Low-Load Prolonged Stretch vs. High-Load Brief Stretch in Treating Knee Contractures

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This study was designed to compare the results of a traditional method of stretching knee flexion contractures by high-load brief stretch (HLBS) with the results of an experimental method of prolonged knee extension by skin traction, low-load prolonged stretch (LLPS). End range of passive knee extension was measured by standard goniometry. Subjects were 11 nonambulatory residents of a nursing home who had demonstrated gradually progressive bilateral knee contractures. Each subject served as his or her own control with one lower limb receiving LLPS and the other limb receiving HLBS and passive range of motion (PROM). Sequential medical trials were used as the clinical research design. Whether comparing the LLPS limb PROM measurements pretreatment and posttreatment (p ≤ .05) or the HLBS to the LLPS limb PROM recordings posttreatment (p ≤ .05), the results demonstrated a preference for LLPS in the treatment of knee contractures in the immobile nursing home resident.

Key Words: Contracture, Knee, Physical therapy.

Many elderly individuals demonstrate limited movement abilities; a frequent consequence is the development of knee contractures. Despite the efforts of an active physical therapy maintenance program at a county nursing home, including daily range of motion (ROM) and passive stretching techniques, these chronic knee contractures continued to be a problem. This study was designed to compare a more traditional method of stretching knee contractures, high-load brief stretch (HLBS), with an experimental method of prolonged knee extension, low-load prolonged stretch (LLPS).

LITERATURE REVIEW

Experimental and clinical data suggest that the tissue changes, which may cause restricted joint motion in the bedridden elderly, are physiological or morphological and involve intra-articular, periarticular, and extra-articular structures. Neuromuscular dysfunction appears to be a common cause of extra-articular physiological joint restriction. This physiological restriction of muscle length may be a consequence of spinal segment and supraspinal inputs on the gamma loop gain set mechanism. The result is an alteration of extrafusal muscle fiber resting length. Therapeutic exercise techniques have been hypothesized to affect this mechanism directly. The therapeutic techniques of contract-relax and proprioceptive neuromuscular facilitation (PNF), as well as the application of fluoromethane spray and stretch, have all been shown to assist a rapid improvement of restricted joint range excursion.

Gross anatomical, histological, and mechanical data indicate abnormal intra-articular, periarticular, and extra-articular connective tissue structures as the cause of limited passive ROM (PROM). These structures include intra-articular adhesions, periarticular joint capsule stiffness, and shortened extra-articular skeletal muscle. After four weeks of immobilization in a shortened position, cat soleus muscle demonstrated a 40 percent decrease in the number of sarcomeres in series and, therefore, a decrease in length of the parallel elastic component. The decrease in cat soleus muscle length resulted in a shift of its passive length–tension curve to the left and a concomitant decrease in ankle ROM. After four weeks release from immobilization (and normal activity by the cats in their cages during the interim), muscle extensibility and sarcomere number were restored to normal. In another study, joints of monkeys immobilized in shortened positions exhibited decreased ROM, decreased joint capsule length, and loss of extensibility. Reduction of joint ROM and strength of the medial posterior capsule was reported by Lavigne and Watkins to be appreciable at 16 days and marked after 32 days of immobilization.

The mechanism for immobilization-induced capsular restriction of ROM is not well understood and may be multifactorial. Histological studies of immobilized tissue have dem-
onstrated capsular fibrofatty infiltrate, decreased matrix water and glycosaminoglycans, increased major collagen cross-links, and increased total amount of collagen.

Warren et al used rat-tail tendons as an experimental model for clinical stretching techniques. The rat-tail tendons were used to compare two elongation methods similar to those used in this study. Application of low-load, long-duration tension at elevated temperatures, followed by cooling with the load maintained, produced significantly greater residual elongation with less tearing damage to the tissue than high-load, short-duration tension at lower temperatures. The present study included two of the four elements tested by Warren et al: low-load and long-duration tension.

Existing literature supports LLPS as the preferred method of lengthening immobilized, shortened tissues in animal models. Because the very common clinical practice of stretching contractures with manual high loads for periods of a minute or less was contradictory to findings in the literature, this study sought to compare the PROM effects between the clinical treatments of briefly applied manual high loads versus prolonged low loads by skin traction. We hypothesized that if chronic knee flexion contractures of at least 30 degrees in nonambulatory geriatric nursing home subjects are treated with LLPS instead of HLBS, then the passive knee extension ROM will increase significantly.

