Movement System Impairment of the Extremities, Cervical and Thoracic Spines

Chapter 1: Update of Concepts Underlying Movement System Syndromes

Figure 1-1. Hand position for assessing quality of cervical rotation. **A**, Initial position. **B**, Therapist initially follows the motion as the patient actively rotates the head and neck. If there is a movement fault, the therapist gently guides the motion to provide precision as the patient actively rotates the head.

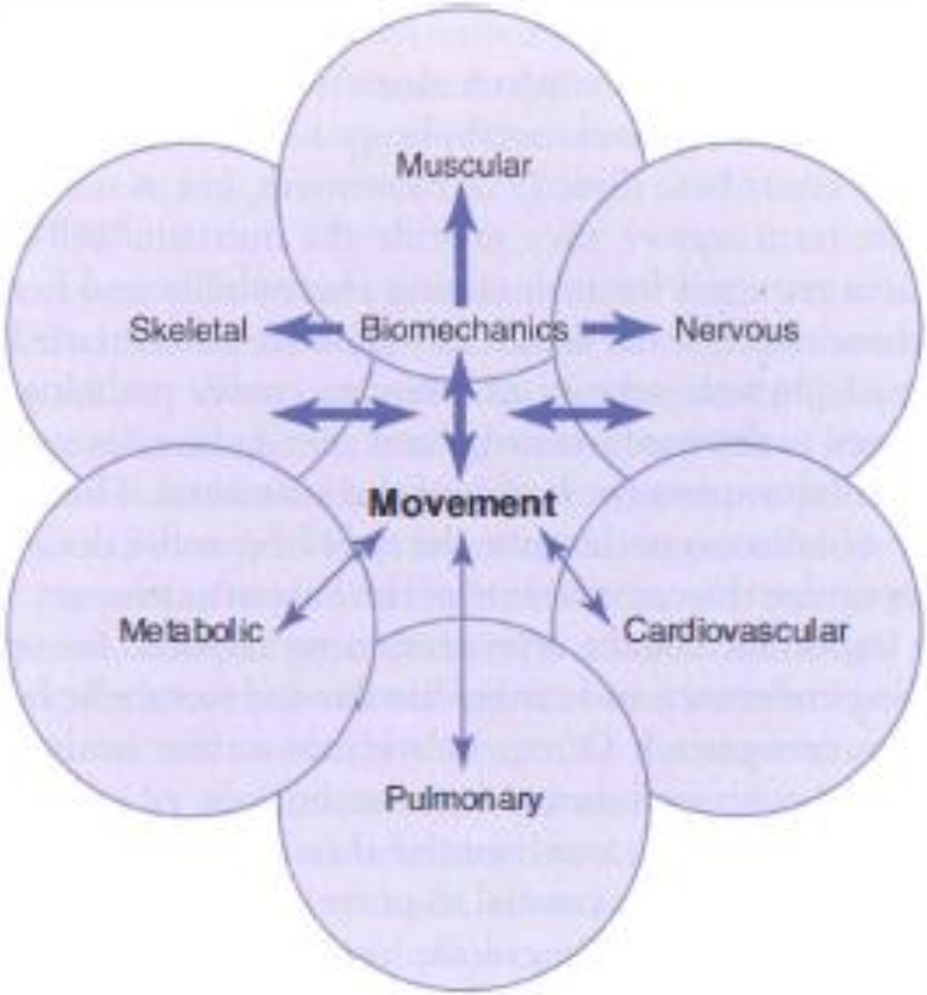

Figure 1-2. Schematic of the physiological systems that comprise the movement system and depiction of biomechanics as an important interface. The relative width of the arrows indicates amount of contribution. The arrows in both directions indicate that not only do these systems produce movement but that they are all also affected by movement.

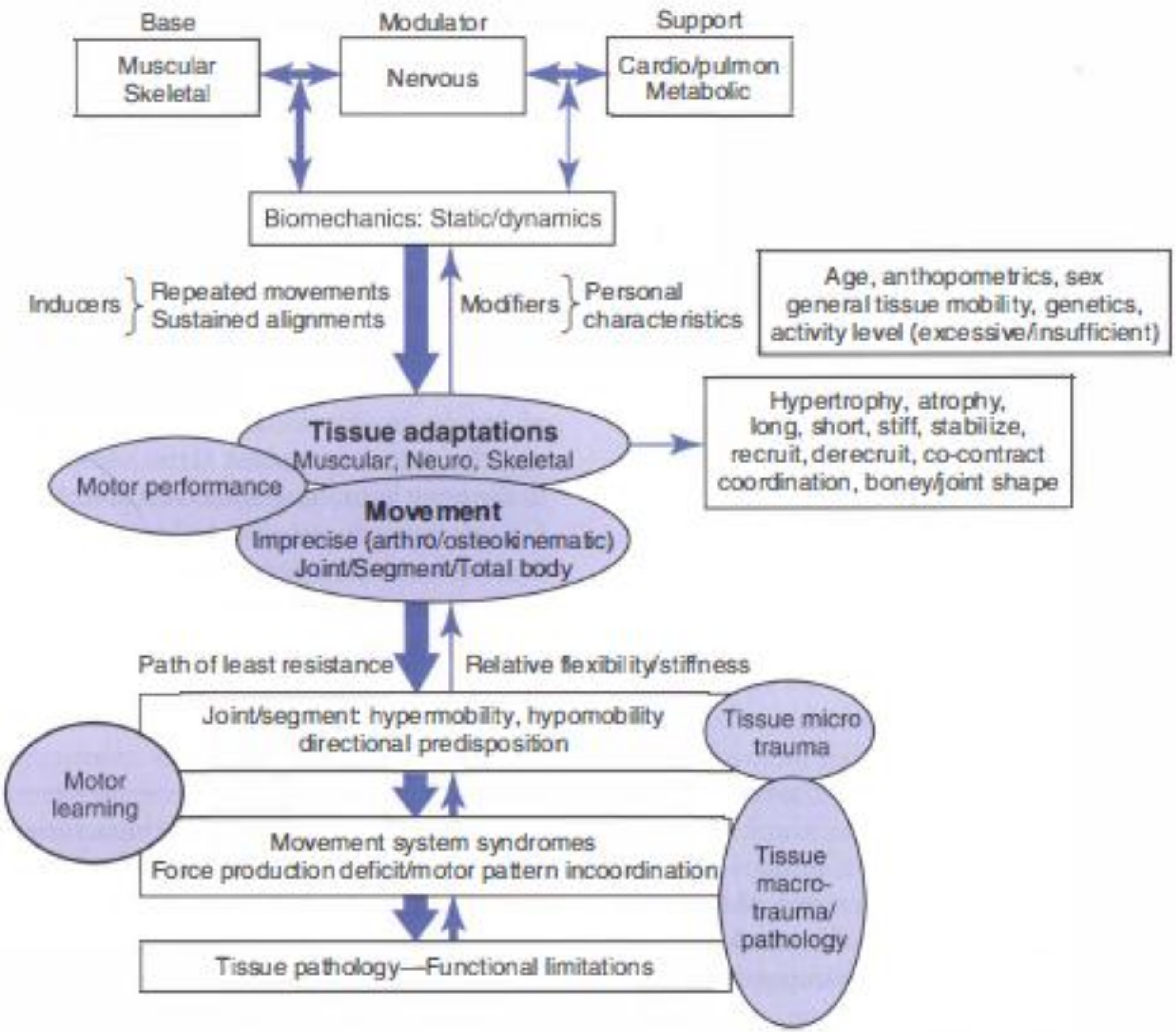

Figure 1-3. The kinesiopathological model of the human movement system depicting factors leading to the development of movement system (MS) syndromes.

Figure 1-4. Forward bending with excessive hip flexion indicates generalized joint hypermobility. The lack of passive tension of the hip extensor muscles contributes to the failure to reverse the lumbar curve during forward bending. Low back pain is alleviated because of the unloading of the spine and the distraction of the trunk in this position. This condition makes maintaining good alignment and movement control difficult.

Figure 1-5. Genu varus and correction. **A,** Postural genu varus of the left knee from hip medial rotation and knee hyperextension. **B,** Correction of knee alignment by contracting hip lateral rotator muscles.

