

## Comparison of Female Geriatric Lumbar-Extension Strength: Asymptomatic Versus Chronic Low Back Pain Patients and Their Response to Active Rehabilitation

Bryon Holmes, Scott Leggett, Vert Mooney, \*Jean Nichols, Scott Negri, and An Hoeyberghs

*Department of Orthopaedics, University of California, San Diego; and \*Department of Physical Education San Diego State University, San Diego, California, U.S.A.*

---

**Summary:** We compared lumbar-extension strength between healthy asymptomatic geriatric females (HEAL) and symptomatic geriatric females (INJ) seeking medical attention for chronic low back pain. The INJ group used the MedX lumbar-extension machine to perform isotonic exercise two times per week and were eventually reduced to one time per week. Range of motion (ROM) and strength were significantly different between groups before beginning the program. After the program, ROM and strength improved significantly and were not different from those of the HEAL group. The average length of treatment was 97 days and 20 visits. Subjective pain ratings were significantly reduced (60%) and exercise weights significantly increased (71%). This reconfirms the notion that many back pain sufferers have weaker lumbar-extension strength and that some symptomatic geriatric women can increase strength with progressive resistance exercise, which leads to decrease in low back pain. **Key Words:** Geriatric-Lumbar extension-Strength-MedX.

---

Patients suffering from chronic back pain typically splint or guard movements that involve the use of the lumbar-extensor musculature. The result of this splinting is disuse of the musculature; disuse leads to atrophy and weakening of the muscle's contractile ability to withstand stress and has been demonstrated to be associated with back pain (3, 14, 25, 34, 36, 39). This continuous cycle is referred to as the chronic deconditioning syndrome. In many cases, lumbar-extension weakness is the manifestation and common pathway of all lumbar spinal disease process.

Documentation of pain is highly subjective; however, quantification of strength and changes in strength, done

accurately, can be objective and highly reliable. The basic principles for increasing muscular strength are overload and progression. The overload principle requires that the targeted muscles be worked at greater than normal levels. The progression principle implies that challenges to the muscles are continually increased as performance increases. Numerous studies have documented significant changes in strength after 8 to 12 weeks of exercise with frequencies of one, two, and three times per week (4, 9, 12, 19, 33, 44, 45).

Men are stronger than women (10, 23, 43), and 18- to 50-year-olds are generally stronger than their older counterparts (26). However, using the basic principles for developing muscular strength, the geriatric population should be able to achieve the same relative gains as does the younger population (5, 16, 22, 32, 35).

No information exists on the response of lumbar-extension strengthening exercises in the geriatric female

---

Address correspondence and reprint requests to Dr. V. Mooney, University of California, San Diego, 4150 Regents park Row, Suite 300, San Diego, CA 92037, U.S.A.

chronic back pain patient. Our purpose was to describe this population's lumbar-extension strength compared with that of their healthy counterparts, evaluate the efficacy of an isolated lumbar-extension muscular strengthening program, and evaluate the patient's perception of pain before and after the rehabilitation program.

