Review of Physical Therapy Alternatives for Reducing Muscle Contracture

DIANNE B. CHERRY, MS

Passive stretching is a technique frequently used to treat muscle contractures; however, because it can activate the stretch reflex and has little carry-over, it may not be as effective as other modes. Four approaches to treating muscle contracture are described: 1) activation or strengthening of the weak opponent, 2) local inhibition of the contracted muscle, 3) general inhibition of hypertonus, and 4) passive lengthening. Specific examples of techniques, their rationales, and suggestions for use of each are discussed.

Key Words: Contracture, Exercise therapy, Muscles, Physical therapy.

A primary objective of physical therapy is maintaining or regaining range of motion in cases of orthopedic or neuromuscular dysfunction, in order to prevent or reduce myostatic contracture. A muscle may become tight and develop a myostatic contracture if the joint it crosses does not go through full range of motion regularly. Manual passive stretching of the tight structures is frequently used to prevent or reduce such contractures.1-4 Passive stretching is the most obvious and direct solution; unfortunately, stretching may be of limited effectiveness and is often painful.4 Research in kinesiology and neurophysiology provides some alternatives to passive stretching. These alternatives will be reviewed, and the purposes and rationale of each will be considered.

There are many possible causes of myostatic contracture, which can be understood as an intrinsic muscle shortening sufficient to prevent full range of motion, though at the end of the available range there is a resiliency or spring. The problems of limited range of motion caused by capsulitis, bony deformity, skin or soft tissue contracture, or fixed irreversible muscle contracture of long-standing duration are best treated by modalities and methods other than those to be discussed here. Individual muscles will not be discussed, since contracture can present a problem in almost any muscle. For clarity, the tight or contracted muscle will always be referred to as the antagonist, for it opposes the motion desired, while its opponent on the other side of the joint will be referred to as the agonist, whose movement would be in the direction desired to reduce the contracture.

CAUSES OF CONTRACTURE

Most definitions of muscle contracture include the concept that a muscle or group of muscles has shortened sufficiently to prevent complete range of motion of the joint or joints it crosses.2-4 The shortening may be caused by intrinsic adaptive change in response to prolonged positioning, as often occurs after orthopedic immobilization.2 Another cause is poor positioning, as in poliomyelitis or myelomeningocele with dynamic imbalance of muscle power, when a stronger, unopposed muscle shortens and is never lengthened by its weak opponent.1,5 Contracture may also result from influences extrinsic to the muscle; for instance, CNS damage can cause spasticity and prolonged fixed postures.5 The result may be the same as in intrinsically caused contracture, with the spasticity “accompanied by reciprocal inhibition and weakness in the antagonist muscle group, giving rise to imbalanced muscle pull and the development of contractures.”6 (Wyke's use of the term antagonist is opposite to the meaning used in this article.)

ALTERNATIVE APPROACHES TO REDUCING MUSCLE CONTRACTURE

Passive stretching uses forced motion to restore the normal range of motion when this range is limited by loss of soft tissue elasticity.3 Its effect on muscles is to lengthen the elastic portion of the muscle passively, allowing greater length and hence greater range at

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Ms. Cherry is Assistant Professor of Physical Therapy, Department of Health Science, Cleveland State University, Cleveland, OH 44115 (USA).

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the affected joints. However, "any increase in range obtained by forced motion will be lost unless maintained by active motion or by supportive devices."\(^3\)

Passive motion requires no participation by the patient and results in no motor learning, so it does not improve the capacity for active motion of the tight muscle or its opponent. Muscle tightness is therefore likely to recur. Also, inasmuch as passive lengthening stimulates the stretch reflex,\(^7\) which causes the muscle to contract even more, passive stretching becomes a self-defeating activity. Thus, passive stretch may not be the technique of choice in treating muscle tightness. Alternative solutions for lengthening contracted muscles should be explored.

