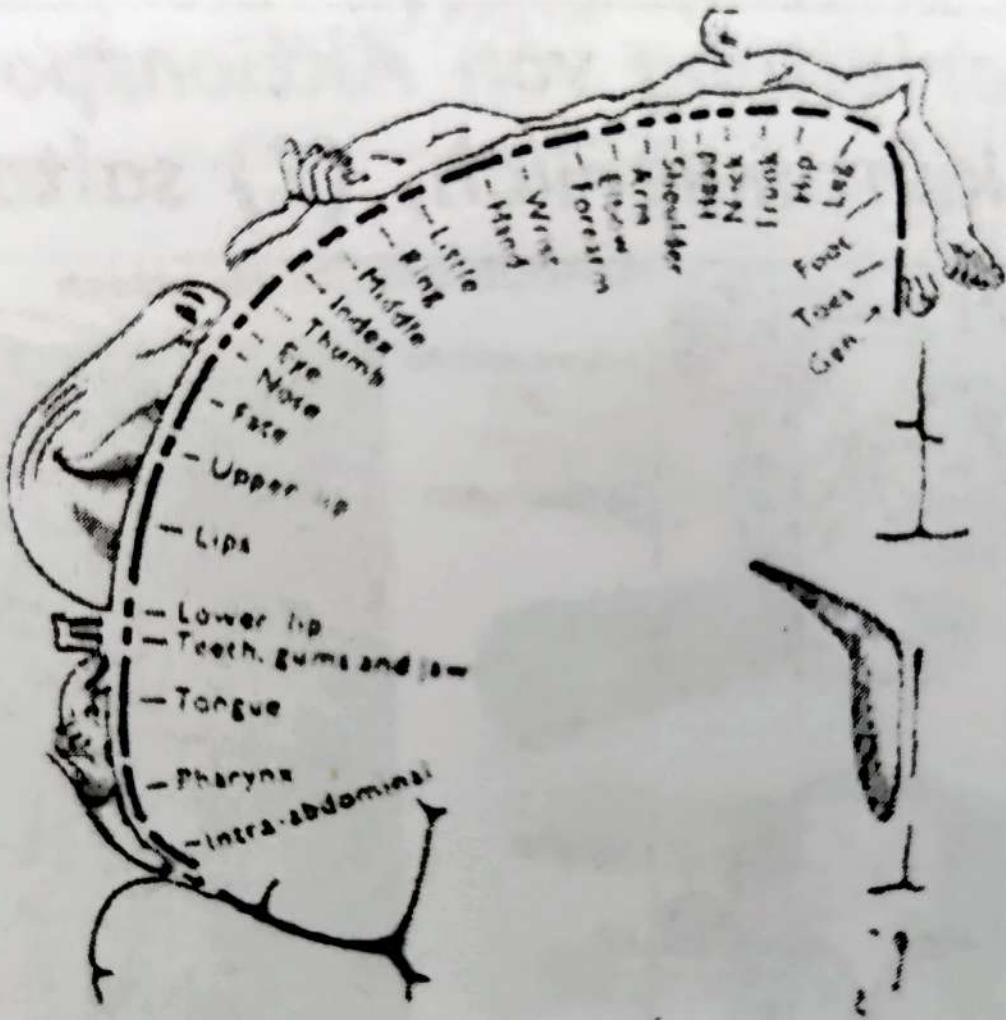
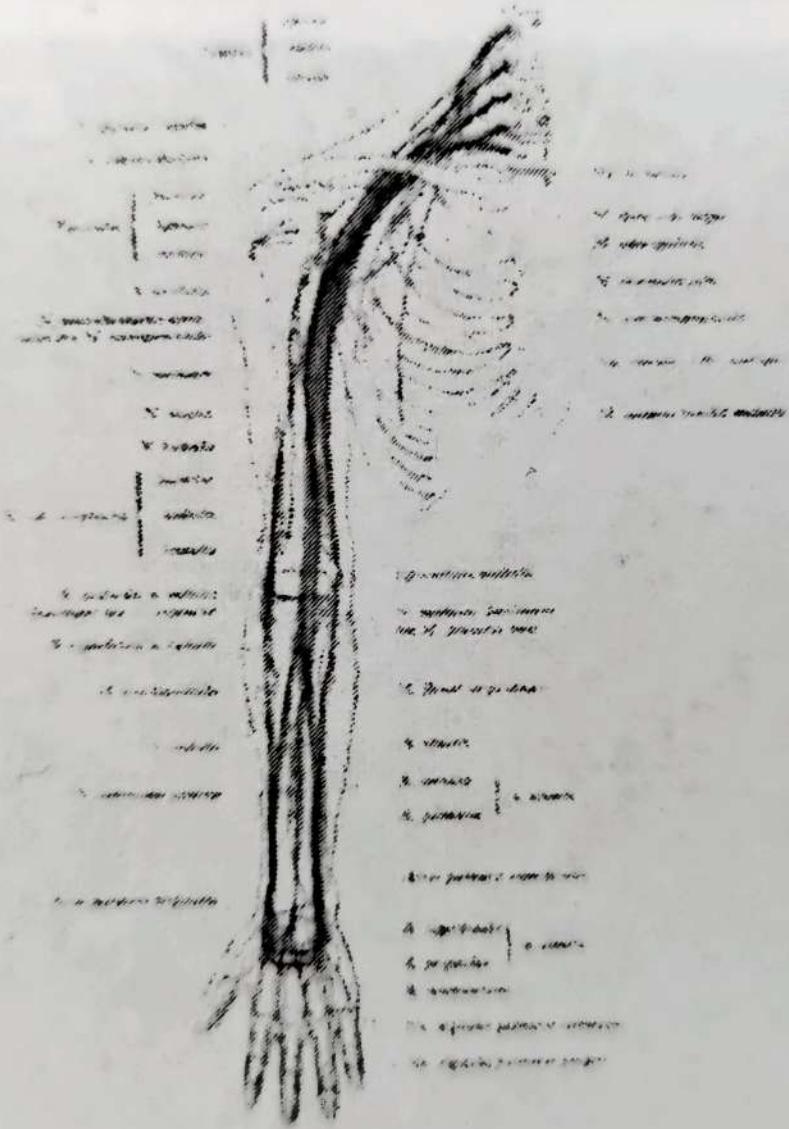
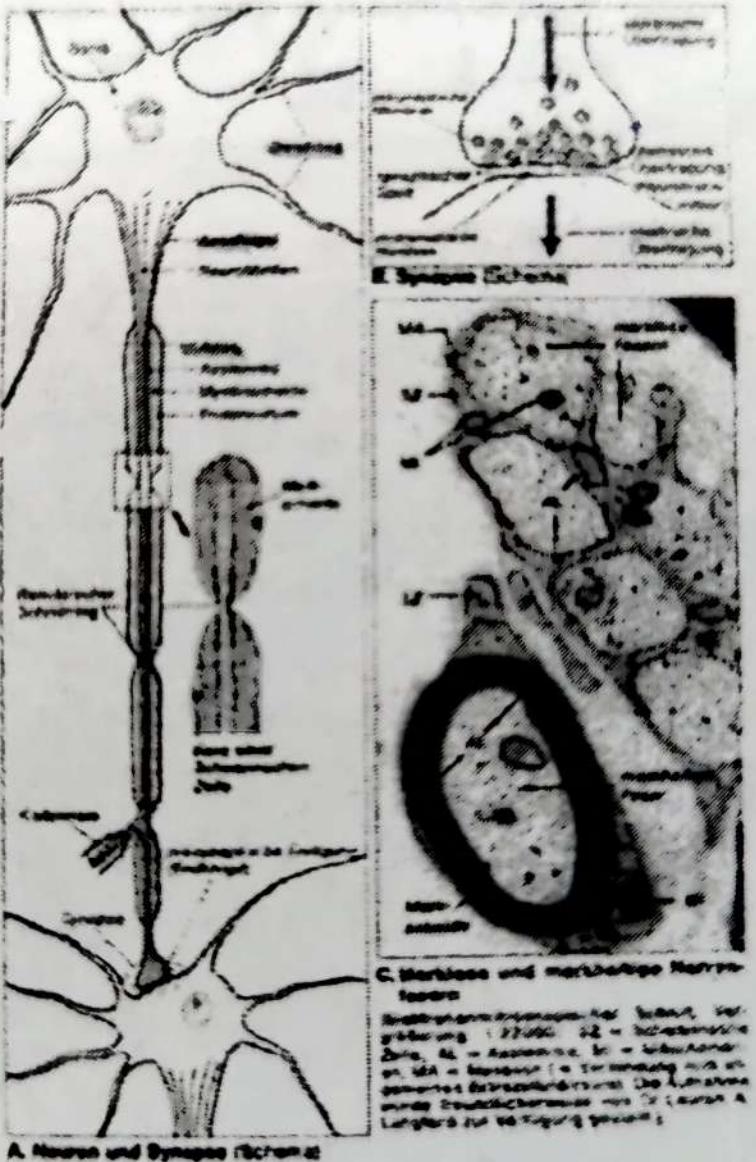


7.163A The motor homunculus showing proportional somatotopical representation in the main motor area. After Penfield & Rasmussen 1950.



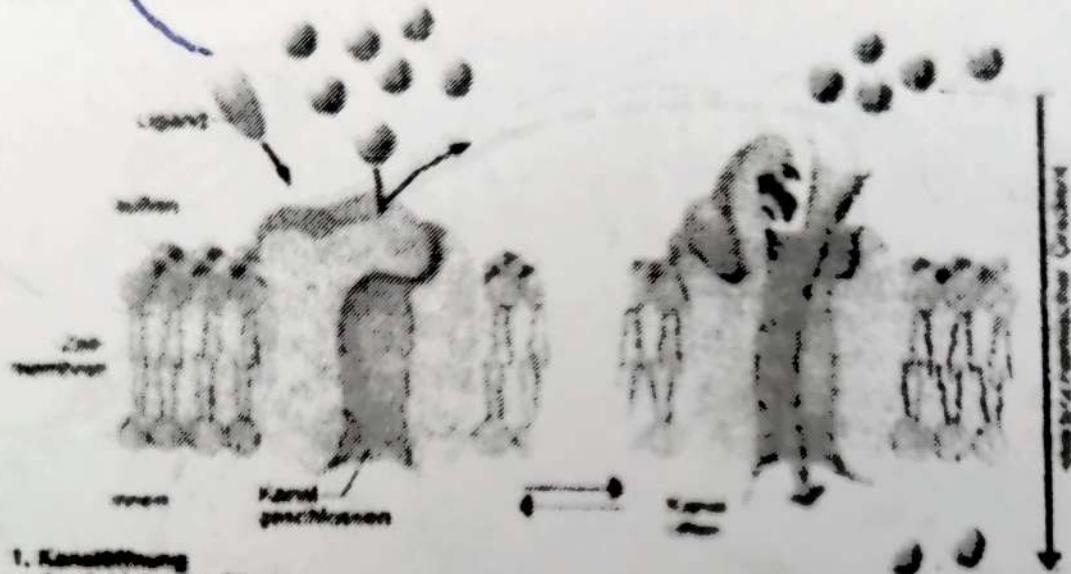
7.1638 The sensory homunculus showing proportional somatotopical representation in the somatosensory cortex. After Penfield & Rasmussen 1950.



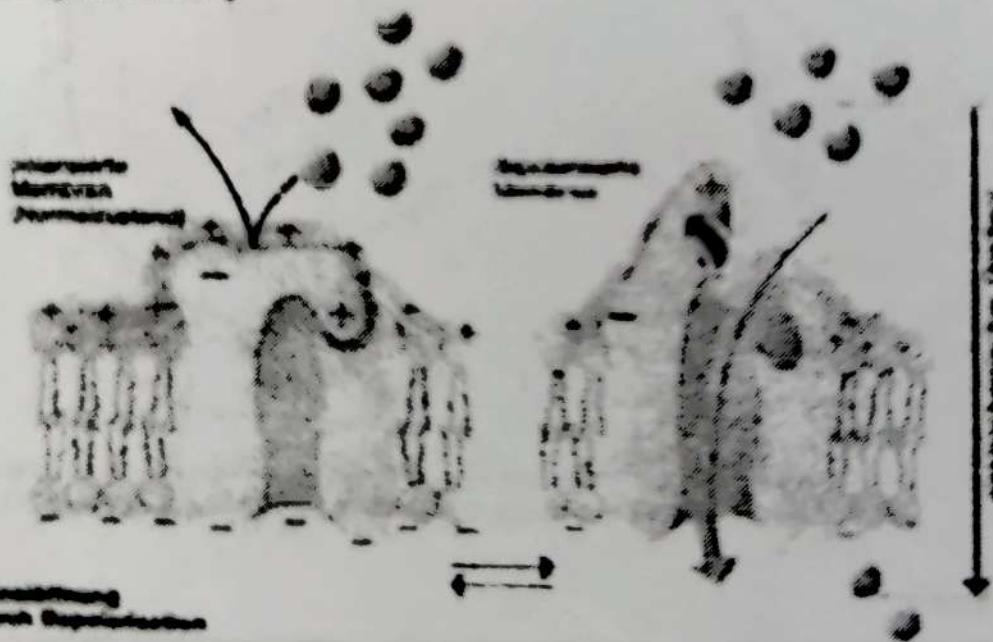


Ionenkonzentrationen im Intra- und Extrazellulärraum (mmol/l)

	Zytosol	Interstitium
Na ⁺	8-30	145
K ⁺	100-155	4,4
Ca ⁺⁺	0,0001	3,0
Mg ⁺⁺	~0,1	0,9
Cl ⁻	4-30	117
HCO ₃ ⁻	8-15	27
große Anionen	100-150	---

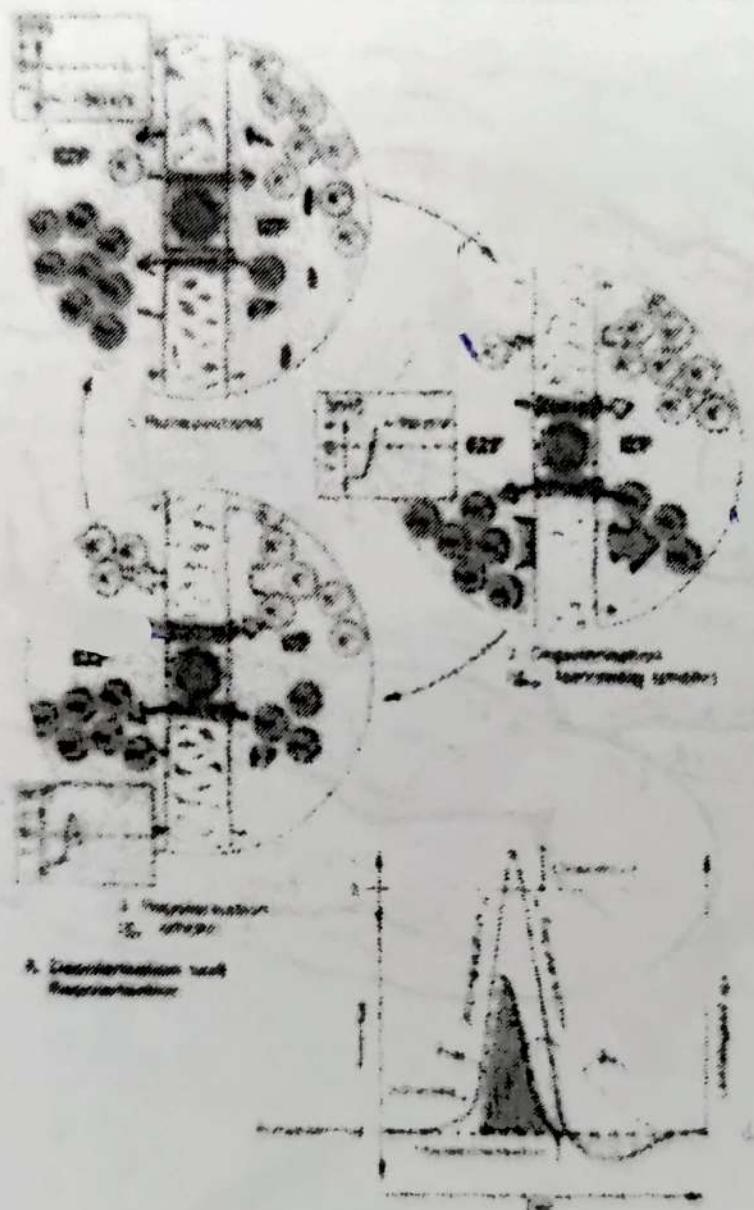


1. Kontraktion
durch Lipotensin-Sekretion

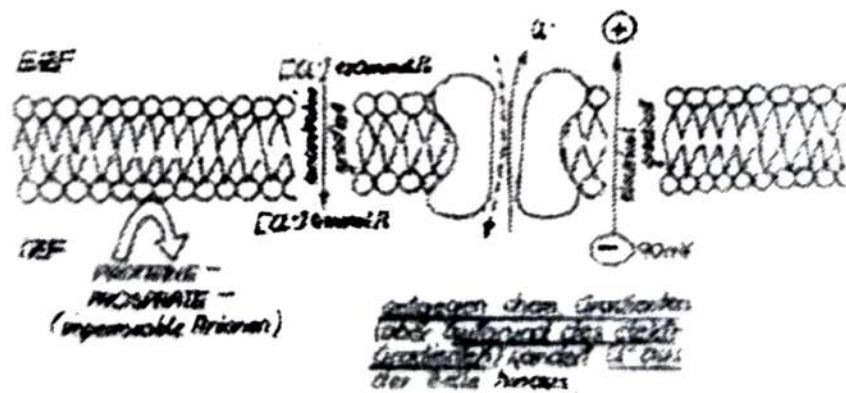
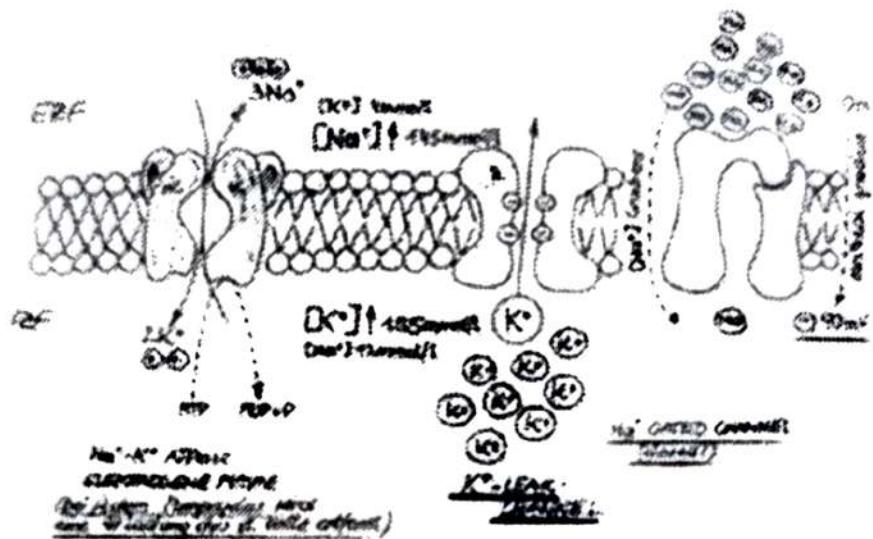


