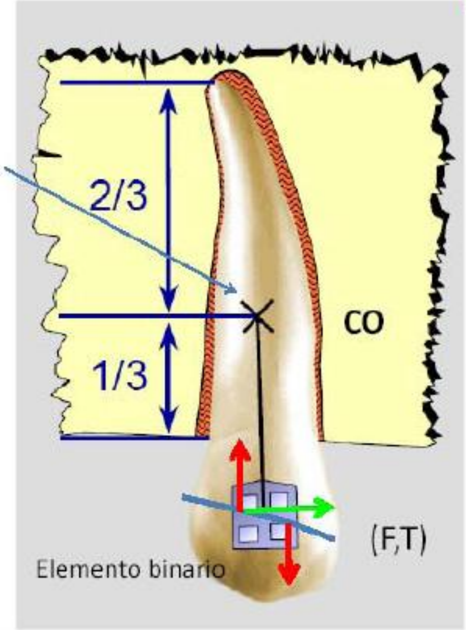


Cm de dos elementos

Cm de maxilar

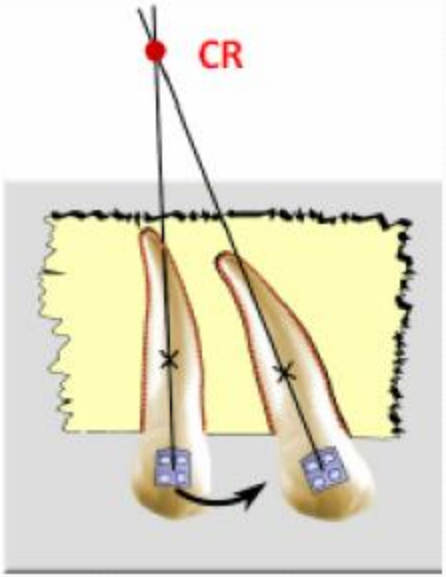
ig. 1-2 Centro de resistencia para **A** un segmento de dos dientes y **B** un maxilar.

Centro de oposición = punto en que las fuerzas sobre el bracket se reflejan sobre el diente



CENTRO DE ROTACION

Es un punto creado o producido dependiendo de las fuerzas que apliquemos y es el punto sobre el cual se va a inclinar o va a rotar el diente, puede o no coincidir con el centro de resistencia.




Fotografia Paciente Universidad de Cuenca


Fotografia Paciente Universidad de Cuenca


Fotografia Paciente Universidad de Cuenca

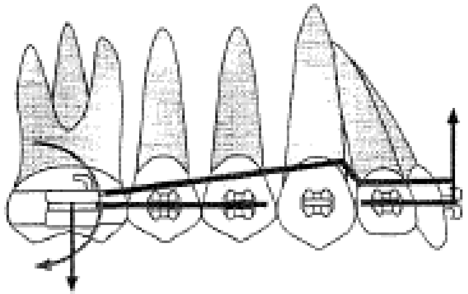


Fig. 2.32. Forces and torques applied by the intrusion arch in Fig. 2.31. (Reprinted from [81]. Used with permission of Elsevier)

FUERZAS Y TORQUES IV
Investigación Ortodóntica en La Plata

APPLICATIONS OF VERTICAL BRACKETS IN ORTHODONTIAL TREATMENTS: A LASER SPECKLE STUDY.

M. Abbattista, L. Abbattista, N. Rodríguez, R. Torroba, L.M. Zerbino, M. Gallardo and M. Garavaglia

LASERS AND APPLICATIONS, Editors: W. O. N. Guimaraes, C. T. Lin and A. Mooradian. Springer Series in Optical Sciences, **26**, 261, Springer-Verlag, Berlin, 1981.

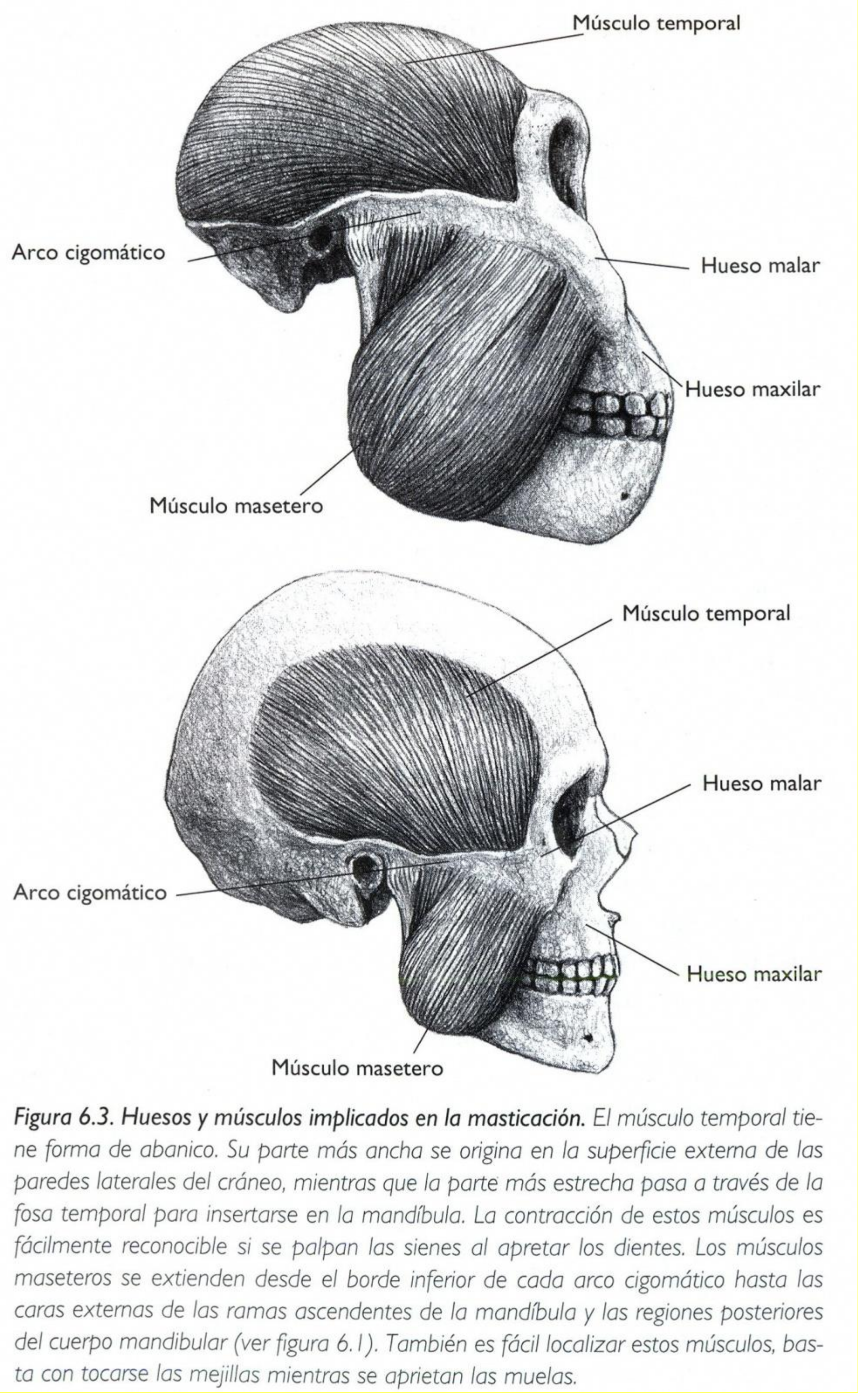


Figura 6.3. Huesos y músculos implicados en la masticación. *El músculo temporal tiene forma de abanico. Su parte más ancha se origina en la superficie externa de las paredes laterales del cráneo, mientras que la parte más estrecha pasa a través de la fosa temporal para insertarse en la mandíbula. La contracción de estos músculos es fácilmente reconocible si se palpan las sienes al apretar los dientes. Los músculos maseteros se extienden desde el borde inferior de cada arco cigomático hasta las caras externas de las ramas ascendentes de la mandíbula y las regiones posteriores del cuerpo mandibular (ver figura 6.1). También es fácil localizar estos músculos, basta con tocarse las mejillas mientras se aprietan las muelas.*

LA ARTICULACION TEMPORO-MANDIBULAR Componente del sistema estomatognático

altamente informativa para la construcción de filogenias.

Paranthropus æthiopicus

Y

Homo sapiens

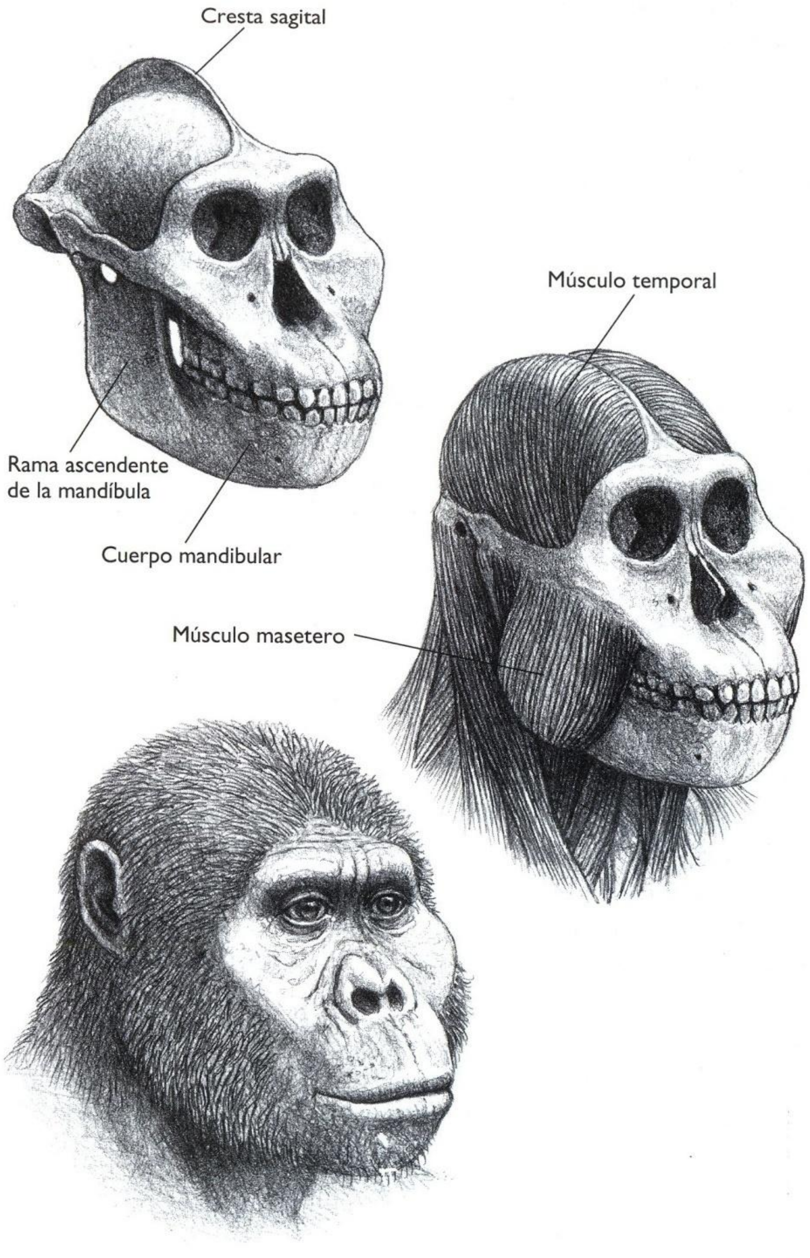


Figura 6.1. Macho de Paranthropus aethiopicus.