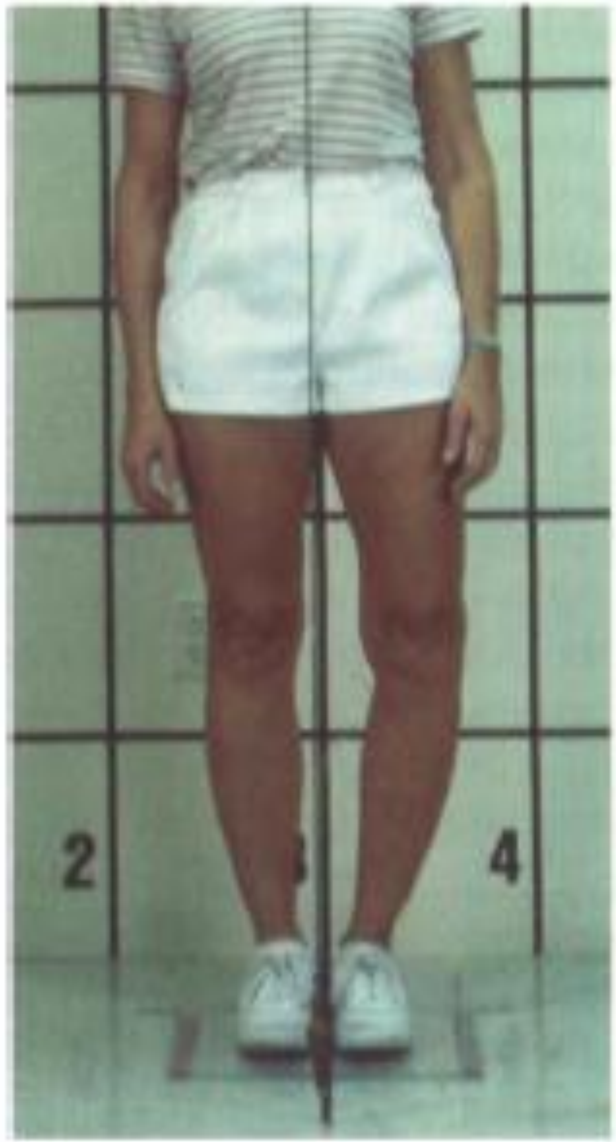

Figure 1-6. Structural genus varus of left knee. This degree of varus and the enlargement of the knee is indicative of degenerative joint disease.

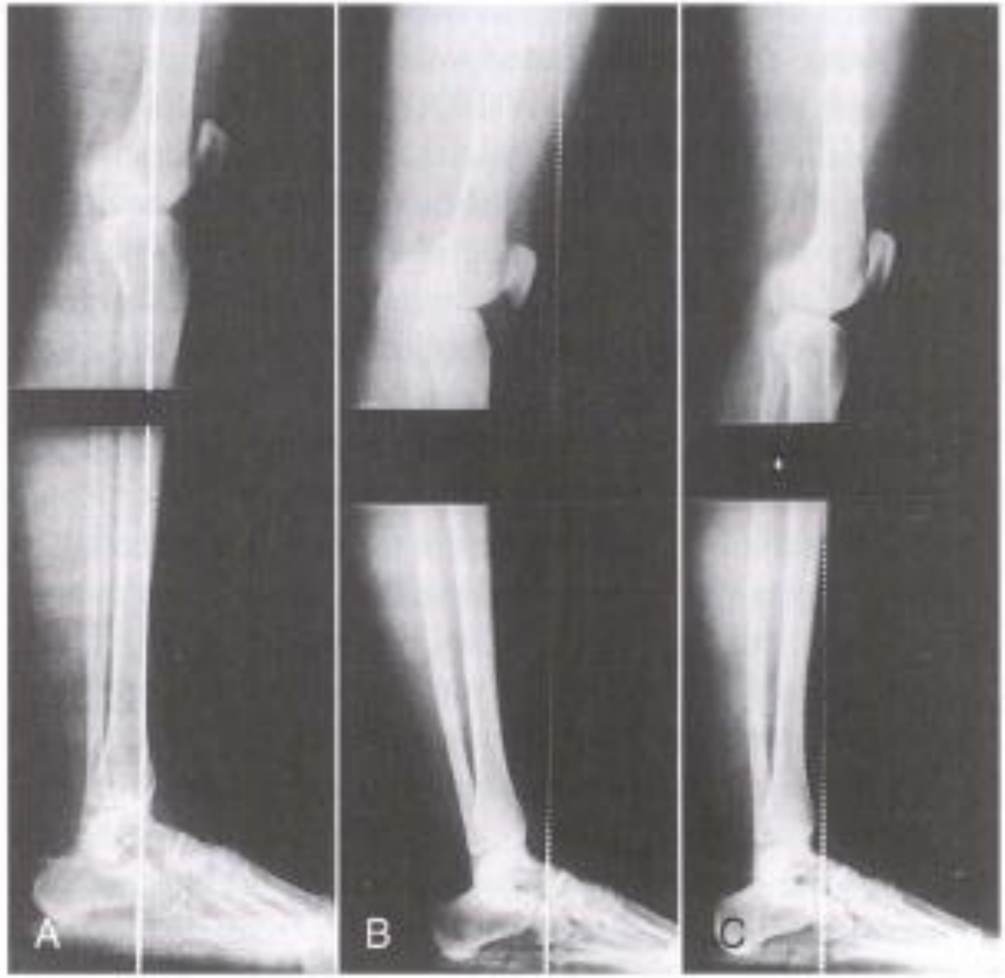

Figure 1-7. **A,** Normally aligned knee. **B,** Hyperextended knee. **C,** Hyperextended knee in the corrected position. The bowing of the tibia and fibula in the knee that has been maintained in hyperextension for years is consistent with the effects on bone expressed in Wolff's law. (From Kendall FP, McCreary EK, Provance PG: *Muscles: testing and function*, ed 4, Philadelphia, 1993, Lippincott Williams & Wilkins.)

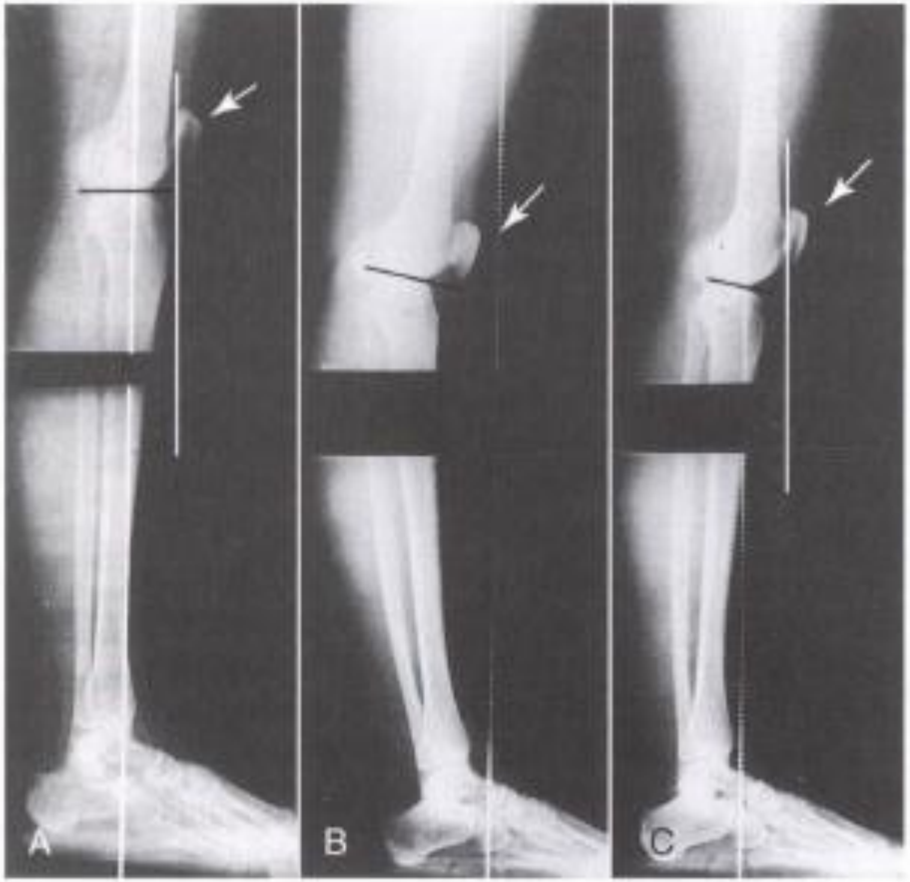

Figure 1-8. **A,** Normally aligned knee. **B,** Hyperextended knee. **C,** Hyperextended knee in the corrected position. In addition to the bowing of the tibia and fibula in the hyperextended knee, a number of other factors could predispose this knee to injury. The articular surface of the tibia is not horizontal, the femur is forward of the tibia, stressing the cruciate ligaments, and the patella sets low, reflecting minimal use of quadriceps. (From Kendall FP, McCreary EK, Provance PG: *Muscles: testing and function*, ed 4, Philadelphia, 1993, Lippincott Williams & Wilkins.)