Thomas Auger 2. Kontraktion
durch Rezeptor-Blockade

Motor Muskel



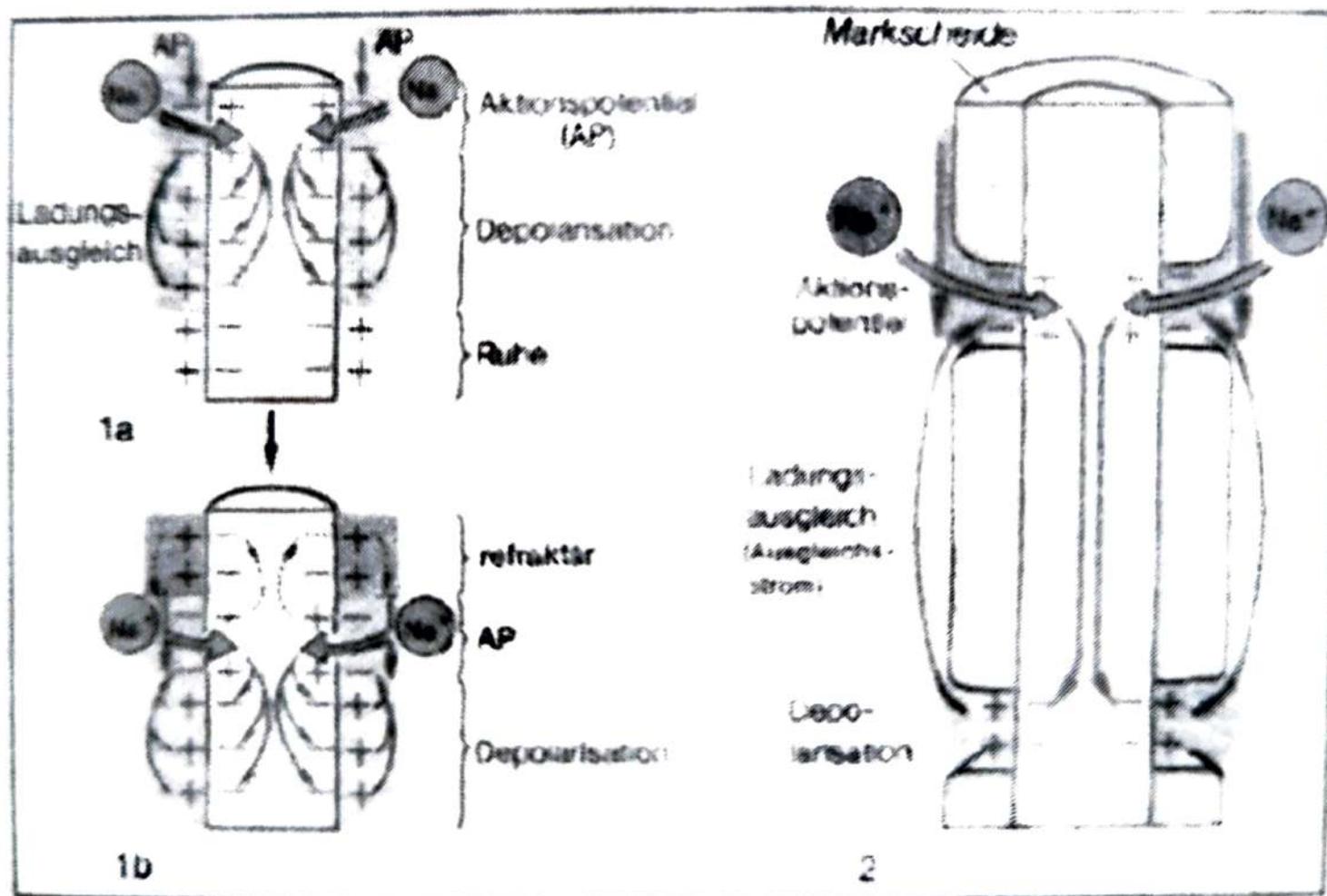
URSACHEN des RUMENEMBRONPOTENTIALS

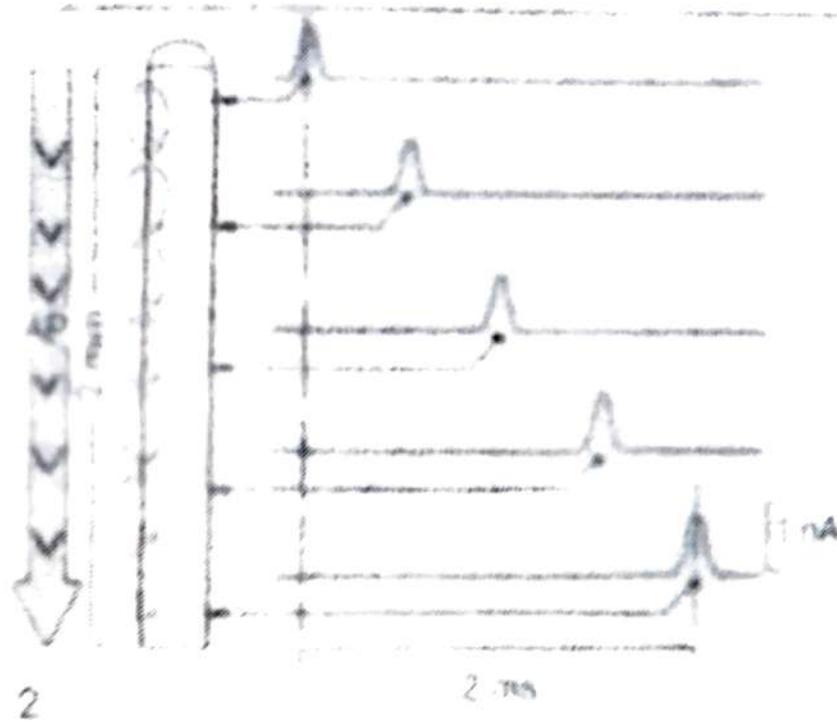
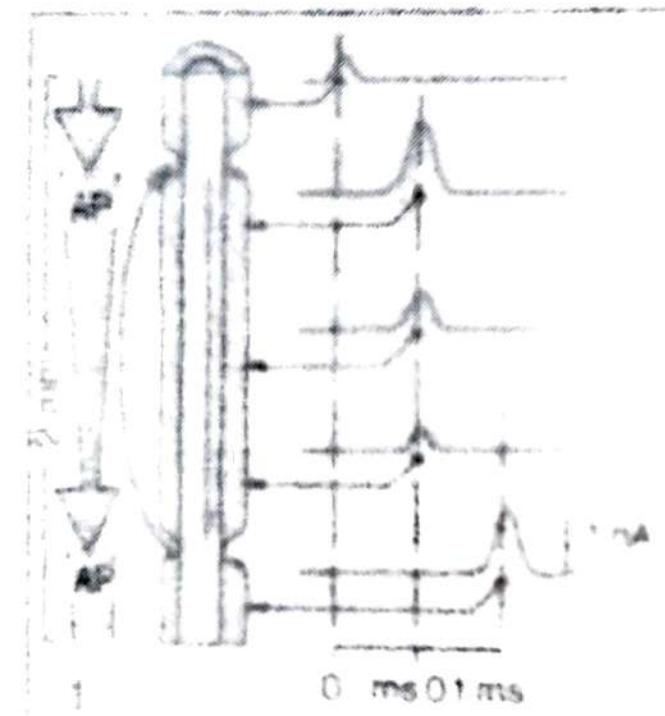


Das Ende der Diffusion von K^+ und Cl^- steht dann ein, wenn der IonenGradient = Elektro Gradient d.h. diebrochenen Gradient = 0

Weiterleitung von Aktionspotentialen

(1) kontinuierlich, (2) saltatorisch





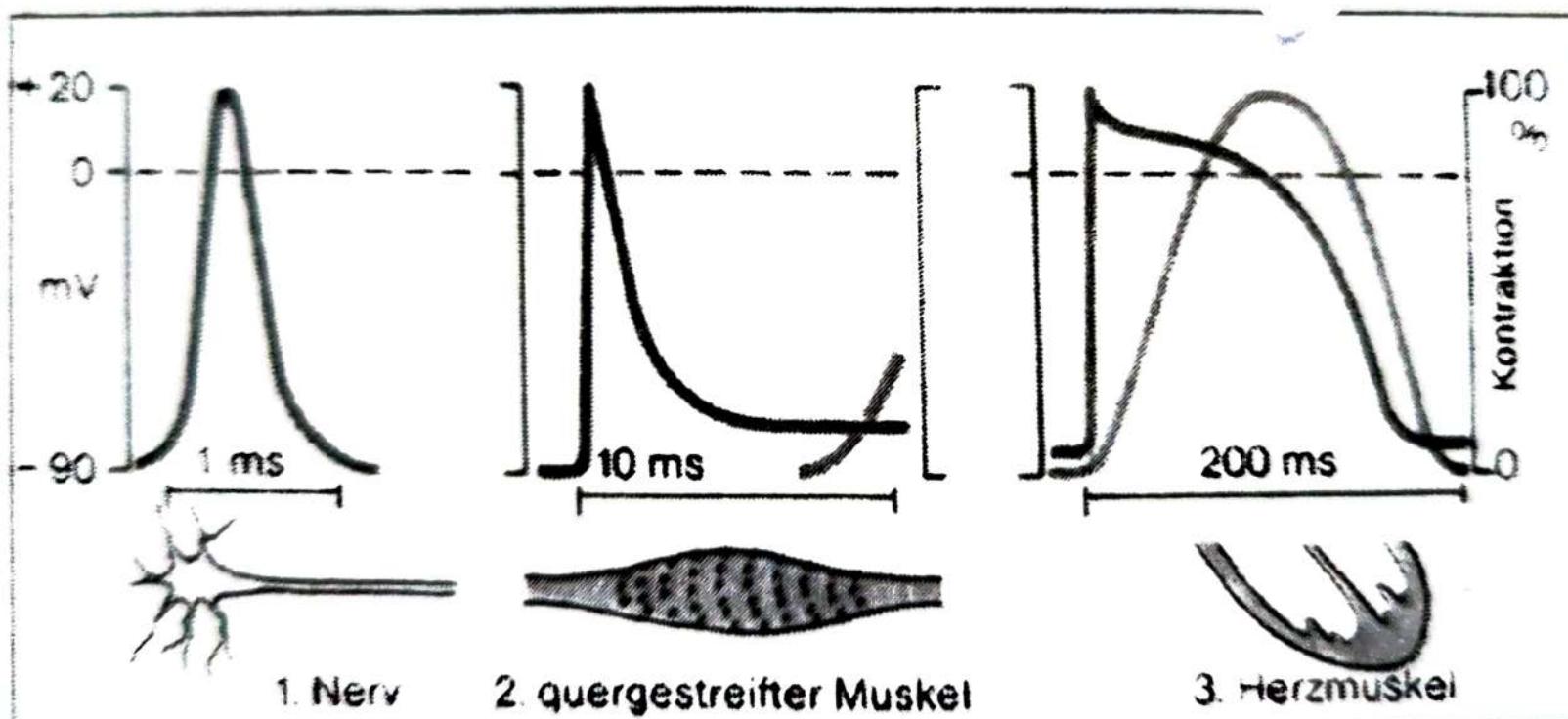
B. Impulseausbreitung (Aktionsströme) an der markhaltigen und marklosen Nervenfaser:

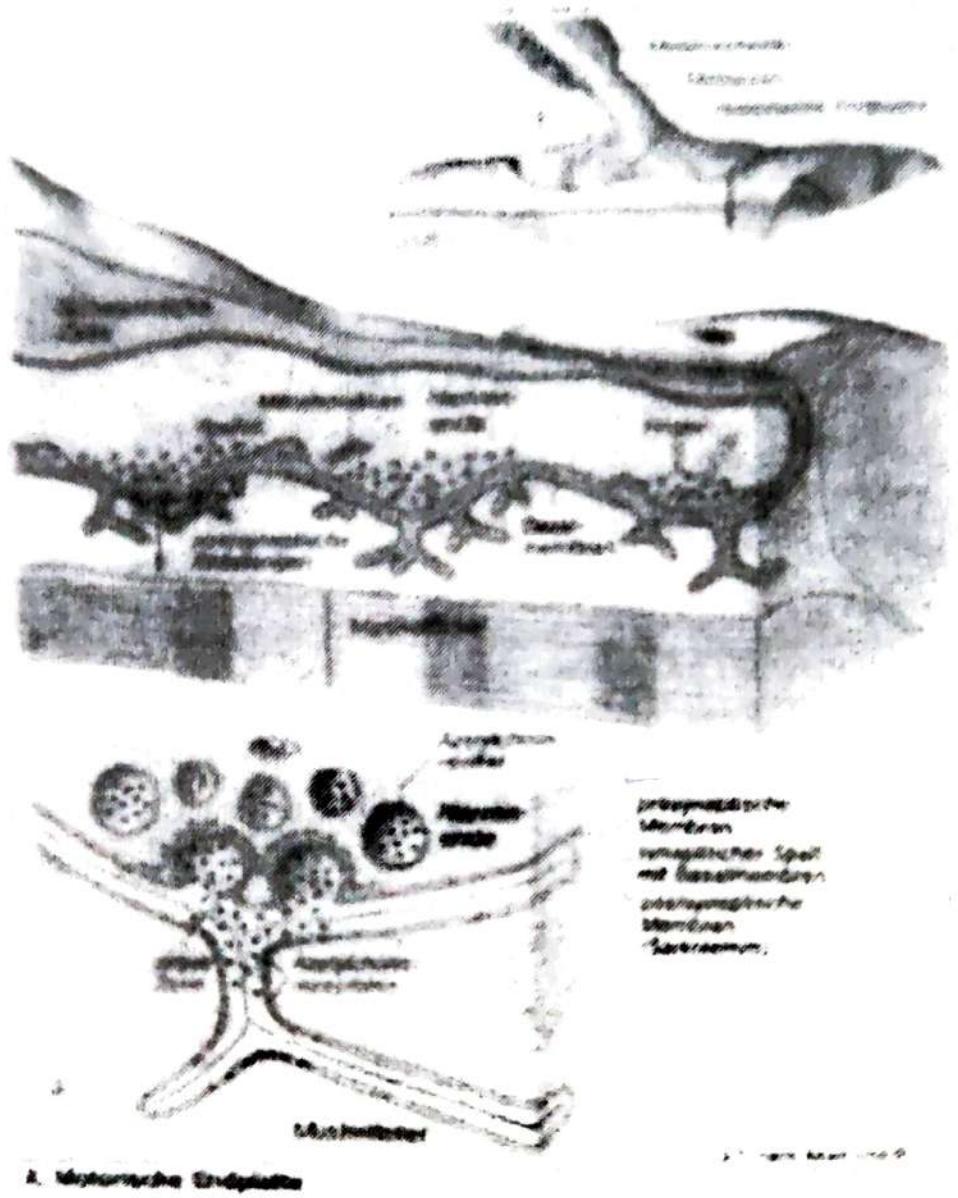
Faserart	Funktion (z. B.)	Durchmesser (µm)	Leitungsgeschwindigkeit (m/s)
A _a	Muskelspindel- und Sehnenorgan-afferenzen; Skelettmuskelefferenz	15	70-120
A _I	Hautafferenzen (Tastsinn)	8	30-70
A _V	Muskelspindellefferenz	5	15-30
A _B	Hautafferenzen (Temperatur und „schneller“ Schmerz)	3	12-30
B	sympathisch präganglionär	3	3-15
C	Hautafferenz („langsamer“ Schmerz); sympathisch postganglionär	1 (marklos)	0,5-2

C. Einteilung der Nervenfasern

(nach Erlanger u. Gasser)