LA ARTICULACION TEMPORO-MANDIBULAR III

CRESTA SAGITAL DEL MACHO *Paranthropus æthiopicus*

Cresta Sagital

La **cresta sagital** es una protuberancia ósea que recorre la parte superior del cráneo, pasando por el medio de éste. La presencia de esta protuberancia indica una excepcional fuerza de los músculos de la mandíbula, ya que la cresta sagital sirve principalmente para la unión del músculo temporal, que es uno de los principales músculos masticadores. El desarrollo de esta cresta se supone estar ligado con el desarrollo del mismo músculo.

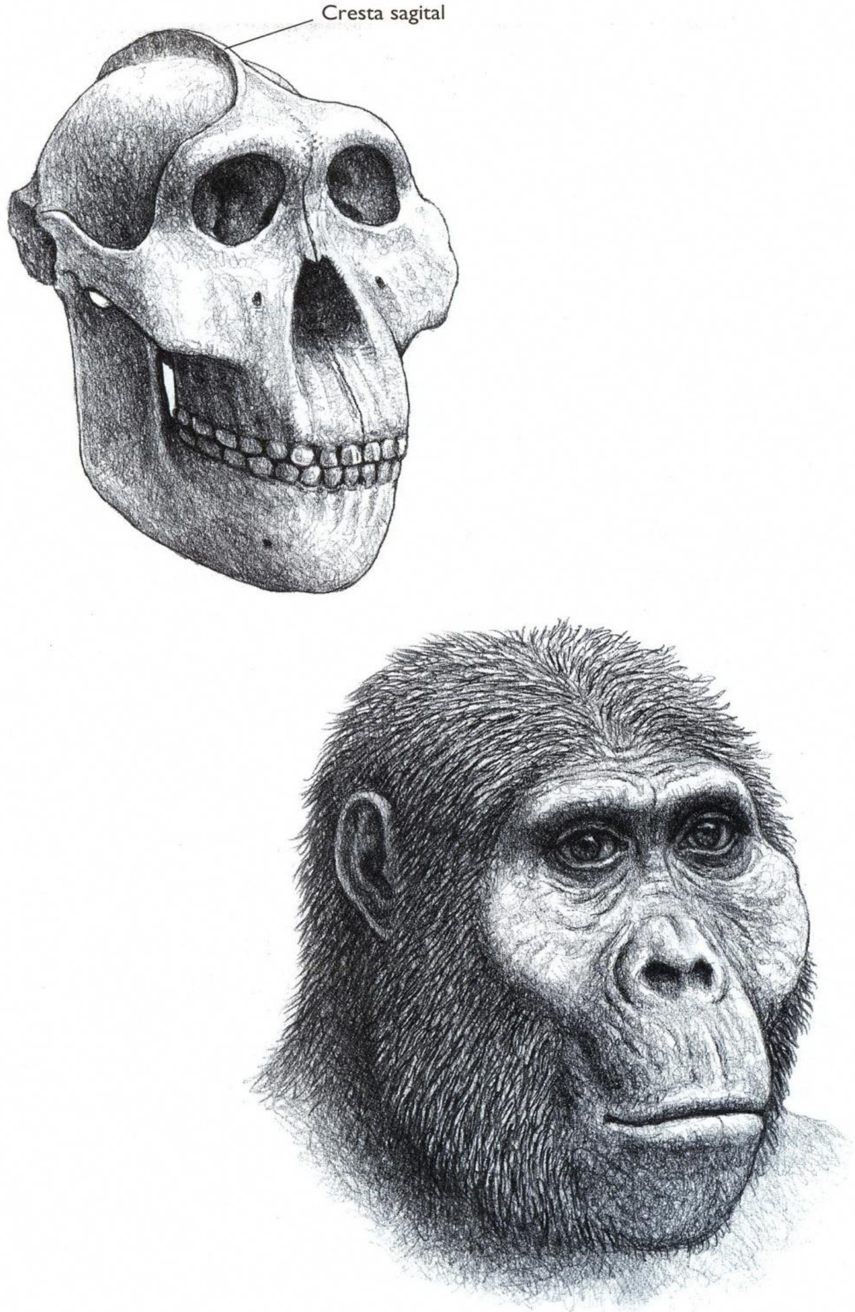


Figura 6.2. Macho de Paranthropus boisei.

CRESTA SAGITAL DEL MACHO *Paranthropus boisei*

Réplica del cráneo de
Paranthropus boisei.
Cráneo descubierto
por Mary Leakey en
Olduvai Gorge,
(1,75 millones de años)
Mandíbula descubierta
por Kamoya Kimeu 1964
(1,5 millones de años)

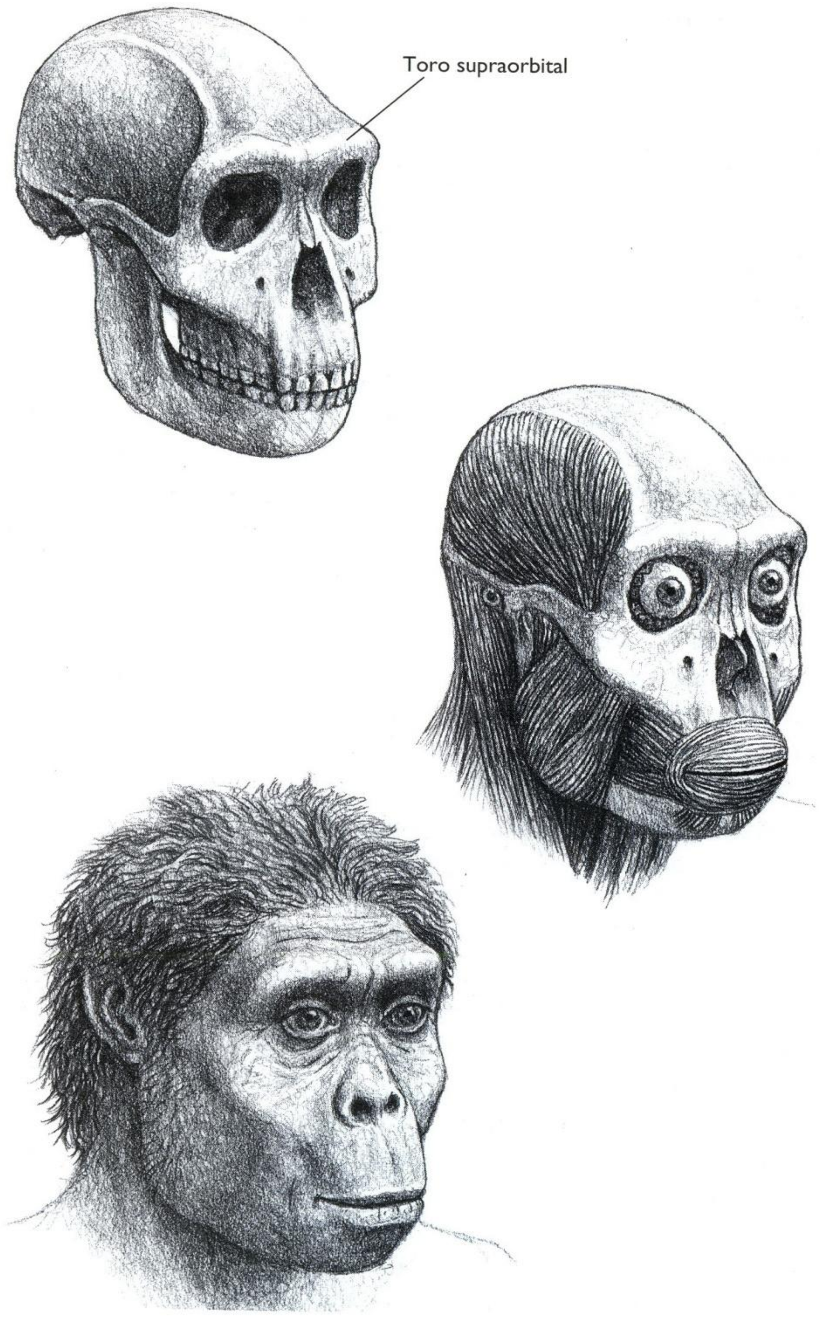


Figura 7.2. Individuo femenino de Homo habilis.

DOBLE CRESTA SAGITAL DE INDIVIDUO FEMENINO *Homo habilis*

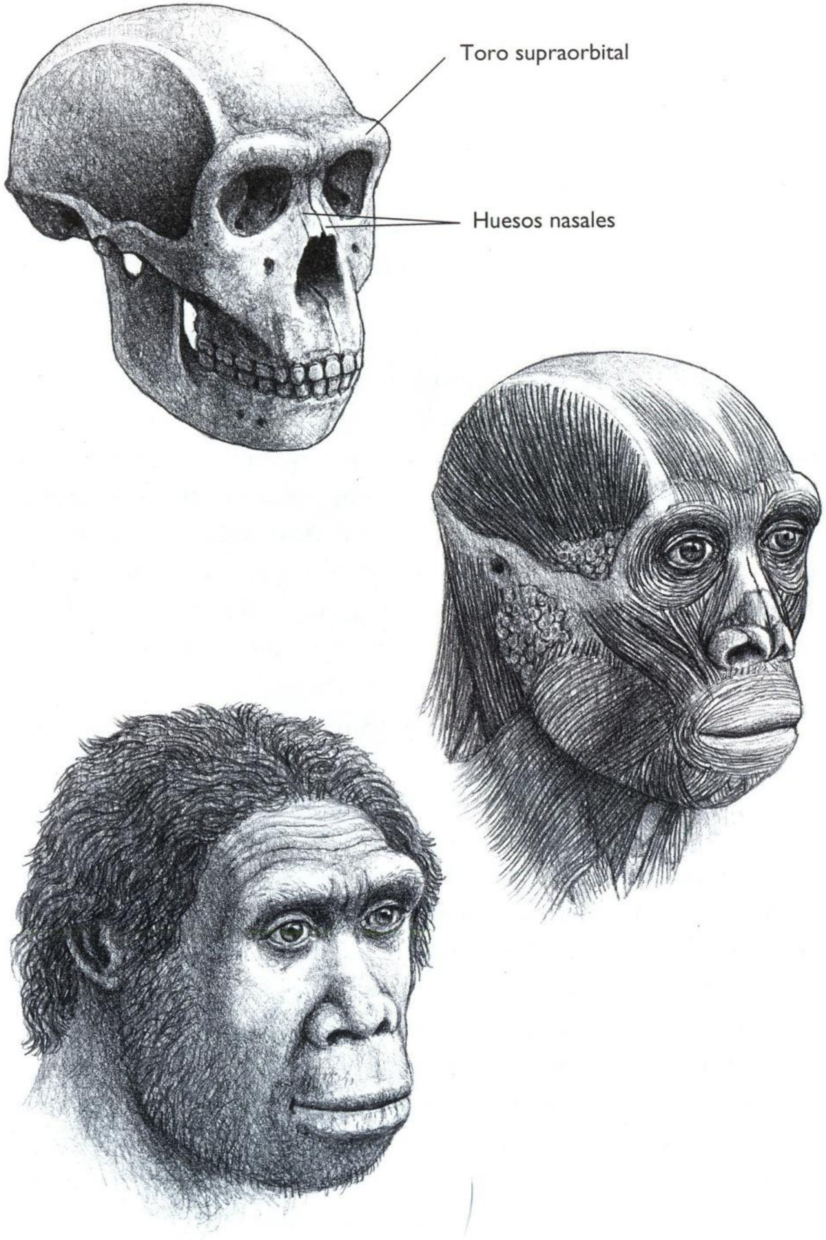


Figura 7.3. Individuo masculino de Homo ergaster.