## METHODS

### Subjects

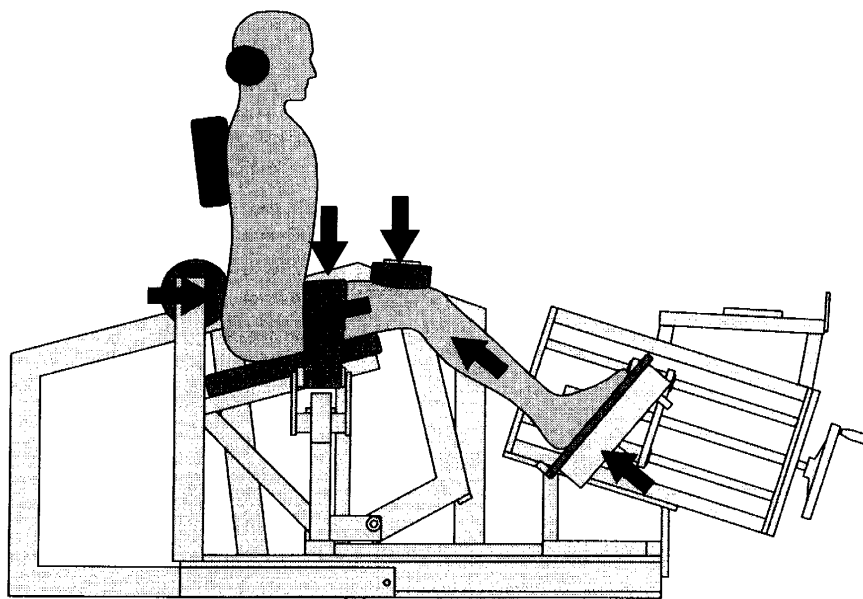
Thirty-eight ( $n = 38$ ) female subjects (age,  $68.3 \pm 6.6$  yrs; height,  $162.7 \pm 6.5$  cm; weight,  $66.2 \pm 10.4$  kg) were involved in this investigation. Eighteen of the subjects were chronic back pain patients (INJ,  $n = 18$ ) who were physician referred to our active rehabilitation program. Diagnosis of this group was varied and ranged from degenerative disk disease to postsurgical fusion. Twenty healthy asymptomatic (HEAL,  $n = 20$ ) subjects were recruited from an ongoing community adult fitness program. Participants in the HEAL group had been involved for >6 months in an aerobic (walking) or a combined aerobic and strength-training program. None of these patients were being cared for under workers' compensation insurance or were involved with disability claims. We recognize that the effectiveness of treatment programs may be clouded by motivational issues (24, 29, 30, 42).

### Strength Testing

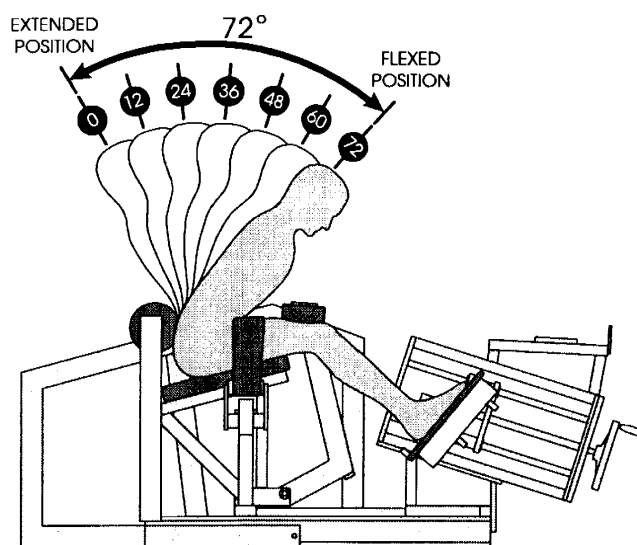
All subjects' isolated lumbar-extension isometric strength was tested using a computerized MedX Lumbar Extension Machine. This testing device blocks pelvic rotation during trunk extension, thereby isolating the movement of lumbar extension for testing (Fig. 1). Isometric testing allows for the correlation of position and torque and was conducted at common test angles of 72, 60, 48, 36, 24, 12, and 0° of range relative to the lumbar-extension machine (Fig. 2). In this system, 0° represents full extension, not neutral position. Initial testing was done on two separate days; the second day's test results were used for statistical considerations. Other authors have described this procedure to be highly reliable for quantifying lumbar-extension torque curves (18).

All subjects were tested at common test angles within what they described as their pain-free range of motion (ROM). All isometric testing was symptom limited. At each test angle, patients were instructed slowly to extend back against the machine's movement arm; if they felt any increased pain or discomfort, they were instructed to discontinue attempts at extension and slowly to relax.

Quantification of lumbar-extension strength in the INJ group was done at the beginning and end of their involvement in the active rehabilitation program. Quan-



**Fig. 1.** Force direct through the feet is transmitted through the femur, fixating the pelvis against the pelvic-restrained pad. This prevents posterior pelvic rotation during extension, thereby isolating lumbar-extension movement during testing and exercise.