Aktionspotentiale von Nerv und Muskel





A. Myxomycete Plasmodium

Muskelaufbau



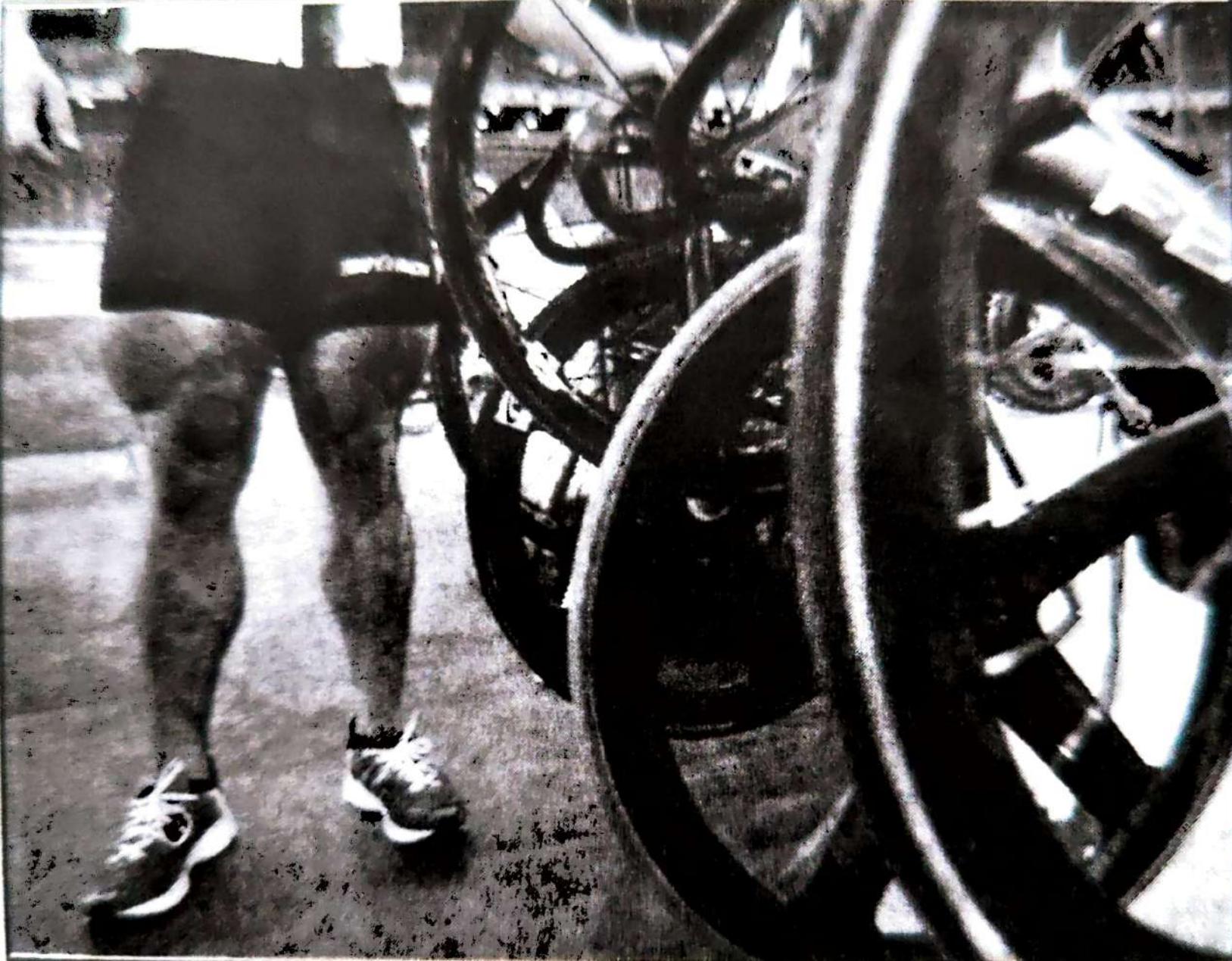
Muskel

Muskelfaser

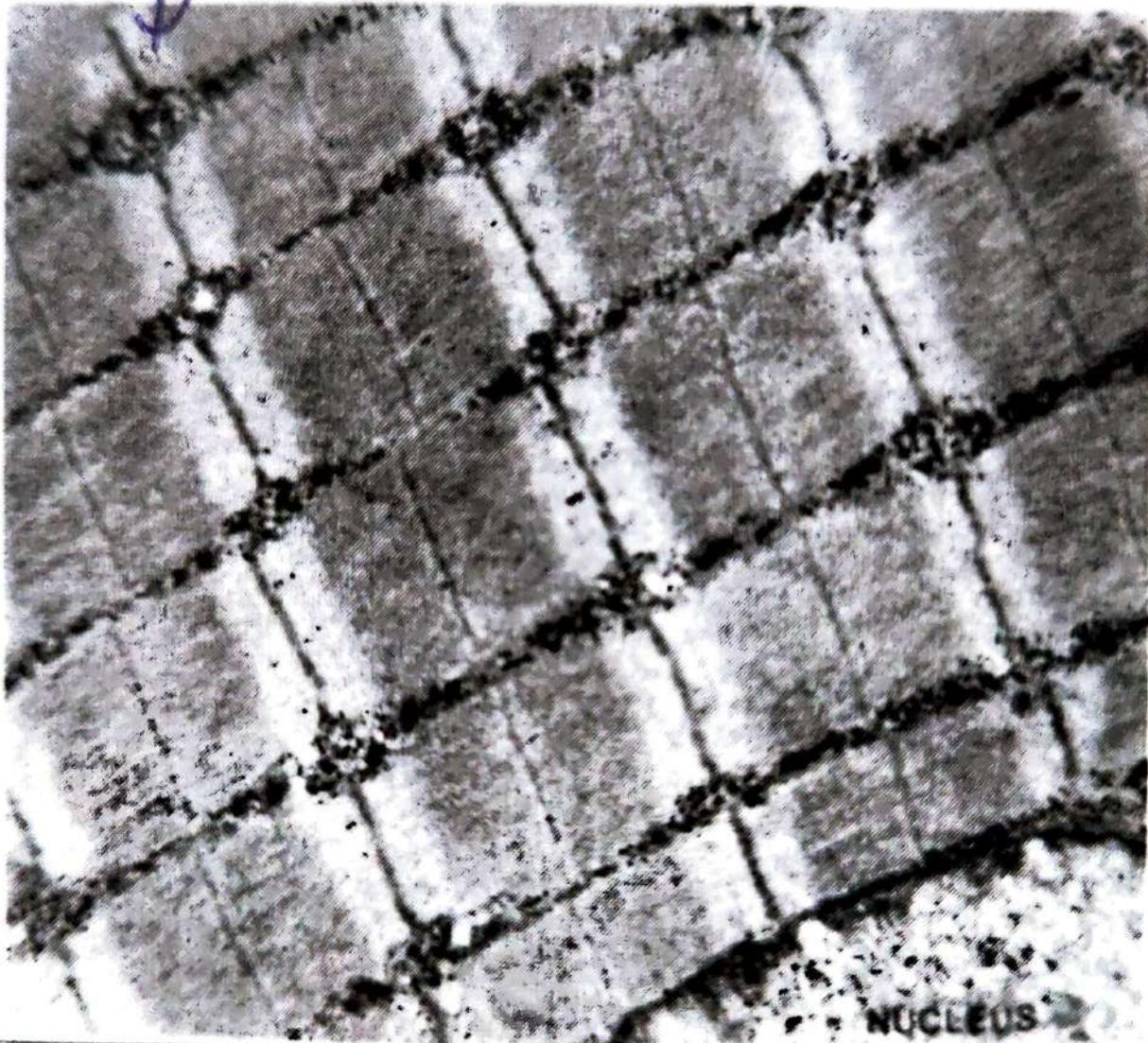
Myofibrillen

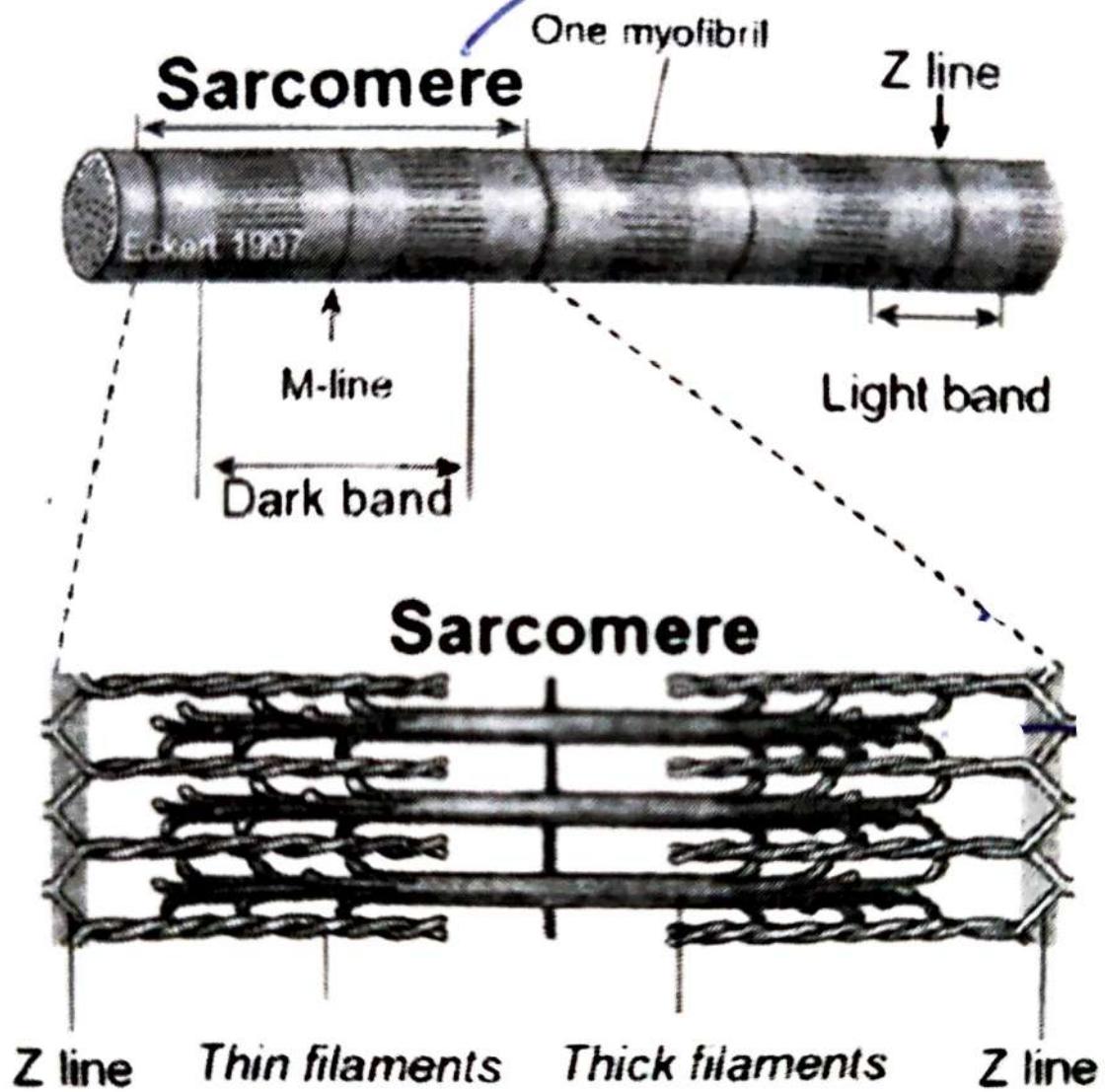
Myofilamente

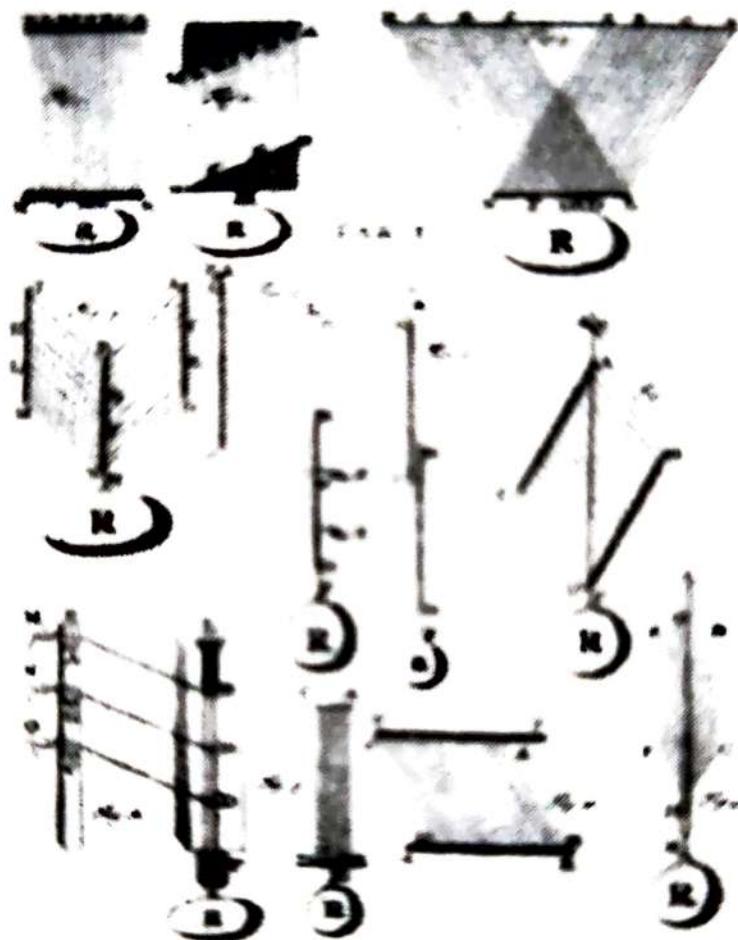
Myosin
Aktin



Skeletal Muscle







Borelli, 1680

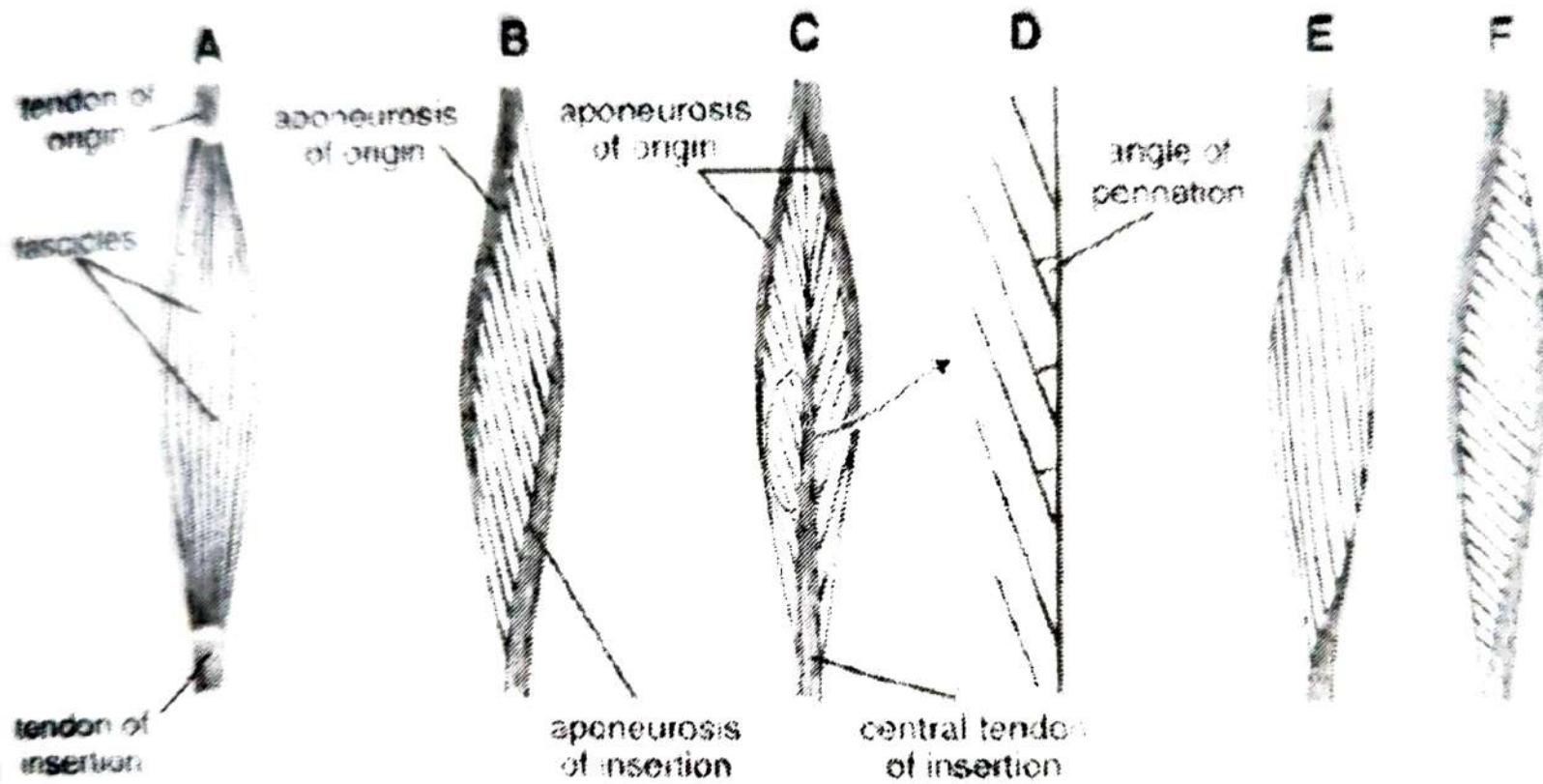
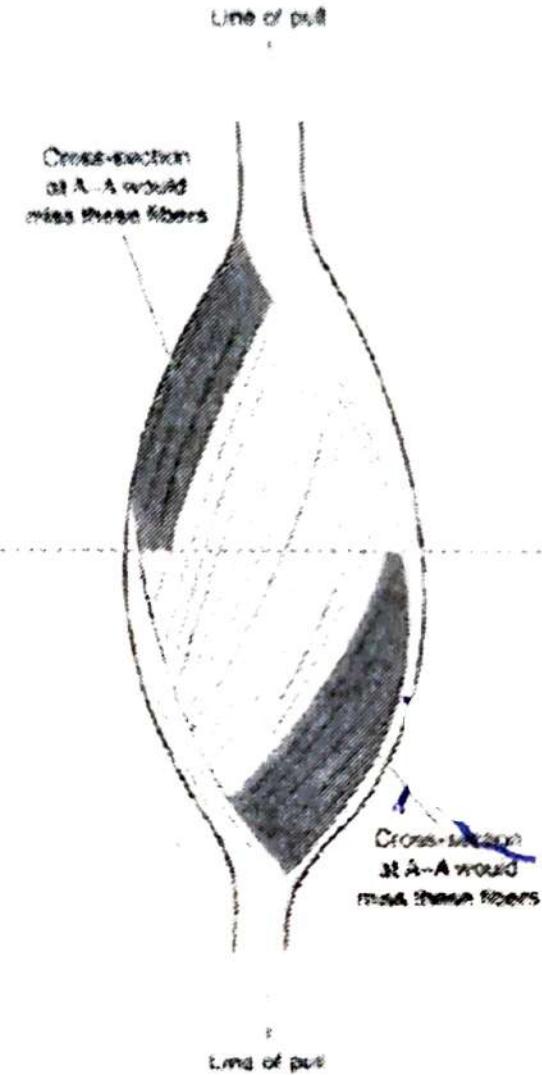
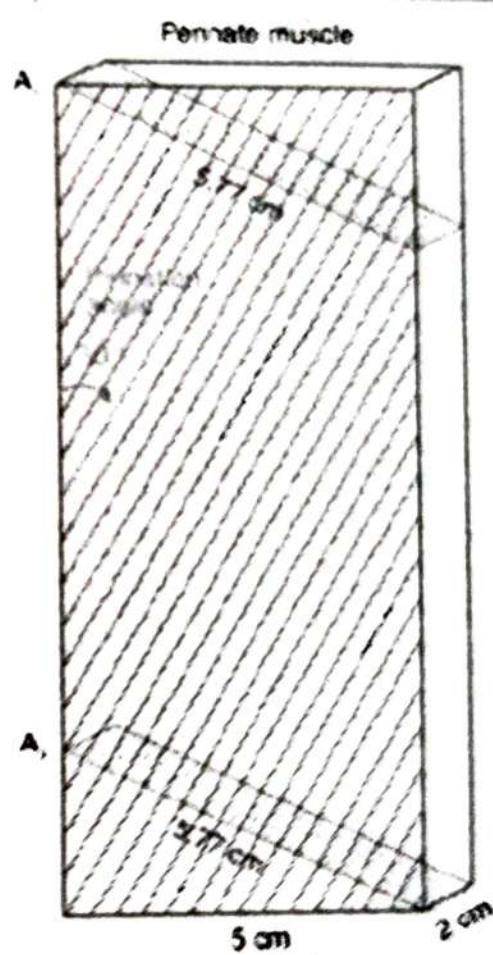
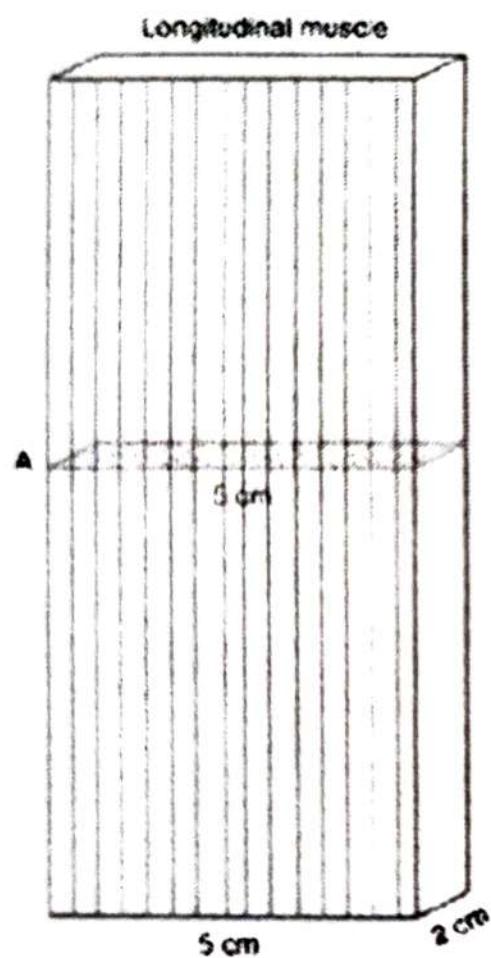


Figure 9.4. The internal architecture of skeletal muscles. (A) nonpennate; (B, C) bipennate; (D) tripennate.





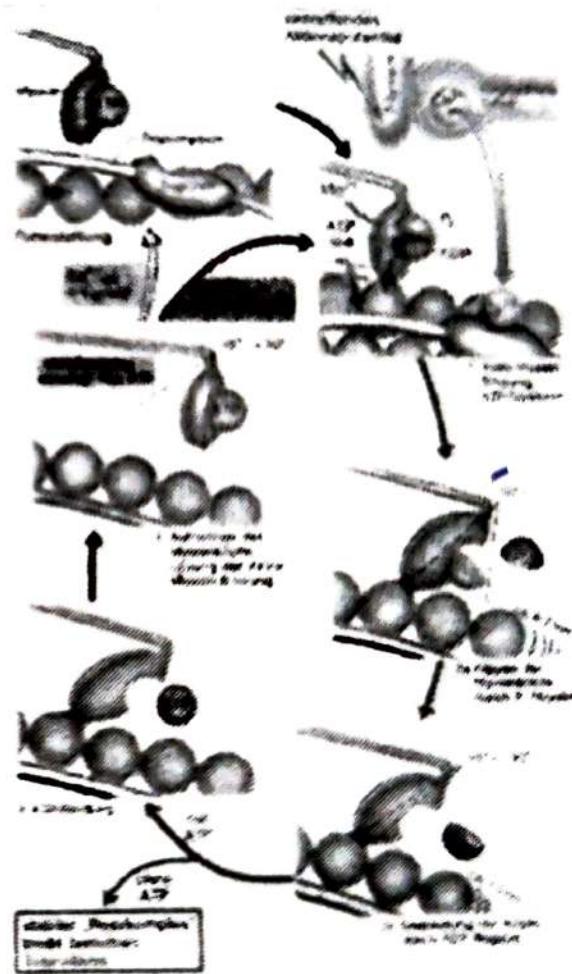
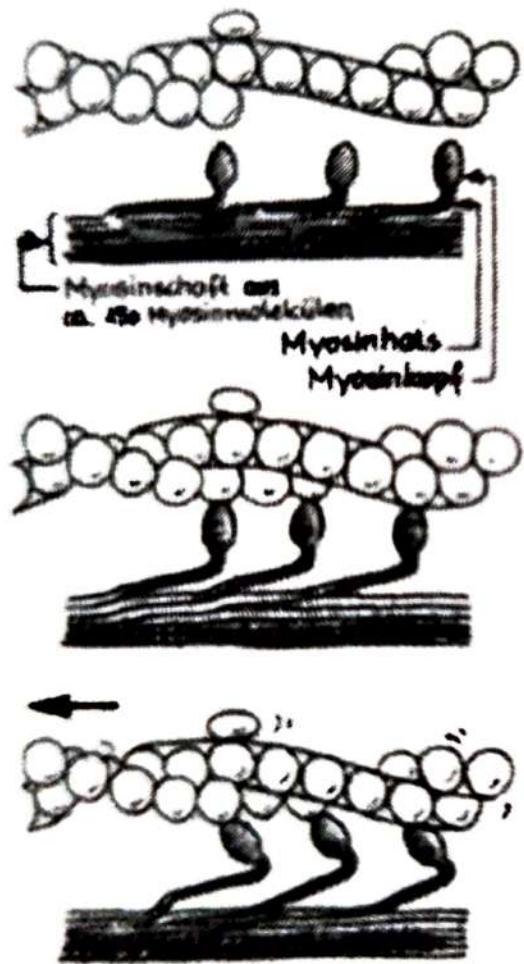
Comparison of total cross-sectional areas of longitudinal and pennate muscles of the same volume. The cross-sectional area, A , of the longitudinal muscle is $5 \text{ cm} \times 2 \text{ cm} = 10 \text{ cm}^2$. The cross-sectional area of the pennate muscle is $\Sigma A = A_1 + A_2 = (5.77 \text{ cm} \times 2 \text{ cm}) + (5.77 \text{ cm} \times 2 \text{ cm}) = 11.54 \text{ cm}^2 + 11.54 \text{ cm}^2 = 23.08 \text{ cm}^2$.

Table 3.3 Mass, Length, and PCA of Some Muscles

Muscle	Mass (g)	Fiber Length (cm)	PCA (cm ²)	Pennation Angle (deg)
Sartorius	75	38	1.9	0
Biceps femoris (long)	150	9	15.8	0
Semitendinosus	75	16	4.4	0
Soleus	215	3.0	58	30
Gastrocnemius	158	4.8	30	15
Tibialis posterior	55	2.4	21	15
Tibialis anterior	70	7.3	9.1	5
Rectus femoris	90	6.8	12.5	5
Vastus lateralis	210	6.7	30	5
Vastus medialis	200	7.2	26	5
Vastus intermedius	180	6.8	25	5

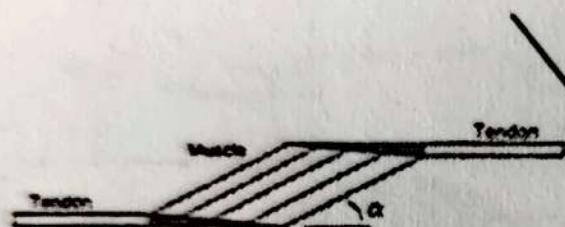
[Winter 1990]

Kontraktionsmechanismus

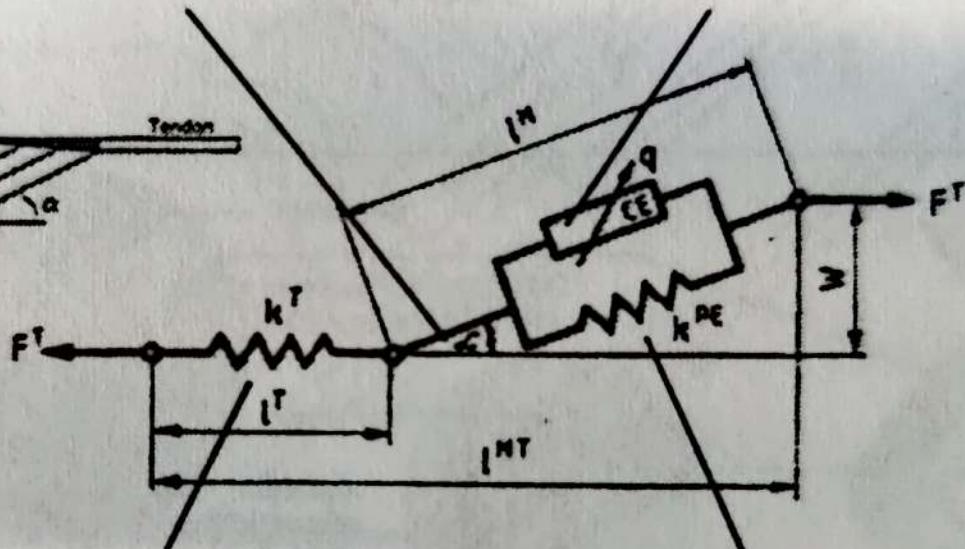


Muskel-Sehnenmodell

Fiederungswinkel



kontraktiles Element



Sehne

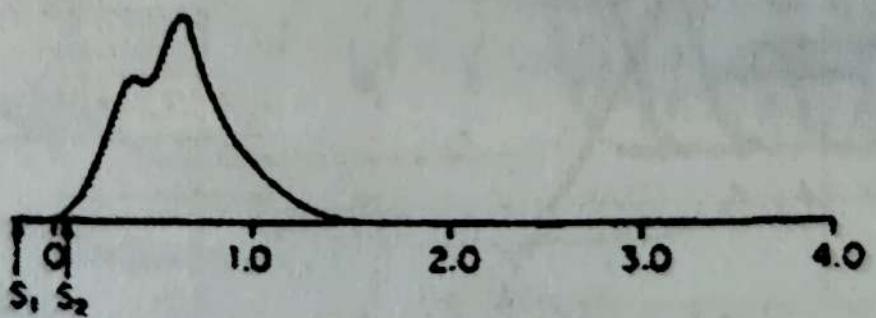
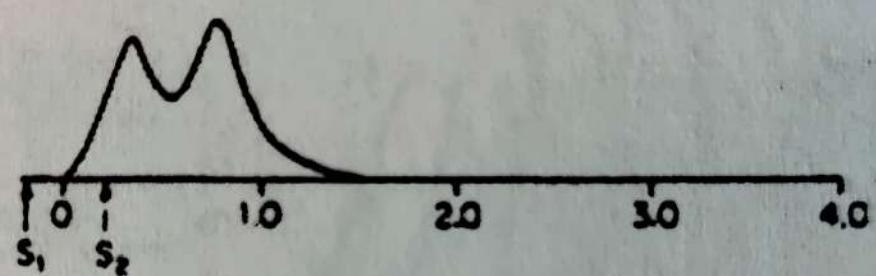
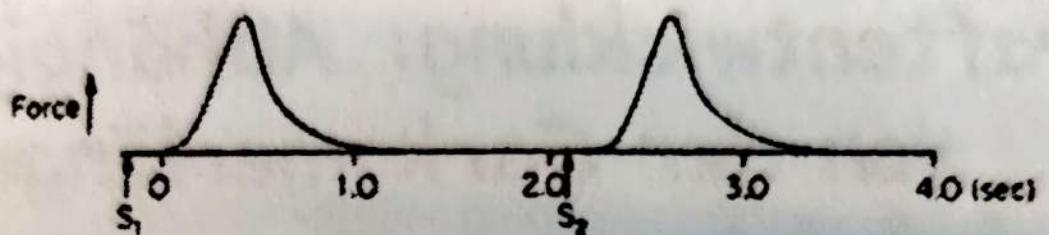
parallel elastisches Element

