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Dynamic Stabilization of the Trunk

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The lumbopelvic region, because it is the hub of our antigravity weightbearing, is the most vulnerable area for spraining and straining tissues. It is also, however, the most difficult area to treat because of our inability to completely control the healing of these injured tissues. Properly identifying and accurately assessing the biomechanics of injury and understanding the basic science of the processes of soft tissue healing are critical in order to initiate proper goal-oriented treatment geared toward regaining normal function of the injured area. If normal function is not restored, frequent reinjury and chronic symptoms often occur. Because of the background and the knowledge in anatomy, biomechanics, and kinesiology the physical therapist is the most qualified to begin a program geared toward properly managing this region. Unfortunately, too often it is a decrease in overall fitness as well as asymmetrical skeletal forces that predispose the lumbopelvic region to injury. That is, it is almost as if these people are "accidents waiting to happen." Attempting to undo that which has been progressing for years is a difficult problem for those who treat lumbopelvic pain. This paper sets forth one rational approach for effectively stabilizing and treating these conditions.

Every human being who walks upright and lives past the age of 20 engages in a continuing battle against the forces of gravity in which the physiological condition of the musculoskeletal system is crucial. The responsibilities that come with maturity are usually nonphysical in nature, and unless they fight the tendency, most individuals lead increasingly sedentary lives. People who sit for most of the day often develop a round-shouldered posture with accompanying fatigue and lack of endurance of the scapular and spinal musculature. Adaptive shortening occurs in the anterior shoulder, and physical changes occur that move the antigravity weightline (a postural line that demonstrates the manner in which any given skeleton is responding to gravity) forward and produce a counteracting force of backward bending, simultaneously increasing lumbar lordosis. This posture not only forces the apophyseal joints into an end range of extension, but also renders them vulnerable to injury because of their unaccustomed new job of supporting the body weight.[1]

Similar progressions occur in the condition of the individual who steadily gains weight in the third, fourth, and subsequent decades of life.[18, 19] The force of increasing body weight can combine with the inferior migration of the anterior aspect of the pelvis to move the weightline forward. This movement forces the individual to adopt a backward bending position, abnormally stressing low back tissues. The person who experiences this progression is likely to wind up being unable to maintain any type of prolonged activity against gravity and to be especially vulnerable to increasingly sedentary lifestyles and soft tissue injury. This article is written in the hope of helping to assure that the therapist who confronts such patients has a comprehensive knowledge of specific anatomical and functional aspects of the musculoskeletal system that are crucial to maintain erect posture and in winning the battle against gravitational force. This understanding provides a rational basis not only for treating the immediate problem but also for helping the afflicted patient decrease the likelihood of reinjury.

The person with a skeleton made asymmetrical by structural or functional leg length differences faces a problem compounded because of the manner in which the gravitational forces alter from normal.[6] If a middle-aged person has a short right leg, for example, and has gained 20 pounds over the last years, the abdominal wall may be relatively weak and the left apophyseal joint vulnerable to

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excessive force. The biomechanics of this antigravity situation involves a tilting of the pelvis and sacral base to the right (Fig. 1), accompanied by side bending and associated rotation of the lumbar spine in the opposite direction (Fryette's law).[16] Consequently, the force in the left L5–S1 apophyseal joint are those of extension and compression, while those forces in the right apophyseal joint are in the opposite, or flexion and distraction. When the stabilizing musculature in the asymmetrical skeleton loses endurance, often after prolonged postures of sitting and standing, the body position changes and the focal point of abnormal biomechanics is on the tissues of this region, especially that of the left L5–S1 apophyseal joint and the more vertical left sacroiliac joint. Under these circumstances, abnormal forces can exceed the supporting capabilities of the area, resulting in tissue destruction which causes remodeling to begin.