**Fig. 2.** Common isometric testing positions used to correlate position and torque.

tification of the HEAL group's lumbar-extension strength was done once and was based on the efforts produced on their second test visit.

### Rehabilitation

The INJ group used the MedX lumbar-extension machine to do isolated, isotonic lumbar-extension exercises during their rehabilitation phase. The patients exercised at their own speed through flexion (eccentric) and extension (concentric) cycles of isotonic resistance exercise. They were encouraged to exercise slowly so as to take 3-4 s for each cycle. Thus each exercise session took >2 min. The exercise workload was based on a patient's ability to perform 20 controlled repetitions with a given workload. If a patient performed >20 repetitions, the workload for the next visit was increased. All exercise sessions were performed through the patient's greatest pain-free ROM. Patients were initially seen two times per week for the first 4 weeks. At the 4-week period, patients' visits were reduced to one time per week if the limitation of the exercise sessions was momentary muscle fatigue. If, during an exercise period, the session was stopped because of an increase in pain, then a two-time-per-week sessions was continued. Essentially, those patients who could tolerate higher intensity exercise sessions were reduced to one time per week; those who could not maintained a two-time-per-week regimen.

Patient's lumbar-extension strength was assessed every 4 weeks. Program completion was based on a lack of improvement from one test date to another or a complete reduction in pain verbalization by the patient.

### Pain

Pain within the INJ group was assessed using a 10-point analog scale. Patients were asked to verbalize on a scale of 1 to 10 what their average levels of back pain were for the previous week, with 1 being no pain, and 10 being maximum pain. Pain scores were completed initially and every 4 weeks before strength-testing sessions.

### Data Analysis

Descriptive statistics were performed using the Stat-View statistical analysis software package.

Isometric torque was measured in foot-pounds and converted to Newton-meters. Means and standard deviations were calculated for each angle of measurement and ROM on the HEAL and INJ group. Isometric torque, pain, ROM, isotonic workload, work time, and repetitions in the INJ group were measured initially (INJpre) and finally (INJpost). One-way analysis of variance procedure (ANOVA) was used to compare torque by angle between the HEAL, INJpre and INJpost groups. A two-tailed t test used to compare pain, dynamic exercise, work time, and repetitions between the INJpre and INJpost groups. Statistical significance was accepted at a probability of 0.05.

### RESULTS

There was no difference in descriptive data of age, height, and weight between groups (Table 1). The HEAL group was significantly stronger than the INJpre group at all testing angles. After the INJ group rehabilitation, there were significant differences between INJpre and INJpost, but no difference between INJpost and the HEAL group (Fig. 3). Relative increases in torque ranges from 39 to 84 % increase from the flexed (72°) to extended (0°) position (Table 2).

Subjective ratings of pain decreased significantly from 5.3 to 2.1 from the INJpre to INJpost group. INJpre ROM ( $59.2 \pm 10.8^\circ$ ) was significantly less than that of HEAL ( $76.2 \pm 6^\circ$ ). After the rehabilitation program, INJpost ROM ( $68.2 \pm 4.7^\circ$ ) was significantly greater than that of INJpre but not different from that of HEAL; this

**TABLE 1.** Characteristic information between groups

Group	Age (yr)	Height (cm)	Weight (kg)
HEAL	$68.4 \pm 5.8$	$162.6 \pm 5.5$	$69.1 \pm 10$
INJ	$68.2 \pm 7.5$	$162.8 \pm 7.5$	$63.2 \pm 10.3$

No difference ( $p > 0.05$ ) between groups.  
HEAL, healthy, asymptomatic; INJ, symptomatic.