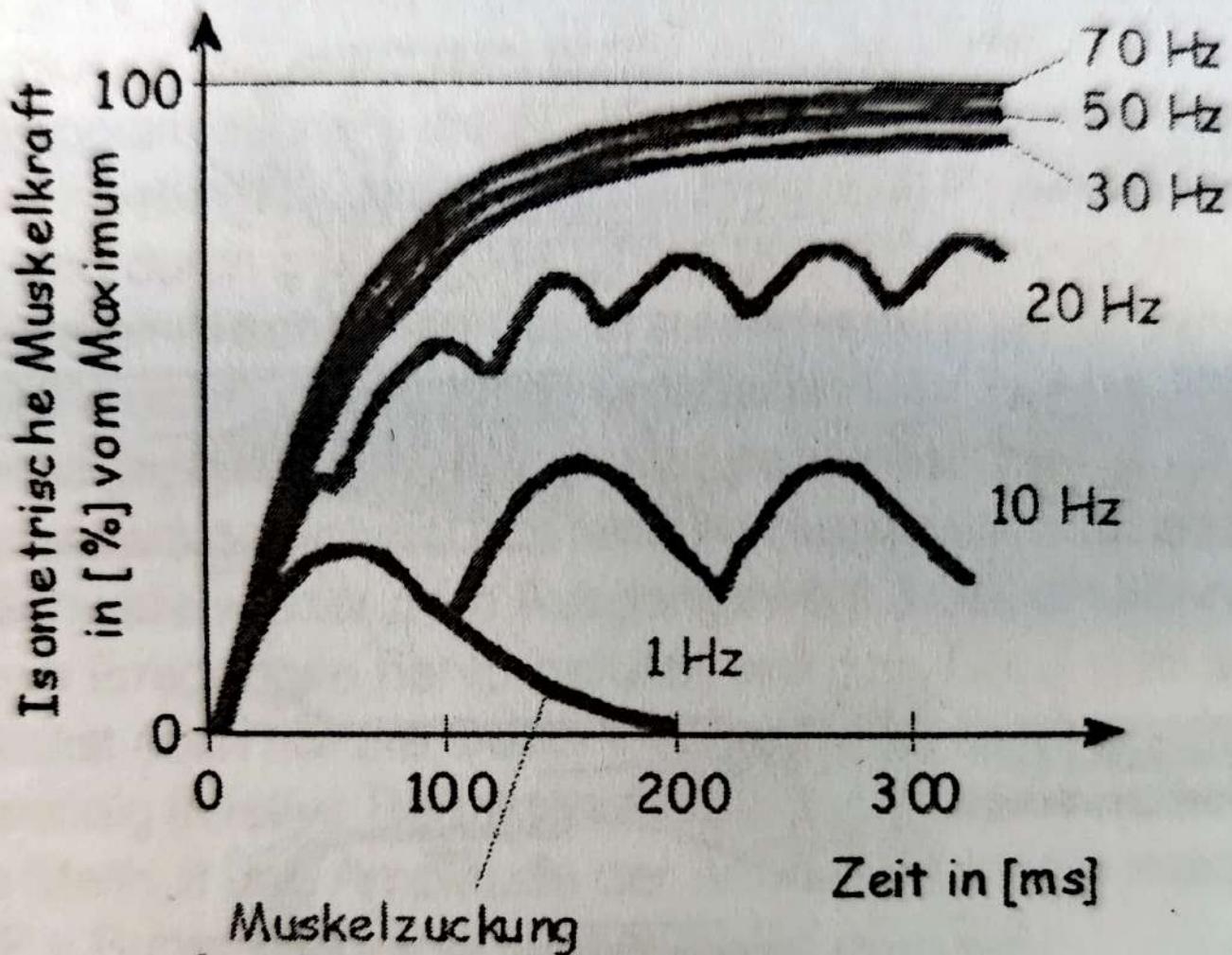
$$F^M = F^{CE} + F^{PE}$$

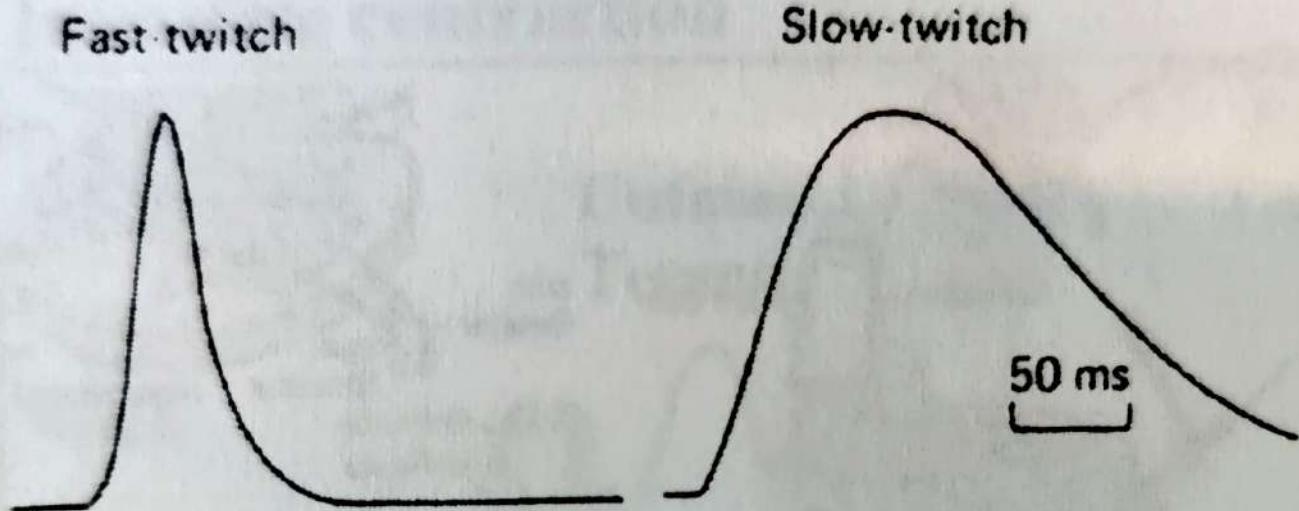
$$F^T = F^M \cdot \cos \alpha$$

$$L_0^M \sin \alpha_0 = l^M \cdot \sin \alpha = W = \text{const}$$

$$l^{MT} = l^M \cdot \cos \alpha + l^T$$

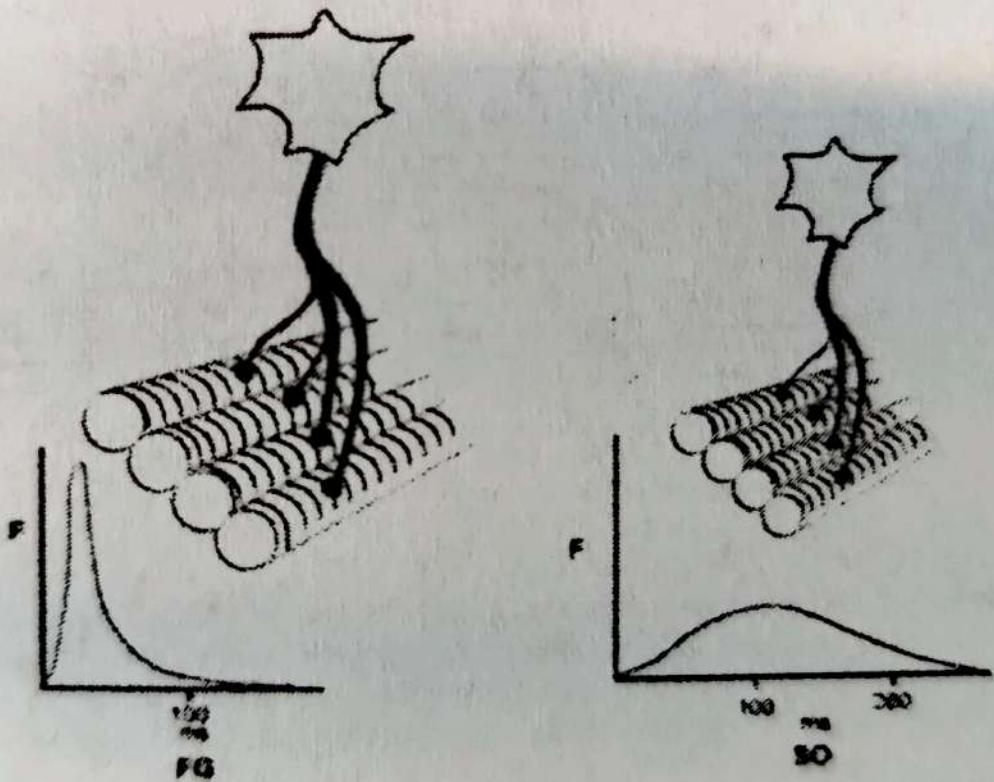




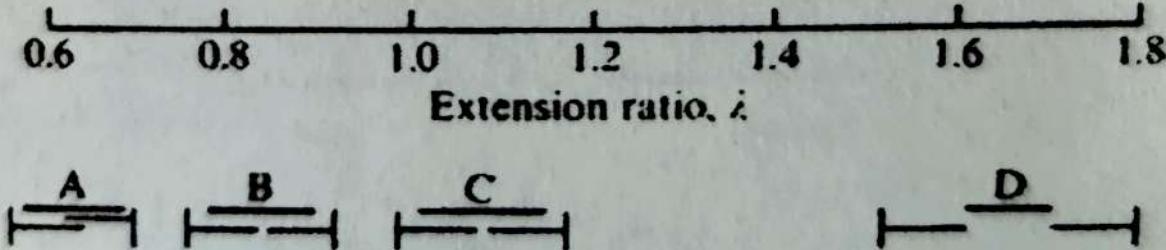
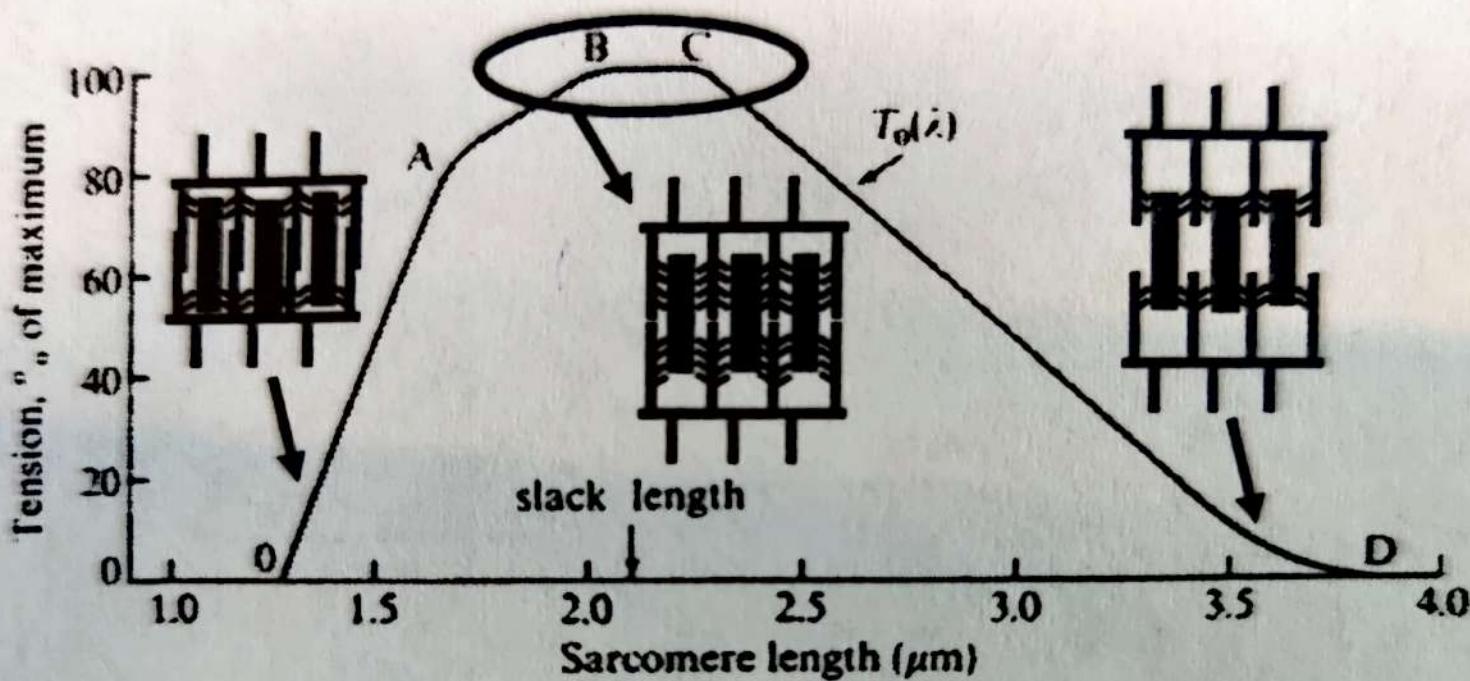


Fast and slow twitch muscles [Keynes & Aidley 2001]

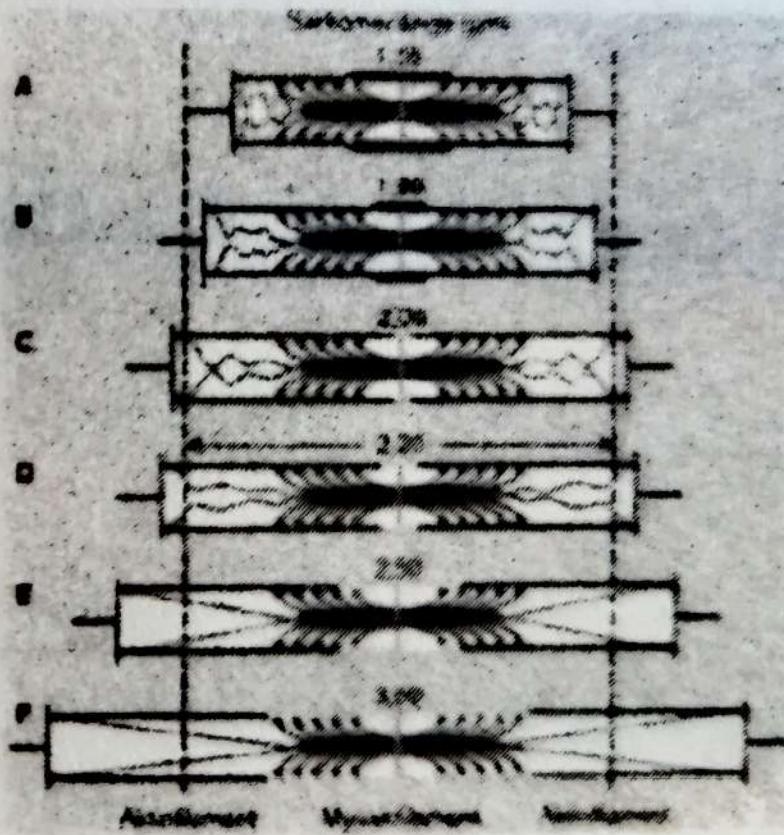
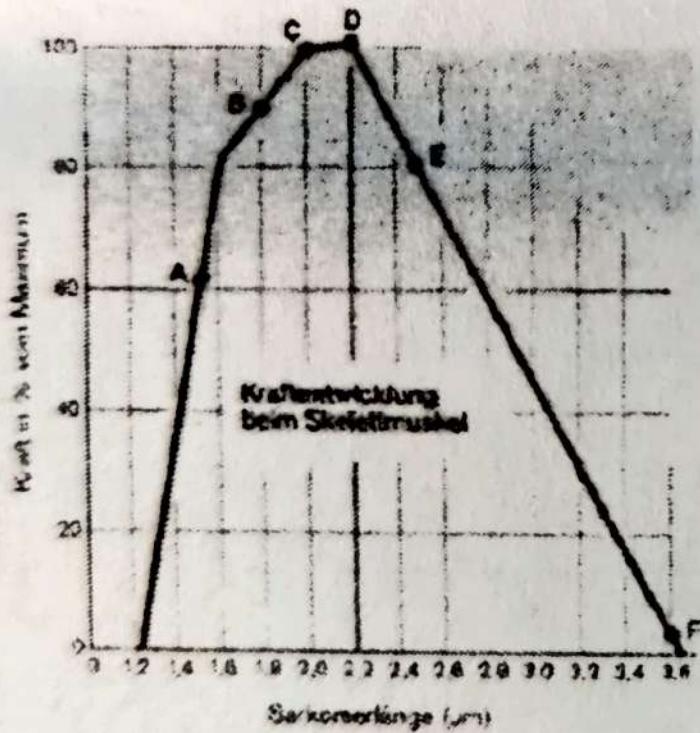
Schematic of the differences in the size of motor units. Typical twitch response, size of the motor nerve, and typical recruitment are illustrated.