DOBLE CRESTA SAGITAL DE INDIVIDUO MASCULINO *Homo ergaster*

GORILAS vs HUMANOS

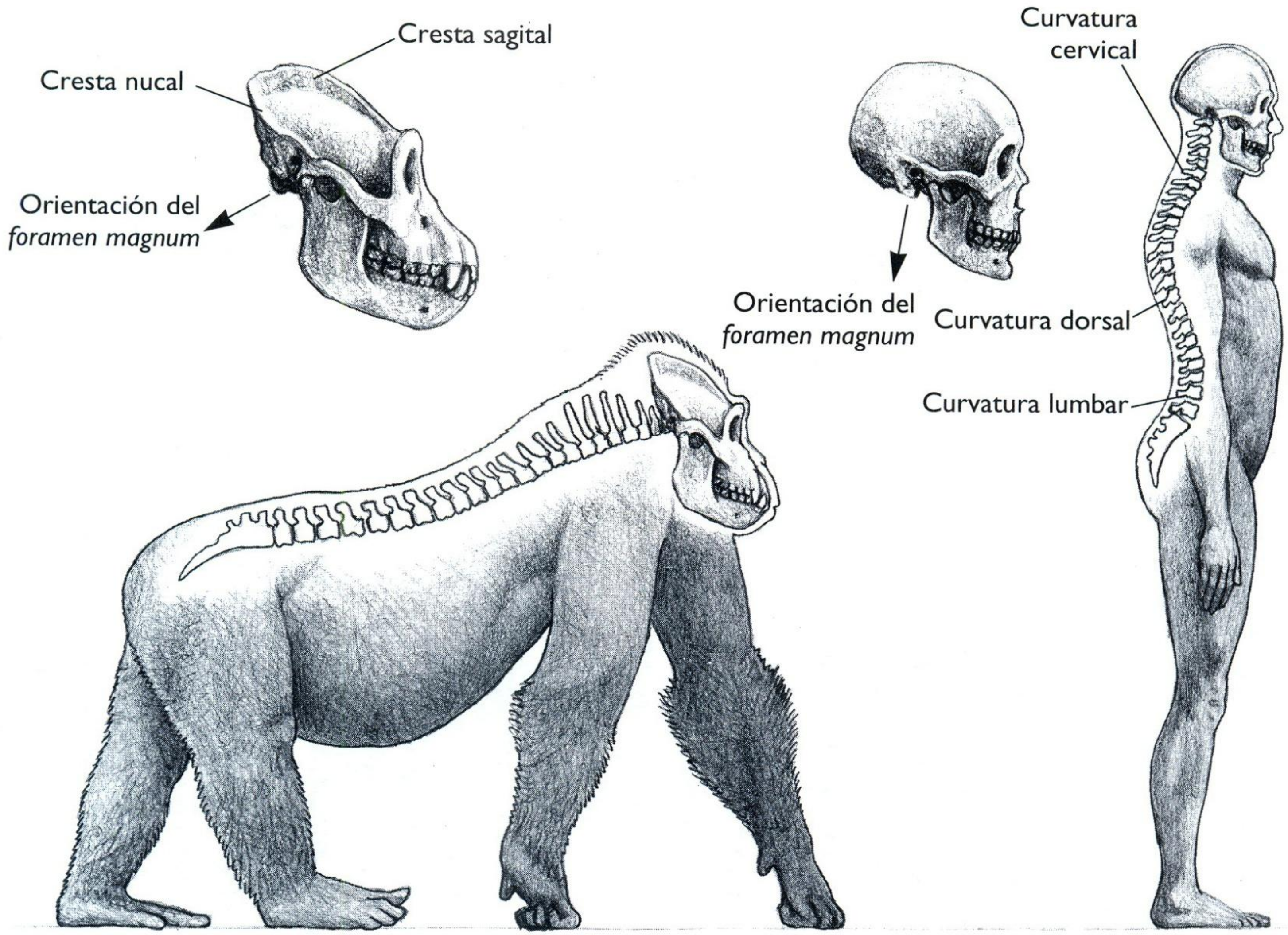
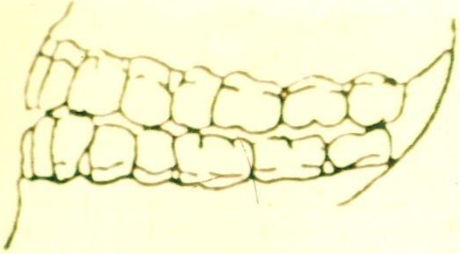
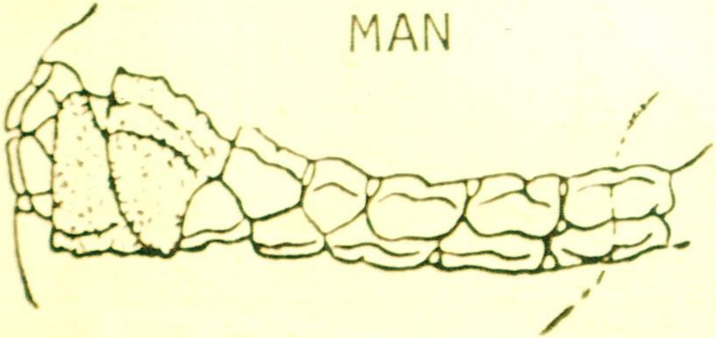


Figura 5.4. Curvaturas de la columna vertebral y orientación del foramen magnum *en gorilas y humanos.*

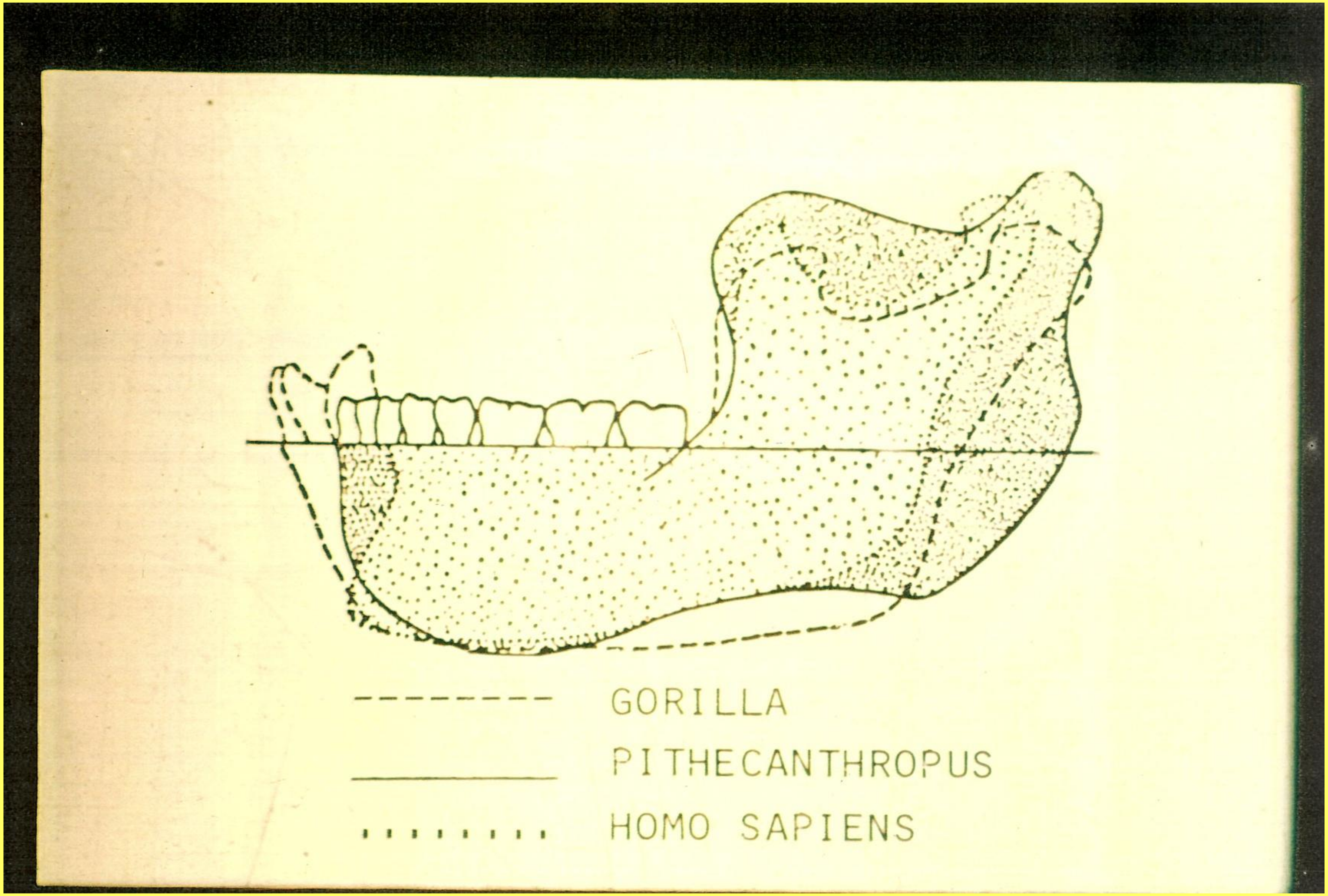
Australopitecus afarensis 3.5M.a	*Homo habilis 2,5-1.,8 M.a.*	*Homo ergaster 1,8-.a.*	*Homo erectus 1,8-.a*	*Homo heidelbergensis 800.000-*	*Homo neandertalensis 130.000-30.000a.*
- Dentición similar a simios. - Incisivos centrales con forma de espátula. - Fila de molares y PM paralela - Arco dentario en forma de U. - Diastema canino. - Biprotrusión marcada	- Fila de molares y PM paralela. - Arco dentario en forma de U. - Disminución del diastema canino. - Biprotrusión marcada. - V.C:700 cc.	- Dentición de menor tamaño que A. afarensis - Fila de molares y PM semi-paralela. - Arco dentario en forma de U-V. - Desaparece diastema canino. - Biprotrusión. - V.C	- Dentición similar a H. sapiens - Desaparición de diastema canino. - Arco dentario con forma de V - .Molar y PreMolar de mayor tamaño. - Mandíbulas robustas. - V.C:1000 cc.	- Dentición similar a H. sapiens - Ausencia de diastema canino. - Arco dentario con forma de V. - •1 Molar de mayor tamaño que 3Molar. - V.C: 1300 cc.	- V.C: 1500 cc. - Dentición similar a la nuestra. - Cresta adamantina entre cúspides V-Len H. neandertalensi -Mayor densidad de estrías de Retzius * enH. sapiens