The body responds, or remodels itself, in different ways proportional to the repeated stresses placed upon it. For example, the left ventricle of the heart of a long distance runner gradually develops a greater internal diameter than usual and hence, increases cardiac ouput. By contrast, the heart of a weightlifter eventually develops an exceptionally thick myocardium to overcome the peripheral resistance of maximal muscle contraction.[7,15] In essence, Wolfe's law which pertains to stress-induced changes to bone actually applies

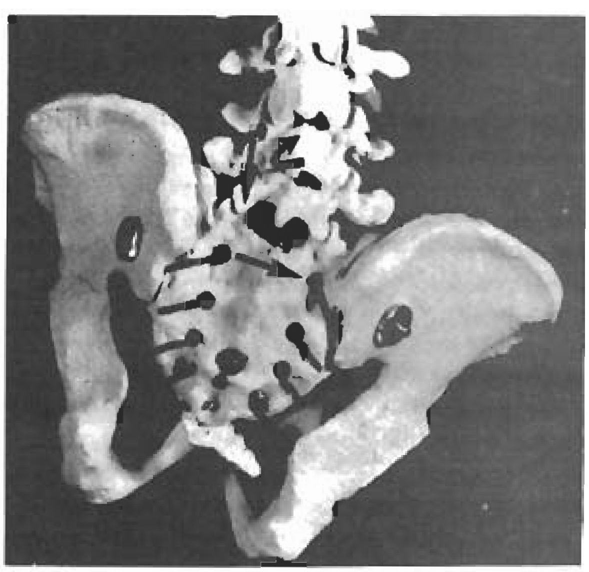

Fig. 1. *The adaptive changes that accompany a structural or functional short right leg. The arrows represent a description of Fryette's law, i.e., side bending and rotation occur opposite in the erect lumbar spine.*

to most tissues of our bodies.[20,22] The spine also responds to consistent stresses placed upon it. For example, the body of the vertebra responds to asymmetrical stresses of a short leg by building more bone on the side of the long leg.[8] This building of cortical bone and the realignment of trabecula is proportional to the compressive forces exerted as the lumbar spine side bends away from the short leg. For instance, a right short leg causes left lumbar side bending. This compensation causes the vertebra to bear weight on the left side of the vertebra rather than centrally (Fig. 1). And according to Wolfe's law, osteoclastic activity is enhanced; that is, the body of the vertebra responds by remodeling itself to adapt to these forces placed upon it.

Inactivity, weight gain, skeletal asymmetry, and factors such as traumatic injury and the inexorable process of aging by itself,[14,18,19] all contribute to the success or failure of the battle against gravity. In any of these cases, forcing soft tissue such as ligaments and joint capsules to bear abnormally heavy weight loads can increase demands on their supporting capabilities and cause both mechanical and chemical deformation. The deformation stimulates the nociceptive receptor system[24] and eventually symptoms begin. Very often, the symptoms culminate in excruciating low back pain and immediate demand for professional help.

As human posture evolved, the center of gravity in the skeleton moved, eventually settling in the area of the anterior aspect of the second sacral vertebra. The lumbopelvic region, which includes the L4–L5 vertebral bodies, the pelvis, and the hips, became the hub of weightbearing. Here, the weight of the head, neck, arms, and trunk collectively known as the trunk forces (P), meet the forces transmitted from the ground through the lower extremity. The latter can be termed the ground forces (R) (Fig. 2). This area is the hub of all the body movement, and although efficient movement depends upon this area being very stable, no part of the body is more vulnerable to tissue sprains and strains or to the changes brought on by aging, i.e., decreased muscular strength and shifts of body alignment resulting in antigravity postures.