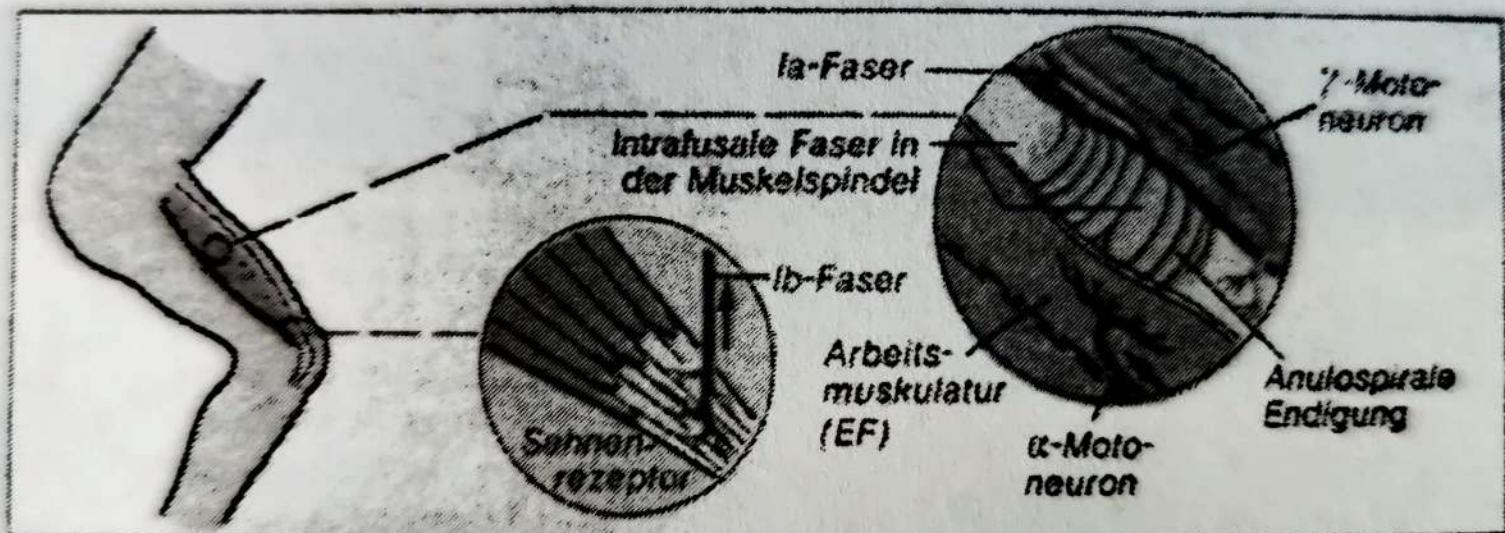
Kraft-Längenfunktion



Kraftentwicklung: Abhängigkeit von der Sarkomerlänge

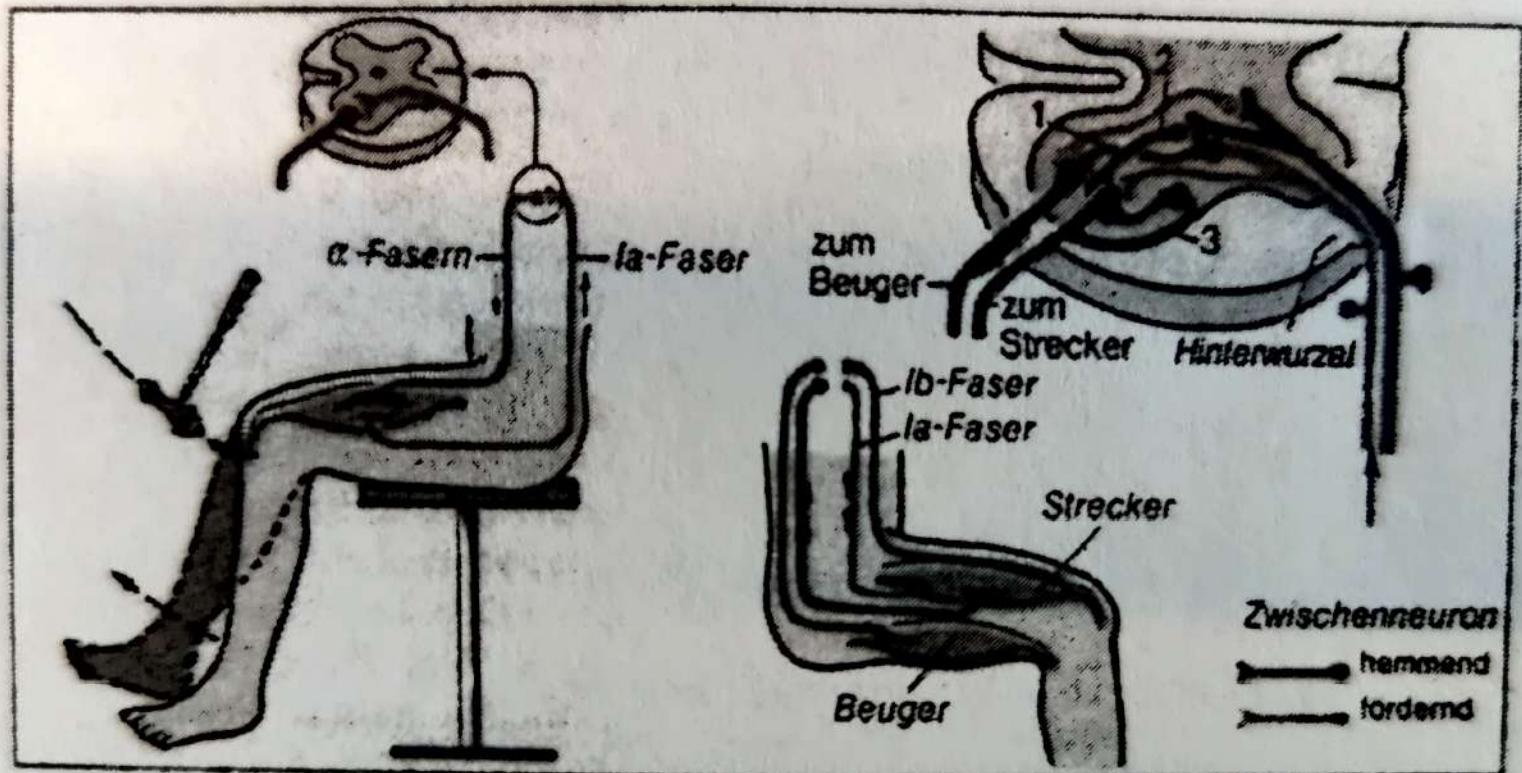


Reflex

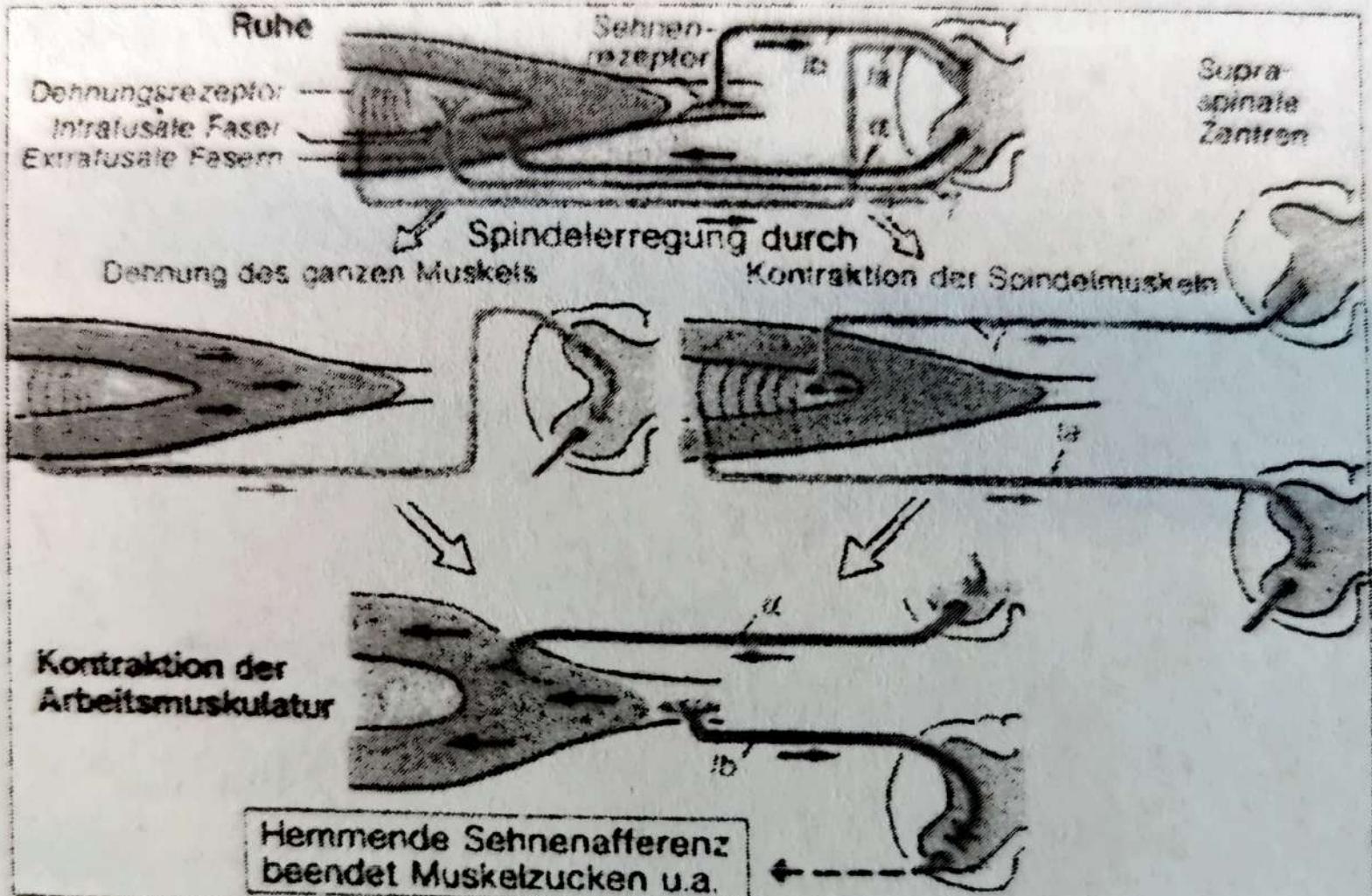


A. Muskelspindel und Sehnenrezeptor

Reflex

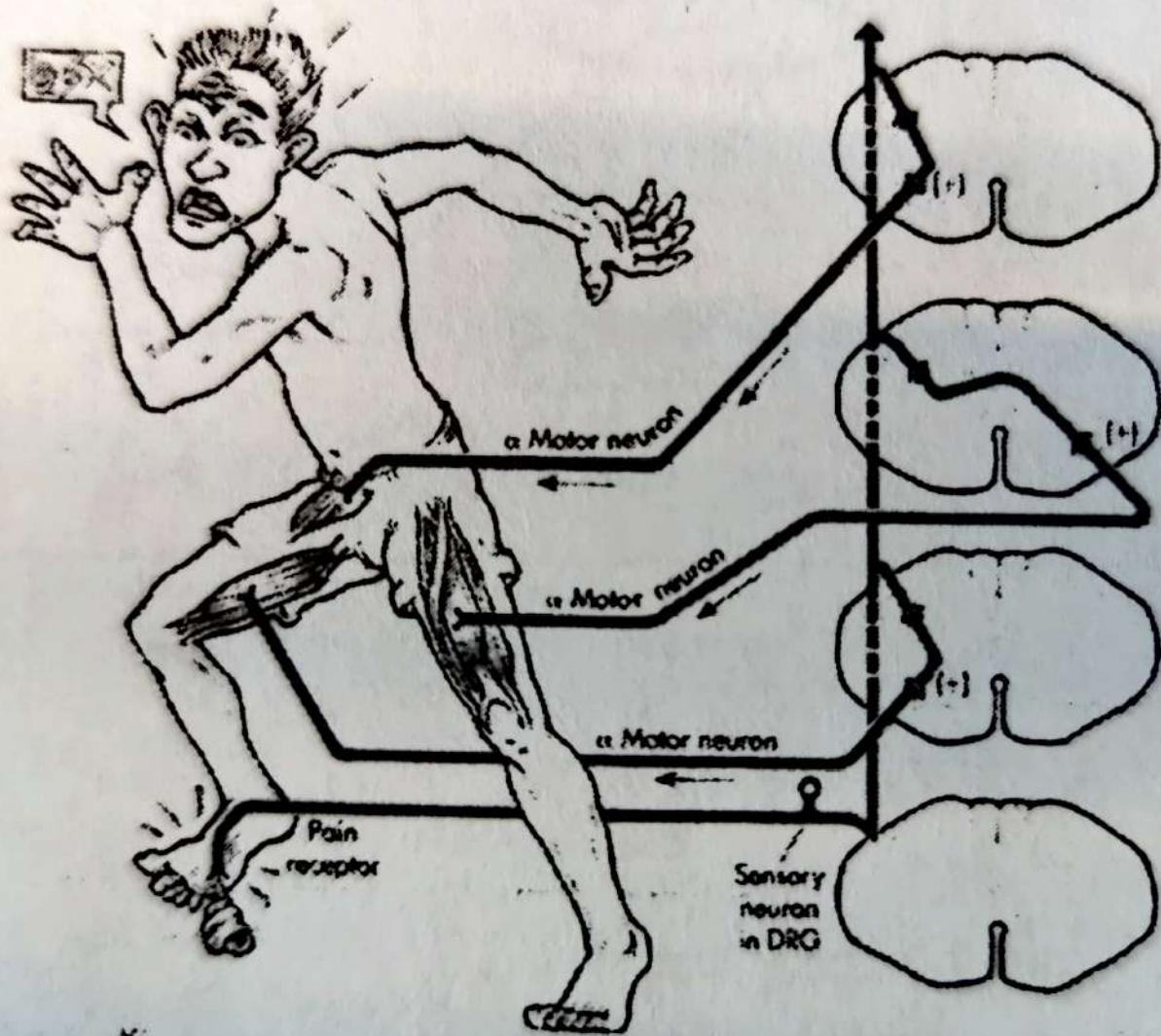


B. Dehnungsreflex



C. Funktion der Muskelspindeln

Beugereflex



Leonard,
1998, S. 9
Motor-Mechanik

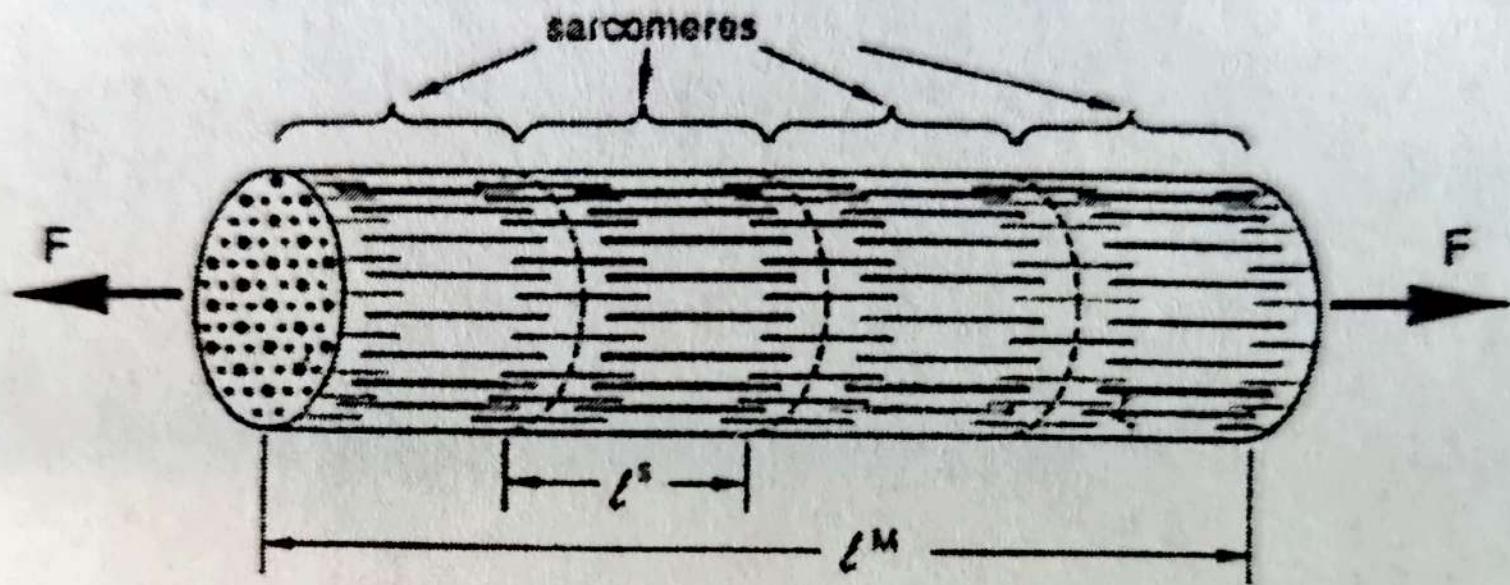


FIGURE 2. Muscle fiber and sarcomere structure. Each fiber (length L^M) consists of a series of sarcomeres. Each sarcomere has the same length L^S and experiences the same force F . Myosin myofilaments (dark lines) overlap with actin myofilaments (thin lines), and cross-bridges (not shown) are formed when the sarcomere is activated. Through cross-bridge energetics and the sliding of filaments, the fiber can develop force and shorten.

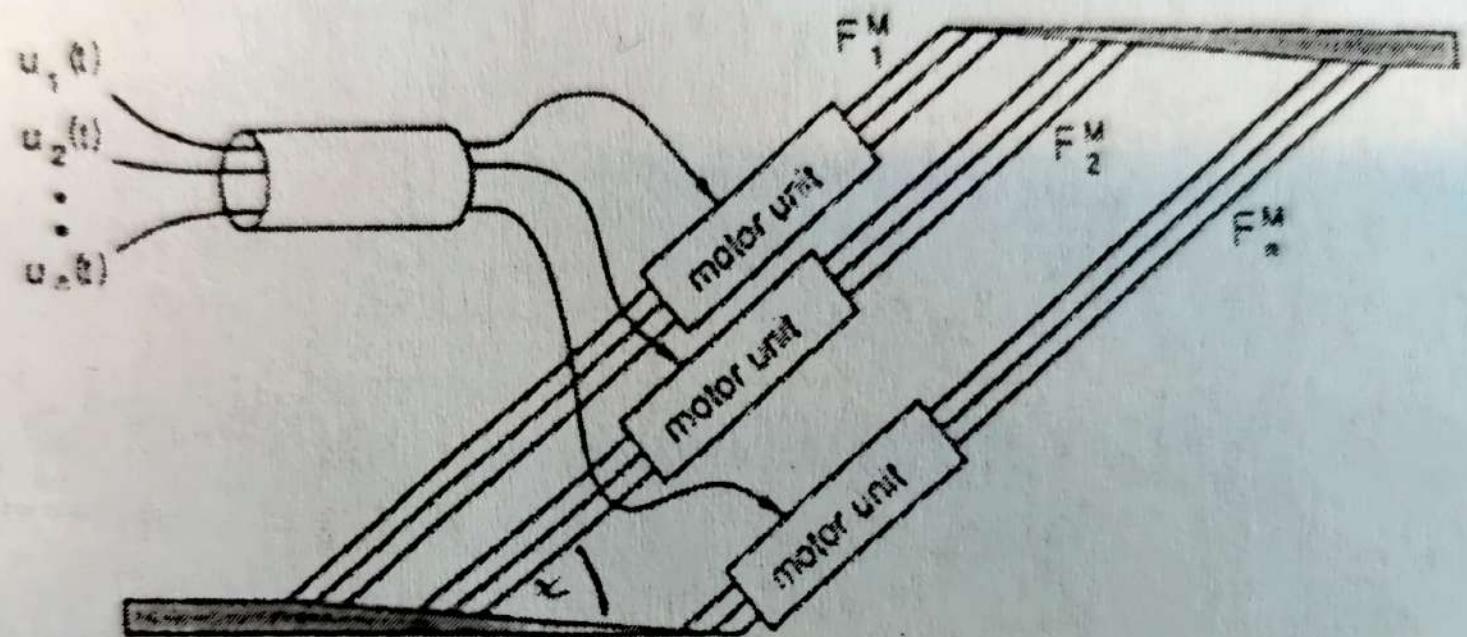


FIGURE 1. Schema of the collective function of motor units of one muscle. Each motor unit is functionally disjoint from the others, including the set of muscle fibers innervated by each motor-nerve axon. The action-potential discharge pattern of each axon i ($u_i(t)$ for axon i) excites the muscle fibers of that motor unit i and generates the collective force F_M^i of the fibers (called the force output from motor unit i).

Membranpotential

[mV]

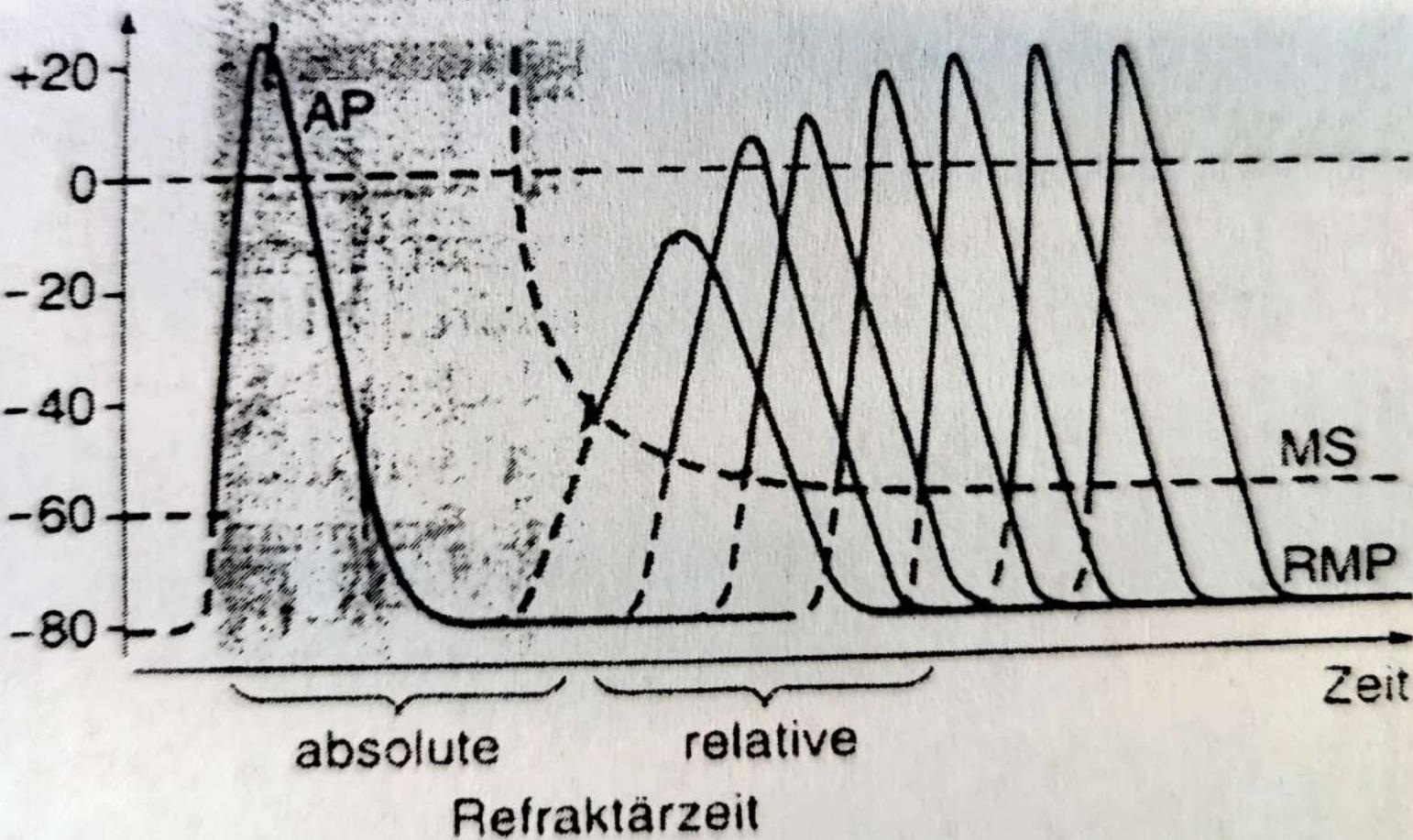
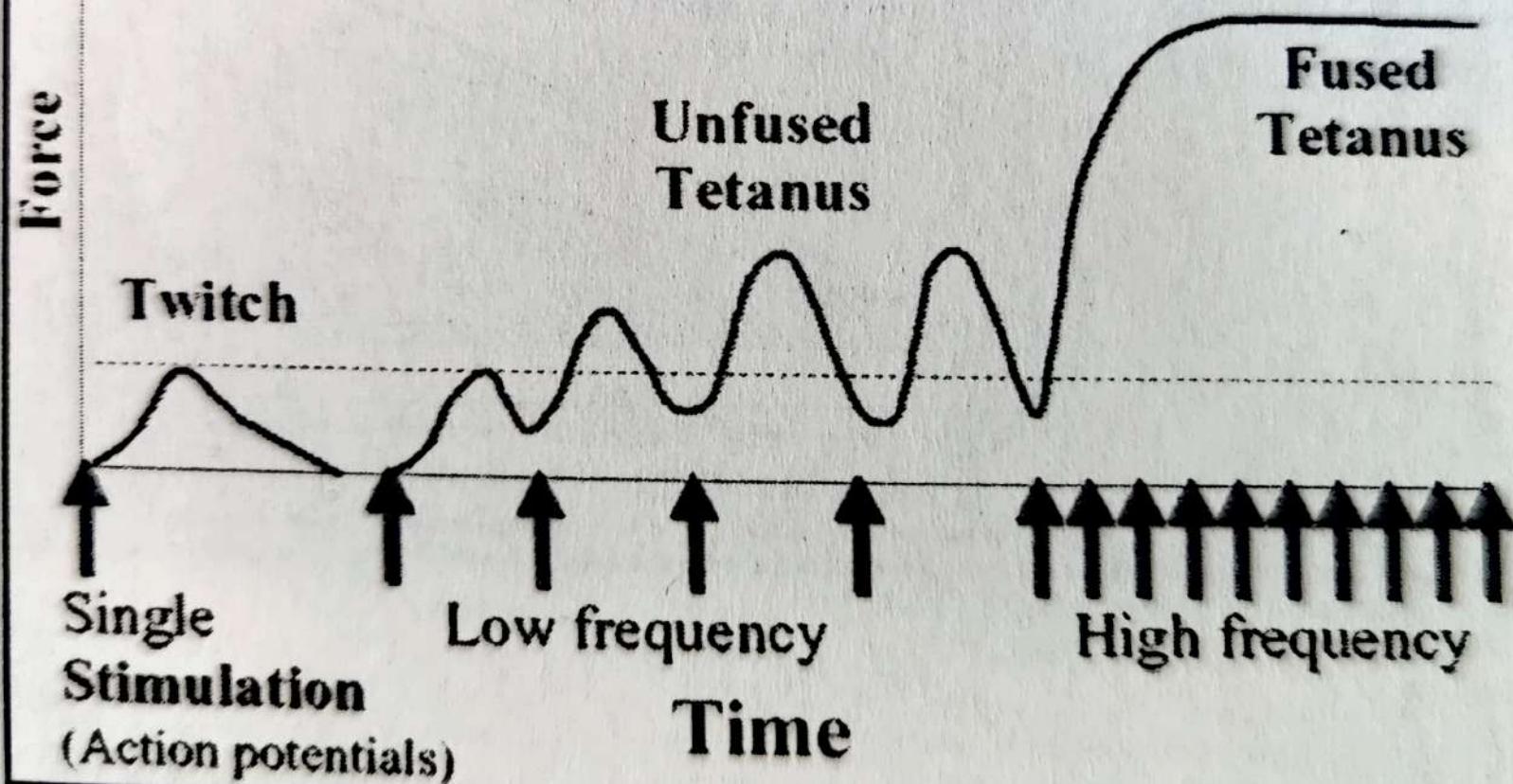


Abb. 2-11 Darstellung der Refraktärität eines Neurons im Anschluß an ein Aktionspotential (AP).

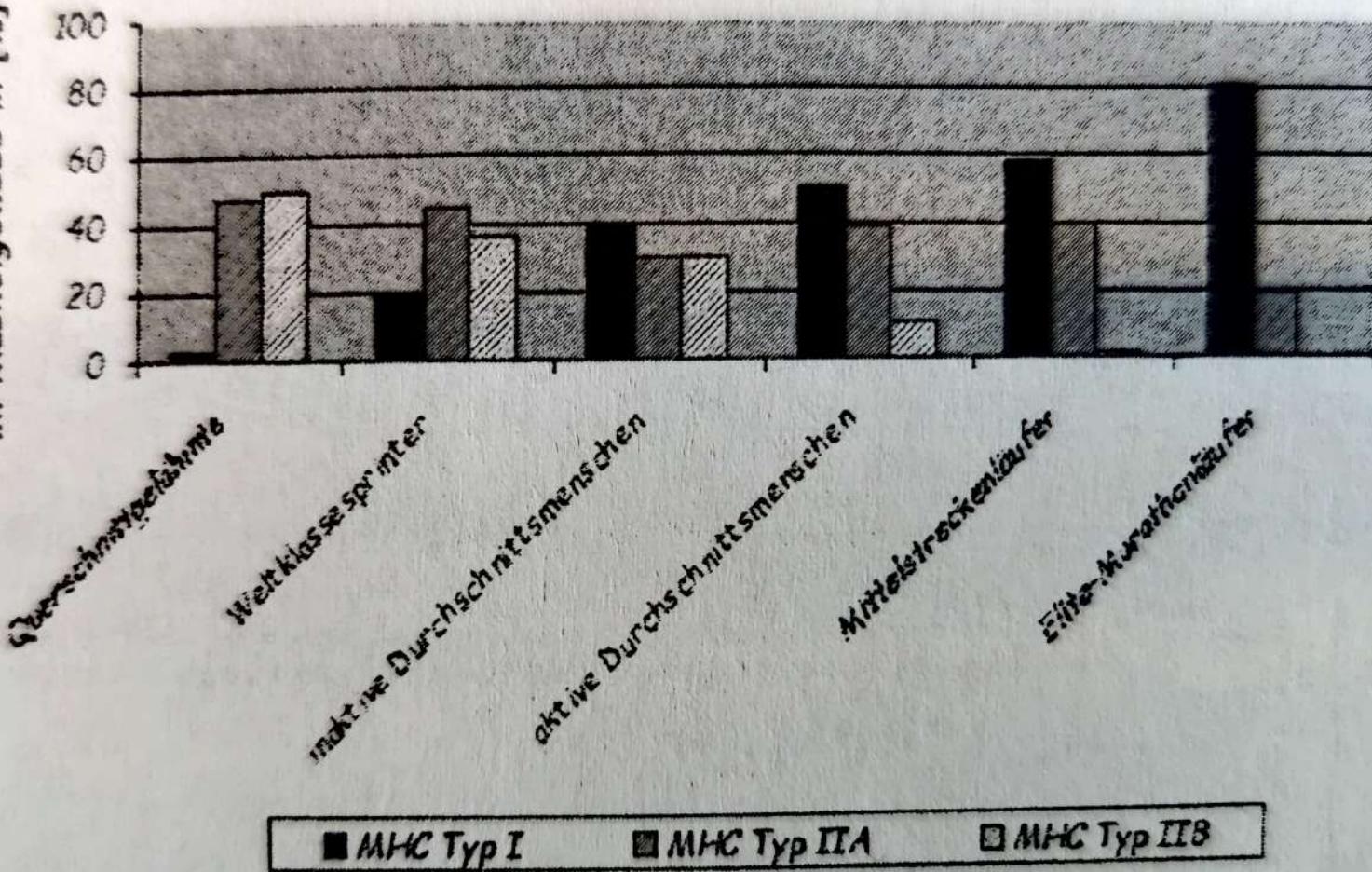
Die Depolarisationen, die bis zum Überschreiten der Membranschwelle (MS; gestrichelte Kurve) erreicht werden müssen, sind durch gestrichelte Linien gekennzeichnet. Im unmittelbaren Anschluß an das erste Aktionspotential kann die Schwelle nicht überschritten und damit kein zweites Aktionspotential ausgelöst werden (absolute Refraktärzeit). Mit zunehmendem zeitlichem Abstand vom ersten AP nähert sich die Schwelle wieder dem Ausgangswert. Dadurch können weitere Erregungen hervorgerufen werden. Dazu sind jedoch zunächst noch höhere Depolarisationen als beim ersten AP notwendig (relative Refraktärzeit). In der relativen Refraktärzeit sind Steilheit und Amplitude der Aktionspotentiale reduziert. RMP = Ruhemembranpotential [5].