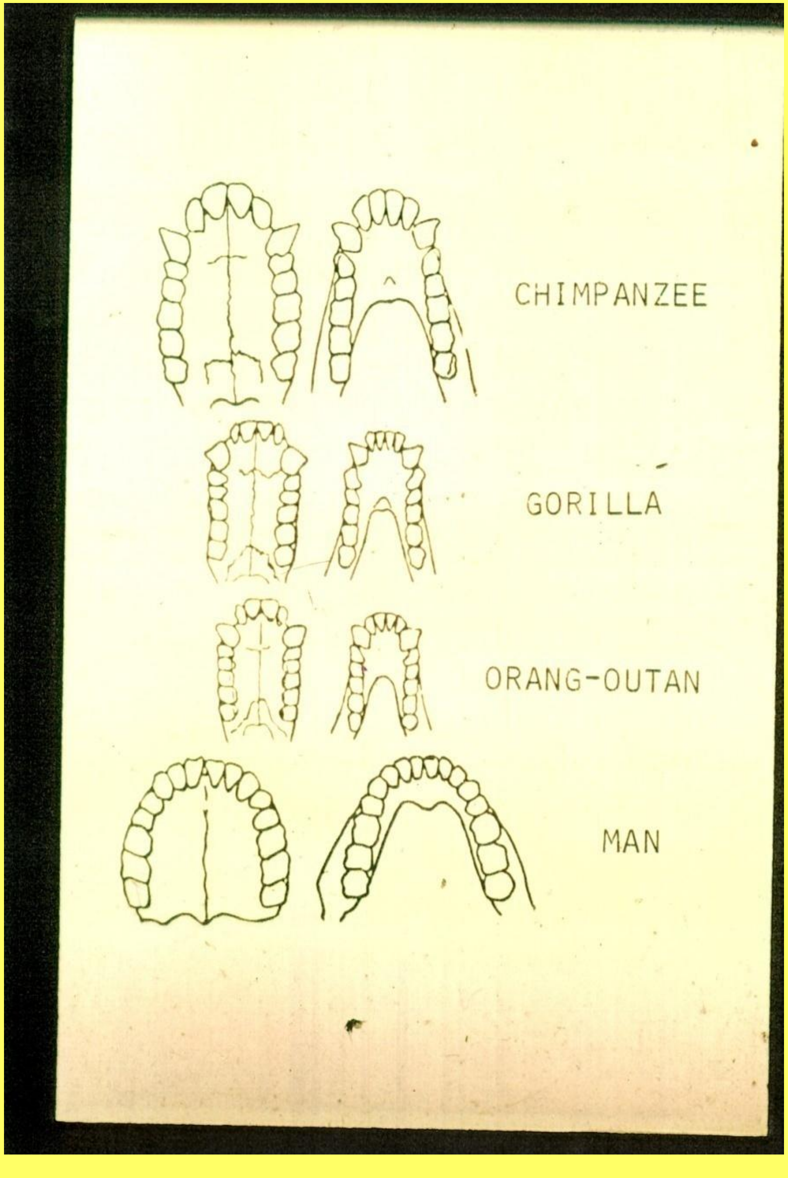


MAN



GORILLA


GORILLA
PITHECANTHROPUS
HOMO SAPIENS

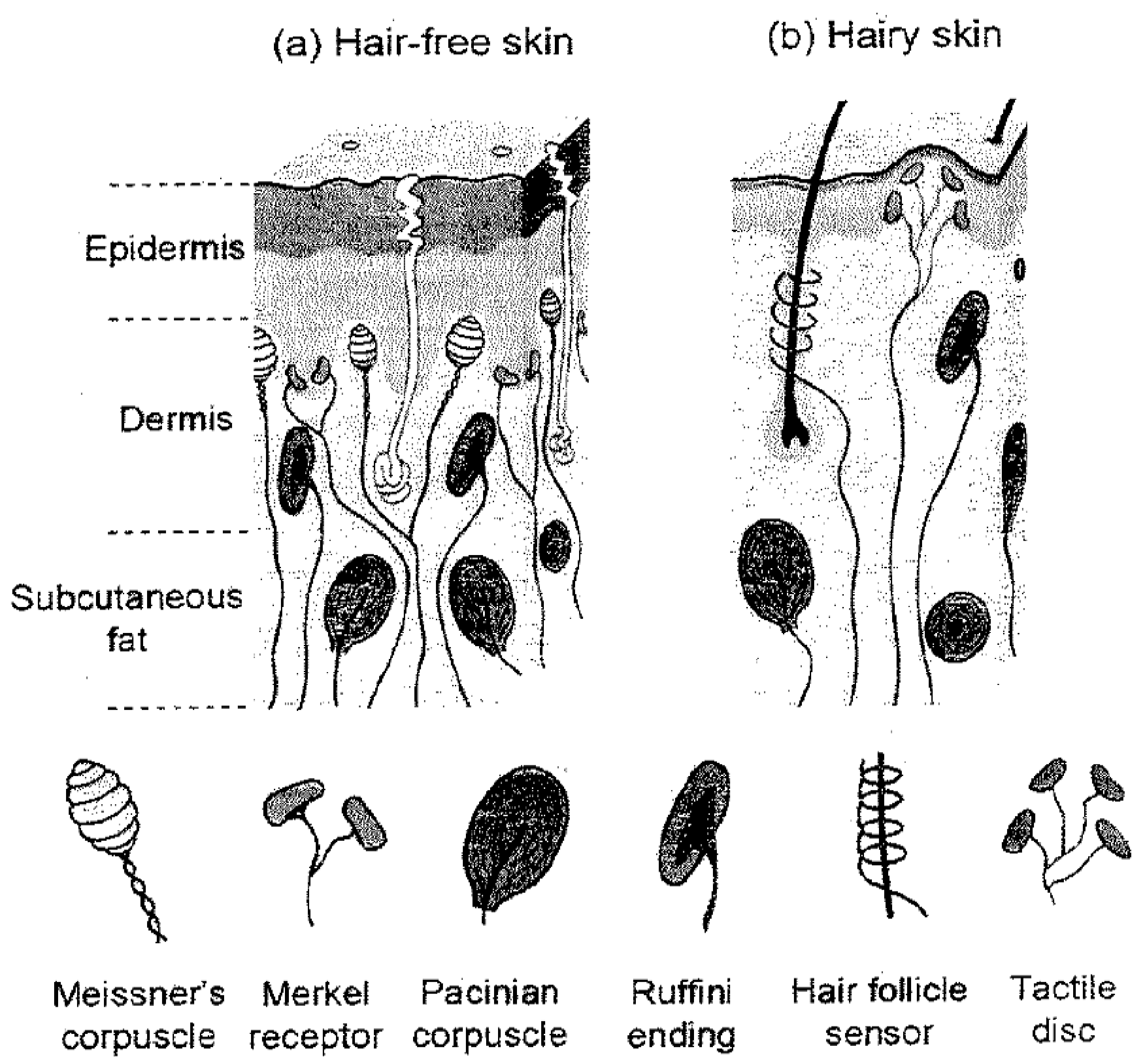

CHIMPANZEE
GORILLA
ORANG-OUTAN
MAN

BIOFISICA

CAPITULO 2

El Sentido del Tacto.

EL SENTIDO DEL TACTO I



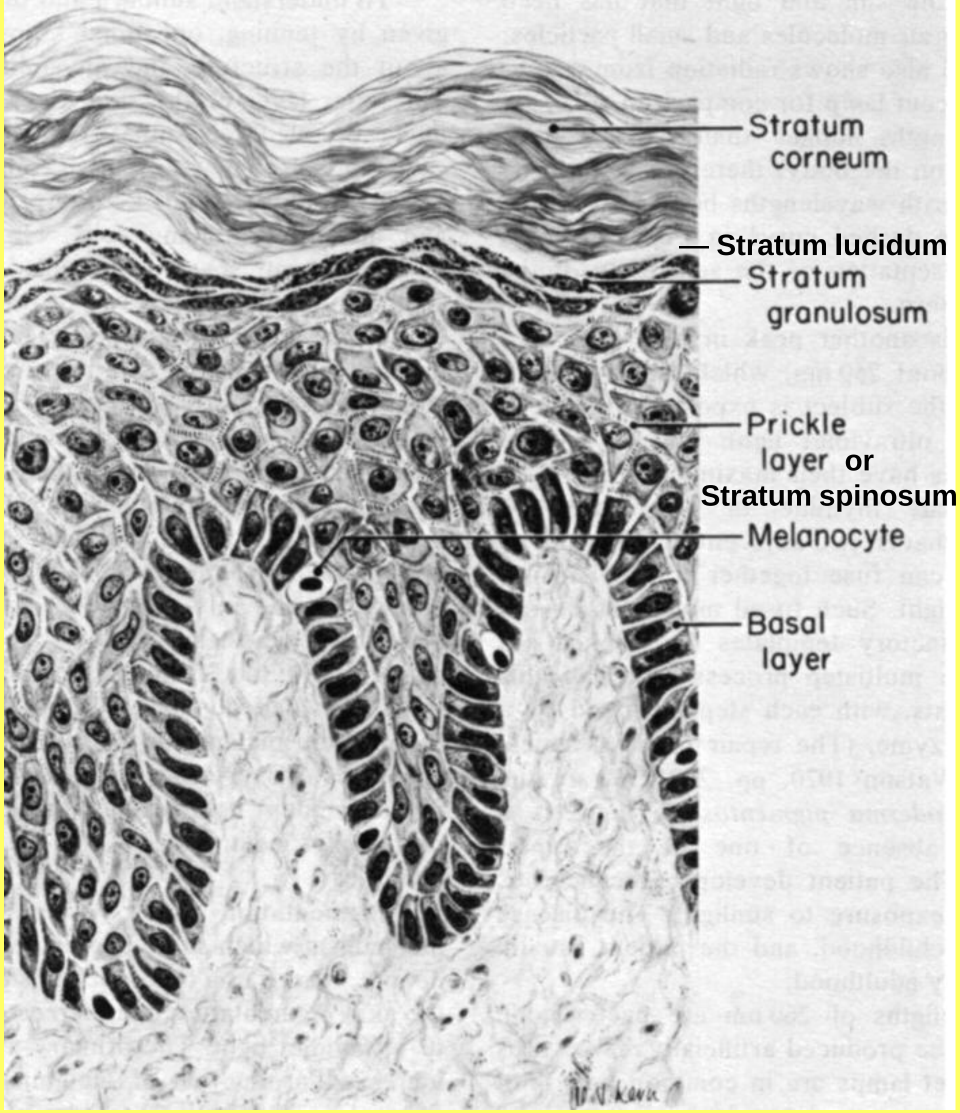
Sensaciones cutáneas o tacto.

Sensaciones de posición de los miembros y de la cabeza o propriocepción.

Sensación de movimiento o kinestésica.

