Original Article

Kurume Medical Journal, 46, 91-96, 1999

Efficacy of Aquatic Exercises for Patients with Low-back Pain

MAMORU ARIYOSHI, KYOSUKE SONODA*, KENSEI NAGATA*, TAKERU MASHIMA*, MICHIHISA ZENMYO*, CHINSU PAKU*, YOSHIAKI TAKAMIYA*, HIROKI YOSHIMATSU*, YOSHIMASA HIRAI*, HIDEKI YASUNAGA*, HIDETOSHI AKASHI, HIROYASU IMAYAMA, TOMOHISA SHIMOKOBE, AKIO INOUE* AND YOSHITERU MUTOH**

Department of Surgery, Kyoritsu Hospital, Kitakyusyu 804-0073, *Department of Orthopaedic Surgery, Kurume University School of Medicine, Kurume 830-0011 and **Department of Physical and Health Education, Graduate School of Education, University of Tokyo, Tokyo 113-0033, Japan

Summary: We have studied 35 patients (25 female and 10 male) with low-back pain who were managed with aquatic exercises after an appropriate period of treatment for their condition in the medical institution. The exercises employed consisted of strengthening exercises for the abdominal, gluteal, and leg muscles, stretching of the back, hip, hamstrings, and calf muscles, walking in water, and swimming. All the patients had been participating in the exercise program for more than 6 months. The frequency of performing exercises was once a week for 7 patients, twice a week for 19, and 3 or more times a week for the remaining patients. The method used in this study was a survey questionnaire which was composed of questions about the patient's physical and psychological condition. Those patients who had performed exercises twice or more in a week showed a more significant improvement in the physical score than those who performed exercises only once a week. More than 90% of the patients felt they had improved after 6 months of participation in the program. The improvement in physical score was independent of the initial ability in swimming. The results obtained suggested that exercises in water may be one of the most useful modes of exercise for a patient with low-back pain.

Key words aquatic exercise, low-back pain, questionnaire

INTRODUCTION

Patients who suffer from low-back pain cannot avoid periods of rest when their symptoms become worse, which leads to atrophy of the ventral and dorsal muscles of the trunk and to reduced function of the spine. Dysfunction of the ventral and dorsal muscles which stabilize the spine leads to abnormal stress or undesirable load on the joints or ligaments of the spine. These weakened muscles cannot stabilize the spine and the patient develops an ever-worsening condition in the back muscles and related structures. The importance of strengthening and fitness exercises for the weakened stabilizing muscles of the spine has now achieved wide acceptance [1-12]. However, we cannot avoid the weight load on the spine in any type of exercises on land [13-15]. On the other hand, we can control it when performing exercises in water [16,17]. It is recognized that exercise in water can be an effective and useful treatment especially for patients with arthritis or orthopaedic dysfunctions who have difficulty with weight-bearing when exercising on land [16]. However, little attention has been paid to the practical efficacy of exercise in water for patients with low-back pain. We have made a series of exercises in water for a patient with low-back pain and have studied the efficacy of these exercises using a questionnaire method.

MATERIALS AND METHODS

Thirty-five patients, 25 female and 10 male, with

Received for publication September 25, 1998
Address correspondence to: Mamoru Ariyoshi, M.D., Department of Surgery, Kyoritsu Hospital, 1-25 Meiji-machi, Tobata-ku, Kitakyusyu 804-0073, Japan. Tel: 81-93-871-5421 Fax: 81-93-882-1666

low-back pain participated in the program of aquatic exercises which was arranged for these patients after an adequate period of treatment in hospital. Their average age was 49 (range from 23 to 72) years, the average height was 159.2 (range from 147 to 173) cm, and the average weight was 57.3 (range from 40 to 75) kg. All the patients were treated in some orthopaedic hospital and the cause of low-back pain was lumbar spondylotic deformance in 18, lumbar disc herniation in 5, lumbar spinal canal stenosis (LCS) in 2, and repeated muscular disorder in 10. Two patients with lumbar disc herniation and one with LCS were treated operatively. The others were treated non-operatively. All participated in this program after hospital treatment of at least 3 months.