The musculoskeletal system is designed to provide the erect body with symmetrical support to counteract forces of gravity. The muscles which keep the body upright can be divided by function into prime movers and segmental stabilizers. Stabilizing the skeleton requires that the normal

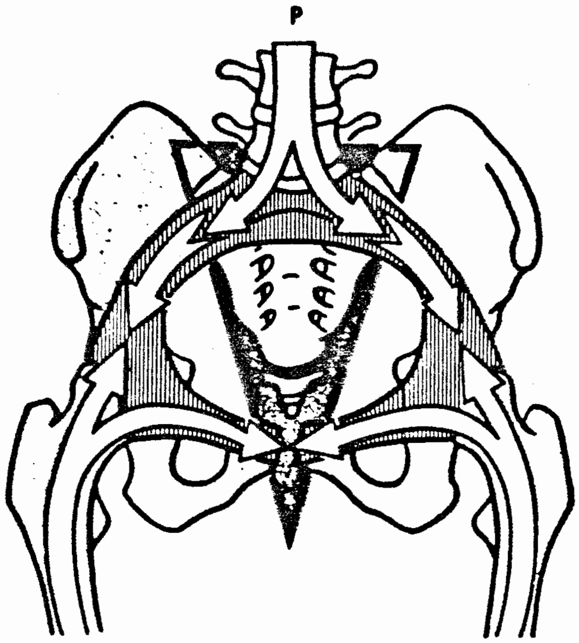

Fig. 2. *The description of how the forces of the trunk (P) meet the forces from the ground (R) at the hub of weightbearing, i.e., the lumbopelvic region. (From Kapandji: The Physiology of the Joints, Vol 3, ©Churchill Livingstone.)*

strength of this stabilizing musculature be maintained. Three specific muscle groups are important to maintaining the stability of an anatomically correct weightline. These include the abdominal wall, the erector spinae (including the intersegmental spinal musculature), and the gluteus maximus muscles. At normal length and strength, these three groups of muscles act together to transfer both trunk forces and ground forces to tissues which have evolved to serve this purpose: the vertebral body, the intervertebral disc, and the abdominal viscera.

In addition to these groups of essential muscles, another element important to maintaining the stable weightline is the lumbodorsal fascia.[10] The lumbodorsal fascia, or aponeurosis, is a very thick, broad tissue which covers the lumbopelvic region.[2] It envelopes the erector spinae muscle group and has attachments to the spinous processes and transverse processes of the lumbar vertebrae (Fig. 3)[11] and the latissimus dorsi from above, the gluteus maximus from below (Fig. 4), and the transverse and internal oblique muscles from the abdominal wall in front (Fig. 5).

As muscles strengthen, the biochemistry of the contractile unit changes proportional to the way it is being stressed. Submaximal prolonged activities that stress the aerobic energy pathways reveal changes in muscle which include increased myoglobin content, increased numbers of mitochondria, and increased aerobic enzymes.[5,9,12,17] Conversely, weight training in the form of repetitive maximum lifting, or anaerobic training, stimulates changes in anaerobic enzymes such as phosphofructokinase and myokinase,[5,7,13,21] and increases force production capabilities. Both types of training make the muscle more efficient in performing work demanded of it. Weight training, however, also increases muscular "tone." Although the concept of tone remains to be fully explained, it is generally agreed that when tone exists, an increased tension remains within the muscle when it rests, placing greater than usual tension forces on its attachments. Physical therapists can use the concept of tone in an effort to dynamically stabilize areas of the body such as the low back. Strengthening increases the tone of these muscles and tissues foster increased stability of the low back, helping to assure proper weightbearing, assisting in diminishing excessive forces from injured tissues, and reducing the chances of further injury.

TREATMENT

Too often the treatment of back pain is aimed at alleviating the symptom without regard to underlying causes. A disregard for overall function increases the likelihood of reinjury. It is imperative that the clinician have a solid understanding of the function of the fibroblast as it heals and remodels injured tissue. It is known that sprain and/or strain to the connective tissue, tendons, ligaments and fascia set into action a process of healing that is designed to stabilize, or heal together, the torn tissue. Normal movement or function of that tissue is often compromised during this process. The decrease in the normal function renders the area vulnerable to reinjury, which must be the focus of the clinician. It is not imperative that the exact tissue be recognized, but rather what abnormal, often asymmetrical force is reaching that tissue, therefore altering its normal functional healing process. Inactivity leads to regional inflexibility. It is not uncommon to uncover in the patient's history many episodes of exacerbation of the same symptom, the only differences being in intensity, frequency, and duration of symptom. The intent of treatment must be to assure proper healing of the wound while maintaining function of the surrounding tissue.[23] This can be accomplished by controlling the healing of injured tissue,