Kraftentwicklung in Abhängigkeit von der Aktivierungsfrequenz

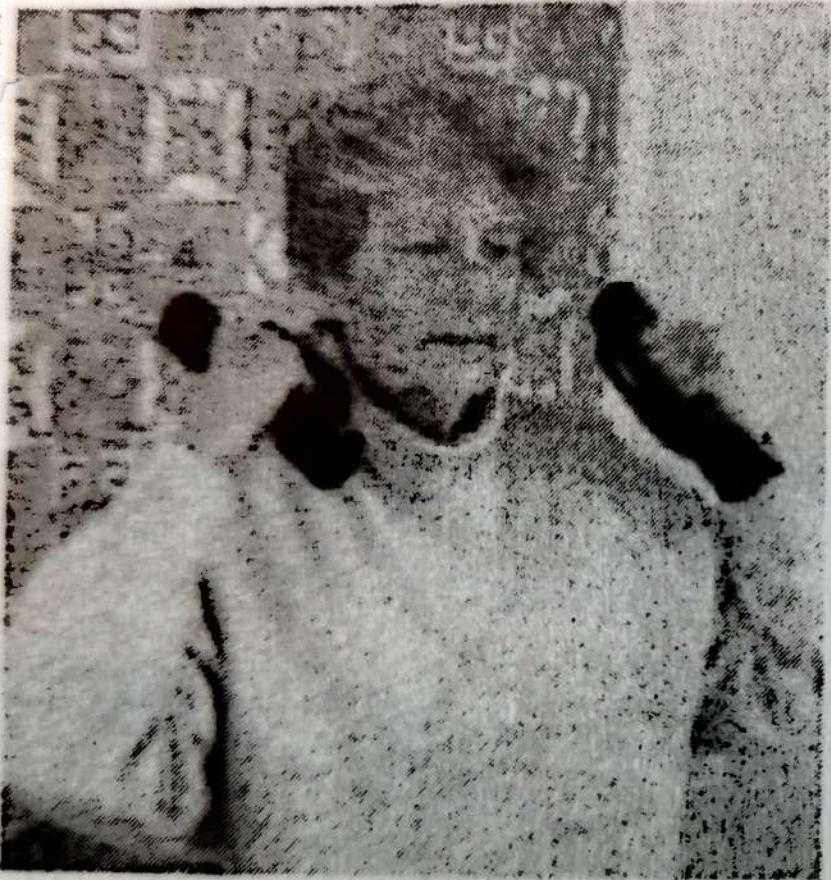
Isometric contraction



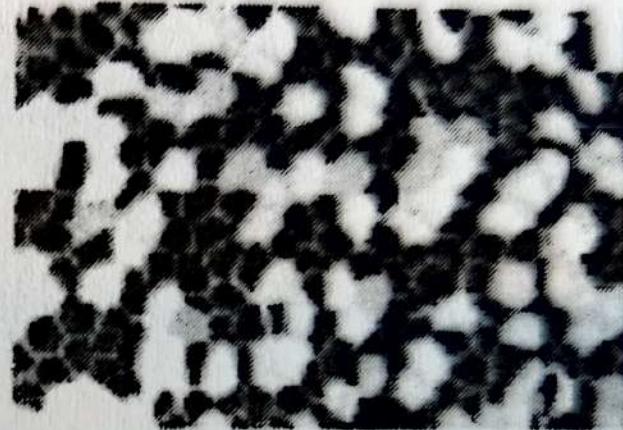
Anteile des Myosintyp's im Muskelgewebe in [%]



Laura D'Angelis / CORBIS



Thomas Angeli

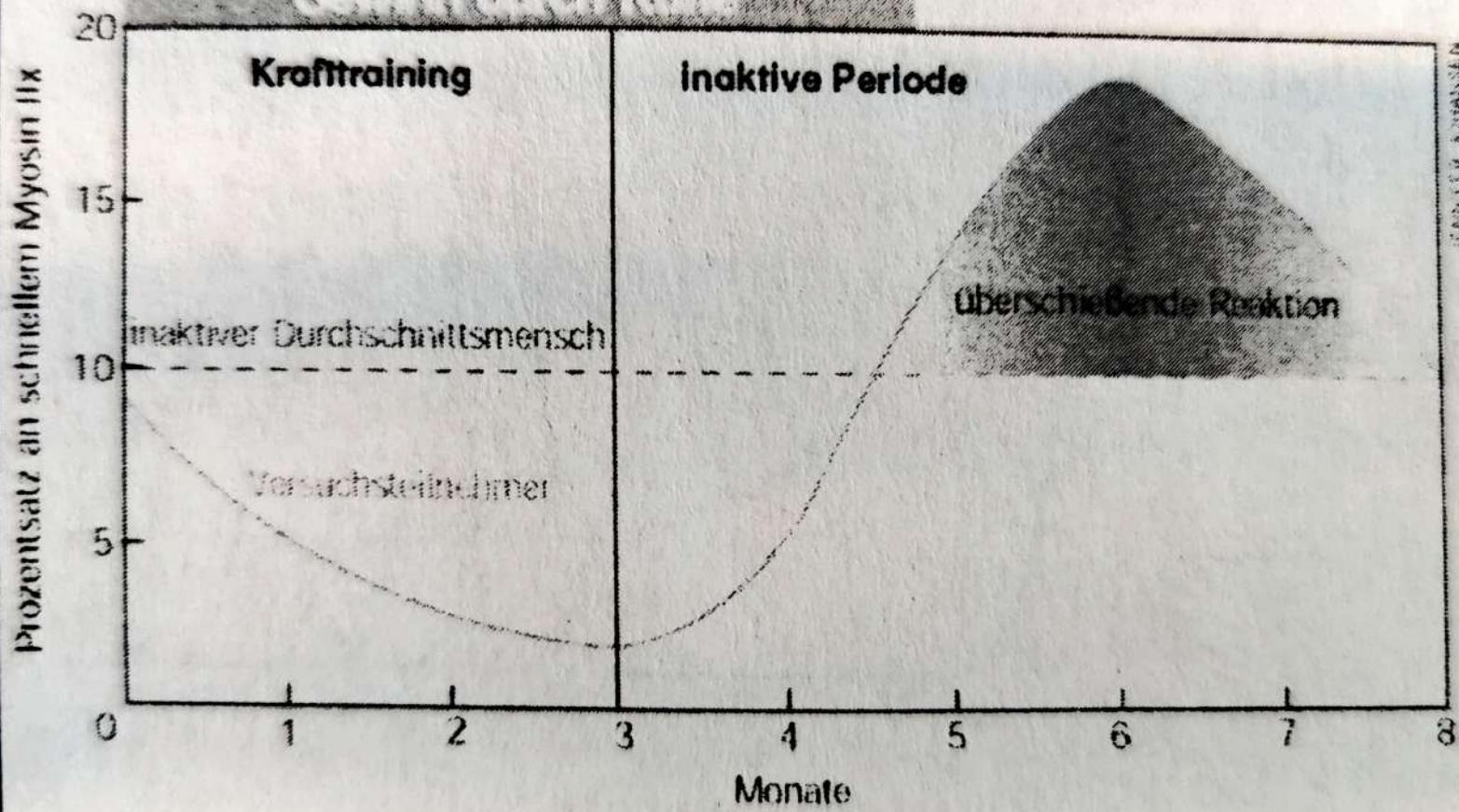


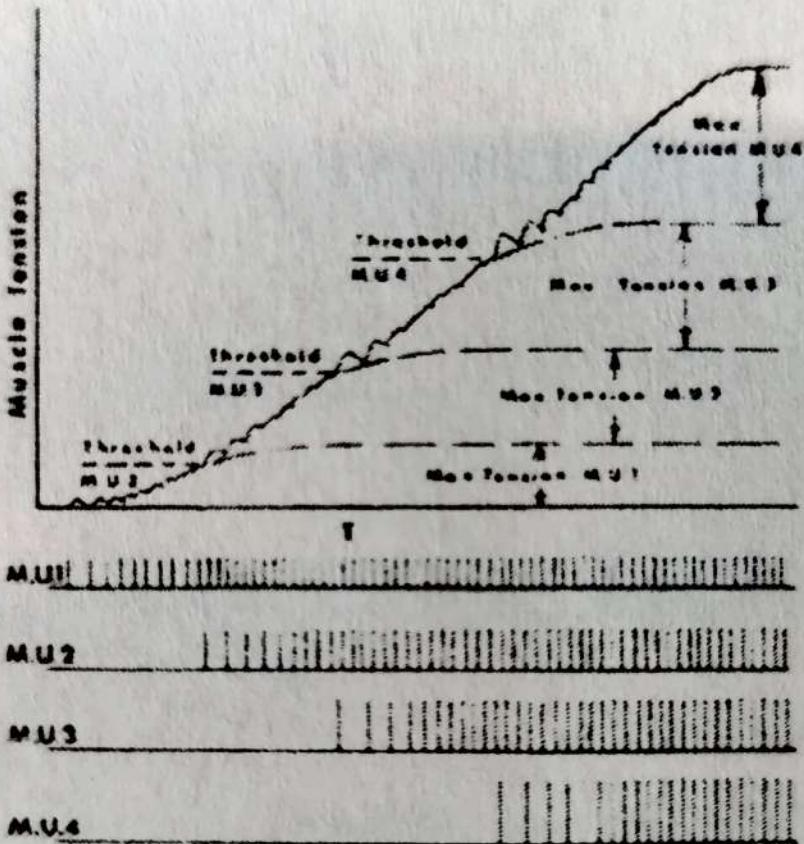
VO: Der Motor Muskel

Jesper L. Andersen



Jesper L. Andersen





The order in which motor units get recruited is not random. Smaller motor units get recruited first followed by larger ones (see figure 4). This makes sense because small motor units are used for fine control which is required at low forces. At higher forces small changes in force are not necessary. If big motor units fired off force you would not be able to apply very small forces at all.

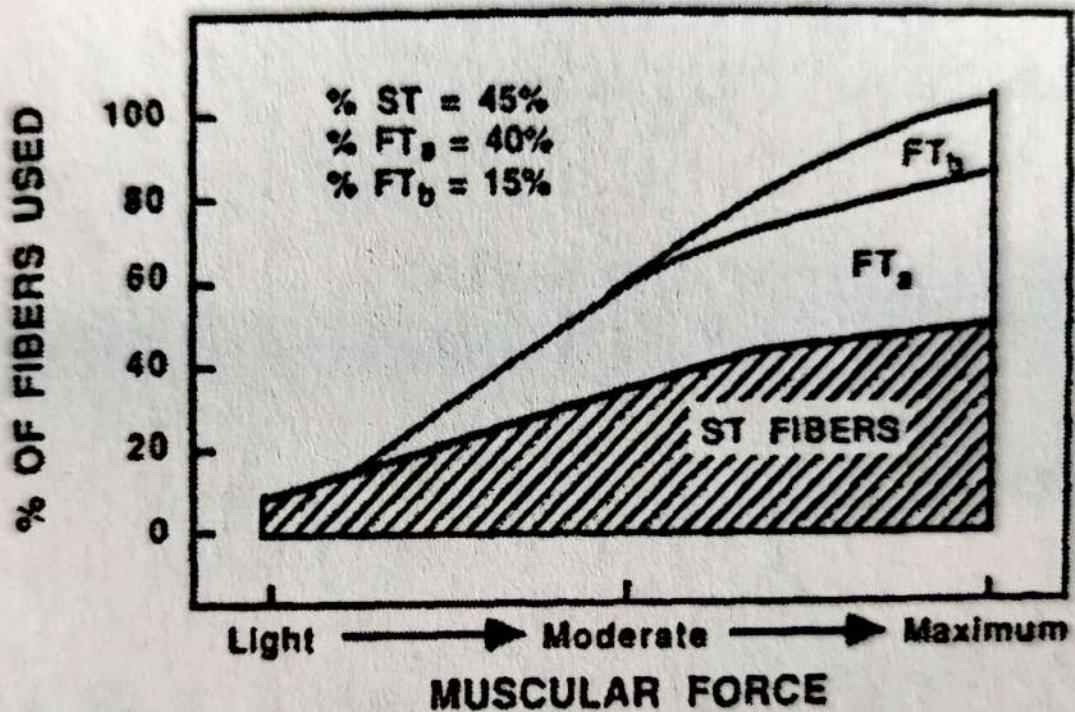
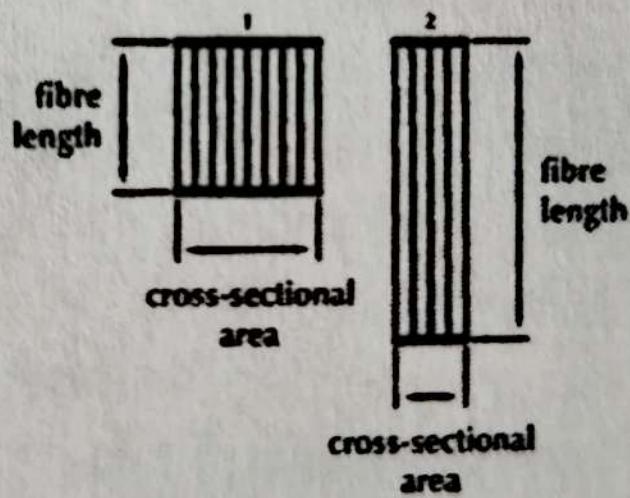
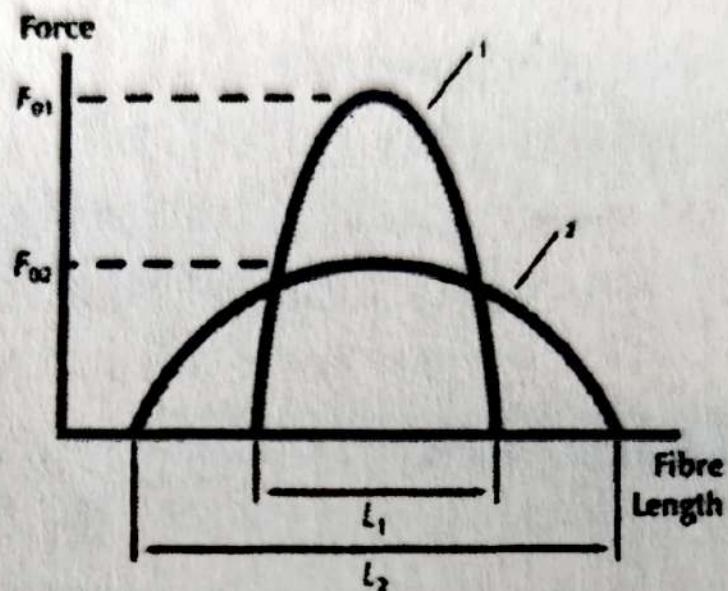
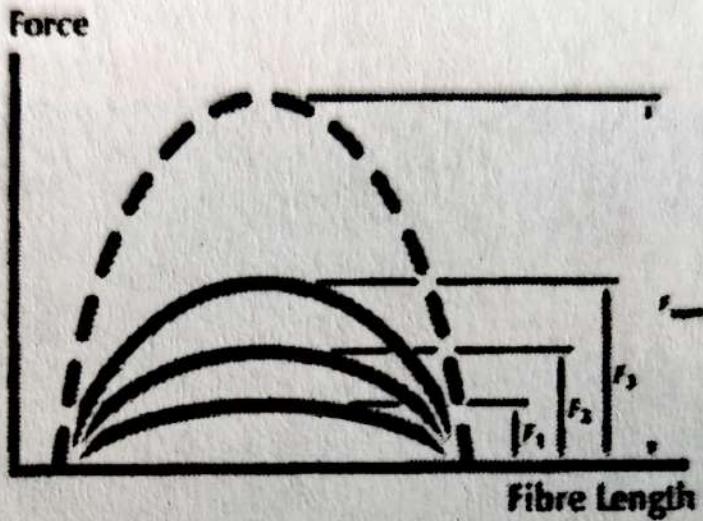


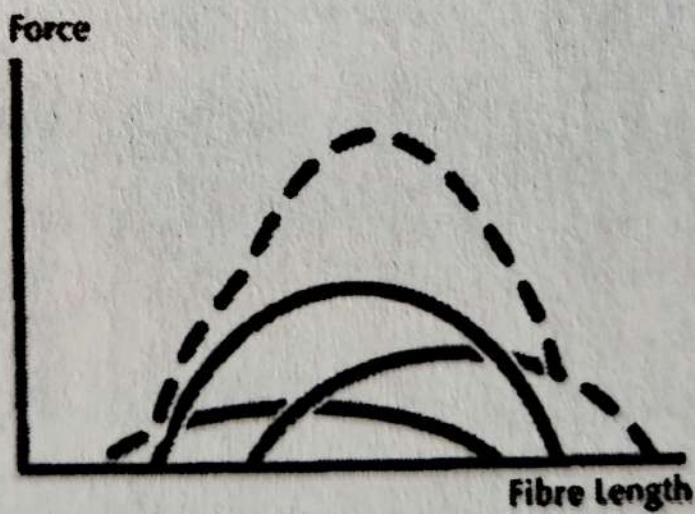
Figure 1-11 The ramp-like recruitment of muscle fibers in varied levels of muscular effort. Whereas light force requirements only use the slow-twitch fibers, heavy loads on the muscle will result in the recruitment of all three types of muscle fibers.



(a)



(b)



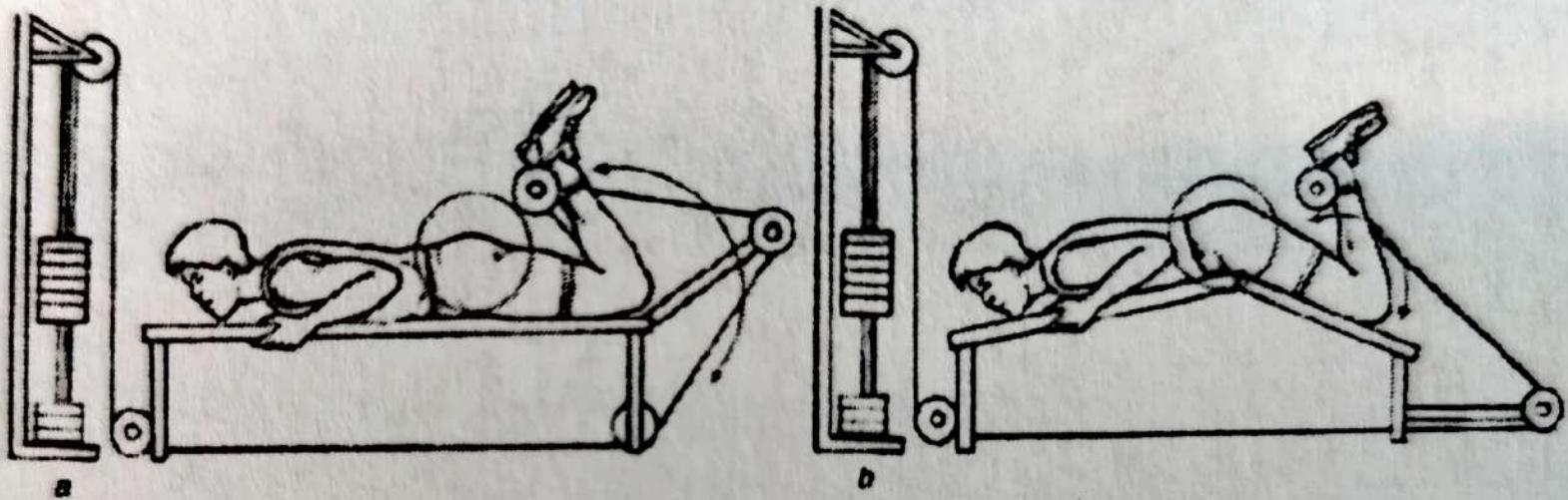
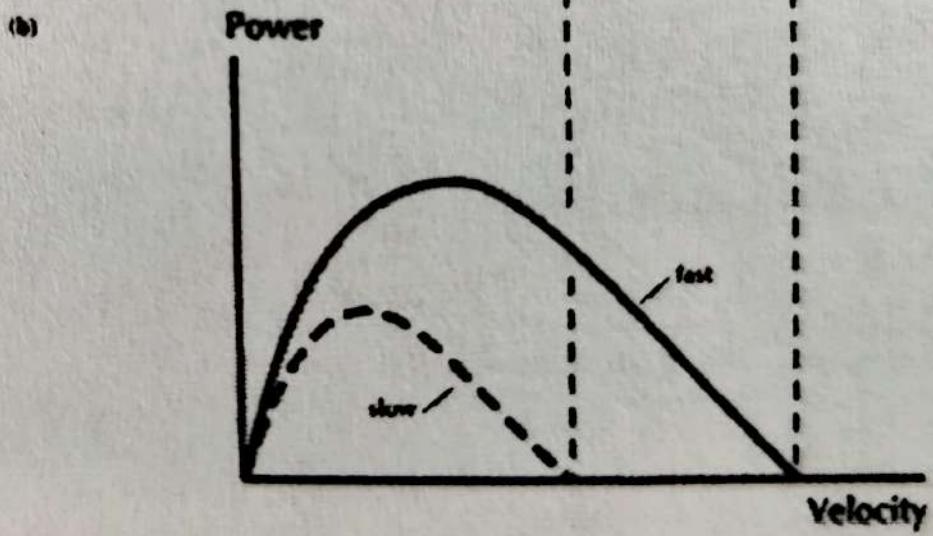
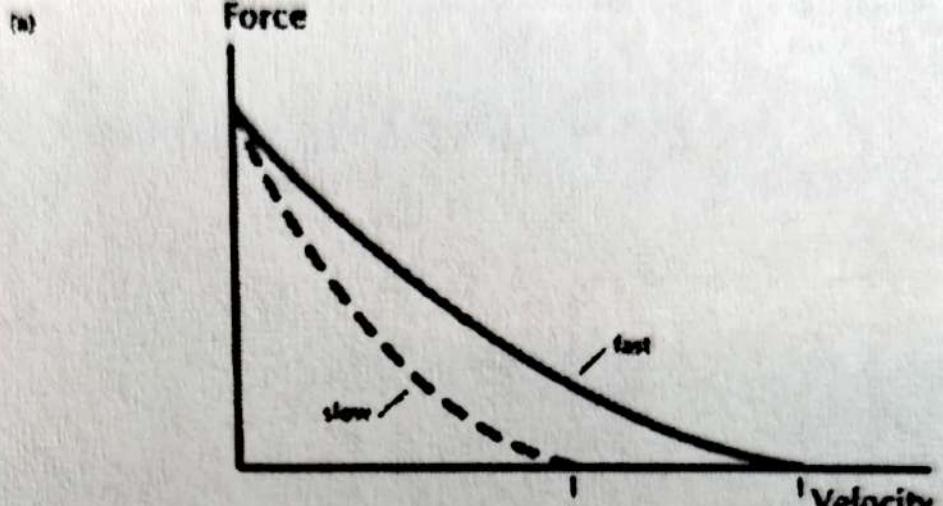
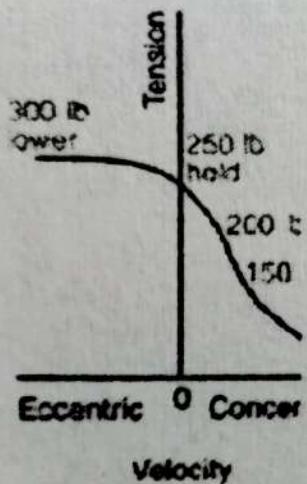


Figure 14.18

Machines for exercising hamstring muscles. In (a), muscle length is very short and its ability to create tension is limited. In (b), muscle length is longer due to flexion at the hip and its ability to create tension is greater.