Distribución:
Lengua: 25/cm^2
Espalda: 0,02/cm^2

EL SENTIDO DEL TACTO II



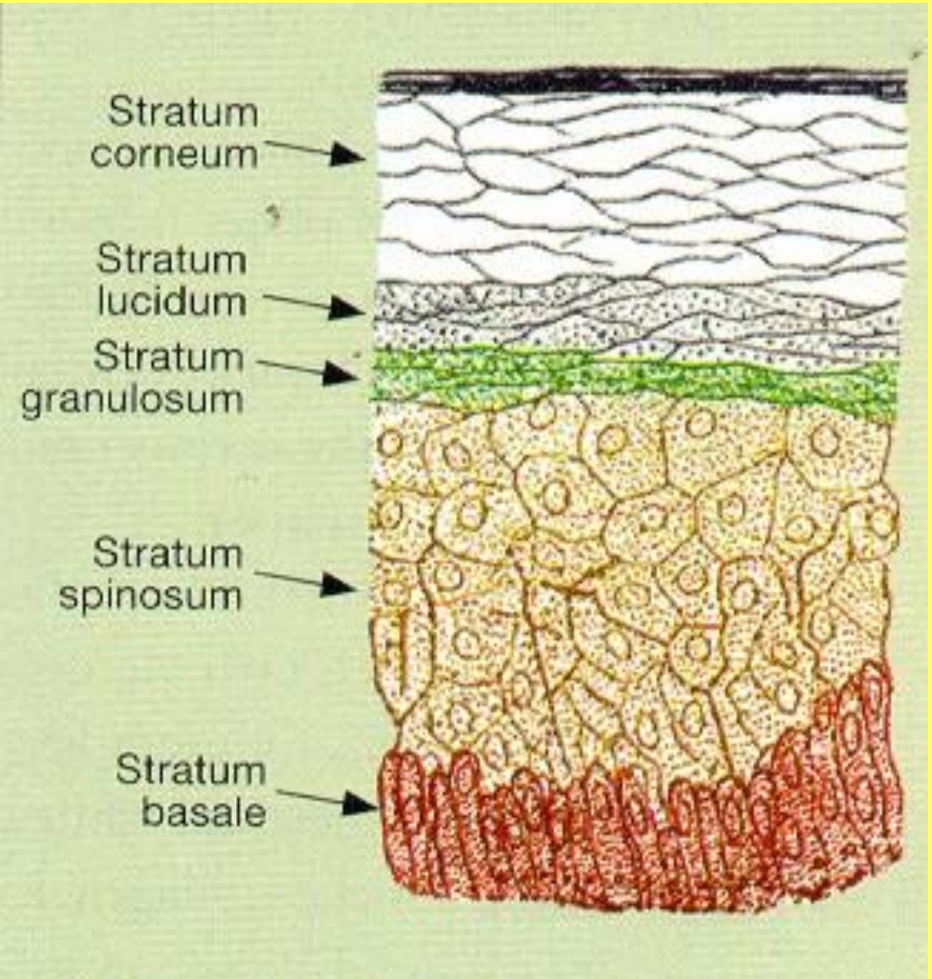
EPIDERMIS

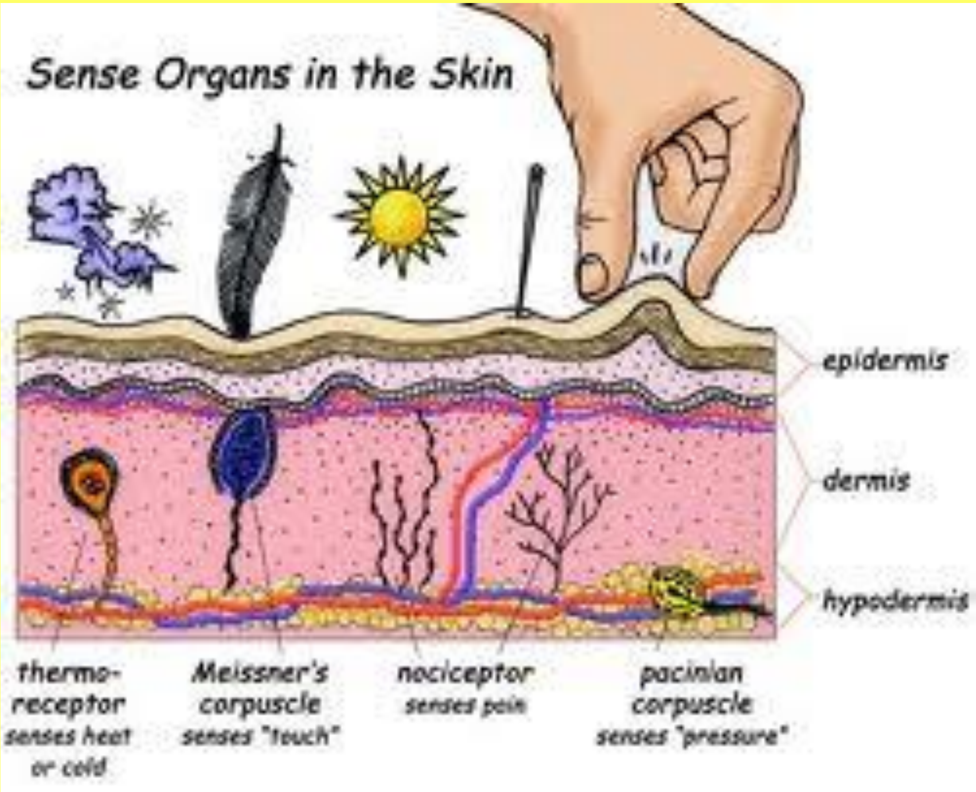
El 90% de sus **células basales** producen **keratina** y el 10% son **melanocitos** que producen **melanina**, el pigmento de la piel. El **stratum spinosum** tiene unas siete capas de células. Sobre ellas se desarrollan el **stratum granulosum** y el **stratum lucidum**, con dos o tres capas de células cada uno. Finalmente el **stratum corneum** se compone de keratina y detritus celulares en forma de escamas.

Su espesor es variable según distintas partes del cuerpo y oscila de 0,5 a 1,1 mm.