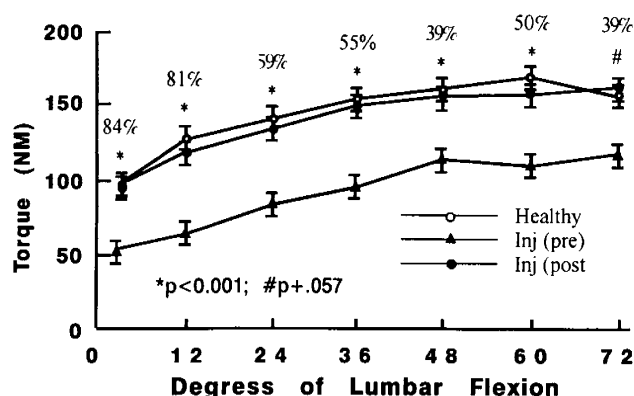


FIG. 3. Isometric torque after rehabilitation program. Relative strength gains listed above.

represents a 15% increase in ROM. During the rehabilitation period, dynamic isotonic exercise resistance weight increased significantly (71%) from  $21.5 \pm 4.3$  to  $36.9 \pm 7.9$  kg. The average number of repetitions from the first exercise session to the last increased from  $11 \pm 3.2$  to  $16.1 \pm 8$ . The work time, which designates the amount of time it required the patients to perform their repetitions, increased from  $144 \pm 27.6$  to  $167.6 \pm 54.2$  seconds from the first to last exercise session (Table 3).

One patient who was diagnosed with a pseudoarthrosis of an old L4-to-sacrum fusion did increase in strength; however, her levels of pain on the analog scale increased from 5 to 6. Another severely degenerative scoliosis patient received no improvements in her strength or levels of pain; however, her ROM did improve from 60 to 72°. Their data were included in all of the statistical analysis.

TABLE 2. Mean isometric torque values (N•m) for each angle, and change within the INJ group

	Angle (degrees of lumbar flexion)						
	0°	12°	24°	36°	48°	60°	72°
INJ <sup>pre</sup>	51.6 ± 25.3	65.6 ± 28.6	85.7 ± 38.3	97.2 ± 33.8	112.8 ± 34.7	106 ± 22.7	117.5 ± 16.4
INJ <sup>post</sup>	95.5 <sup>a</sup> ± 31.9	118.9 <sup>a</sup> ± 38.2	136.2 <sup>a</sup> ± 44.3	150.6 <sup>a</sup> ± 45.3	156.9 <sup>a</sup> ± 48.9	158.6 <sup>a</sup> ± 38.3	163.7 <sup>b</sup> ± 36.0
HEAL	97.6 ± 42.3	127.3 ± 47.6	141.8 ± 44.3	155.3 ± 49.8	158.9 ± 43.3	167.1 ± 47.5	158.8 ± 47.2
Change (%) INJ <sup>pre</sup> vs. INJ <sup>post</sup>	84	81.0	59.0	55.0	39.1	49.6	39

<sup>a</sup>INJ<sup>post</sup> significantly ( $p < 0.001$ ) greater than INJ<sup>pre</sup> but not different from HEAL.

<sup>b</sup>INJ<sup>post</sup> significantly ( $p = 0.057$ ) greater than INJ<sup>pre</sup> but not different from HEAL.

TABLE 3. Pre- and postrehabilitation parameters

Group	Pain	ROM°	Stack Weight (kg)	Stack Reps	Load Time (s)
INJ <sup>pre</sup>	5.3 ± 2.3	59.2 ± 10.8	21.5 ± 4.3	11 ± 4.3	144 ± 27.6
INJ <sup>post</sup>	2.1 ± 1.9 <sup>a</sup>	68.1 ± 4.7 <sup>a</sup>	36.9 ± 7.9 <sup>a</sup>	16.1 ± 8.0 <sup>a</sup>	167.6 ± 54.3 <sup>a</sup>
HEAL		67.2 ± 6.0 <sup>b</sup>			

<sup>a</sup>INJ<sup>post</sup> significantly ( $p < 0.05$ ) different from INJ<sup>pre</sup>.

<sup>b</sup>HEAL significantly ( $p < 0.05$ ) different from INJ<sup>pre</sup> but not INJ<sup>post</sup>.

## DISCUSSION

These results confirm the notion that back pain sufferers have weaker lumbar-extension strength than their asymptomatic counterparts (4, 11, 27, 28, 40). The data also documents that geriatric women have the ability to increase their strength levels through a regimen of progressive resistance exercise and that this increase in strength appears to be associated with a decrease in most patients in low back symptoms.