Example of muscle stretch [McGinnis 1999]

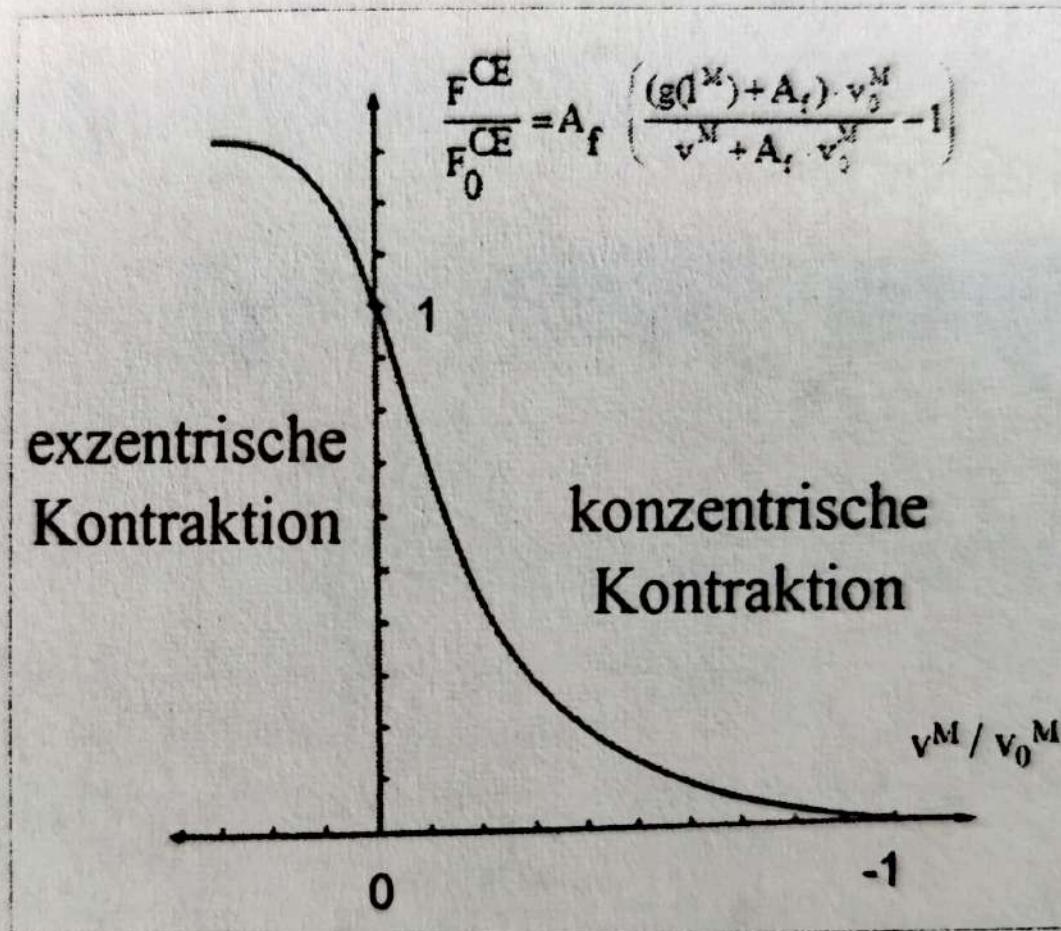




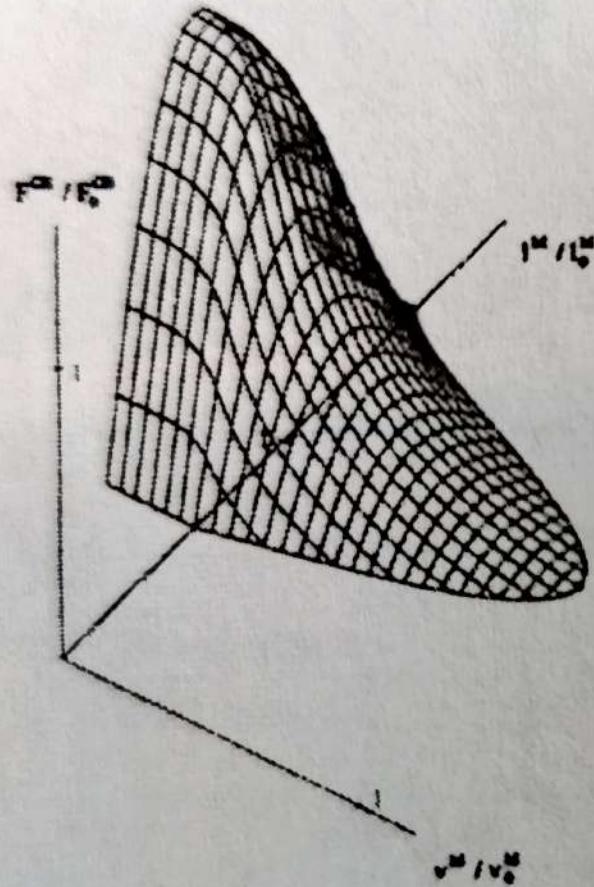
$$\begin{aligned}
 300 \text{ lb} &= 136 \text{ kg} \\
 250 \text{ lb} &= 113 \text{ kg} \\
 200 \text{ lb} &= 91 \text{ kg} \\
 150 \text{ lb} &= 68 \text{ kg}
 \end{aligned}$$

The effect of contraction velocity [McGinnis 1999]

Kraft-Geschwindigkeitsfunktion



Relativer Muskelkraftverlauf



$$\frac{F^{CE}}{F_0^{CE}} = A_f \cdot \left(\frac{(g(l^M) + A_f) \cdot v^M}{v^M + A_f \cdot v^M} - 1 \right)$$

• A_f dimensionsloser Hill-Parameter

$$A_f = 0,1 + 0,4 \cdot FC^{\text{fast}}$$

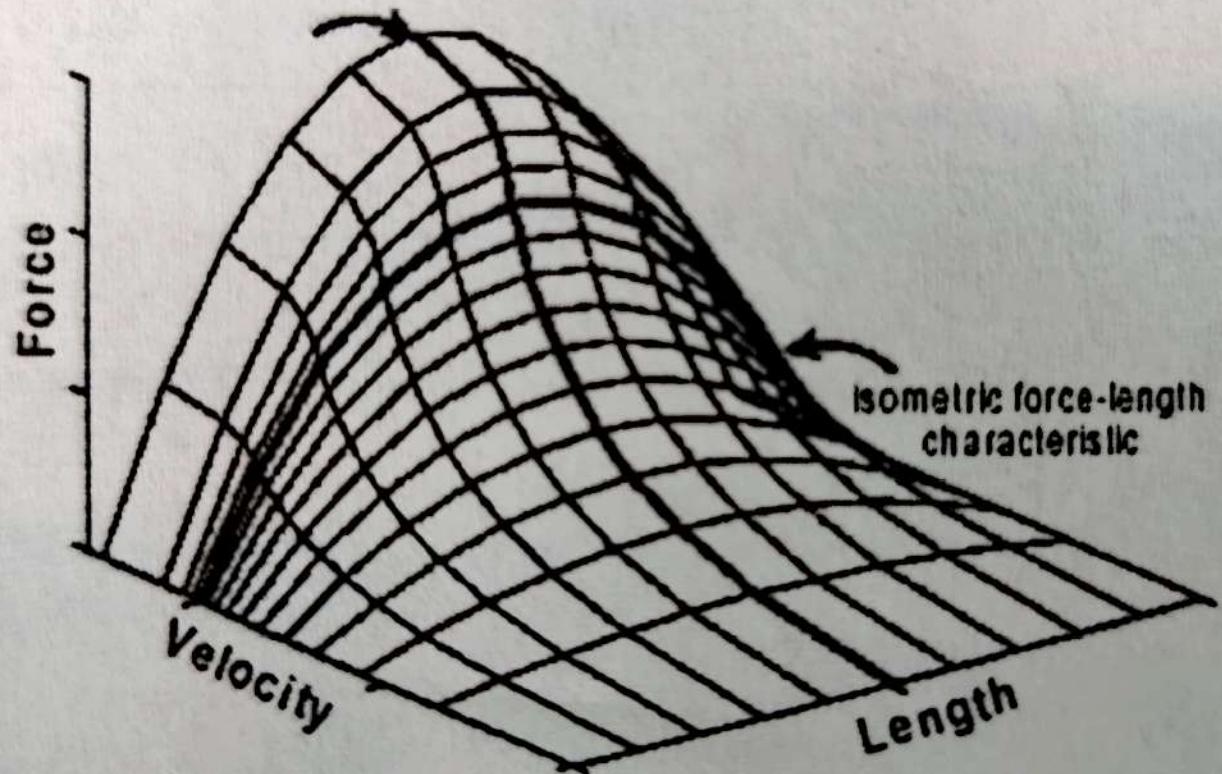
lt. Winters & Stark (1988)

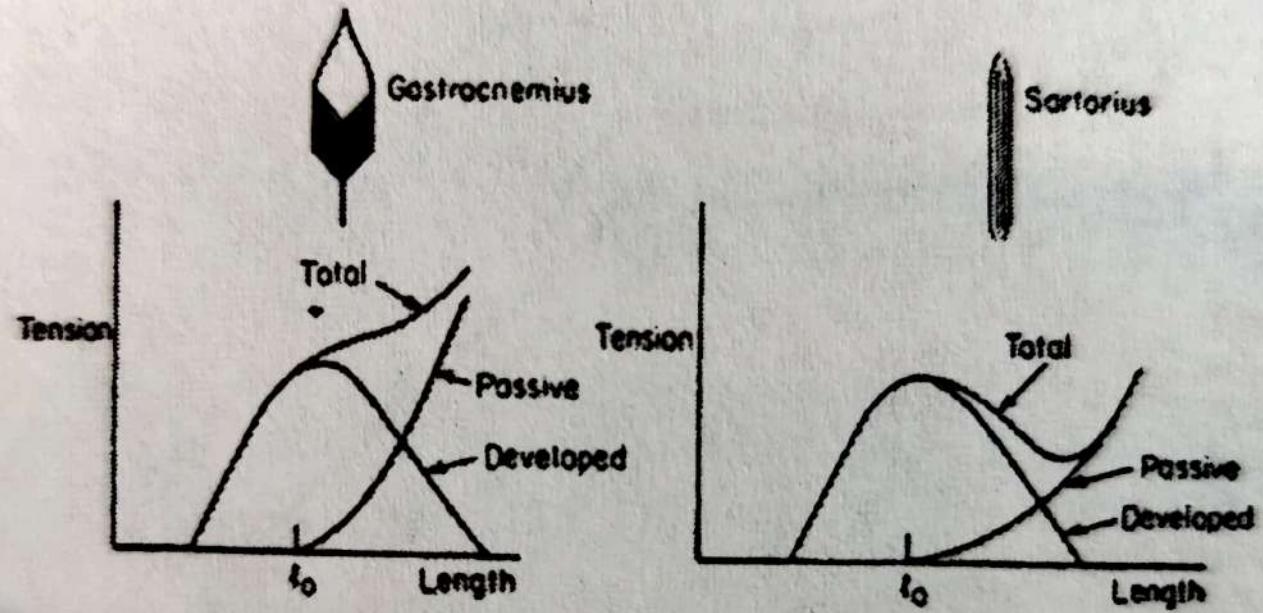
• g beschreibt die Abhängigkeit der bezogenen aktiven Muskelkraft von der bezogenen Muskellänge unter isometrischen Bedingungen

$$v_0^M = K_1 \cdot l_0^M + K_2 \cdot l_0^M \cdot FC^{\text{fast}}$$

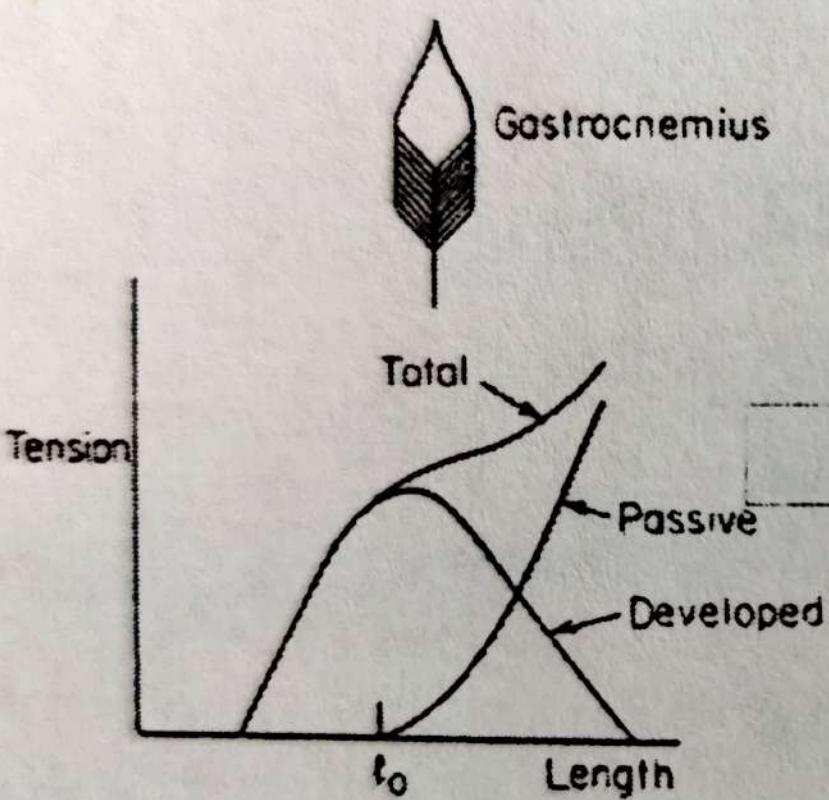
$$K_1 = -2 \text{ s}^{-1}, \quad K_2 = -3 \text{ s}^{-1}$$

lt. Winters & Stark (1988)





Muskelkraftverlauf über der Muskellänge



$$\frac{F^{PE}}{F_0^M} = \frac{V_L}{e^{shpe} - 1} \cdot \left(e^{\frac{shpe \cdot x^M}{x_{max}^M}} - 1 \right)$$

x^M Längung des Muskels ($x^M = l^M - l_0^M$)

x_{max}^M max. Längung des Muskels ($x_{max}^M = l_{max}^M - l_0^M$)

shpe Gestaltparameter für das PE - Element

shpe = 3 lt. Pawlitsch (1992)

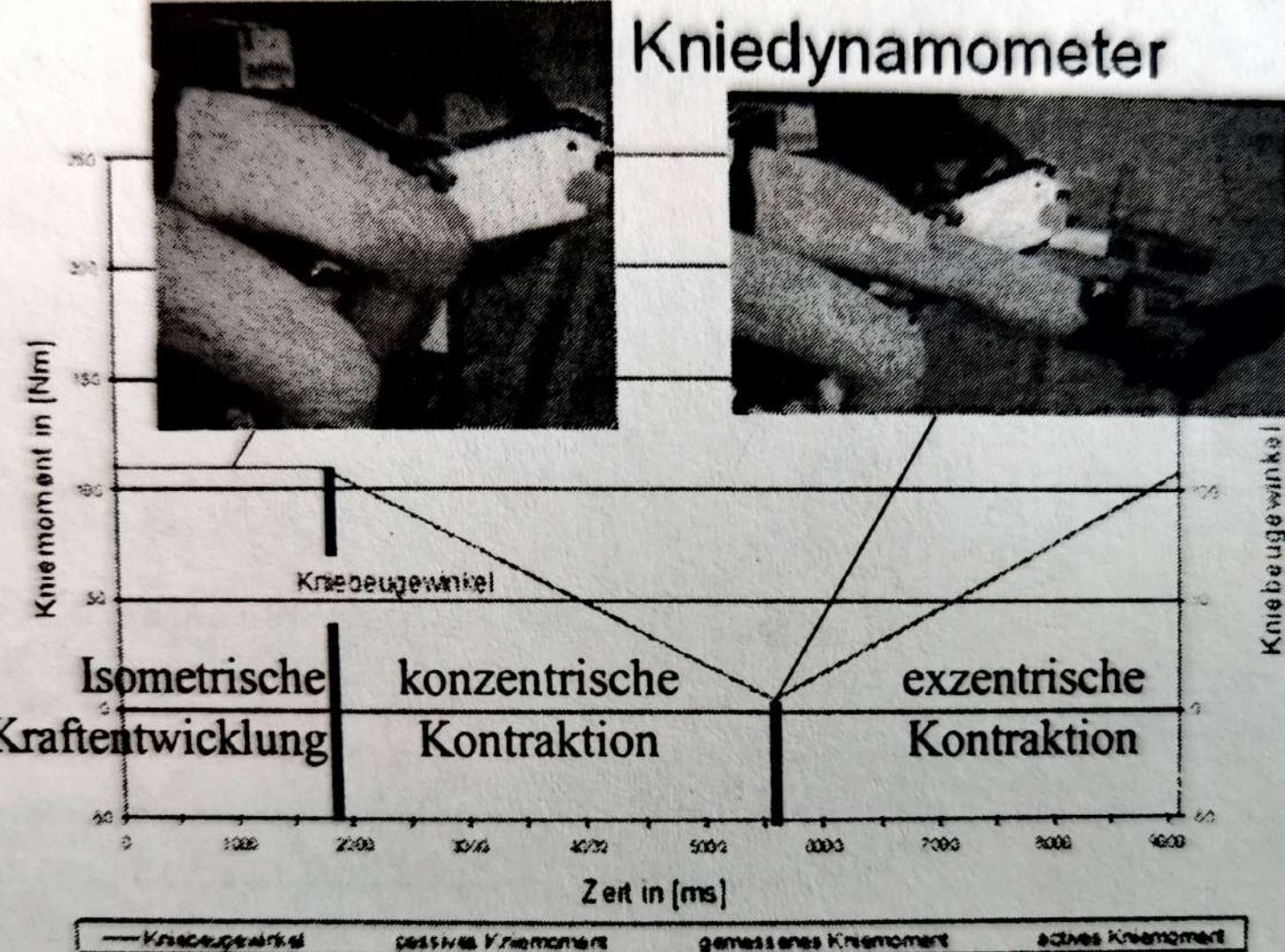
$V_L \approx 1.5$ lt. Hatze (1981); Pandy et al. (1990)

Modellierung der Sehne

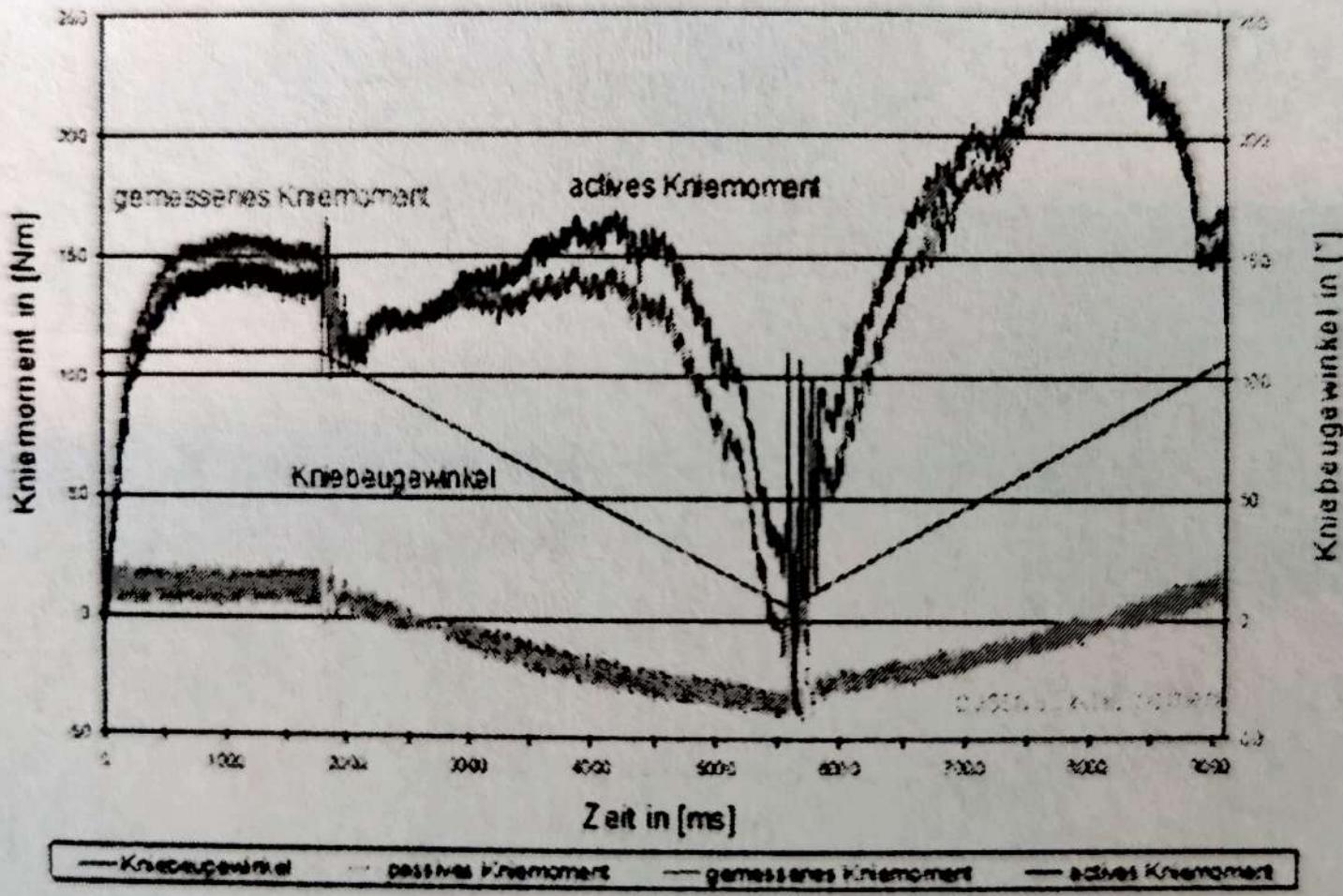
$$\frac{F^T}{F_0^T} = \frac{1}{e^{sh\pi} - 1} \cdot \left(e^{\frac{sh\pi \cdot x^T}{x_0^T}} - 1 \right)$$