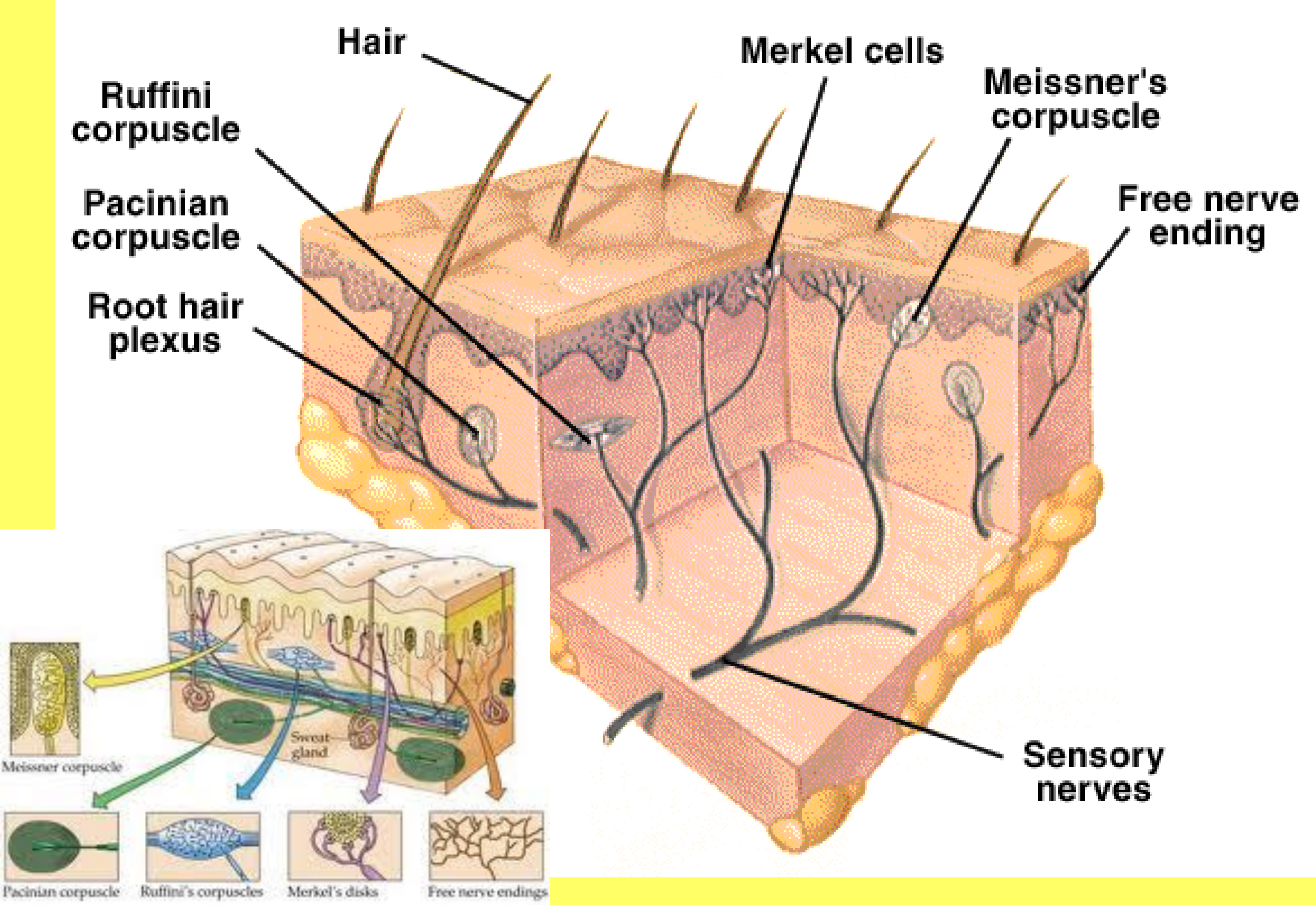
EL SENTIDO DEL TACTO III

Epidermis, dermis e hipodermis

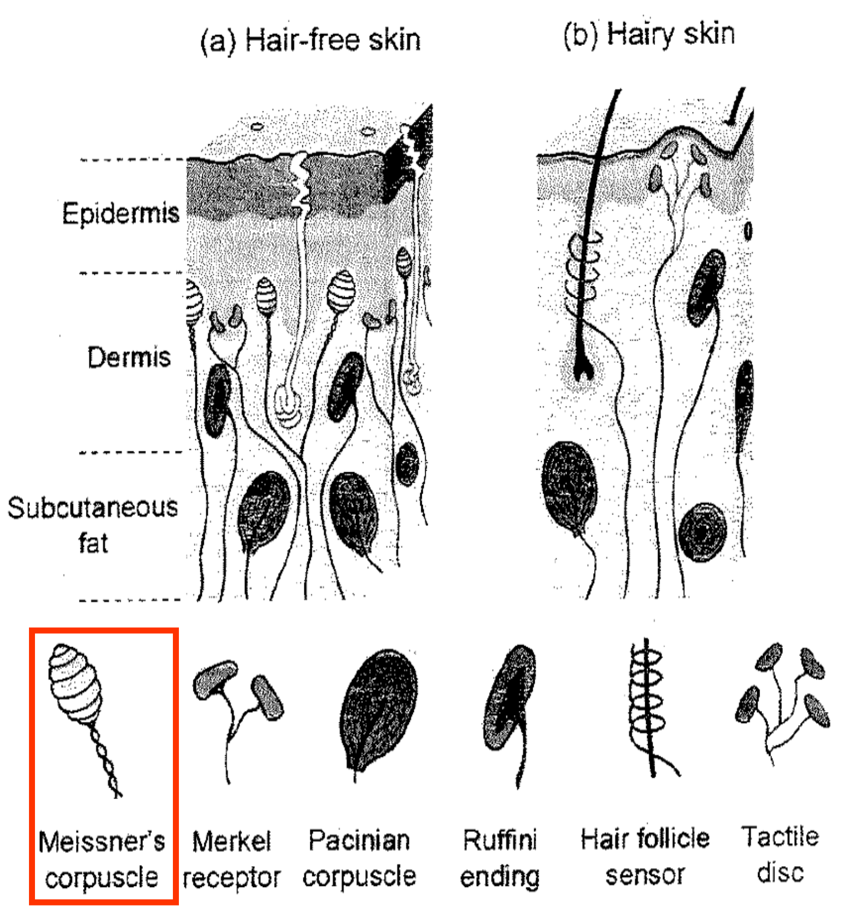


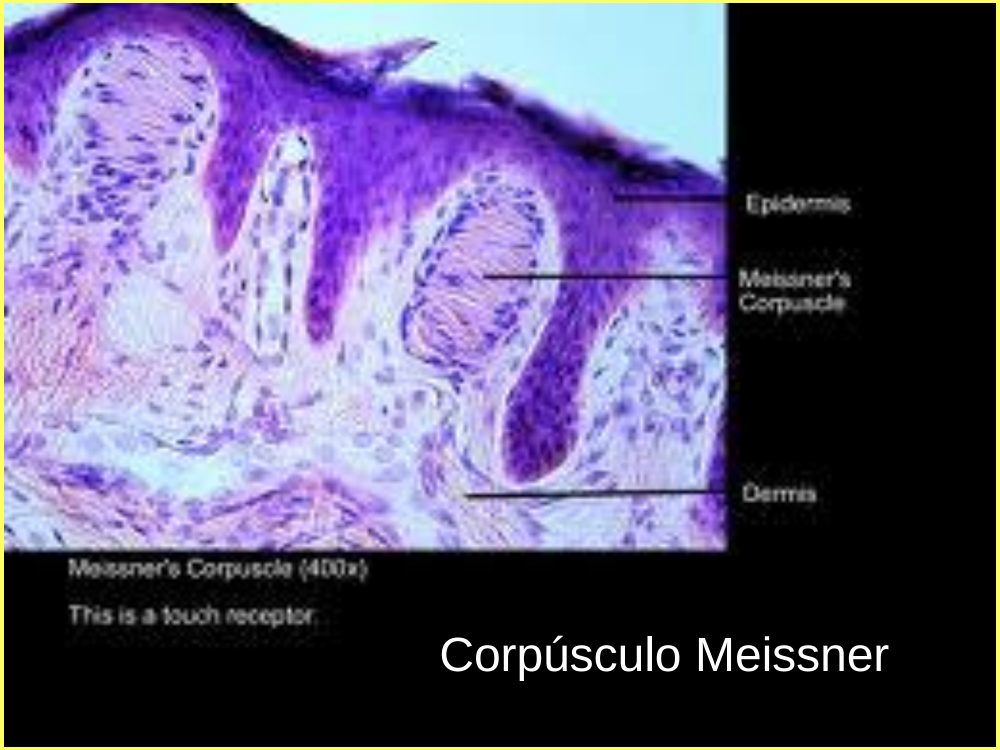


EL SENTIDO DEL TACTO IV



EL SENTIDO DEL TACTO V

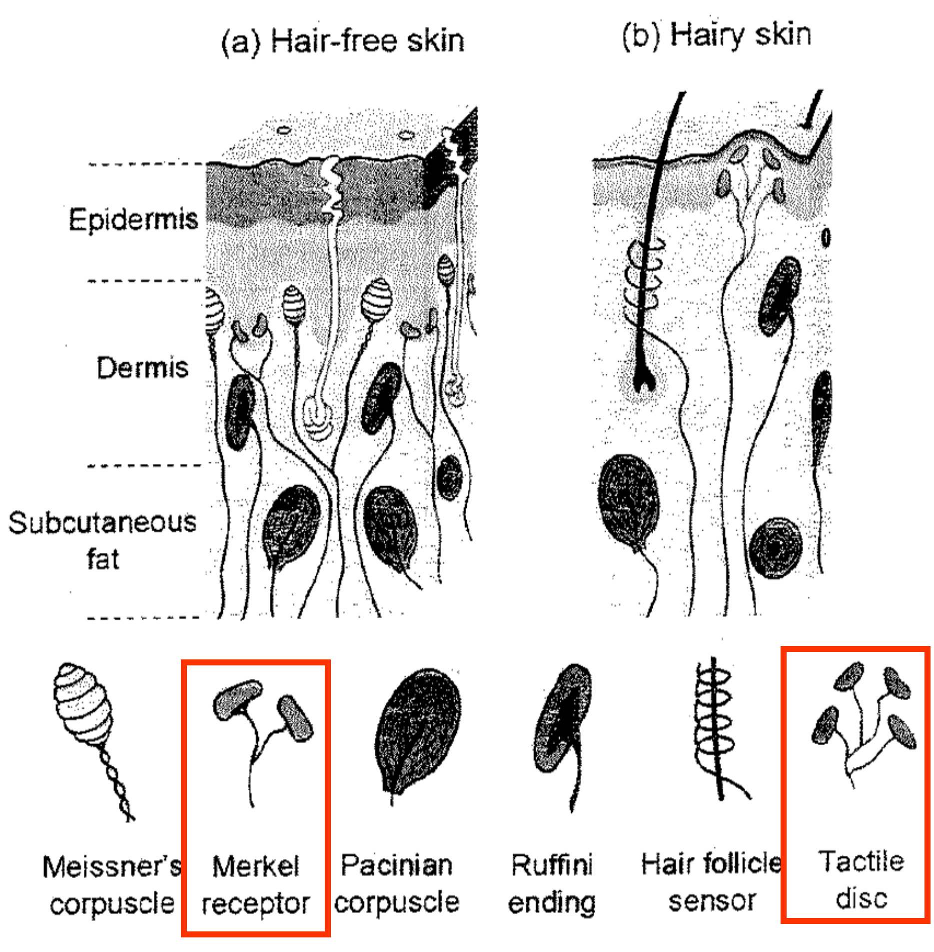


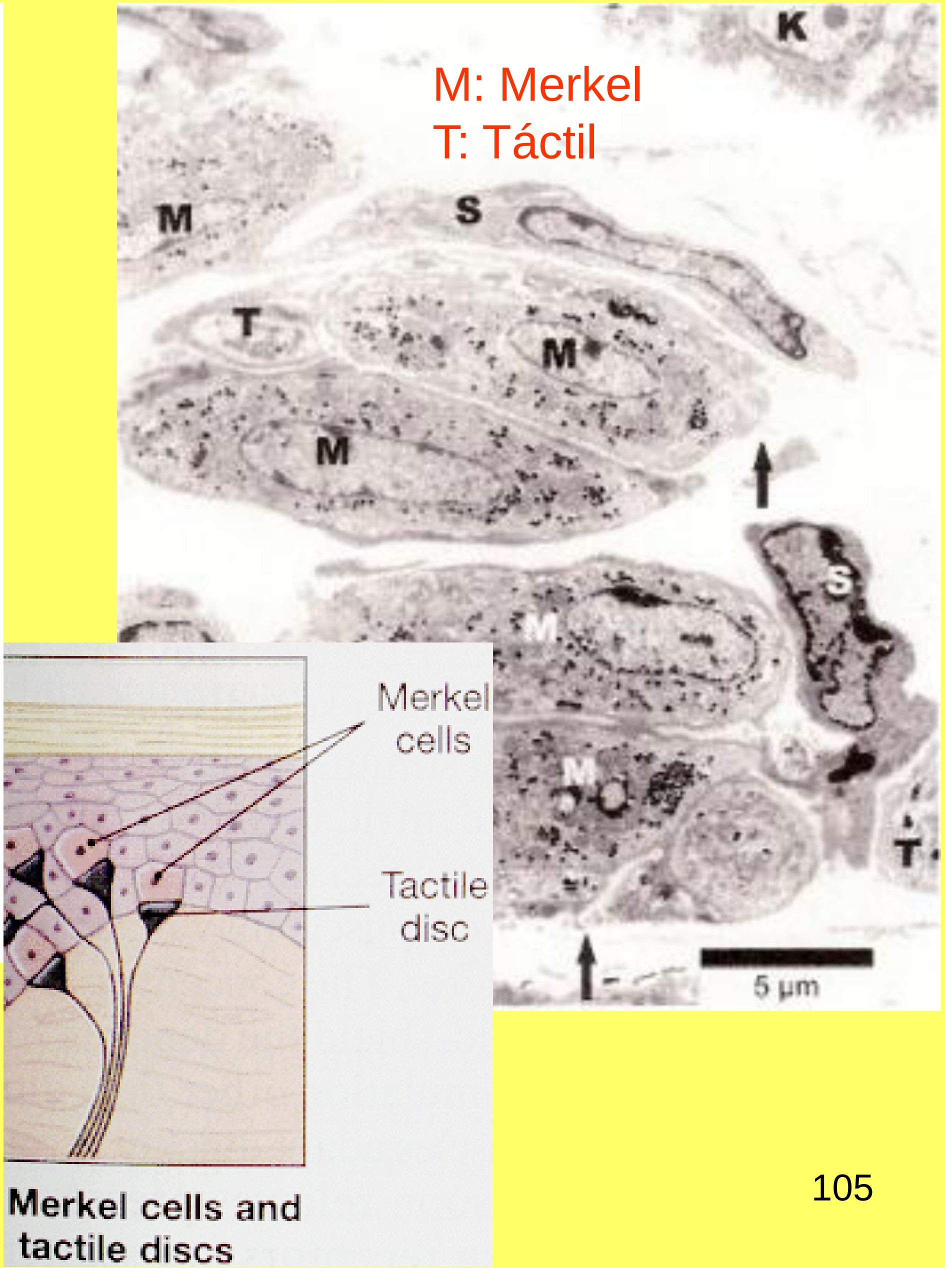


Corpúsculo Meissner

Detectan suaves golpecitos
de frecuencias de 3 a 40 Hz,
ellos se aprecian como aleteos.