The program consisted of exercises performed outside or inside the swimming pool (Fig. 1). The outside-the-pool exercises aimed at strengthening the abdominal and gluteal muscles. Isometric rectus and oblique abdominal muscles exercises in the supine position with hips and knees bent were recommended. A simple sit-up exercise was avoided, as a sit-up from the supine position with hips and knees bent increases the lumbar disc pressure [14]. In static stretching of the back and hip muscles, the patient pulls the knees up to the chest as far as possible while maintaining the supine position and repeats this slowly. This is not a reverse curl exercise which is a strengthening exercise for the abdominal muscles. Any hyperextension or tendency to hyperextension was avoided when the legs returned to the floor. The aquatic exercises were static stretching of the hamstrings and calf muscles; 25 m front, back and side ways walking; 25 m front jogging; 5 times front leg raising, back leg raising, and side leg raising; 5 times bobbing and jumping; and 25 m swimming crawl or back stroke. Each exercise was repeated 3 or 4 times in each session. The whole session required about 90 min. The frequency of participating in this program was once a week for 7 patients, twice a week for 19, and 3 or more times for 9. These patients had been participating in the program for

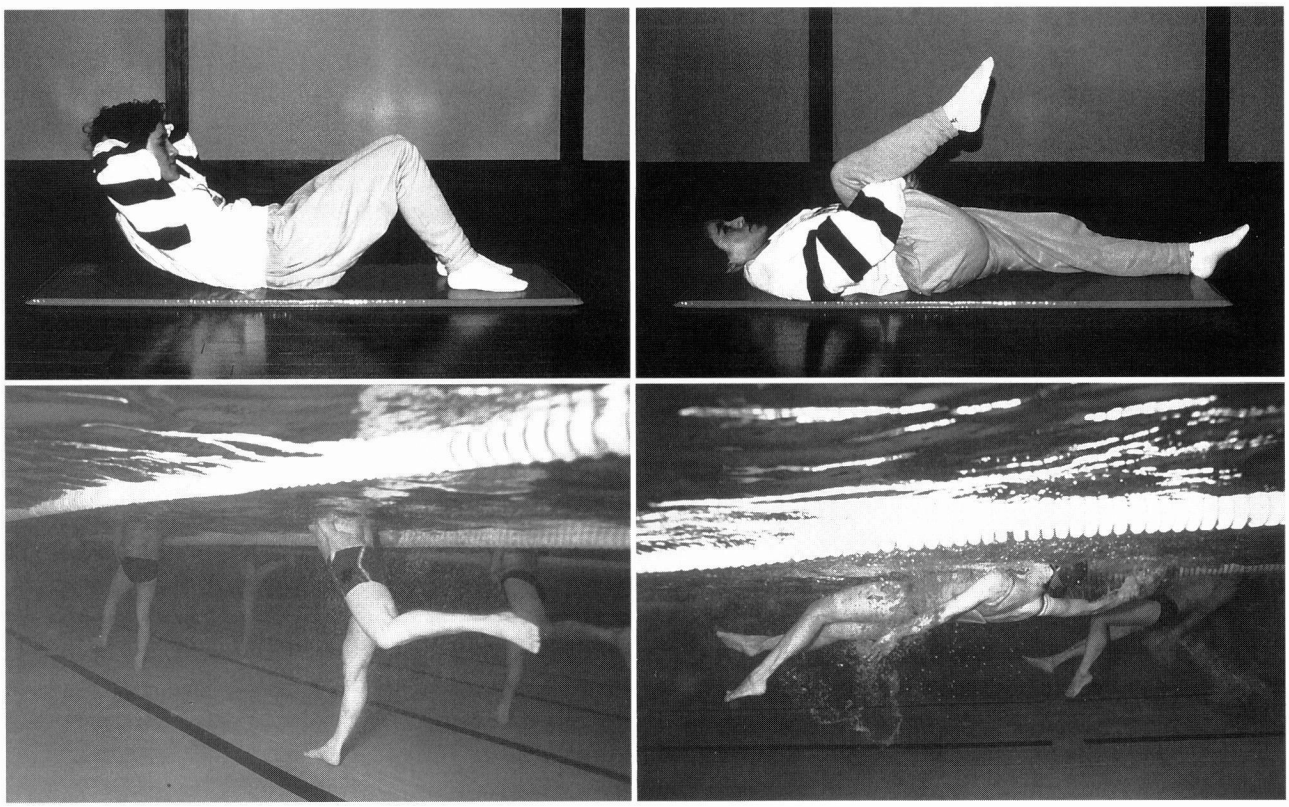

Fig. 1. Examples of exercises. upper left, Strengthening exercises for the abdominal and oblique abdominal muscles performed outside the pool. Exercises carried out lying on the back with hips and knees bent. upper right, Stretching of back and gluteal muscles also performed outside the pool. lower left, Leg raising exercises in the pool. lower right, Backstroke swimming with helper on her body.

more than 6 months. An indoor pool with 120 cm water depth, 29 degrees of water temperature, and 31 degrees of room temperature was used for the exercise.

The method used in this study was a survey questionnaire. All the patients surveyed filled out questionnaires. The questionnaire was composed of two parts, one about physical condition and the other about psychological condition. The former included questions about conditions in daily life, degree of low-back pain, condition of low-back pain, condition of movement of trunk, condition of