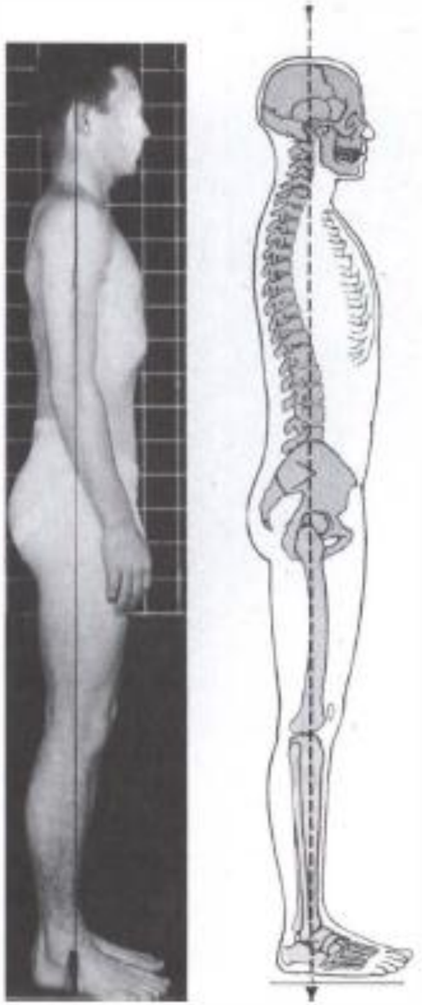

Figure 1-9. Ideal alignment. Optimal distribution of forces on bones and joints and the length and balanced stiffness of muscles and supporting structures. Also, with this type of alignment, when the individual leans forward slightly, the posterior muscles become active. When the individual leans backward, the anterior musculature becomes active. Thus ideal alignment aides the balanced participation of musculature. (From Kendall FP, McCreary EK, Provance PG: *Muscles: testing and function*, ed 4, Philadelphia, 1993, Lippincott Williams & Wilkins.)

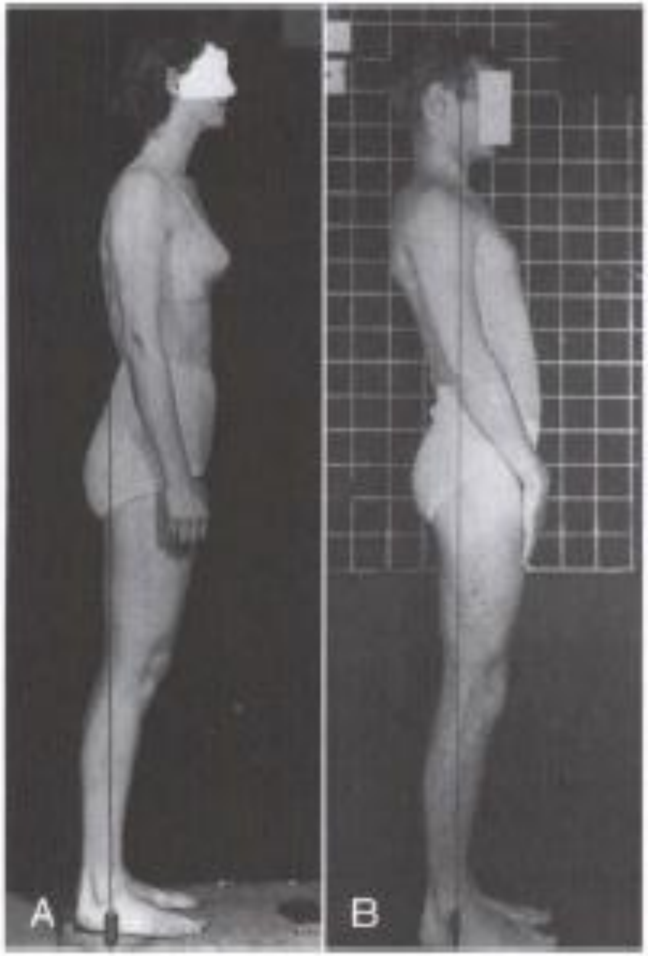

Figure 1-10. Two variations in the relationship of the trunk to the line of gravity. **A**, In the forward-leaning individual with the line of gravity posterior to the trunk, the back extensor muscles are active. **B**, In the backward-leaning individual with the line of gravity anterior to the trunk, the abdominal muscles are active. (From Kendall FP, McCreary EK, Provance PG: *Muscles: testing and function*, ed 4, Philadelphia, 1993, Lippincott Williams & Wilkins.)

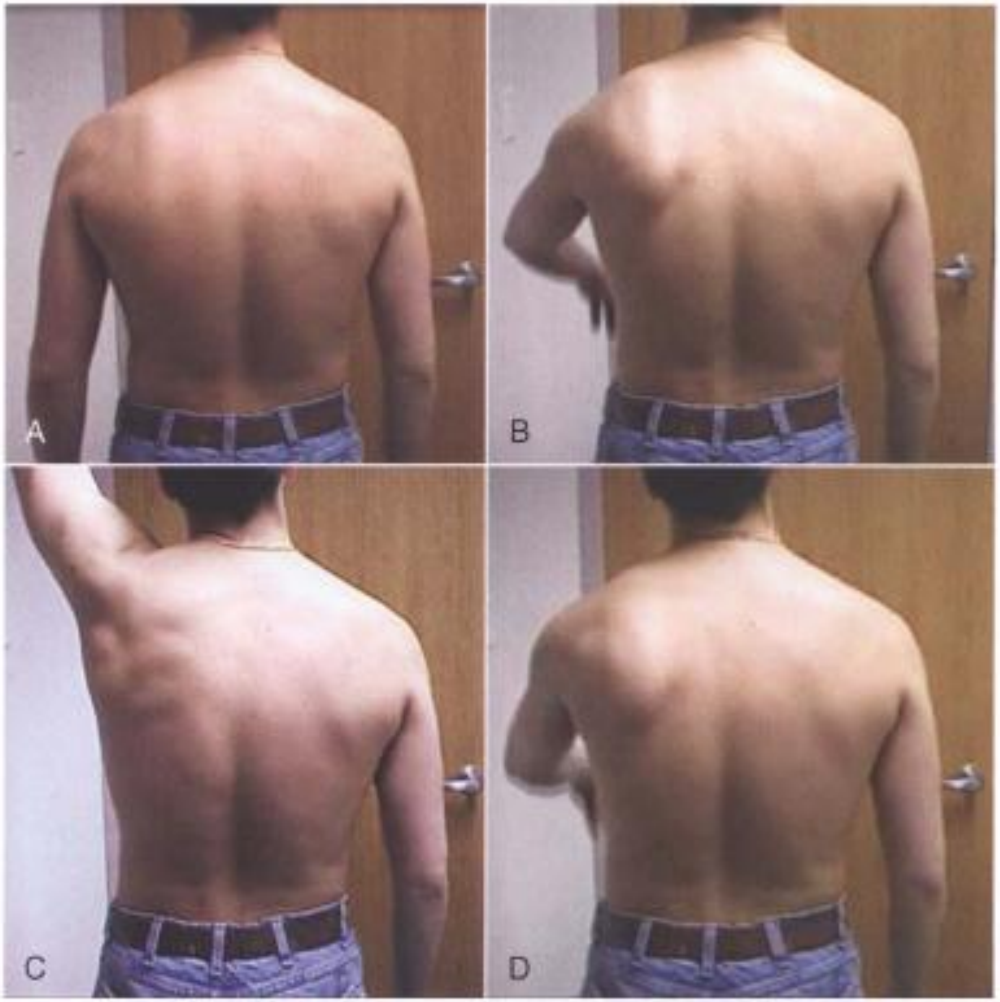

Figure 1-11. A right-handed construction worker with pain for 2 years in the left scapular area. All diagnostic studies were negative. **A,** Abduction, anterior tilt, and internal rotation of the left scapula. **B,** Shoulder flexion causes almost immediate scapular anterior tilt, abduction, and internal rotation, causing the scapula to appear to wing. **C,** The patient has almost full range of motion (ROM) of shoulder flexion without scapular winging, which is inconsistent with severe weakness of the serratus anterior muscle. **D,** During the return from shoulder flexion, the scapula abducts, tilts anteriorly and internally rotates, the same faults evident during flexion.

Figure 1-12. **A,** Two months later, third physical therapy visit. The scapula alignment is still impaired, but the vertebral border is not as prominent and the humerus is not as abducted or internally rotated, suggesting improvement in the scapular alignment. **B,** During shoulder flexion, the scapula no longer tilts anterior or internally rotates, thus not appearing to wing. **C,** Shoulder flexion range of motion is increased. **D,** During the return from shoulder flexion, the scapula is not tilting anteriorly or rotating internally, thus not appearing to wing.

Figure 1-13. Learned movement pattern and correction with instruction. **A,** During sit-to-stand, the patient demonstrates her learned pattern of putting her knees together by hip adduction and internal rotation, as well as using her hands as an additional support. **B,** Able to come to standing while keeping her hips and knees in correct alignment and without support from her hands.