**METHOD**

**Subjects**

Criteria for admission to this study were 1) the presence of bilateral knee flexion contractures of at least three-months duration and at least 30 degrees short of full passive extension and 2) the inability to walk or pivot transfer without maximal assistance. Eleven geriatric subjects who were nonambulatory and who had demonstrated gradually progressive bilateral chronic knee-flexion contractures ranging from 30 degrees to 132 degrees short of full passive end-range extension participated in this study. Subjects served as his or her own control with one lower extremity receiving the LLPS and the other receiving a traditional combination of both HLBS and PROM. The choice of treatment for each limb was randomly determined. Each treatment was performed twice daily, five days a week for four weeks.

**Procedures**

The lower extremity not chosen to receive LLPS was treated with a traditional regimen of 10 repetitions of passive lower extremity flexion, adduction, and external rotation using PNF diagonals that were followed by the HLBS. The HLBS procedure was considered to be a routine, forced, passive, manual-stretching technique. A maximum manual force was used that did not cause injury. The muscles on stretch were palpably very tight. With the LLPS, this was not the case. The patient’s limb was moved manually at a force and velocity that allowed the soft tissue structures to accommodate to the change in ROM without resulting in excessive resistance, pain on the part of the patient, or the possibility of injury. Once the end range was achieved, this position was manually maintained for one minute. The force was then reduced for 15 seconds. The sequence of HLBS followed by a 15-second rest was repeated three times each treatment session. The total treatment time required for the HLBS and PROM was approximately 15 minutes of patient-practitioner time.

Transmission of LLPS to the limb was accomplished by applying a modified Buck’s skin traction technique (Fig. 1) with the patient in bed. A foam strip measuring 60 in by 3 in by 1 in* was applied to the subject’s lower extremity in a stirrup-like fashion. The central portion of the foam strip was placed at the subject’s heel; its length extended alongside the medial and lateral aspects of the limb. Taped to the center of the foam and positioned at the subject’s heel was a 3-in by 3-in by 0.75-in padded wooden block. A screw eye extended outward from the center of the block and served as an attachment for the pulley rope. The foam strip and block were secured to the limb by two or three 6-in ace bandages. The rope was threaded through a single pulley and a weight was attached to the end. Plastic milk cartons filled with sand were used as weights. The length of each LLPS treatment was one hour; the patient-practitioner setup time required only two to five minutes. Each week the traction weight was increased as follows: week one, 2.27 kg (5 lb); week two, 3.18 kg (7 lb); week three, 4.08 kg (9 lb); and week four, 5.44 kg (12 lb).

In addition to the two methods of stretching described, each subject received a standard upper extremity and trunk program of guided passive movements once daily. This program included 10 repetitions of pelvis-on-trunk rotation and upper extremity PNF diagonals bilaterally.

Standard manual goniometric measurements of the limbs were taken before treatment began and after four weeks of treatment. With the subject in the supine position, a physical therapist moved one limb to its end range of knee extension while also progressing toward maximal hip extension. This end position was maintained for one minute. The knee-extension range was then measured by a second physical therapist. The goniometer arms were aligned parallel to the long axis of the femur and the tibia with the axis at midknee joint. These two tasks were performed by the same individuals throughout the experiment.

* One inch = 2.54 cm.
Sequential medical trials (SMT) were chosen to be the method of experimental design and statistical analysis. This sequential design was considered ideal because 1) subjects could be admitted to the study as they became available, 2) comparisons could be made within the same subject, 3) no statistical computations were necessary, and 4) the experiment could be terminated as soon as statistical significance was achieved (i.e., a predetermined number of subjects was not required).

The SMT plan was designed by Bross. Significance levels were preestablished at the $p \leq 0.05$ level. The outcome measure, passive knee-extension end range, was assessed in two separate test situations. Each test had its own criterion for improvement: Test 1, difference between pretreatment and posttreatment PROM recordings of the LLPS leg must be $\geq 15^\circ$; Test 2, difference in PROM posttreatment change between LLPS and HLBS limbs must be $\geq 10^\circ$.