EL SENTIDO DEL TACTO VI

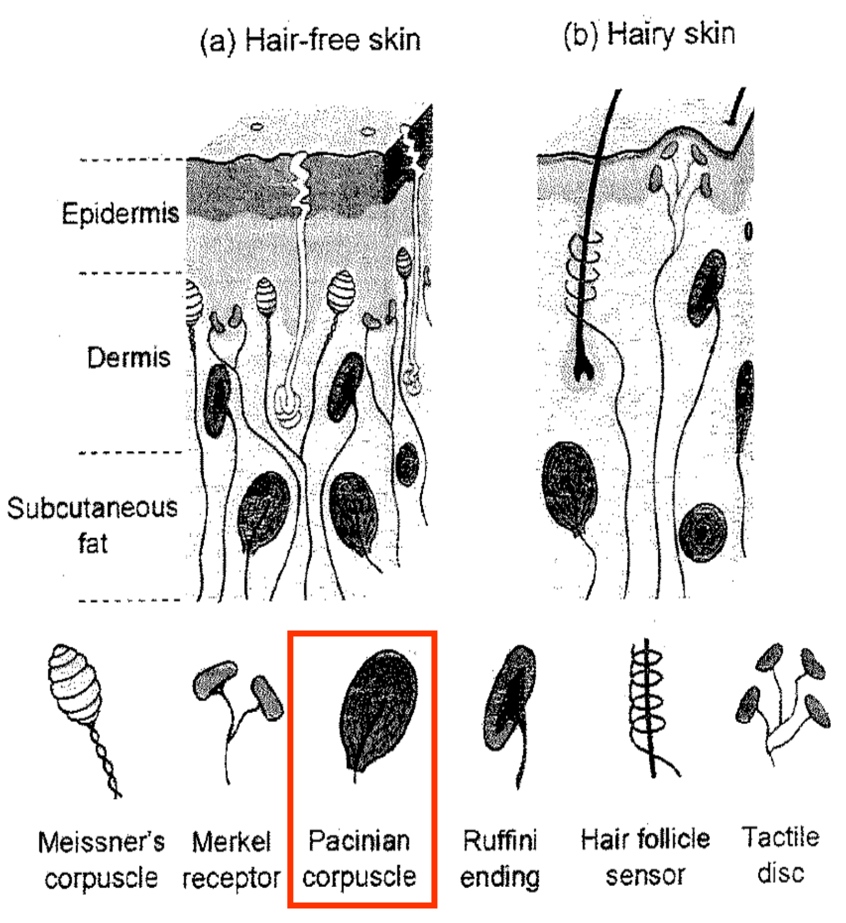


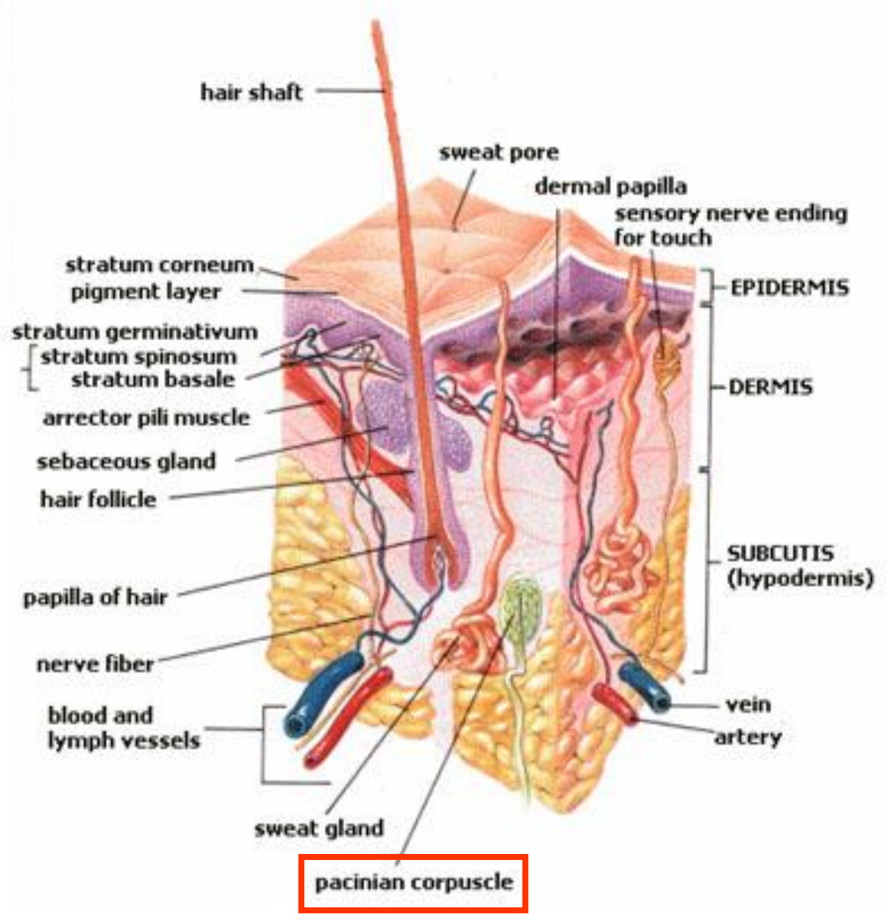


Merkel cells and tactile discs

Detectan variaciones de presión en el rango de frecuencias de 0,3 a 3 Hz.

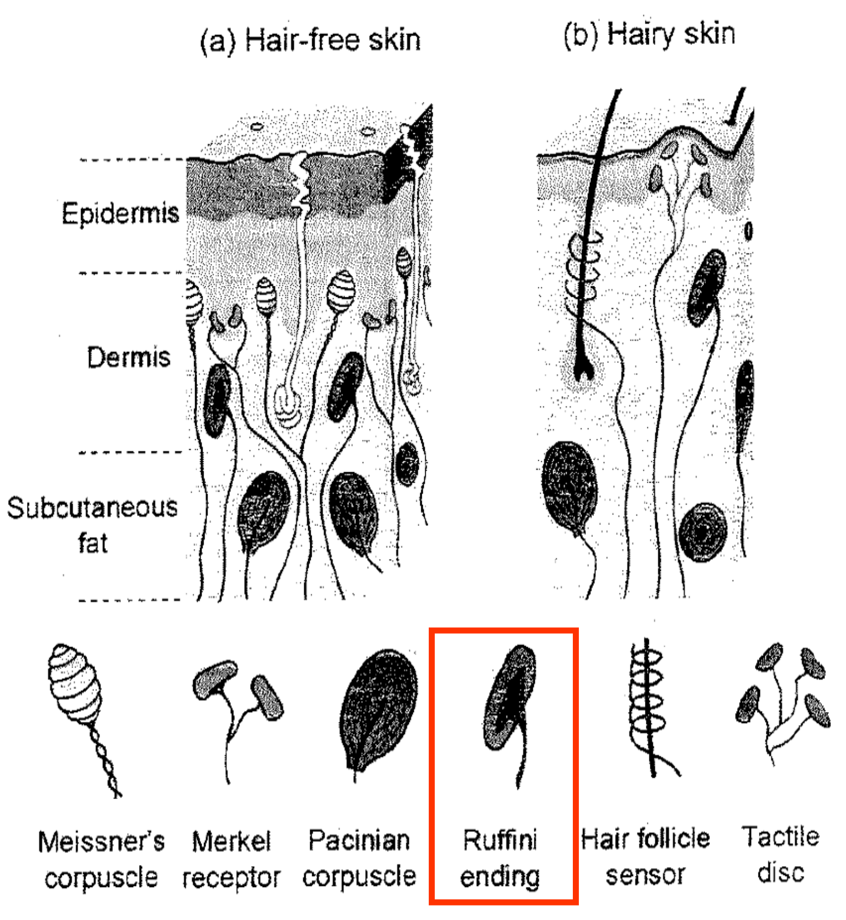
EL SENTIDO DEL TACTO VII

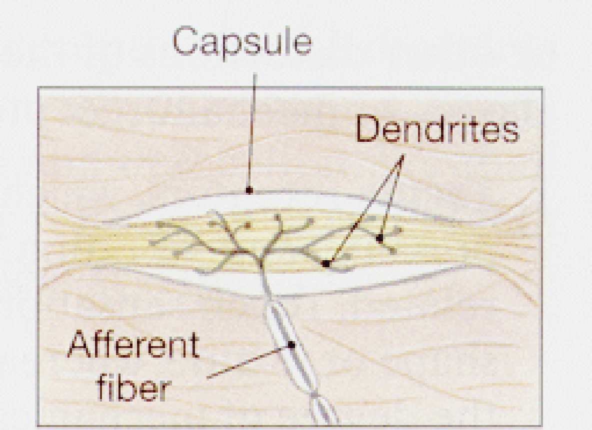




Detectan variaciones rápidas de presión y vibraciones de 10 a 500 Hz. Los pelos estimulan su sensado.

EL SENTIDO DEL TACTO VIII

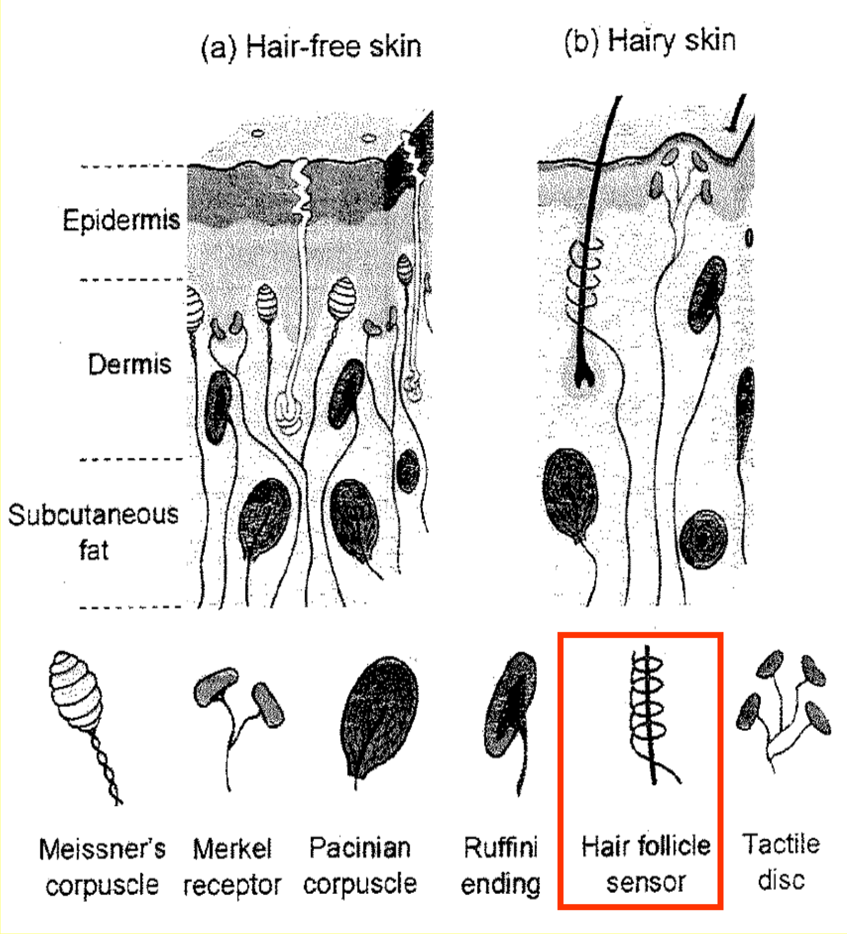


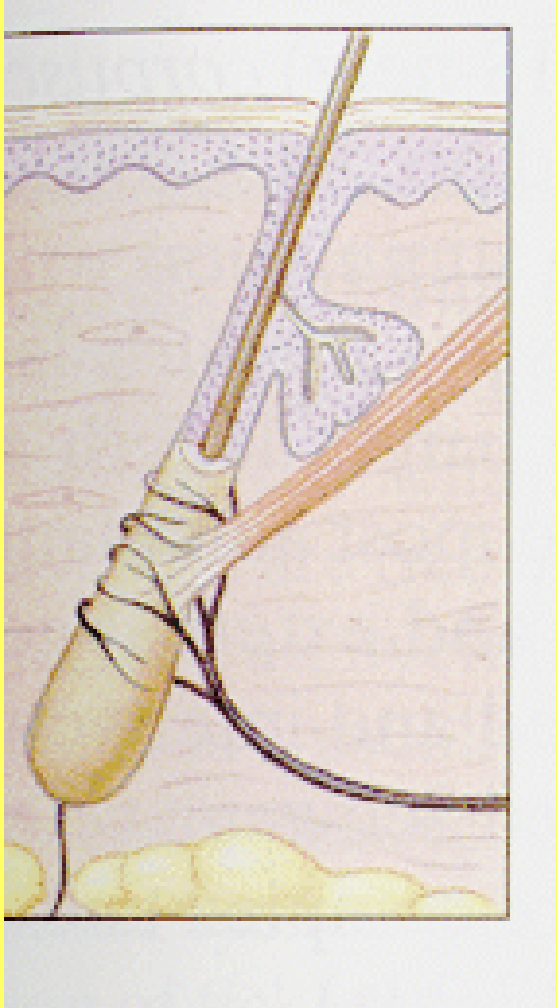


Ruffini corpuscle

Detectan vibraciones muy rápidas de 15 a 400 Hz, como los cambios de la superficie de la piel por su elasticidad. Podrían ser los sensores de calor en el rango de temperaturas de 30 – 48 ºC, con su máxima respuesta en 44ºC.