The strength levels of the HEAL and INJ<sup>post</sup> group are ~1 SD below those reported for asymptomatic women (18). These norms are based on a cross-section of ages from 18- to 65-year-olds; therefore, it is not surprising that the older population is 1 SD below the mean.

The symptom associated with an individual's spinal pathology is pain. During periods of pain and discomfort, an individual will guard or splint all movements in the region of associated pain. This splinting or disuse leads to muscular atrophy, which in turn leads to weakness. Weakness may also be secondary to inhibition caused by the noxious stimuli caused by the pain. This condition, if allowed to continue, may develop into a continually repeating rehabilitating process known as the chronic deconditioning syndrome. In the healthy population, maximal strength gains in 12 weeks are seen at exercise frequencies of three times per week performing three sets of exercise. This represents an 84-day period involving 36 total days for exercise. These exercise session involve three sets per day or a total of 108 sets of specific exercise. Typical strength gains with this protocol will elicit 25 to 30% gains in strength (20).

Our INJ group treatment period lasted 97 days. Of those 97 days, specific exercises were performed on 20 of them; one set was performed per day or a total of 20 sets of specific exercise. The overall changes in strength from the program results in a 39 to 84% increase in strength from the flexed to extended position. Because of the strength improvement of this magnitude, in this short time, they apparently had been initially suffering from deconditioning or inhibition of the lumbar-extension.

sor musculature. At the motor unit level, the source of this inhibition is unknown. Certainly pain must be a factor, but it should be noted that the patient with the pseudoarthrosis had an increase in measured strength and also an increase in pain.

We cannot objectively measure pain and discomfort. We can, however, objectively measure a muscle's voluntary contractile efforts and changes within it. Weakness is associated with the spinal disease process (3, 14, 25, 34, 36, 37, 39). Effective rehabilitation prevents continuation of the chronic deconditioning syndrome; it also reverses a weakened condition by returning an individual to preinjury levels of strength.

An overload stimulus demands that the involved muscles work at greater than normal levels. An overload stimulus improves neural control and increases the muscle contractile protein size (17, 21, 38). Muscle tissue physiologically adapts to its levels of stimulation. Therefore, muscular strength will improve through facilitation of neural control and muscular hypertrophy (31). Mechanical loading also assists in the proper alignment of collagenous tissue during the repair process (15). Not providing mechanical stress allows cellular repair alignment to occur in random order, which in turn leads to adhesions and joint stiffness (1).

Isolation is the key to targeting the specific area of dysfunction (weak link). The human body biomechanical chain is only as strong as its weakest link. Isolating a movement makes it possible to provide a progressive overload stimulus to the weakened atrophic musculature. Without isolation, the overload stimulation will not target the muscle group in question, and the efficacy of a rehabilitation program will be compromised. Isolating a joint movement provides the safest environment in which to provide overload principles. During isolated movements, other muscle groups do not assist or substitute in performance efforts.

The goal of any rehabilitation program is to restore an individual to preinjury levels of strength and function. During the first 4 weeks of a program, two sessions per week are recommended. Initially, patients are suffering from a chronic deconditioning syndrome. This is characterized by pain, which encourages reduced activity, which encourages muscular atrophy, which encourages pain, and the cycle continues. Initial treatment sessions are generally limited by pain and discomfort, not fatigue. After 4 weeks, most patients can tolerate higher intensity, fatigue-limited treatments. For a once per week protocol to be effective, the treatment must isolate the lumbar extensors, it must overload the musculature of the lumbar extensors, and it must be progressive.

Completion of an active rehabilitation program is repeated by achievement of expected strength levels, resolution of pain complaints, or a lack of improvement from one test session to another.

Our patients' treatments were progressive. Their increase in lumbar-extension strength is attributed to the isolated, progressive treatment program they received.

The restored levels of strength and ROM for our patients will probably be maintained if they continue to participate in activities of daily living. This is demonstrated by the HEAL group's baseline levels of lumbar-extension strength, which they exhibit and maintain by an active lifestyle with no specific lumbar-extension exercises.