walking. The latter was about the subjective impressions of 6 months experience of the program. The questionnaire was filled under supervision before entering the program and after 6 months or more of participation in the program. Each question had 4 possible answers, as follows: Concerning conditions of daily life, A, normal, no limitations; B, almost normal, minor limitations; C, major limitations; D, cannot do anything without help. Concerning the degree of low back pain, A, no pain; B, minor pain; C, considerably major pain; D, major pain. Concerning the duration of low back pain, A, free from pain; B, pain sometime; C, pain often; D, always pain. Concerning the mobility of the trunk, A, normal range of motion; B, mild limitations; C, considerably severe limitations; D, severe limitations. Concerning the impairment of walking, A, normal; B, almost normal; C, limping; D, cannot walk without help. These results were scored as 1 point for A, 2 points for B, 3 points for C, and as 4 points for D. We compared the total score for physical condition before and after the program. The questions concerning psychological condition tested the subjective assessment of the exercise treatment as follows: A, very satisfactory; B, satisfactory; C, no change; D, contrary to the expectation. Swimming ability was evaluated by questionnaires composed of 10 elements; walk in water, jump in water, run in water, immerse face, sink completely, float with face up, float with face down, swim on back, swim on chest, dive in water. Each element was scored and divided into 2 grades as follows: can be done well (10 points) or not (0 points).

RESULTS

The questionaire was completed by all participants. The mean value of the physical scores after participating in the program was 9.7±4.7 (n=35) which was significantly ($p<0.05$) lower than the initial score obtained before participation (11.7±3.3, n=35) (Fig. 2). The mean value of the physical score after participating in the program obtained from the individuals who had performed the exercises twice or more in a week (7.3±3.7, n=9) was significantly ($p<0.05$) lower than initial score (12.6±4.6, n=9)

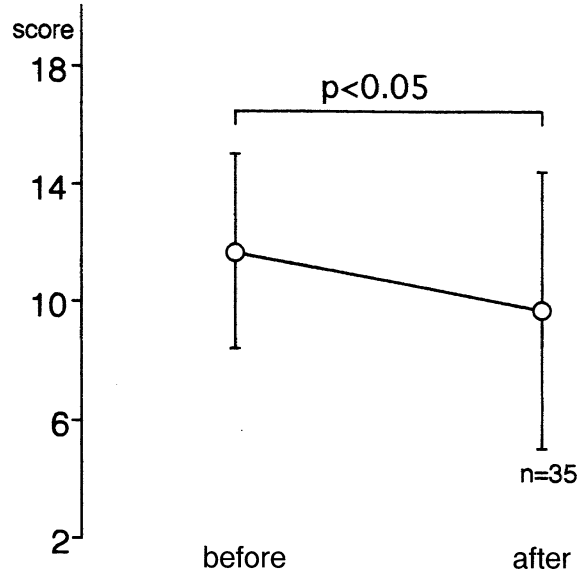

Fig. 2. Physical scores before and after (6 months) participation in the program. Open circles and vertical bars represent the mean values and S.D. (n=35).