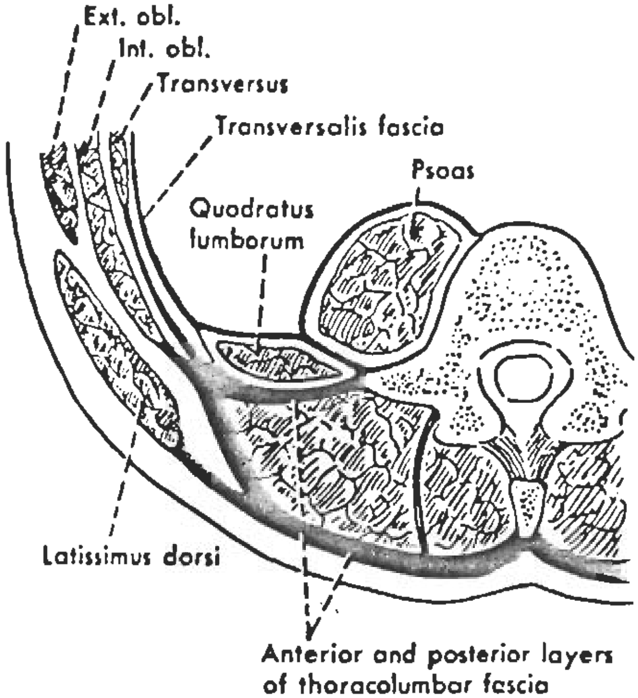

Fig. 3. The attachments of the lumbodorsal fascia (thoracolumbar fascia) as shown in a cross section of the lower lumbar spine. (From Hollinshead: Textbook of Anatomy, Harper & Row.)

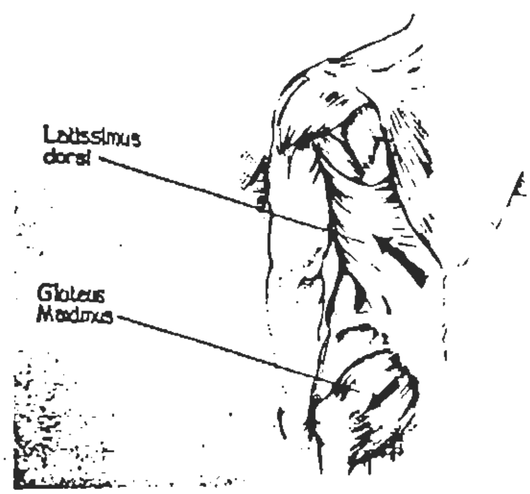

Fig. 4. A description of the superior and inferior forces on the lumbodorsal fascia (aponeurosis).

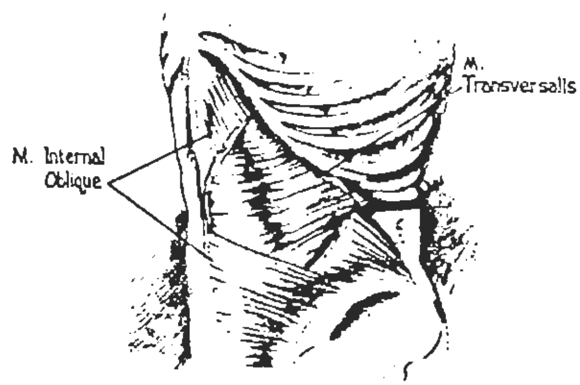

Fig. 5. A description of the posterior to anterior horizontal forces of the transversus abdominis (M. Transversalis) and the internal oblique portions of the abdominal musculature on the lumbodorsal fascia.

or minimizing nociceptive discharge of the affected tissues so that there is no dysfunction or shortening.