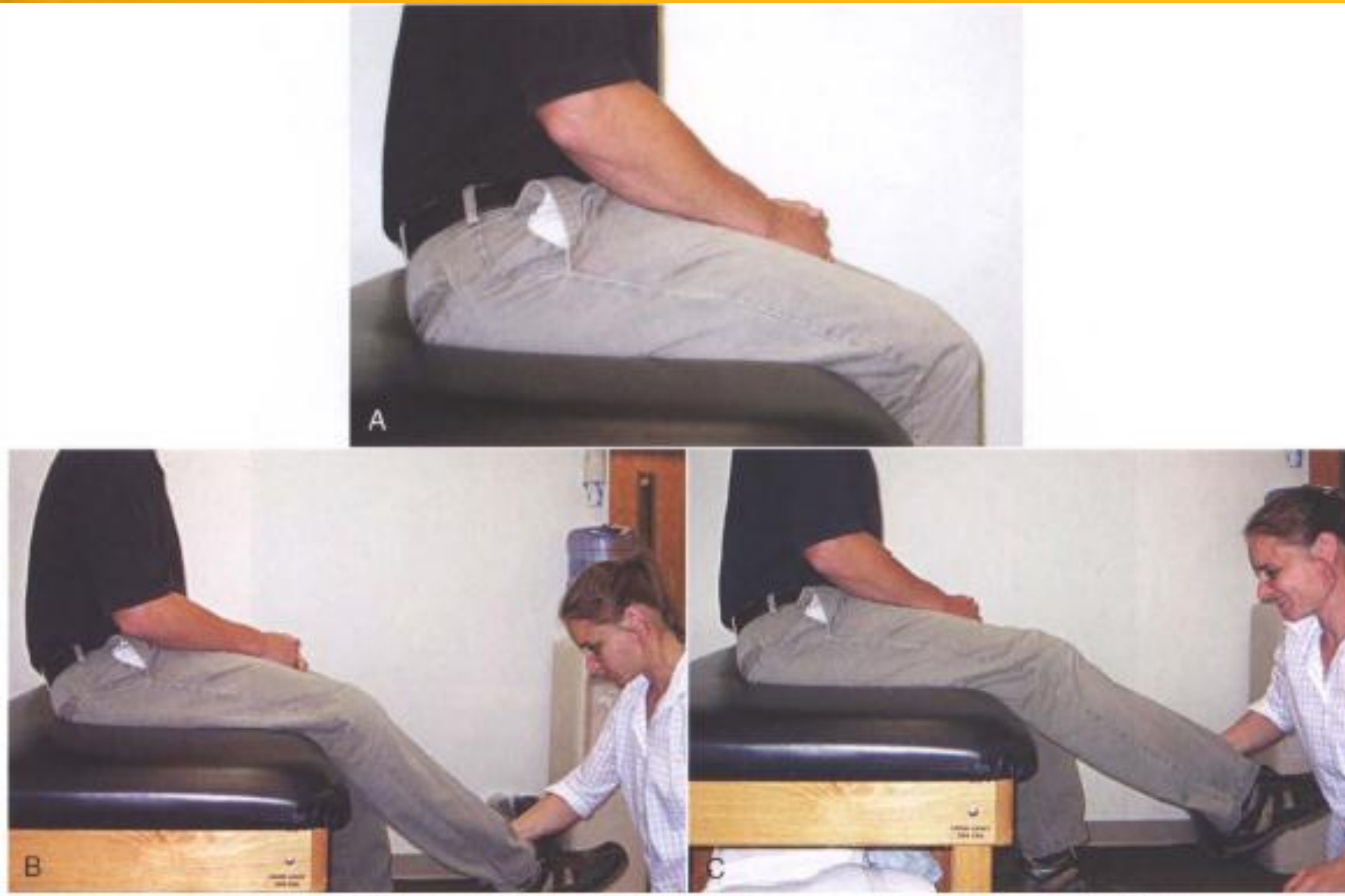

Figure 1-14. **A**, Patient's hip joint angle is almost 90 degrees with his knees flexed. **B**, With passive knee extension to only 45 degrees, his pelvis tilts posteriorly, and his lumbar spine flexes. The position of the pelvis and lumbar spine indicates that the hamstring muscles are stiffer than the supporting tissues of the lumbar spine. The alignment change occurred before the end of the excursion of the hamstring muscles. **C**, When the hip joint angle is maintained at 90 degrees, the knee cannot be fully extended. The hamstring muscles are short.

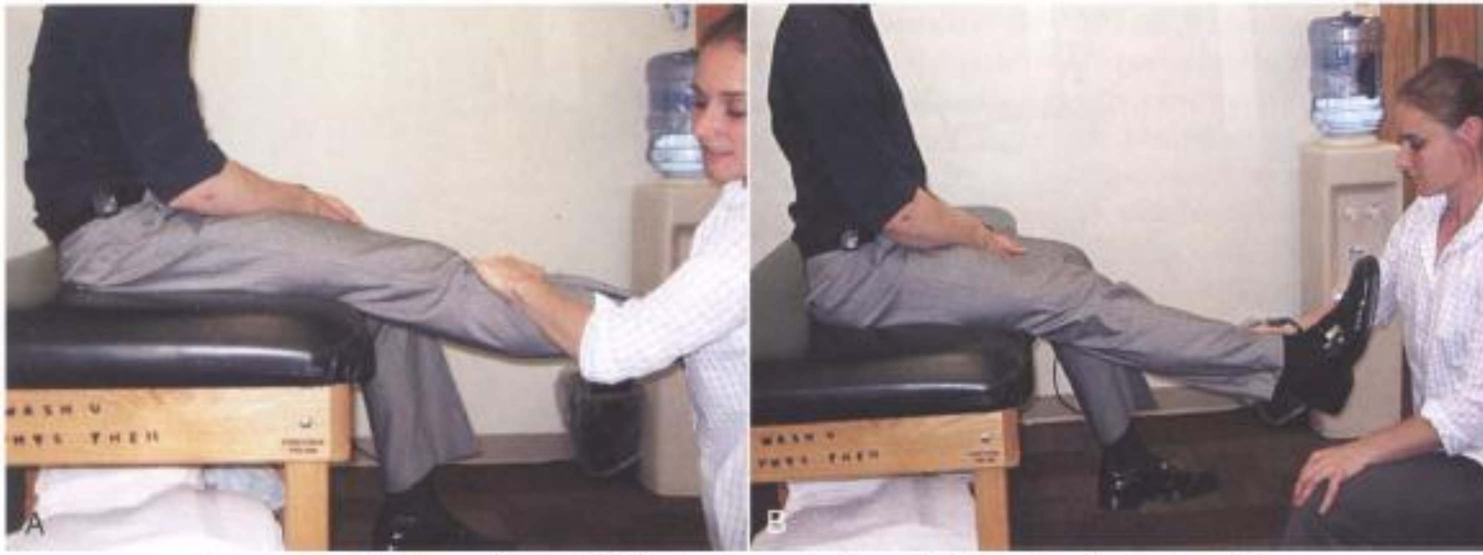

Figure 1-15. **A,** The patient's pelvis is tilted posteriorly, and his lumbar spine is flexed when his knee is passively fully extended. The position of the pelvis and spine can be the result of relative flexibility, which indicates that the hamstrings are stiffer than the supporting tissues of the lumbar spine but not that the hamstring muscles are short. **B,** The patient's hip joint angle is 90 degrees, and no motion of the pelvis or lumbar spine occurs when the knee is fully extended passively. The hamstring muscles would not be considered short.

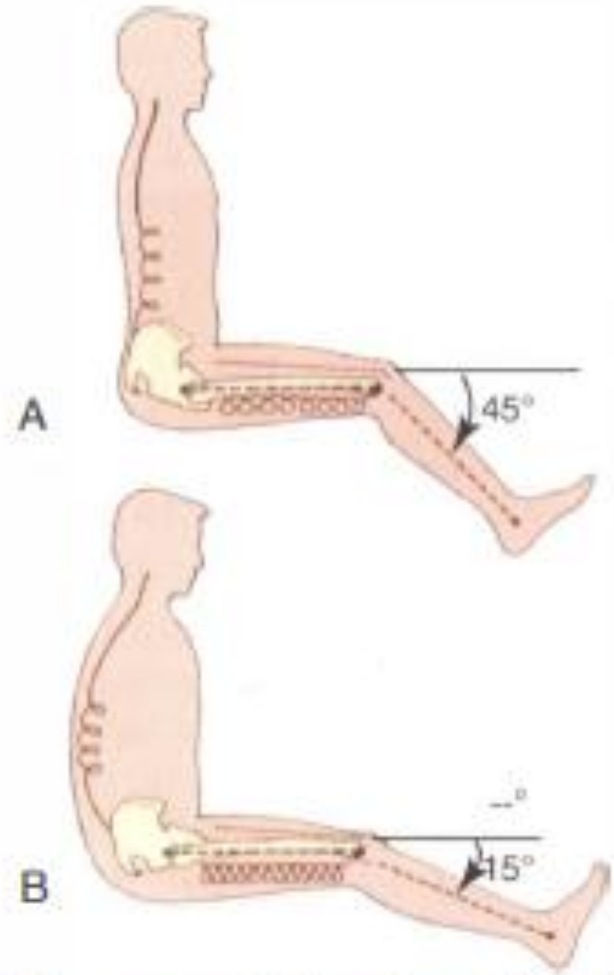

Figure 1-16. Diagrammatic illustration of the effect of relative stiffness of the back extensor muscles and the hamstring muscles. **A**, The back extensor muscles are stiffer than the hamstring muscles, so the knee does not extend. **B**, The back extensor muscles are less stiff than the hamstrings, therefore the pelvis posteriorly tilts and the lumbar spine flexes as the knee extends.