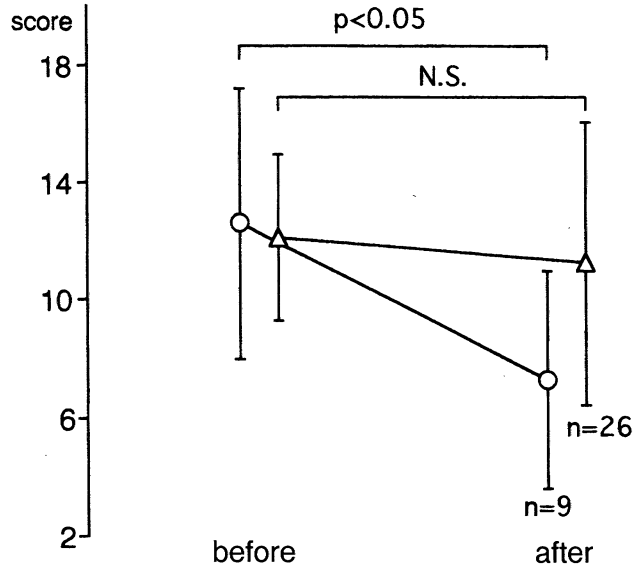

Fig. 3. Physical scores before and after (6 months) participation in the program. Open circles and vertical bars represent the mean values and S.D. of the persons who had been performing exercises twice or more a week (n=9). Open triangles and vertical bars who had been performing exercises once a week (n=26).

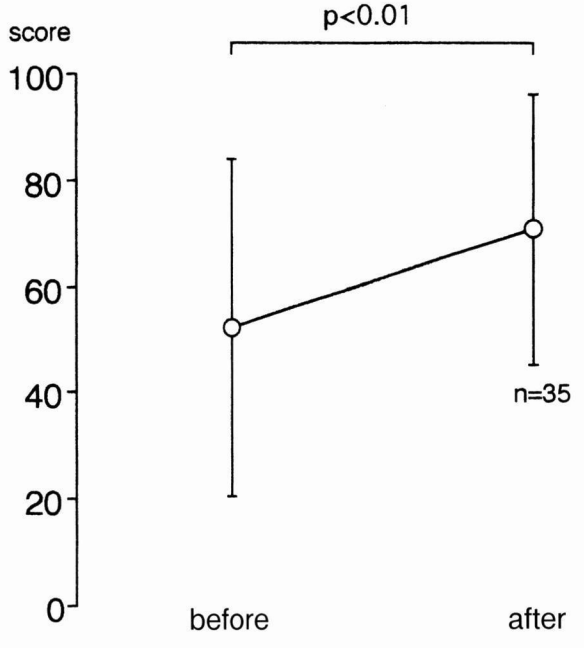

Fig. 4. Physical scores before and after (6 months) participation in the program of aquatic exercises. Open circles and vertical bars represent the mean values and S.D. (n=35).