- F^T : Sehnenkraft bei maximaler isometrischer Muskelkraft
 E^M : $F^T = E^M \cdot \cos(\alpha_c)$
 x^T : Sehnenlängung ($x^T = l^T - l_0^T$)
 x_0^T : Sehnenlängung mit maximaler isometrischer Muskelkraft
 F_0^T : $x_0^T = e^{\frac{1}{2}} \cdot l_0^T$,
 ϵ^T : Dehnung der Sehne bei F^T ,
 $\epsilon^T = 0.027$ lt. Hoy, Zajac & Gordon (1990)

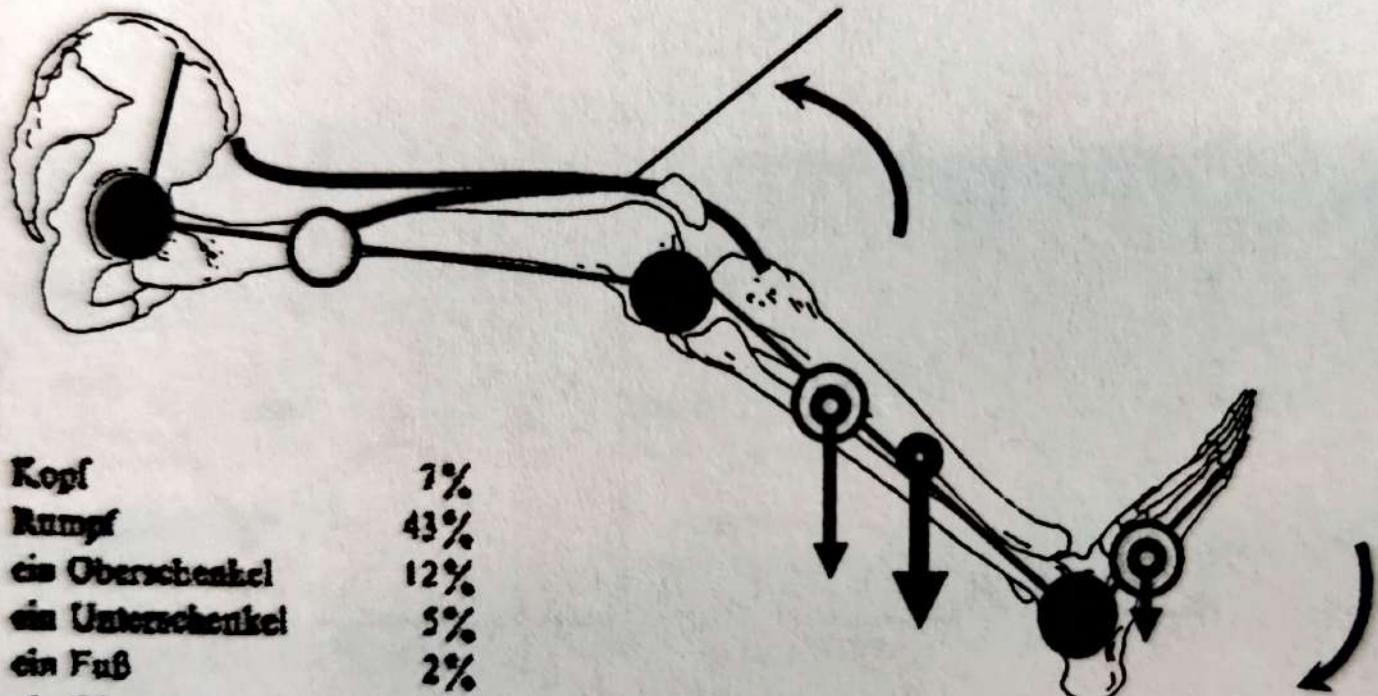
Kniedynamometer



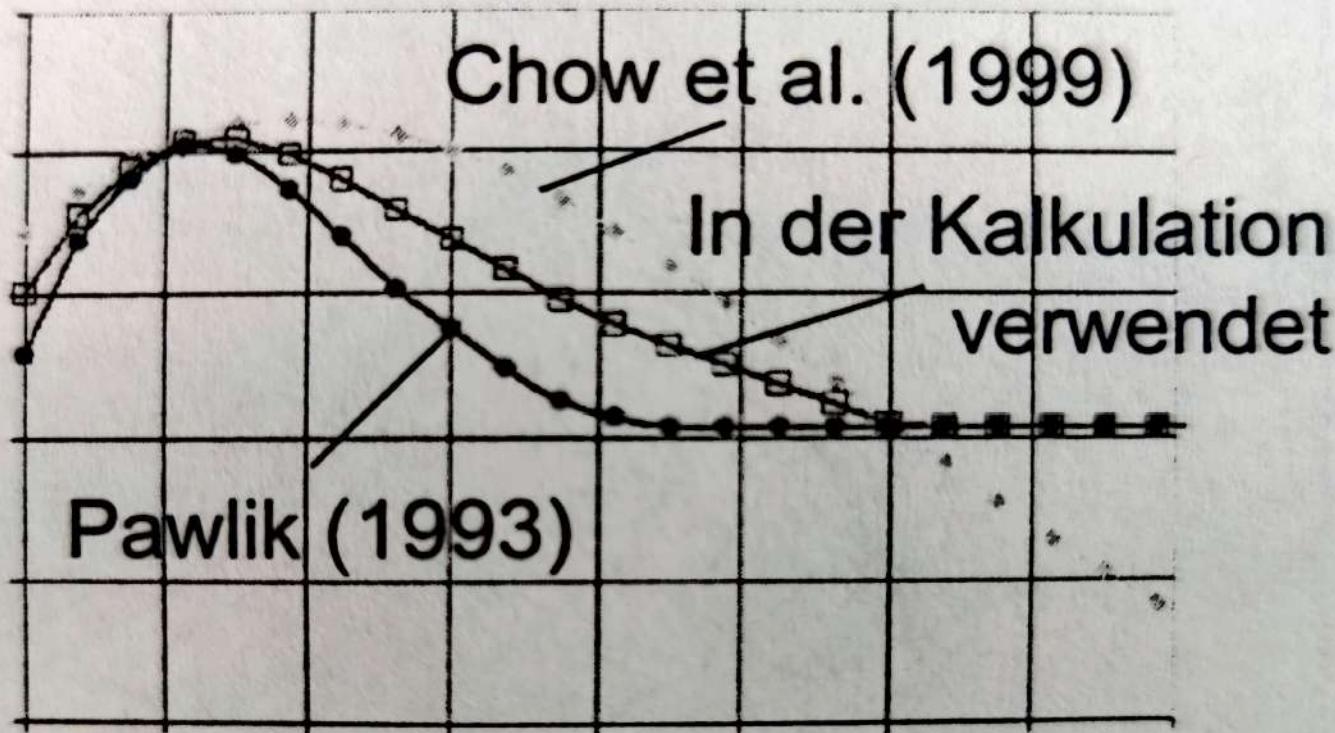
Messzyklus am Kniedynamometer



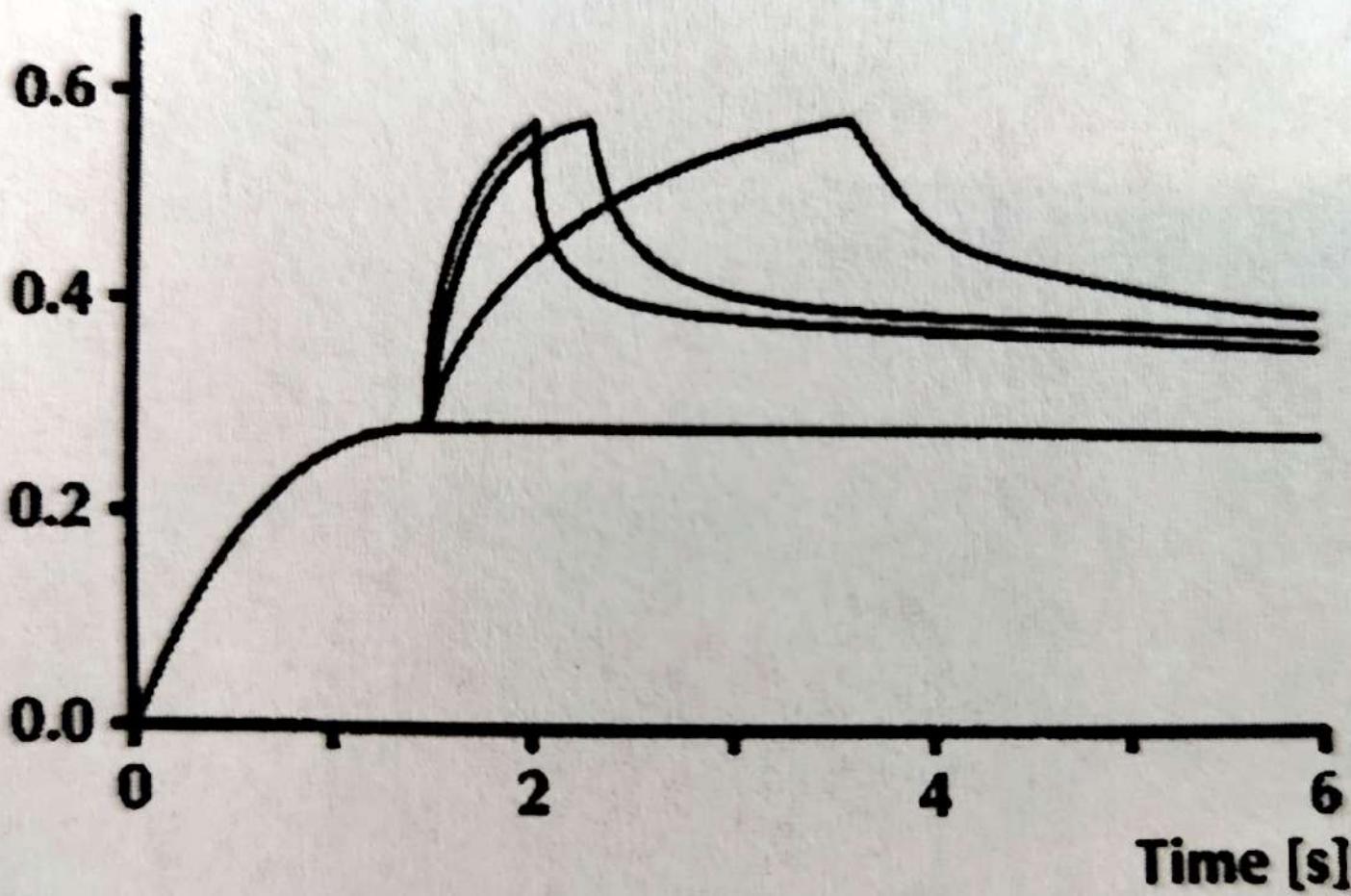
m. quadriceps

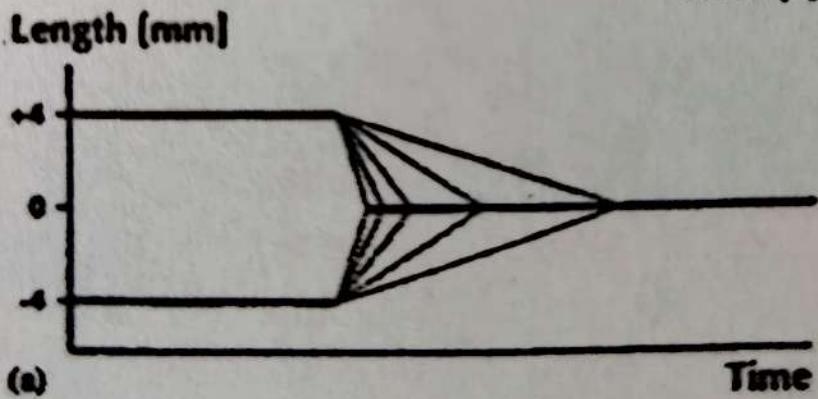
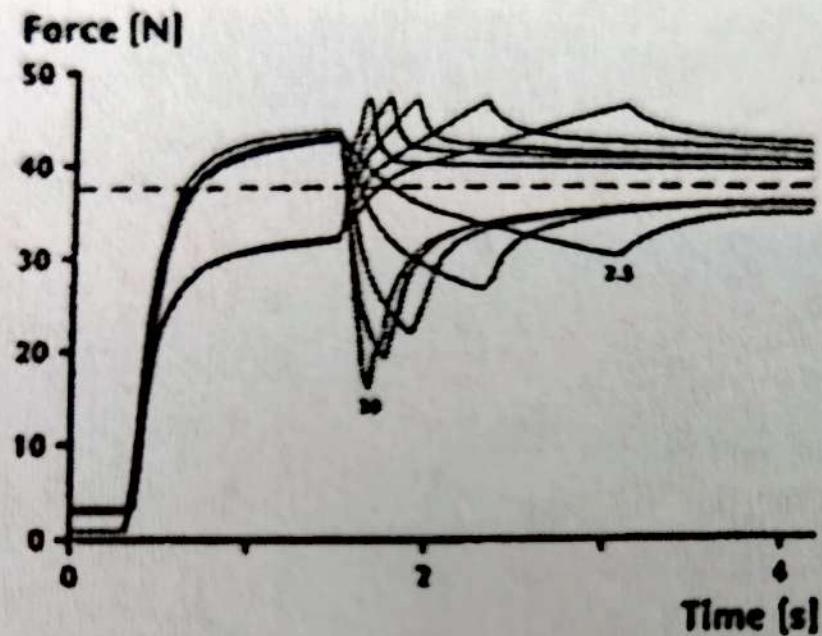


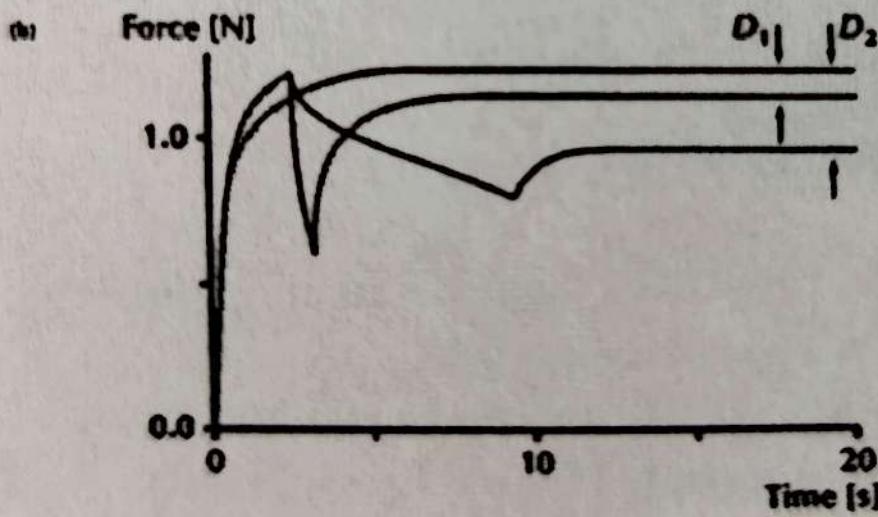
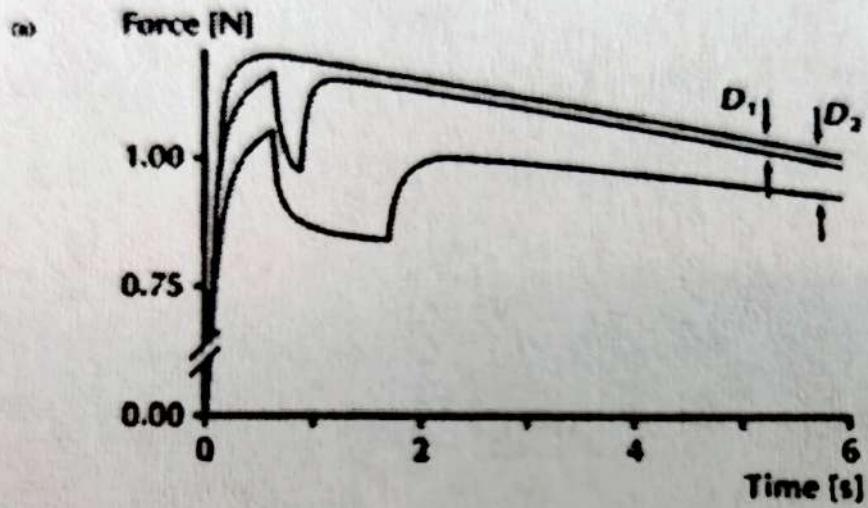
Hebelarmverlauf des m. quadriceps im Kniegelenk

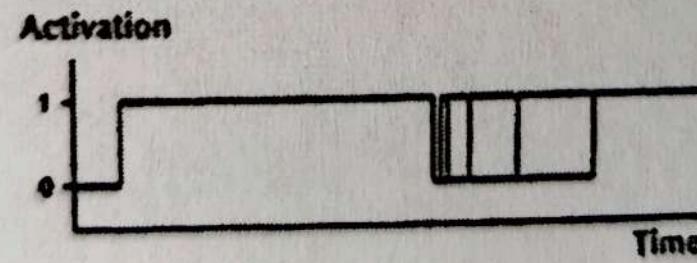
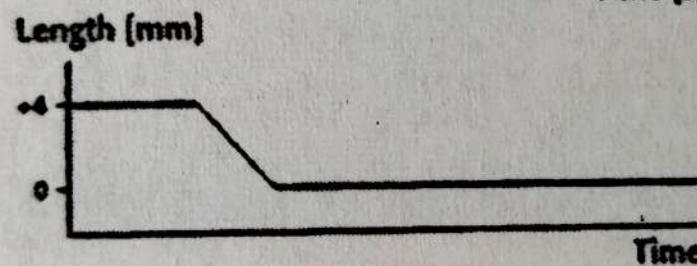
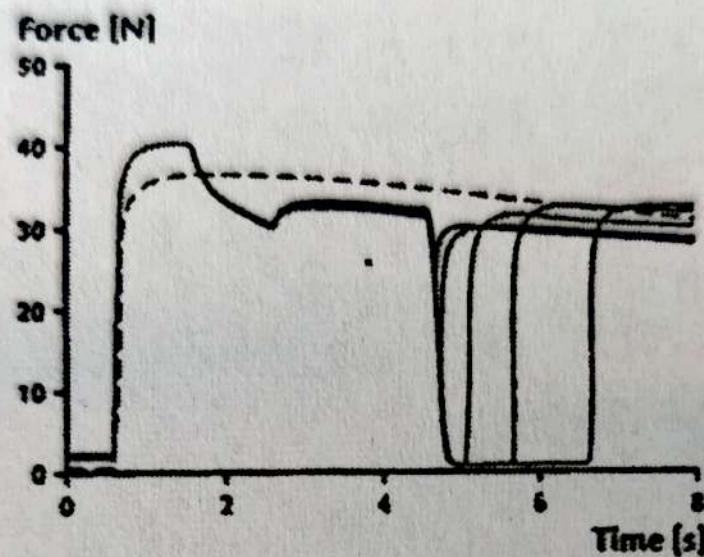


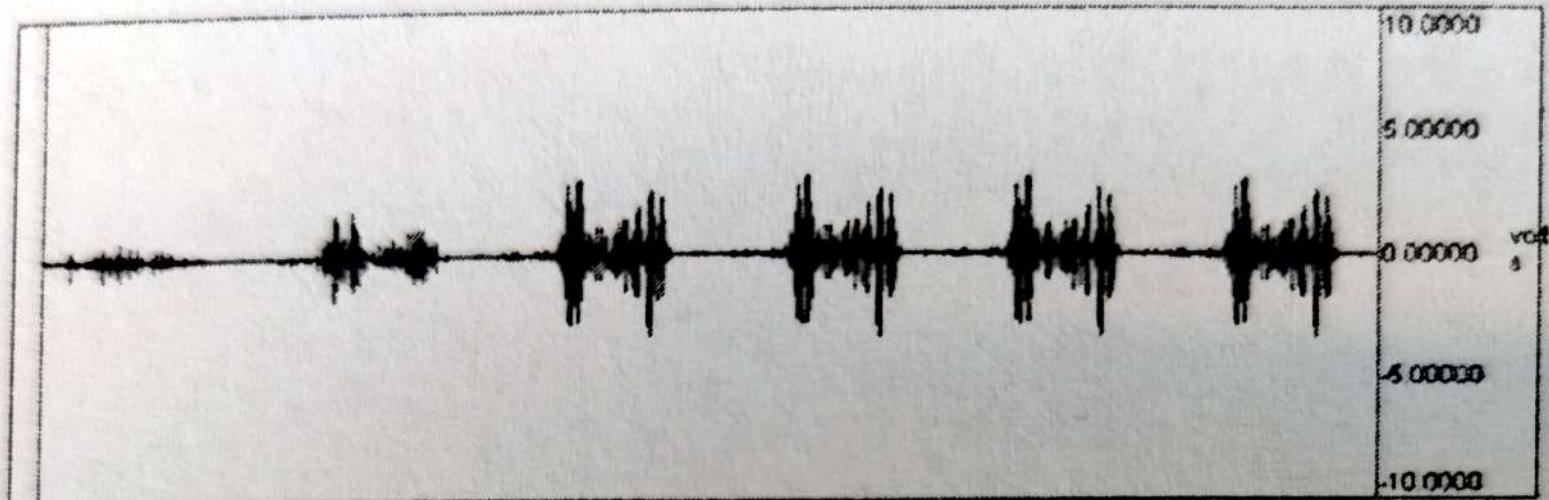
Force [N]











This EMG recording of the biceps muscle reflects a subject performing six arm curls. The first three curls were made using an increasing weight and the last four curls were performed with the same weight. The subject paused momentarily between lifting the weight (concentric movement) and returning back to the starting (eccentric movement) position. Notice the difference in EMG activity between the increasing weight, and the difference between the concentric and eccentric movement.