Specific lumbar-extension exercises that increase lumbar-extension strength are associated with decreased subjective levels of pain and increased ROM. They have been demonstrated as useful for the conservative treatment of low back pain in older women.

## REFERENCES

1. Akeson WH, Amiel D, Abel M, Garfin S, Woo S: Effects of immobilization on joints. *Clin Ortho* 219:28-57, 1987
2. Akeson WH, Amiel D, Mechanic GL, Woo SLY, Harwood FL: Collagen cross-linking alterations in joint contractures: changes in the reducible cross-linking in periarthral connective tissue collagen after nine weeks of immobilization. *Connect Tissue Res* 5:15, 1977
3. Alaranta H, Tallroth K, Soukka A, Heliövaara M: Fat content of lumbar extensor muscles and low back disability: a radiographic and clinical comparison. *J Spinal Disord* 6:137-140, 1993
4. Alston W, Carlson K, Feldman D: A quantitative study of muscle factors in the chronic low back syndrome. *J Am Geriatr Soc* 14:1041-1047, 1966
5. Aniansson A, Gustafsson E: Physical training in elderly men with special reference to quadriceps muscle strength and morphology. *Clin Physiol* 1:87-98, 1981
6. Berger RA: Effect of varied weight training programs on strength. *Res Q* 33:168-181, 1962
7. Booth F: Physiologic and biomechanical effects of immobilization on muscle. *Clin Orthop* 219:15-30, 1987
8. Bortz W: The disuse syndrome. *West J Med* 141:691-694, 1984
9. Braith RW, Graves JE, Pollock ML, Leggett SL, Carpenter DM, Colvin AB: Comparison of two versus three days per week of variable resistance training during 10 and 18 week programs. *Int J Sports Med* 10:450-454, 1989
10. Brown HC, Wilmore JH: The effects of maximal resistance training on the strength and body composition of women athletes. *Med Sci Sports* 6:174-177, 1974
11. Cady LD, Bischoff DP, O'Connell ER, Thomas PC, Allan JH: Strength and fitness and subsequent back injuries in firefighters. *J Occup Med* 21:269-272, 1979
12. DeLorme TL, Watkins AL: Techniques of progressive resistance exercise. *Arch Phys Med* 29:263-273, 1948
13. Fleck PL, Kraemer WJ: Designing Resistance Training Programs, Champaign, IL, Human Kinetics Book, 1987
14. Flicker PL, Fleckenstein JL, Ferry K, et al.: Lumbar muscle usage in chronic low back pain. *Spine* 18:582-586, 1993
15. Frank C, Akeson WH, Woo SLY, Amiel D, Coutts RD: Physiology and therapeutic value of passive joint motion. *Clin Orthop* 185:113, 1984