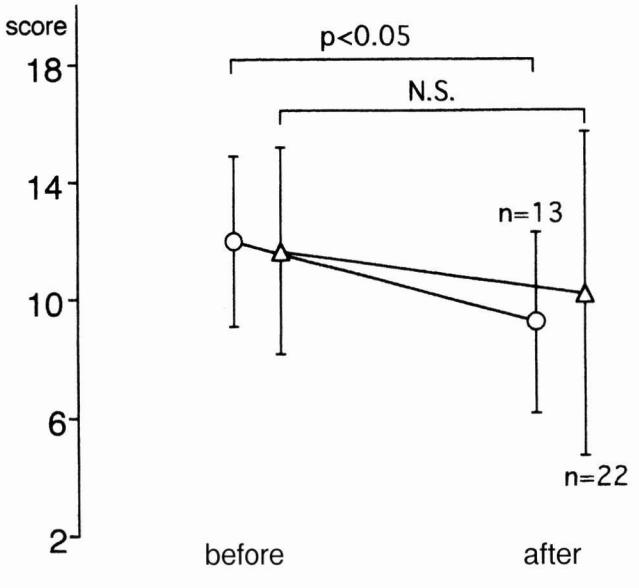

Fig. 5. Swimming ability scores before and after (6 months) participation in the program of aquatic exercises. Open circles and vertical bars represent the mean values and S.D. of the persons whose swimming ability scores were less than 40 points initially (n=13). Open triangles and vertical bars represent the mean values and S.D. of the persons whose swimming ability scores were more than 41 points initially (n=22).

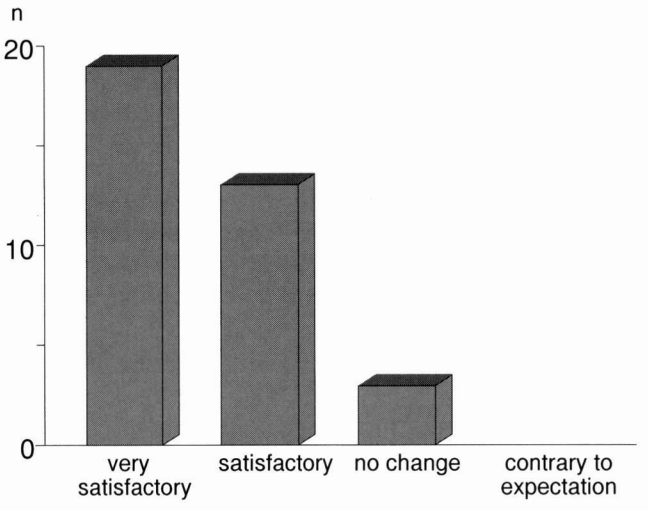

Fig. 6. Subjective impression after 6 months participation in the program of aquatic exercises. Each column represents the number of persons for very satisfactory, satisfactory, no change, and contrary to expectation.

obtained from these individuals before participation. On the other hand, there was no significant difference between the mean value of physical score after (10.5±4.8, n=26) and before (11.4±2.8, n=26) participating in the program in the case of the individuals who performed once a week (Fig. 3).

Swimming ability was developed by this exercise treatment. The mean value of swimming ability score after participating in the program (70.6±25.5, n=35) was significantly higher than the initial score (52.3± 31.7, n=35) (Fig. 4). Initially, 13 of the participants had less than 40 points of swimming ability score and 22 had more than 41 points of swimming ability score. In the persons who had less than 40 points initial swimming ability score, the mean value of the physical score after participating in the program (9.2 ±3.1, n=13) was significantly ($p<0.05$) lower than the initial physical score (12.0±2.9, n=13) (Fig. 5). In the persons who had more than 41 points initial swimming ability score, the mean value of the physical score after participating in the program (10.0± 5.5, n=22) was not significantly different from the initial score (11.5±3.5, n=22) but showed a tendency to decrease (Fig. 5).

Concerning the subjective assessment of the program, the answer was very satisfactory in 19 (54.3%) persons, satisfactory in 13 (37.1%), and no change in 3 (8.6%). There was no person who felt the result of the exercise treatment was contrary to expectation after participating in the program (Fig. 6). Four

(21.1%) of the 19 persons who felt very satisfactory and 7 (53.8%) of the 13 who felt satisfactory after participating in the program had not improved physical score.

The mean value of BMI (Body Mass Index) after participating in the program (21.9±1.9, n=35) was not significantly different from the initial value (22.6 ±2.3, n=35).