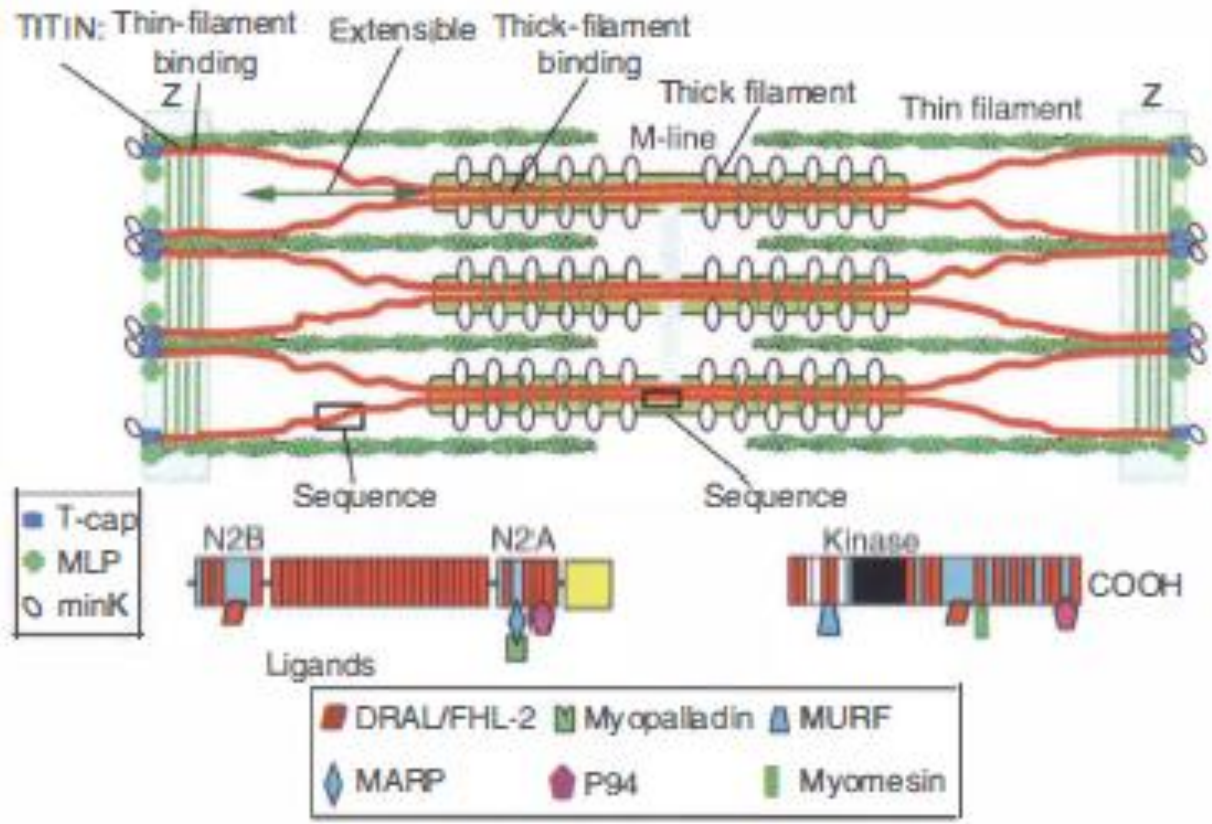

Figure 1-17. Schematic of the sarcomere illustrating the attachments of titin. (From Granzier HL, Labeit S: The giant protein titin: a major player in myocardial mechanics, signaling, and disease, *Circ Res* 94:284-295, 2004.)

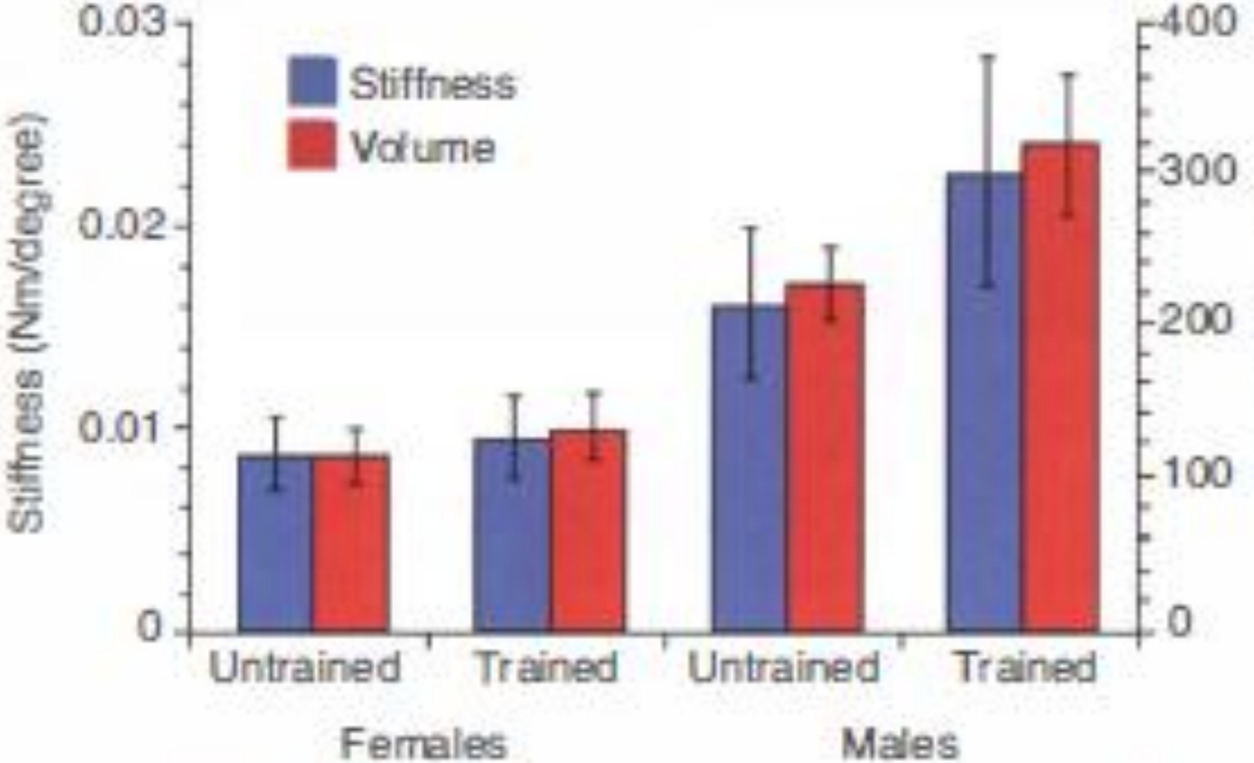

Figure 1-18. Relationship between passive stiffness and muscle volume. There is a high correlation between muscle size and passive stiffness, therefore the greater the hypertrophy of a muscle the greater the resistance to passive elongation. (From Chleboun GS, Howell JN Conatser RR, et al: The relationship between elbow flexor volume and angular stiffness at the elbow, *Clin Biomech* 12(6):383-392, 1997.)

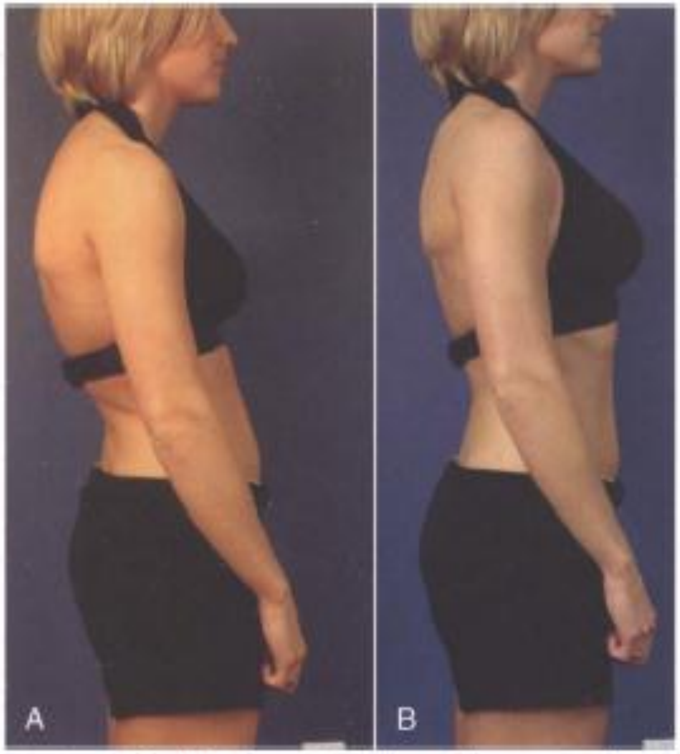

Figure 1-19. Implications of standing alignment and passive stiffness. **A,** Natural standing alignment with minimum energy expenditure. The swayed back trunk with the thoracic kyphosis indicates the thoracic back extensor muscles are not as stiff as the rectus abdominis muscle. The swayback minimizes the activity of the lumbar back extensor muscles, thereby not contributing to anterior tilt of the pelvis that is associated with action of these muscles. The anterior pelvic tilt indicates that the hip flexors are stiffer than the abdominal muscles that do not generate counter-balancing passive tension at the correct length to maintain ideal pelvic alignment. **B,** Active contraction of thoracic back extensor muscles improves her thoracic alignment. The emphasis of her treatment program is to improve the participation of the external oblique abdominal muscle more than the rectus abdominis to achieve correct pelvic tilt without increasing the thoracic kyphosis. The permanent correction requires enough change in the *passive tension and length* of the abdominal and thoracic back extensor muscles to "hold" the correct alignment *passively* and not actively.