16. Frontiera WR, Meredith CN, O'Reilly KP, Knuttger HG, Evans WJ: Strength conditioning in older men: skeletal muscle hypertrophy and improved function. *J Appl Physiol* 64:1038-1044, 1988
17. Goldberg AL, Etlinger JD, Goldspink DF, Jablonski C: Mechanism of work-induced hypertrophy of skeletal muscle. *Med Sci Sports* 7:185-198, 1975
18. Graves JE, Pollock ML, Carpenter DM, et al: Quantitative assessment of full-range-motion isometric lumbar extension strength. *Spine* 15:284-289, 1990
19. Graves JE, Pollock ML, Foster D, et al: Effect of training frequency and specificity on isometric lumbar extension strength. *Spine* 15:504-509, 1990
20. Graves JE, Webb D, Pollock M, et al: Effect of training with pelvic stabilization on lumbar extension strength. *Int J Sports Med* (11), 1990
21. Gutmann E, Hajek I: Differential reaction of muscle to overload in compensatory hypertrophy and increased phasic activity. *Physiol Bohemos* 20:205-212, 1971
22. Hagberg JM, Graves JE, Limacher M: Cardiovascular responses of 70-79 year old men and women to exercise training. *J Appl Physiol* 66:2589-2594, 1989
23. Hetrick H, Wilmore JH: Androgen levels and muscle hypertrophy during an eight-week training program for men/women [Abstract]. *Med Sci Sports* 11:102, 1979
24. Hirsch G, Beach G, Cook C, et al: Relationship between performance on lumbar dynamometry and Waddell score in a population with low back pain. *Spine* 16:1039, 1991
25. Hultman G, Nordin M, Saraste H, Ohlson H: Body composition, endurance, strength, cross-sectional area, and density of MM erector spinae in men with and without low back pain. *J Spinal Disord* 6:114-123, 1993
26. Larsson L: Physical training effects on muscle morphology in sedentary males of different ages. *Med Sci Sports Exerc* 14:203-206, 1982
27. Manniche C, Hesselsoe G, Bentzen I: Clinical trial of intensive muscle training for chronic low back pain. *Lancet* 1:1473-1476, 1988
28. Mayer T, Gatchel R, Kishino N: Objective assessment of spine function following industrial injury: a prospective study with comparison group and one-year follow-up. *Spine* 10:482-493, 1985
29. Mayer TG, Smith SS, Keely J, et al: Quantification of lumbar function. Part 2, Sagittal plane trunk strength in chronic low back patients. *Spine* 10:765, 1985
30. Mellin G, Harkapaa H, et al: Outcome of multimodal treatment including intensive physical training of patients with chronic low back pain. *Spine* 18:825, 1993
31. Moritani T, DeVries HA: Neural factors versus hypertrophy in time course of muscle strength gain. *Am J Phys Med* 58:115-130, 1979
32. Moritani T, DeVries HA: Potential for gross muscle hypertrophy in older men. *J Gerontol* 35:672-682, 1980
33. O'Shea P: Effects of selected weight training programs on the development of strength and muscle hypertrophy. *Res Q* 37:95-102, 1966
34. Parkkola R, Rytokoski R, Kormanen M: Magnetic resonance imaging of the discs and trunk muscles in patients with chronic low back pain and healthy control subjects. *Spine* 18:830-836, 1993
35. Pollock ML, Carroll JF, Graves JE, et al: Injuries and adherence to walk/job and resistance training programs in the elderly. *Med Sci Sports Exerc* 23:1194-1200, 1992
36. Robinson ME, Cassisi JE, O'Connor PD, MacMillan M: Lumbar IEMG during isotonic exercise: chronic low back pain patients versus controls. *J Spinal Disord* 5:8-15, 1992
37. Ross EC, Parnianpour M, Martin D: The effects of resistance level on muscle coordination patterns and movement profile during trunk extension. *Spine* 18:1829-1838, 1993
38. Rowe RWD: The effect of hypertrophy on the properties of skeletal muscle. *Comp Biochem Physiol* 28:1449-1453, 1969
39. Shirado O, Kaneda K, Ito T: Trunk-muscle strength during concentric and eccentric contraction: a comparison between healthy subjects and patients with chronic low back pain. *J Spinal Disord* 5:175-182, 1992
40. Suzuki N, Endo S: A quantitative study of trunk muscle strength and fatigability in the low-back pain syndrome. *Spine* 8:69-74, 1983
41. Videman T: Connective tissue and immobilization: key factors in musculoskeletal degeneration? *Clin Orthop* 221:26-32, 1987
42. Werneke MV, Harris DE, Lichter RL: Clinical effectiveness of behavioral signs for screening chronic low-back pain patients in a work-oriented physical rehabilitation program. *Spine* 18:2412, 1993
43. Wilmore JH: Alterations in strength, body composition and anthropometric measurements consequent to 10-week weight training program. *Med Sci Sports* 6:133-138, 1974
44. Wilmore JH, Parr RB, Girandola RN, et al: Physiological alterations consequent to circuit weight training. *Med Sci Sports* 10:79-84, 1978
45. Zinovieff AN: Heavy resistance exercise: the Oxford technique. *Br J Phys Med* 14:129-132, 1951.