DISCUSSION

We designed the program on the following basis. Muscle strength and flexibility are important for stabilizing the spine and several types of exercises for low-back pain are known [1,4,18]. Long-term rest for treatment of low back pain weakens these spine-stabilizing muscles. The activity of the abdominal muscles decreases when a brace or corset is worn, because the device assumes the function of these muscles [6]. The abdominal muscles and the vertebral portion of the psoas muscles are involved in producing normal vertebral alignment [19,20]. The pelvis plays a role in keeping the alignment of the spine in the standing position and tilting the pelvis influences the activity of the postural muscles by affecting the static load on the spine [13]. Since weakened abdominal and gluteal muscles, after long-term bed rest, cannot maintain normal inclination of the pelvis which increases lordosis of the lumbar spine, we encourage strengthening of the abdominal and gluteal muscles. All spinal movements involve the combined action of several segments, while the relative motion between any two adjacent vertebrae is small. The first 50 to 60 degrees of spinal flexion occurs mainly in the lower lumbar spine [7] and further flexion needs forward tilting of the pelvis. The posterior hip muscles are active in controlling the forward tilting of the pelvis as the spine is flexed [7]. Flexibility of these muscles allows the smooth motion of the pelvis and lumbar spine, which is the reason why stretching of these muscles is recommended. Body position is a major factor which affects the magnitude of the load on the spine. The relative load on the third lumbar disc in vivo in various body postures have been estimated in detail [14,15]. Trunk flexion in the standing position increases the load by increasing the forward bending movement on the spine. The addition of rotary motion, and accompanying torsional loads, further increases the stresses on the spine [8]. These undesirable effects on the spine limit participation in exercising on land by the patient who have some disorder in their low-back. However, in the supine position, loads produced by the body weight are eliminated and thus loads on the spine are minimal. Furthermore, in the supine position, with hips and knees bent, then lumbar lordosis straightens out as the psoas muscle is relaxed, and the loads are decreased. This allows these strengthening and stretching exercises to be performed on land.

It has been well recognized that exercising in water can be an effective and useful mode of therapeutic exercise, especially for the individuals with arthritis or various orthopaedic dysfunctions who have difficulties with the weight-bearing components of land exercise [16,21]. When exercising in water, buoyancy and the frictional resistance of water have particular mechanical effects on the body. Furthermore, fluid pressure is exerted equally on all surface areas of a stationary immersed body at a given depth. Since the impact load acting on the spine during exercises can be easily controlled by changing the extent of submersion in water, exercising in water may be the most advantageous mode of exercise for individuals with low-back pain. The main part of the exercises in water are walking; forwards, backwards, and sideways. Other exercises except swimming are also performed in the standing position. The effect of buoyancy on the vertical component of the ground reaction force during walking in water has been examined by Nakazawa et al. 1994 [22]. The maximum impact force acting on the lower extremities during walking can be lowered to below 50% of body-weight by standing in water at a depth of 60% of body height [22]. On the other hand, in shallow water the impulse was larger than in land walking. About 120 cm depth of water is thought to be appropriate for aquatic exercises. Strengthening exercises for the gluteus muscles on land often produce pain even when performed in the supine position. In this case, exercising on land is avoided and only exercises in water are recommended. The gluteus muscles can be strengthened by walking in water, as the EMG activities of the hip extensor muscles increase [22].

About 29 degrees of water temperature and 30 degrees of room temperature were employed for the exercises in this study. Immersion in warm water has certain advantages and its beneficial effects have been known since the Hellenic civilization. It causes a general mild vasodiation and relaxation, in addition to a decrease in relative body weight. This hydrotherapy requires more than 30 degrees of water temperature. These circumstances have beneficial effect for

pain release but we cannot continue exercises at such high water temperature. As the warming effect was not a focus in the present program, about 29 degrees of water temperature was employed. This is near the critical water temperature where we can stay stationary without shivering and can continue to do exercises.

How often should the patient perform exercises to obtain a desirable effect? This study found that performing exercises more than twice a week was necessary. The amount of exercising seems to be an important factor to improve the physical score. However, it was surprising that 34.4% of the 32 persons who answered very satisfactory or satisfactory in the question concerning the subjective assessment showed no apparent improvement in physical score. Low-back pain patients in Japan commonly undergo traction therapy, heat therapy, massage, acupuncture, etc. which are termed passive therapy. The exercises which we have recommended have the disadvantage that the patient cannot perform them anywhere, it needs installation of an appropriate pool and also needs zeal for the continuation of the exercises. We speculate that the zeal for continuation even with the disadvantage of installation may play an important role in the improvement of low-back pain.