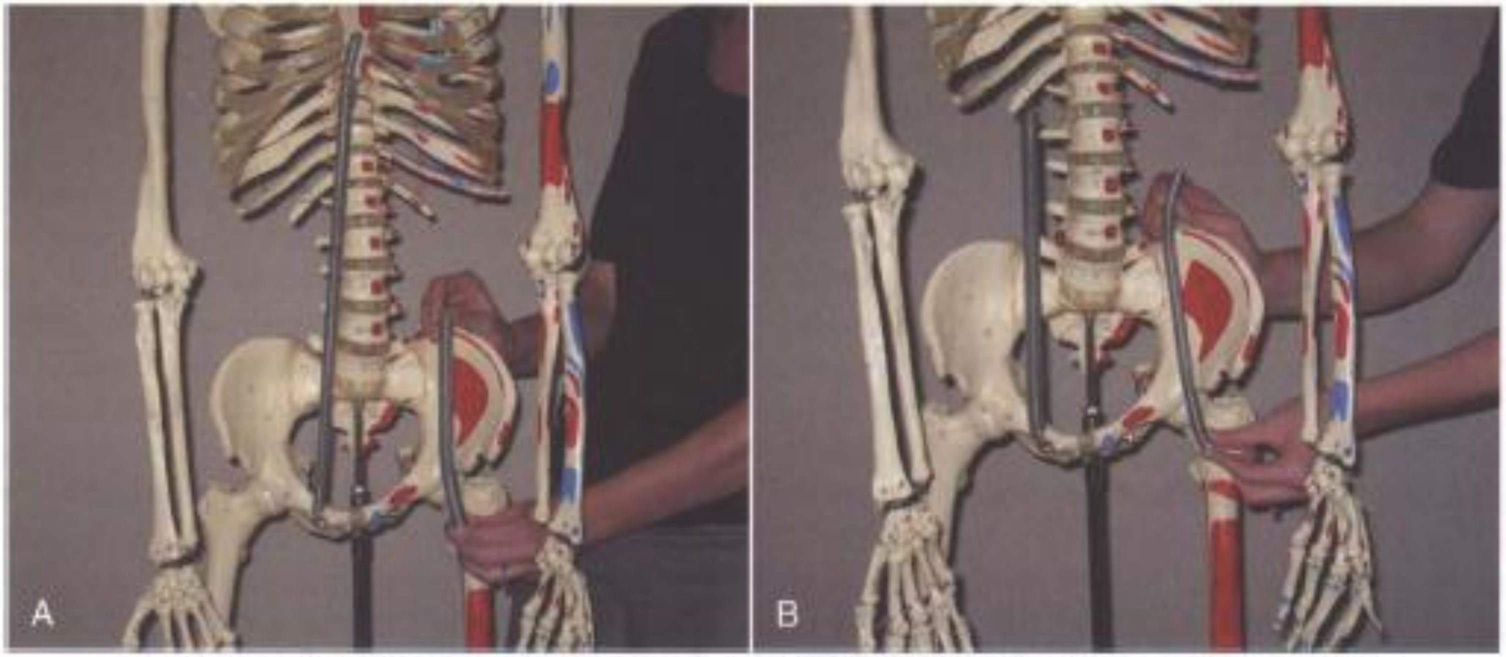

Figure 1-20. Springs depicting the passive tension of the abdominal and hip flexor muscles. The passive tension (stiffness) of muscles exerts an almost constant pull on its attachments. **A**, When the least stiff spring is the abdominal muscles, the stiffer spring of the hip flexors will pull the pelvis into an anterior pelvic tilt. **B**, When abdominal muscles are stiffer than the hip flexor muscles, the pelvis will be maintained in the correct alignment.

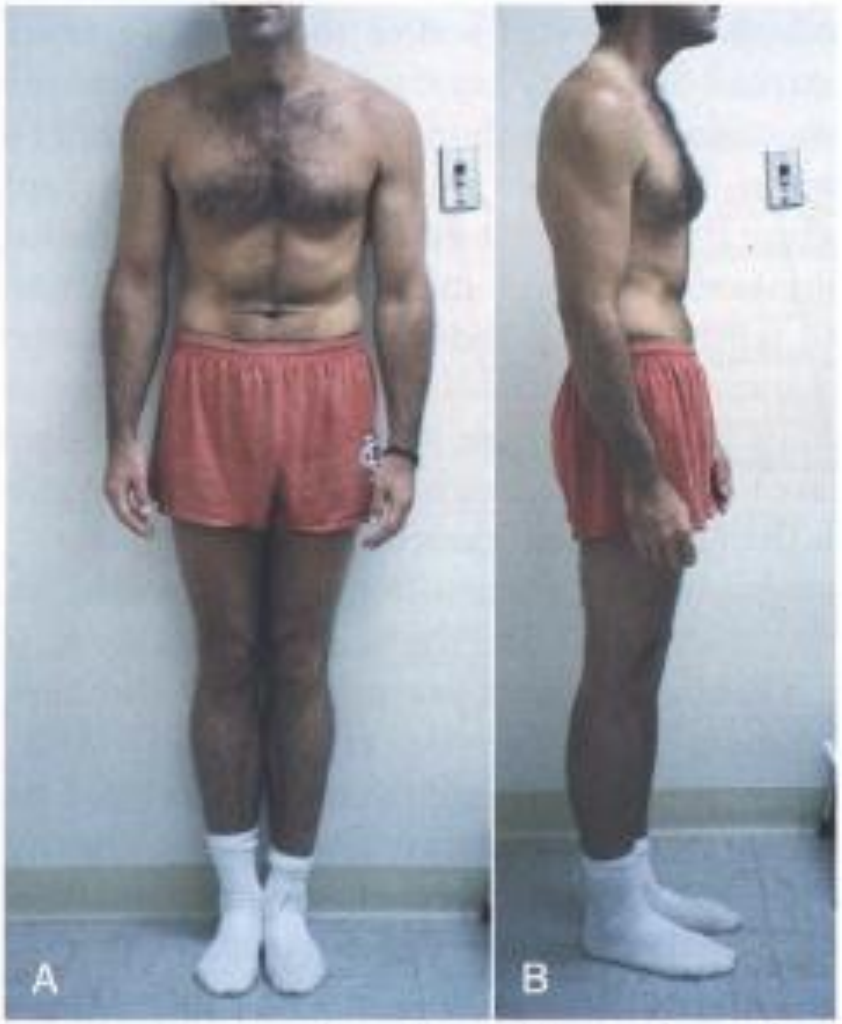

Figure 1-21. Hypertrophy of the abdominal muscles maintained by being the antigravity muscles of the trunk. **A**, Anterior view indicating the muscle definition of the abdominal muscles. **B**, The side view demonstrating that the head and shoulders are swayed back so that the line of gravity is anterior to the trunk. The patient also worked with his arms in front of him causing even more posterior sway of the trunk.

Figure 1-22. Thoracic kyphosis associated with excessive length of the thoracic paraspinal muscles and with laxity of the abdominal muscles.

Figure 1-23. Prominence of abdomen consistent with diminished abdominal muscle stiffness and a diastasis of the linea alba above the umbilicus. Contraction of abdominal muscles with this condition will have a minimal effect on the alignment of the pelvis and rib cage.

Figure 1-24. The modified quadruped position can be used to decrease the thoracic kyphosis and help elongate the trunk. The patient is instructed to allow the upper back to relax, letting the chest drop toward the table. The patient can then rock backward, which provides a slight stretch of the trunk.

Figure 1-25. **A,** Patient sitting slumped with a thoracic kyphosis. **B,** Pushing up in the chair to elongate the trunk. She is not lifting her buttocks off of the chair, but she is just elongating the trunk by pushing into the seat of the chair and locking her elbows. The patient then tries to contract all of her trunk muscles to maintain the trunk alignment, and then she lifts her hands off the seat of the chair. **C,** Side view of the trunk elongation exercise.

Figure 1-26. Stiffness of the scaleni muscles limiting rotation of head and cervical spine. Patient with severe headaches and neck pain with short and stiff abdominal muscles. **A**, Maximum head and neck rotation. **B**, Increased rotation of head and neck when arms are supported and the rib cage is passively elevated.