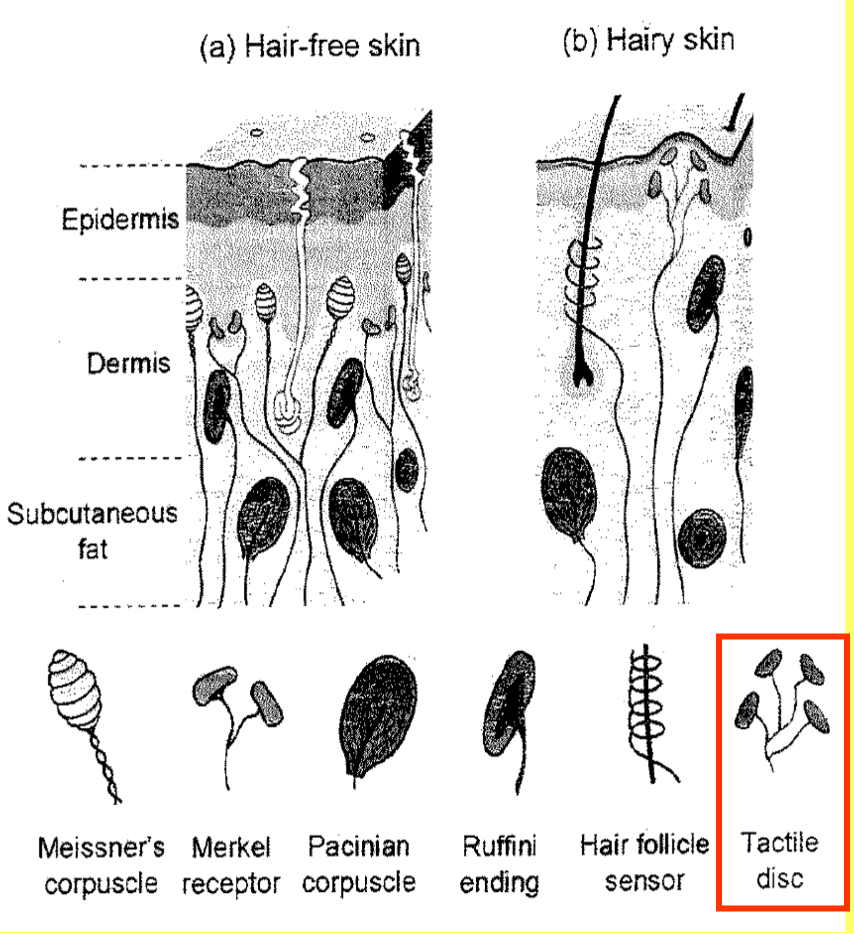
EL SENTIDO DEL TACTO IX

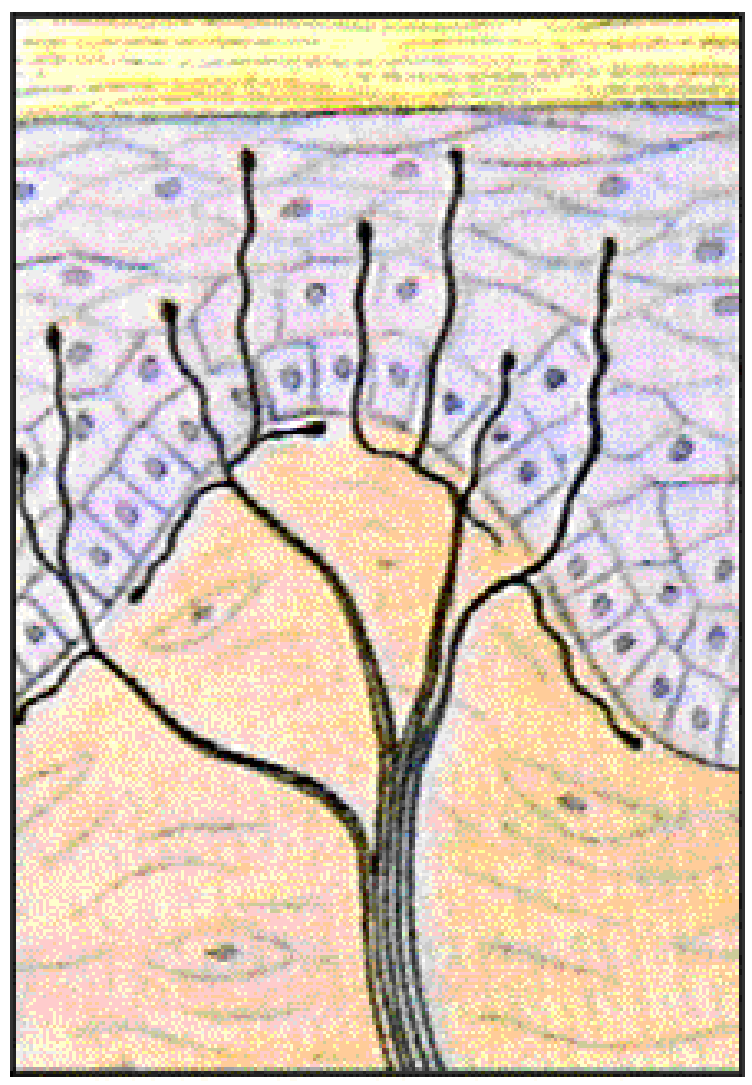




Los sensores de los folículos pilosos detectan los estímulos recibidos por los pelos.

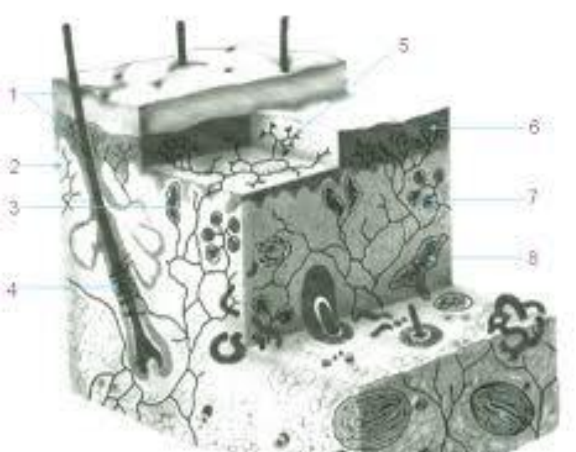
EL SENTIDO DEL TACTO X



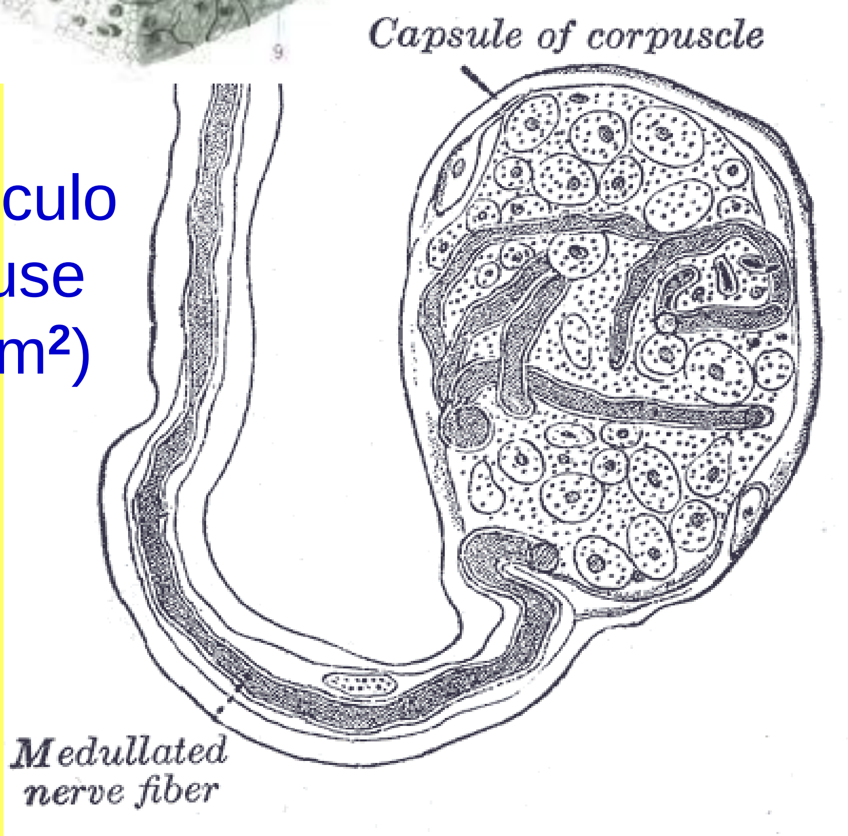


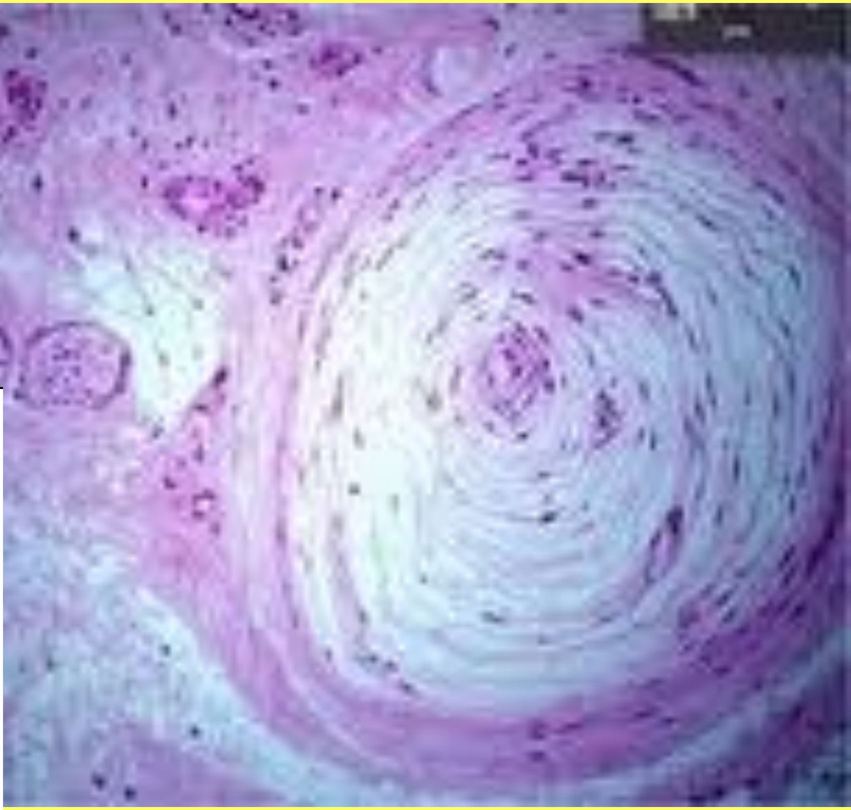
Las terminaciones nerviosas libres y los discos táctiles detectan suaves aproximaciones a la superficie de la piel.

EL SENTIDO DEL TACTO XI



Corpúsculo de Krause ($5\text{-}10/\text{cm}^2$)





Podrían ser los sensores de frío en el rango de 20-45 ºC, con su máximo en 30ºC.

EL SENTIDO DEL TACTO XII

- También existen receptores que sensan presiones y temperaturas extremas, productos químicos corrosivos, etc.
- Las sensaciones de dolor provocadas por sucesos rápidos (golpes) son transmitidas por neuronas cuyos axones están recubiertos por mielina a una velocidad de hasta 30 m/s.
- Las sensaciones de dolores intensos y persistentes (quemaduras) son transmitidas por neuronas cuyos axones no están recubiertos por mielina y lo hacen a una velocidad de 2 m/s y menores aún.