RESULTS

A total of 11 subjects participated in this study before a $p \leq 0.05$ significance level was attained with SMT. The SMT grids for Test 1 (Fig. 2) and Test 2 (Fig. 3) demonstrate how quickly and directly the LLPS was found to be the superior treatment. In Test 1, when comparing pretreatment and posttreatment knee extension of the LLPS limb, 10 of the 11 subjects demonstrated greater than a 15-degree increase in PROM. When comparing the HLBS with the LLPS limb in Test 2, a 10-degree PROM difference in favor of LLPS was demonstrated in the same 10 subjects. Whether comparing the LLPS limb measurements pretreatment and posttreatment (Fig. 2) or the increase in limb measurement of the LLPS versus HLBS limbs posttreatment (Fig. 3), the results demonstrated a preference (greater increase in PROM) for LLPS in treatment of knee contractures of the immobile nursing home resident. The Table offers a synopsis of the raw data from this study.

DISCUSSION

A simple, noninvasive, nonstressful treatment is always desirable, especially in an elderly group. In this sample, patients did not appear to experience pain while receiving LLPS treatment. Trained physical therapy aides were instructed to implement the exercise program and apply the traction apparatus. Inconvenience to the nursing staff was minimal, and the LLPS device did not impede primary care needs of the patients, such as bathing and elimination.

Most of the subjects were characterized by a history of progressive mental confusion, reduction of mobility, and subsequent physical dependence. The use of traction as a treatment for knee contractures in this patient group was initiated long after the early physiological and possible morphological effects of immobility had developed. The goals of this treatment approach were to 1) reduce contractures to aid in ease of nursing care and 2) increase active movement abilities, including standing transfers.

Changes in activities of daily living (ADL) were not objectively measured in this study. None of these subjects, however, became ambulatory, and all continued to require maximal assistance in transferring. Considering the severity and duration of the contractures, as well as the general mental and...
physical debilitation of these subjects, the reduction in contractures was probably inadequate to affect functional level. With another group, ADL changes might have been used as a criterion for improvement. Future investigations could consider the effects of LLPS for early treatment of contractures in mentally alert hospitalized patients.

Individuals with severe joint restrictions, subjects 2 and 11 in the Table, demonstrate greater improvement with the LLPS treatment than those subjects whose initial restrictions were less dramatic. The number of subjects and study procedures cannot confirm this observation, but it does raise the question of whether contractures of different degrees of severity respond better to different stretching procedures. Other possible explanations may lie in the morphological and physiological changes specific to a given disease process. Patients in this study had a variety of diagnoses, as do most geriatric nursing home residents.

We presumed that the effects obtained in this study were the direct result of connective tissue lengthening. Alterations in neurophysiological input, and consequently, the gamma loop, may also have been a factor. Neurological changes occur rapidly and accommodate quickly, and, therefore, were not measured or focused on in this study. The results of this study are in accordance with those of Warren et al who used a rat-tail tendon model to study the effects of load on tissue elongation. Low-load, long-duration tension produced greater elongation of tissues than high-load, short-duration tension. Temperature, a variable not considered in this experiment with humans, was found by Warren et al to enhance tissue elongation in rats.

Sapega et al have published a treatment protocol designed to increase ROM in the postconstricted and immobilized knee. Their protocol was based on principles evolved from the results of in vitro, connective-tissue studies in animals, including the study of Warren et al, and involved the use of heat in addition to low-load, long-duration tension. Their recommended treatment sequence is 1) heating of the shortened tissues, 2) applying the load while maintaining the elevated tissue temperature, 3) maintaining both the load and heat throughout the treatment period, 4) cooling the tissue below the normal body temperature before the load is removed, and 5) removing the load. No experimental data were presented. Sapega et al did not incorporate a traction component into their stretching technique. We believed joint mechanics to be an important consideration. We attempted to apply the load in line with the tibia, so as to distract the knee, and reduce compressive forces that may be created by lengthening of imbalanced shortened tissues. The results of this study may partially reflect the difference in treatment times between the two groups. A future study is planned to compare results of light-load versus heavy-load, skin-traction progression with equal treatment time for groups.

CONCLUSION

Chronic knee flexion contractures are a familiar clinical problem to most physical therapists. This study was performed to compare the results of two methods of treatment (LLPS vs HLBS) in increasing the passive knee extension ROM of knee flexion contractures in a group of elderly, nonambulatory, nursing-home patients. The SMT design allowed the obvious preference for LLPS to be attained at the

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