As with other body tissues, scar tissue is laid down proportionately to forces acting upon it.[3] If injured areas of the low back or low back tissues subjected to excessive postural forces are not properly managed, remodeling of these tissues result in a shortened, nonfunctional position which makes them exceptionally vulnerable to further tearing when activities of daily living are resumed. Mismanagement of these tissues will result in chronic symptoms, frequent reinjury, and noticeable lifestyle changes, inevitably decreasing the level of overall fitness.

Physical therapists with comprehensive knowledge of human biomechanics and basic science of soft tissue healing can assist the patient to control the production of scar tissue so that it forms in the direction of the force, thereby maintaining function. Old collagen bonds are broken down and new ones formed in the lines of movement.[23] One technique for accomplishing this involves using techniques for separating tissue layers and restoring function to surrounding tissues by deep manual movements of one tissue on another in either the same or opposite direction of fibers.[4] Deep massage is most effective when it precedes prolonged passive stretching. Stretching produces the force necessary for achieving physiological and biochemical synthesis and lysis of collagen structures. In addition, the patient must be instructed to avoid assuming body positions that place excessive stress on the injured areas. If the patient is to comply with such instruction, he must understand the body mechanics responsible for his back pain. Once the patient learns how the injury or poor posture evolved, he has a much better chance of complying with the treatment plan and ensuring a speedy tissue repair.

An integral part of managing injury to this part of the body is the design of a weight-training program intended to increase the internal tension of the three muscle groups described earlier, as well as the latissimus dorsi. Lifting cans of soup

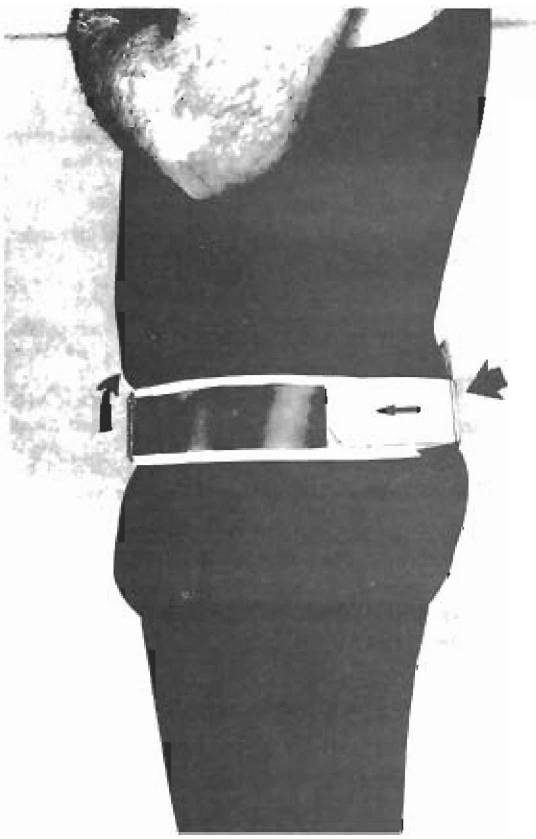

Fig. 6. *A lateral view of the Lumbopelvic Support. Note: This support is tightened from behind causing the forces depicted by the arrows.*