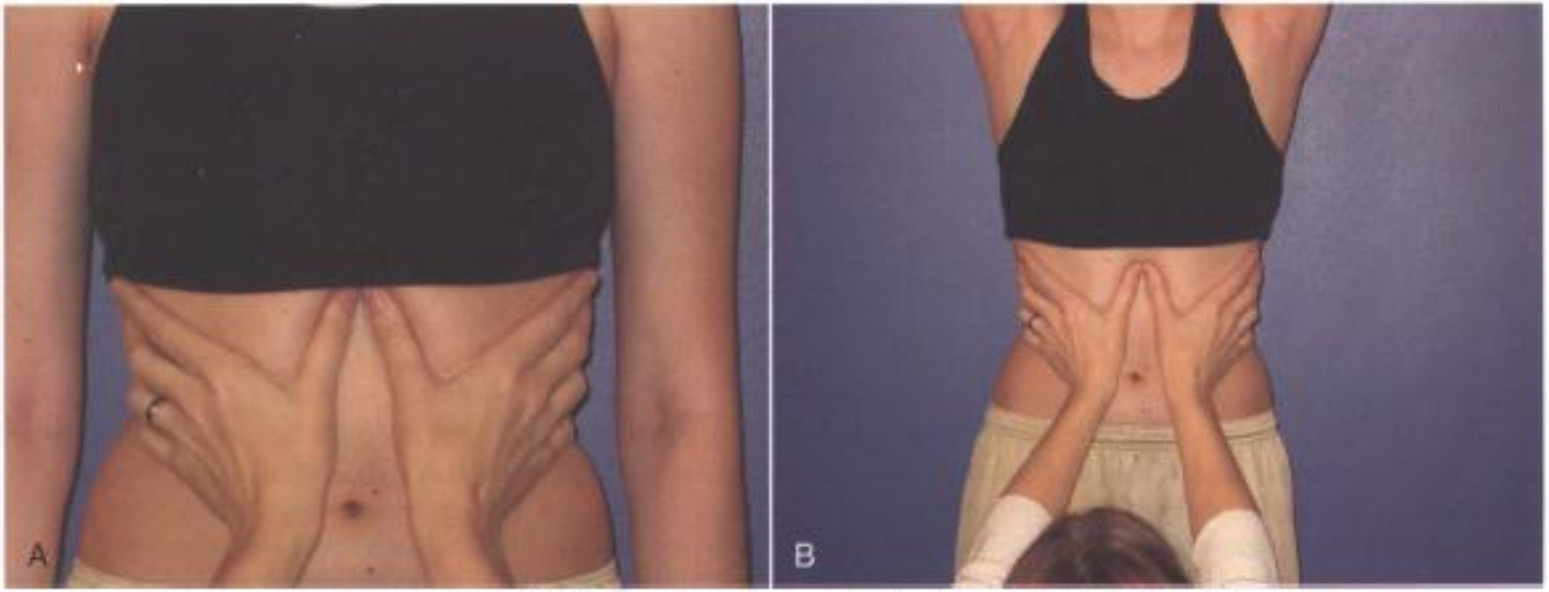

Figure 1-27. Assessing the infrasternal angle as an indication of abdominal muscle resting length. **A**, Narrow infrasternal angle associated with stiffness and/or shortness of the external oblique abdominal muscles. **B**, If the external oblique abdominal muscles are short, the change in diameter of the rib cage during maximum inhalation is less than 2 inches.

TABLE 1-1

Muscle Belly Length, Sarcomere Number, and Sarcomere Length Measurements of Young and Adult Muscles Immobilized in the Lengthened and Shortened Positions*

	Muscle Belly Length (mm)		Sarcomere Number		Sarcomere Length (μm)	
	Experimental	Control	Experimental	Control	Experimental	Control
ADULT						
Lengthened	[10·6 ± 0·16	10·8 ± 0·24]	2560 ± 36	2215 ± 14	2·43 ± 0·049	3·13 ± 0·021
Shortened	[6·3 ± 0·12	6·1 ± 0·17]	1824 ± 28	2283 ± 18	2·08 ± 0·050	1·41 ± 0·018
YOUNG						
Lengthened	5·3 ± 0·25	7·0 ± 0·15	1281 ± 31	1739 ± 24	2·64 ± 0·124	3·10 ± 0·093
Shortened	4·3 ± 0·17	5·7 ± 0·16	1005 ± 19	1826 ± 20	2·40 ± 0·072	1·62 ± 0·081

*In each case, muscles from five animals were used. Data in brackets are not significantly different from each other ($P > 0.1$).

(From Williams PE, Goldspink G: Changes in sarcomere length and physiological properties in mobilized muscles, *J Anat* 127:458-459, 1978.)

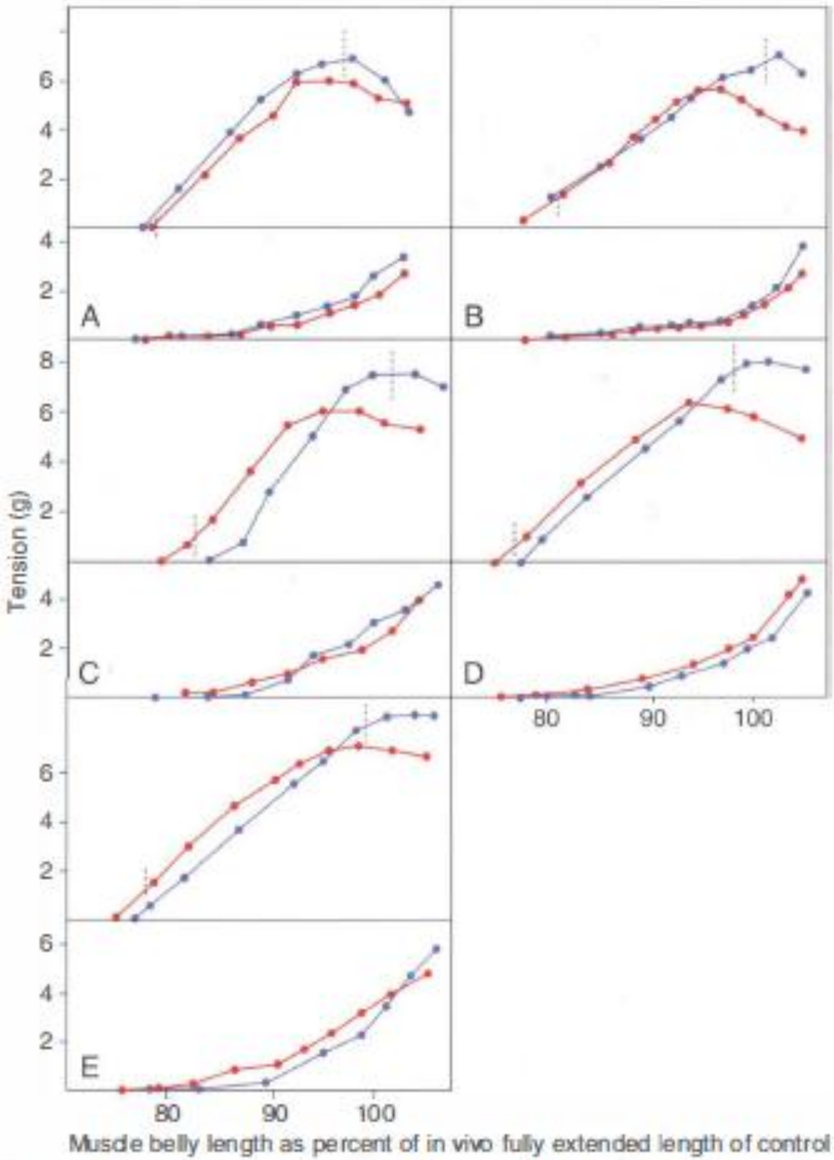

Figure 1-28. Active and passive length-tension curves of mice muscles that have been immobilized in a lengthened position for 3 weeks and compared to control muscles. Note the curves of the lengthened muscles are shifted to the right. *Red line*, Control muscle; *blue line*, experimental-lengthened muscle. (From Williams PE, Goldspink G: Changes in sarcomere length and physiological properties in immobilized muscles, *J Anat* 127:459-468, 1978.)