ACKNOWLEDGMENTS: We thank Ms. Machiko Nagao for technical assistance.

REFERENCES

1. Williams PC. Lesions of the lumbosacral spine. Part II. Chronic traumatic (postural) destruction of the lumbosacral intervertebral disc. J Bone J Surg 1937; 19:690-703.
2. Bartelink DL. The role of abdominal pressure in relieving the pressure on the lumbar intervertebral disc. J Bone J Surg 1957; 39B:718-725.
3. Partridge MJ, and Waters CE. Participation of the abdominal muscles in various movements of the trunk in man. An electromyographic study. Phys Ther Rev 1959; 39:791-800.
4. Pheasant HC. Practical posture building. Clin Orthop 1962; 25:83-91.
5. Kendall PH, and Jenkins JM. Exercises for backache: A double-blind controlled trial. Physiotherapy 1968; 54:154-157.
6. Waters RL, and Morris JM. Effect of spinal supports on the electrical activity of muscles of the trunk. J Bone J Surg 1970; 52A:51-60.
7. Farfan HF. Muscular mechanism of the lumbar spine and the position of power and efficiency. Orthop Clin North Am 1975; 6:135-144.
8. Andersson GBJ, Örtengren R, and Nachemson A. Intradiskal pressure, intra-abdominal pressure and myoelectric back muscle activity related to posture and loading. Clin Orthop 1977; 129:156-164.
9. Hemborg B, Moritz U, Hamberg J, Löwing H, and Åkesson I. Intraabdominal pressure and trunk muscle activity during lifting-Effect of abdominal muscle training in healthy subjects. Scand J Rehab Med 1983; 15:183-196.
10. Suzuki N, and Endo S. A quantitative study of trunk muscle strength and fatigability in the low-back-pain syndrome. Spine 1983; 8:69-74.
11. Hemborg B, Moritz U, Hamberg J, Holmstrom E, Löwing H et al. Intra-abdominal pressure and trunk muscle activity during lifting. III. Effect of abdominal muscle training in chronic low-back patients. Scand J Rehab Med 1985; 17:15-24.
12. White AH. A model for conservative care of low back pain: back school, epidural blocks, mobilization. In: Instructional Course Lectures 34, ed. Stauffers ES, Mosby, St. Louis, pp 78-84, 1985.
13. Floyd WF, and Silver PHS. The function of the erectores spinae muscles in certain movements and postures in man. J Physiol 1955; 129:184-203.
14. Nachemson A, and Elfstrom G. Intravital dynamic pressure measurements in lumbar disks. Scand J Rehab Med 1970 (Suppl); 1-40.
15. Nachemson AL. The lumbar spine. An orthopaedic challenge. Spine 1976; 1:59-71.
16. Eitner D. Exercise in water. In: Physical Therapy for Sports, ed. Kuprian W, Saunders, Philadelphia, pp 154-160, 1982.
17. Ariyoshi M, and Mutoh Y. Aquatic exercises for lumbago. J J Sports Sci 1991; 10:494-503.
18. Kelly RP, and Johnson JT. Acute low back pain. JAMA 1955; 27:1520-1521.
19. Basmajian JV. Electromyograph of iliopsoas. Anat Rec 1958; 132:127-132.
20. Nachemson A. Electromyographic studies on the vertebral portion of the psoas muscle. With special reference to its stabilizing function of the lumbar spine. Acta Orthop Scand 1966; 37:177-190.
21. Ariyoshi M, Nishioka E, Sannomiya T, Takagi K, Ono M et al. Lumbar helper for swimming exercise. Jpn J Orthop Sports Med 1991; 10:9-11.
22. Nakazawa K, Yano H, and Miyashita M. Ground reaction forces during walking in water. In: Medicine and Science in Aquatic Sports 39, ed. Miyashita M, Mutoh Y and Richardson AB, Karger, Basel, pp 28-34, 1984.