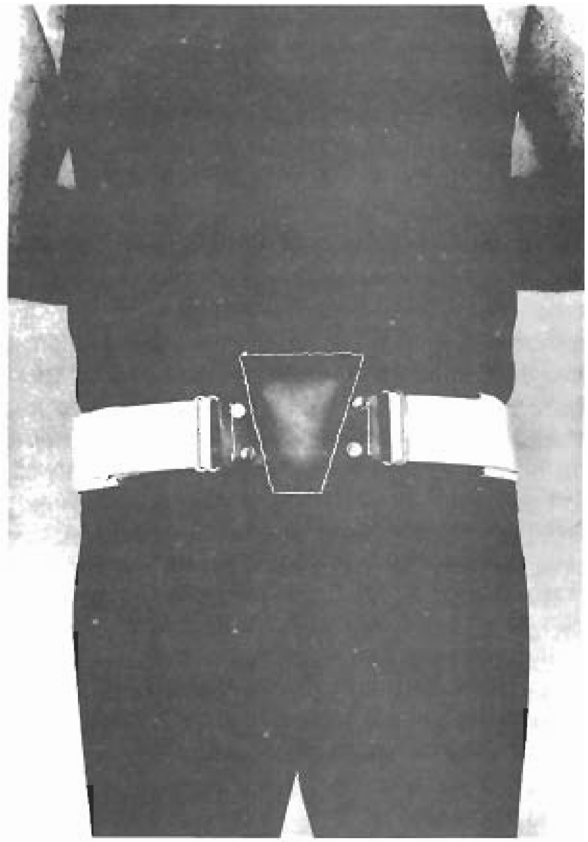

Fig. 7. *Posterior view of the Lumbopelvic Support. Note: This support is designed to be tightened from the back.*

in a purse may be just the ticket for some patients, but this technique does not satisfy the overload principle that is imperative to strengthening these large muscle groups. Maximum exercise using equipment such as Polaris, Nautilus, or Eagle in a pain-free range of motion with emphasis on high repetitions is an excellent way to provide endurance and strength to the large muscle groups so to maintain postural stability, or dynamic stabilization of the trunk. At our clinic, we have treated persons 50 and 60 years of age who have realized considerable relief by making the dynamic stabilization qualities of the musculoskeletal system more efficient. We have yet to find anyone who has faithfully engaged in a strengthening activity at least 3 times a week over a 4-week period who has not noticed positive changes of their musculoskeletal system and an improvement of their overall body image.

Another important part of the initial management of mechanical back pain is the addition of a temporary lumbopelvic support. This support (Figs. 6, 7), which we use when the L5–S1 facet joint or pelvic soft tissue is involved, is designed to create a superior and posterior rotary force on the anterior/superior iliac spines. At the same time it places an anterior/inferior force on the sacrum, causing the sacrum to maintain its position or to move slightly into extension. In essence, this support causes a slight posterior pelvic tilt. These forces secure the sacral position and keep the L5–S1 apophyseal joint from excessive movement in the end range of extension. This combination of forces directs the movement in an invulnerable midrange of the synovial joints. The compressive nature of this support also approximates the posterior lumbopelvic tissues, adding to its stabilization qualities. This temporary biomechanical alteration allows for the proper beginning of soft tissue healing as well as providing a kinesthetic reminder to assist the patient in avoiding movement in the vulnerable reinjury range.

The pelvic band or any lumbosacral support is not a panacea for all back pain, but can play a major role in assisting patients in their fight against gravity. The support is often used to stabilize those aforementioned forces from altering or attenuating the proper healing activities of tissues in question. This stabilization support is used in the back like a sling is used to stabilize an acutely injured shoulder, i.e., the control of unwanted, often destructive forces from entering the region. Once control of the injury or dysfunctional tissue is obtained by improving proper flexibility and dynamic stabilization, the support is no longer needed. This support is often applied to a patient with lumbopelvic mechanical pain; if the patient gains any relief or there is an alteration in perception of symptom, it is likely that the support would help the therapist achieve his/her goal more rapidly.

SUMMARY

In the treatment of low back pain, it is imperative that the clinician accurately and promptly identify injury, and for this, extensive knowledge of basic science of soft tissue healing and antigravity biomechanics is crucial. In addition to healing the wound, the clinician has a further responsibility to educate the patient in three areas: *1)* avoidance of behavior that would cause reinjury or that motion which was the cause of injury; *2)* strengthening of the trunk anatomy to provide maximal stabilization forces to the lumbopelvic region, and especially those muscles and tissues that originate or insert into the lumbodorsal fascia; and *3)* restoration of normal function of soft tissue in a region so to assure a return to active lifestyle. In this effort, it seldom hurts to remind the patient of two old adages: "If you snooze, you lose" and "If you rest, you rust."