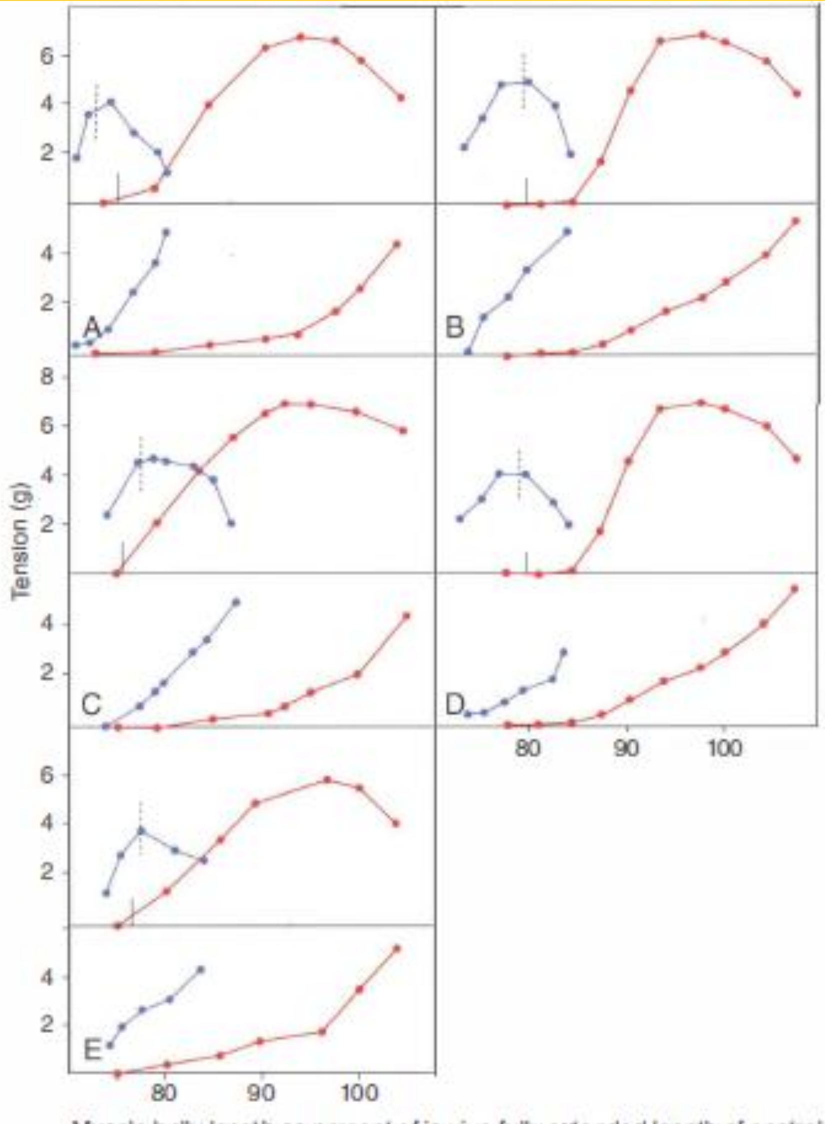

Figure 1-29. Active and passive length-tension curves of mice muscles that have been immobilized in a shortened position for 3 weeks and compared to control muscles. Note the curve of the shortened muscle is shifted to the left. *Red line*, Control muscle; *blue line*, experimental-shortened muscle. (From Williams PE, Goldspink G: Changes in sarcomere length and physiological properties in immobilized muscles, *J Anat* 127:459-468, 1978.)

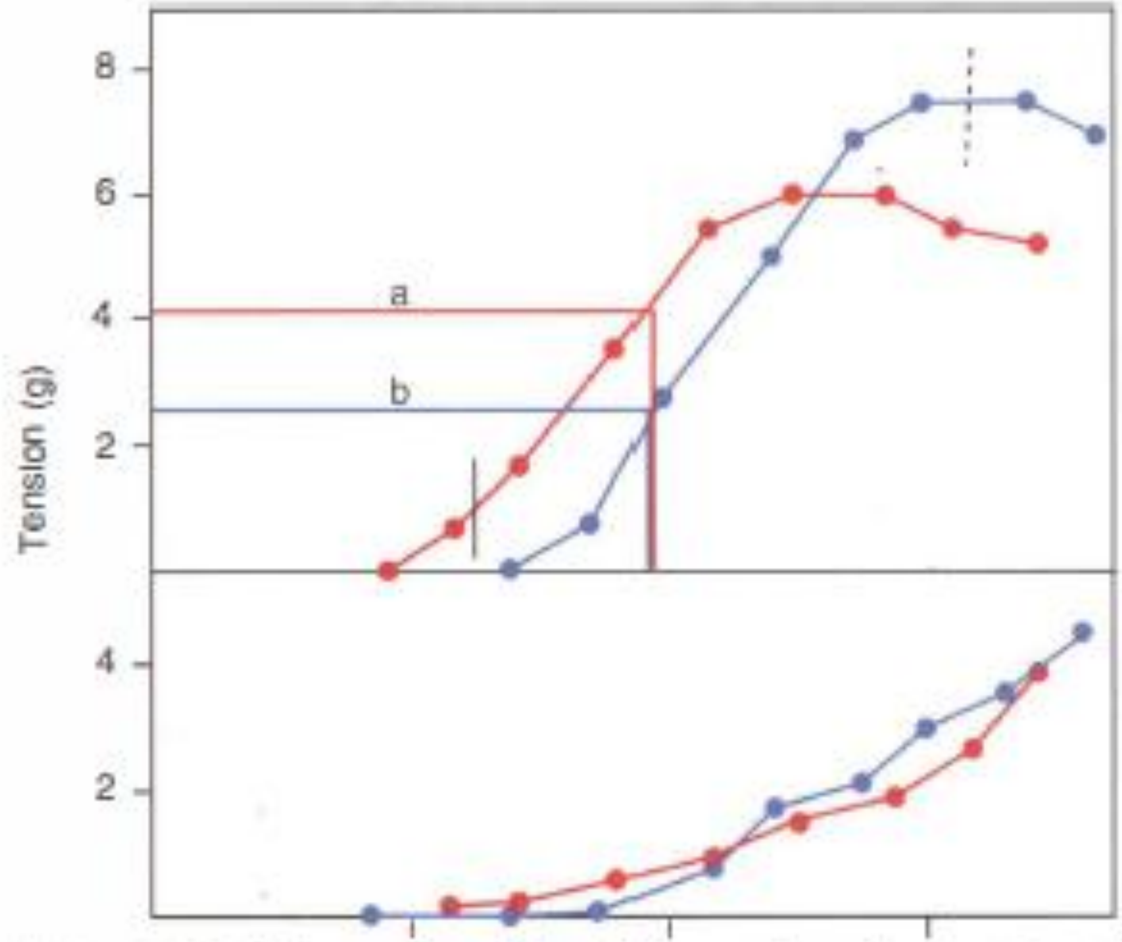

Figure 1-30. Illustration of the effect on the active tension of lengthened muscle. If the control muscle and the lengthened muscle are tested in the same position *(line a)*, the tension is less for the lengthened muscle than for the control *(line b)*. (Data adapted from Williams PE, Goldspink G: Changes in sarcomere length and physiological properties in immobilized muscles, *J Anat* 127:459-468, 1978.)

Figure 1-31. Swayback posture with line of gravity posterior to hip joint, decreasing the hip extensor moment. Associated with poor definition of the gluteal muscles.

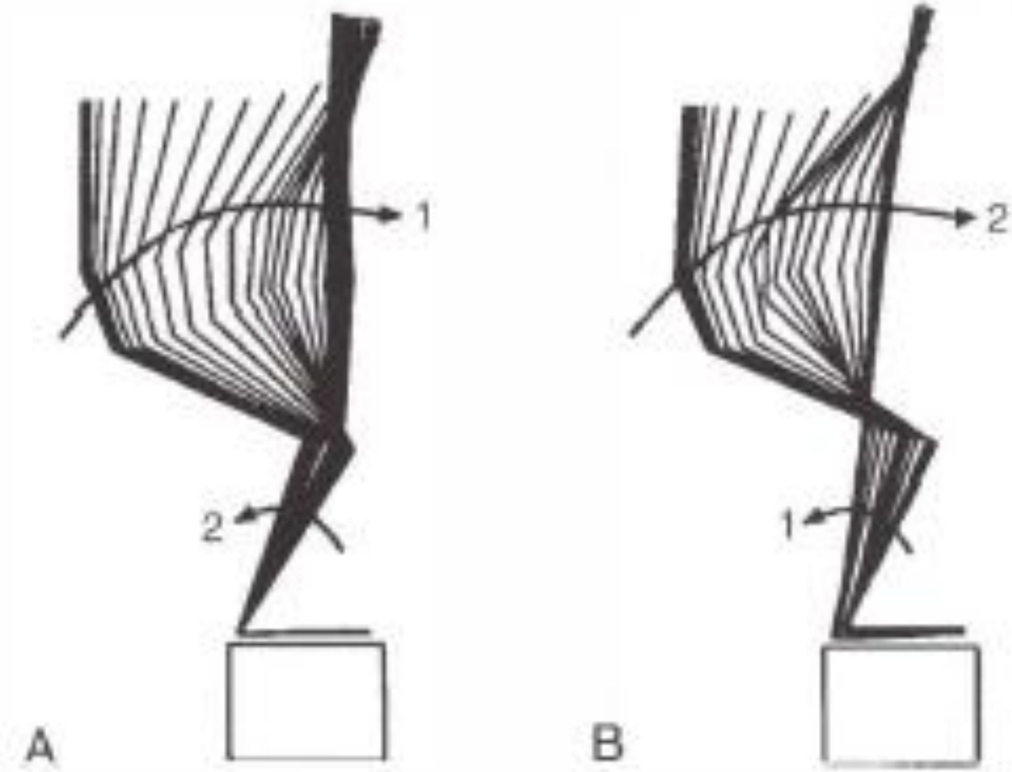

Figure 1-32. Motion analysis display of two strategies controlling the knee motion during stepping up on a footstool. **A,** Strategy in which the body is moved toward the knee that emphasizes control by the knee extensor muscles. **B,** Strategy in which the knee is pulled toward the body that emphasizes control by the hip extensor muscles. (From Sahrmann SA: *Diagnosis and treatment of movement impairment syndromes,* St Louis, 2002, Mosby; courtesy Amy Bastian, PhD, PT.)


The End