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REFERENCES

1. Adams MA, Hutton WC: The effect of posture on the role of the apophyseal joints in resisting intervertebral compressive forces. J Bone Joint Surg (Br) 62:358–362, 1980
2. Bogduk N, Macintosh JE: The applied anatomy of the thoracolumbar fascia. Spine 9:164–170, 1984
3. Cummings GS, Cruthfield CA, Barnes MR: Soft tissue changes in contractures. In: Orthopedic Physical Therapy Services, Vol 1, Sect 2-4, pp 10–95. Atlanta, GA: Stokesville Publishing Co, 1983
4. Cyriax J: Indications for and against deep massage. In: Textbook of Orthopaedic Medicine, Ch 4, Ed 10, pp 30–36. London: Cassell Ltd, 1980
5. Eriksson B, Gollnick P, Saltin B: Muscle metabolism and enzyme activities after training in boys 11–13 years old. Acta Physiol Scand 87:485–497, 1973
6. Friberg O: Clinical symptoms and biomechanics of lumbar spine and hip joint in leg length inequality. Spine 8:643–650, 1983
7. Fox E, Mathews DK: Physiological effects of physical training. In: The Physiological Basis of Physical Education and Athletics, Ch 13, pp 293–333. Philadelphia: Lea and Febiger, 1981
8. Giles LG, Taylor JR: Lumbar spine structural changes associated with leg length inequality. Spine 7:159–162, 1982
9. Gollnick P, Armstrong R, Saltin B, Saibert C, Sembrowich W, Sheperd R: Effects of training on enzyme activity and fiber composition of human skeletal muscle. J Appl Physiol 34:107–111, 1974
10. Gracovetsky S, Fartan HF, Lamy C: The mechanism of the lumbar spine. Spine 6:249–262, 1981
11. Hollinshead WH: Soft tissues of the back. In: Textbook of Anatomy, Ed 3, Ch 15, p 326. Hagerstown, MD: Harper & Row, 1974
12. Holloszy J: Effects of exercise on mitochondrial oxygen uptake and respiratory enzyme activity in skeletal muscle. J Biol Chem 242:2278–2282, 1967
13. Karlsson J, Nordesjo L, Jorfeldt L, Saltin B: Muscle lactate, ATP, and CP levels during exercise after physical training in man. J Appl Physiol 33:199–203, 1972
14. Larson L: Morphological and functional characteristics of the aging skeletal muscle. Acta Physiol Sand (Suppl) 456:9–26, 1978
15. McArdle WD, Katch FI, Katch, VL: Functional capacity of the cardiovascular system. In: Exercise Physiology, Ch 17, pp 219–233. Philadelphia: Lea and Febiger, 1981
16. Mitchel FL, Moran DS, Pruzzo NA: Evaluation and Treatment Manual of Osteopathic Manipulative Procedures, Ed 1, Part I, pp 63–68. Valley Park, MO: Mitchell, Moran, Pruzzo Assoc, 1972
17. Pattengale P, Holloscy J: Augmentation of skeletal muscle myoglobin by a program of treadmill running. Am J Physiol 213:783–785, 1967
18. Shephard RJ: Gross changes in form and function. In: Physical Activity and Aging, Ch 3, pp 52–146. Chicago: Yearbook Medical, 1978
19. Smith EL, Serfass RC: Exercise and Aging: The Scientific Basis. In: Aging and Skeletal Muscle, Ch 3, pp 31–45. Short Hills, NJ: Enslow Publishers, 1981
20. Staff PH: The effects of physical activity on joints, cartilage, tendons, and ligaments. Scand J Soc Med (Suppl) 29:59–63, 1963