Physiology and technique must be considered in selecting the most appropriate method to reduce contracture (Figure). Integrity of the muscle and surrounding muscles and their innervation are important considerations. When tightness is caused by spasticity, the spastic muscle responds to stretch differently than does normal muscle. The spastic muscle or muscle group is characterized by exaggerated resistance to passive stretch and, frequently, powerful reciprocal inhibition of its opponent.\(^3\) Tightness caused by spasticity and tightness of a normal muscle adaptively shortened because of plaster immobilization may require different modes of intervention. Treatment is more effective in preventing contractures from spasticity than it is in reducing it. The ability of the patient to cooperate and participate in treatment is another factor to be considered in selecting a method of treatment.

Four approaches to lengthening or stretching reversible muscle contractures will be discussed. One approach is to activate or strengthen the weak, over-stretched agonist opposing the tight muscle. A second approach is to inhibit selectively the tight muscle so it will tolerate being stretched without immediate activation of the stretch reflex. A third approach is to reduce hypertonus, when present, in the limb or the entire body to allow a spastic tight muscle group to relax and be lengthened. The last approach is passive lengthening. Some of these methods may be used simultaneously—one may enhance another. Many of the techniques proposed have been found to be empirically effective but must be validated by clinical research.

### Activating or Strengthening the Weak Agonist

The agonist working in opposition to a contracted muscle is in a position of excess length, to which it has adapted by changing its spindle bias.\(^8\)\(^,\)\(^10\) The agonist is unable to shorten effectively against the contracture in its antagonist. If innervation is intact and the agonist has the ability to function at all, a double benefit will be gained by improving its ability to contract. If the agonist becomes stronger, it will be able to counter the contracture of the antagonist and pull the joint through more complete range. Also, the antagonist will be reciprocally inhibited,\(^10\) allowing itself to be stretched because the stretch reflex is also inhibited. Ultimately, if the weak agonist can be activated and strengthened, better muscle balance around the joint may result, reducing the potential for recurrence of myostatic contracture.\(^4\)\(^,\)\(^7\)

Strengthening the muscle opposing a contracted muscle is an approach that may be applied to almost any kind of patient in whom the agonist can be activated. Techniques that improve or facilitate the
function of the weak agonist are very useful for orthopedic rehabilitation as well as for treating neurological problems because if innervation is intact, muscles are likely to respond to treatment most optimally. Examples of clinical problems in which activation of the weak agonist may be effective are muscle contracture in the remainder of an amputated limb, after immobilization for a fracture or other reasons, lower motor neuron lesions in which some intact innervation remains, and spasticity and hypertonus.

Selection of technique will depend on the nature of the problem and the ability of the patient to cooperate. Effective strengthening methods that employ resistance or load on the muscle include maximal resistance in diagonal spiral patterns and progressive resistance exercises. Methods that use unconscious automatic responses to activate the weak agonist include elicitation of the righting and equilibrium reactions. The long-term effectiveness of these techniques results from demanding that muscles practice skills that they will be expected to perform when therapy is completed.

If the agonist is extremely weak or inhibited or both, facilitatory techniques may enhance its function and increase its strength, thereby enabling it to oppose the tight antagonist effectively. These facilitation techniques use exteroceptive and proprioceptive stimulation, causing summation in the CNS, which lowers the threshold of efferent, or muscle action, response. Carefully applied stimulation may make it easier for the desired muscle to respond. Many different kinds of techniques facilitate the function of a weak muscle. For example, vibration, quick icing and brushing, and tapping may be done easily with simple equipment. Electromyographic (EMG) feedback has been effective in improving control in muscles opposing spasticity. Proprioceptive neuromuscular facilitation includes a variety of techniques such as manual contacts, traction, approximation, repeated contractions, quick stretch, and resistance. All of these techniques, used individually or in combination, enable a therapist to elicit a response from a weak or inhibited muscle that the patient alone is unable to activate adequately.

Vibration may be particularly useful when the antagonist is spastic and the agonist is very much inhibited. Applying vibration to the weak agonist can help cause activation in that muscle and simultaneous reciprocal inhibition in its spastic antagonist, allowing easier movement in the desired direction.

Local Inhibition

An agonist may be unable to contract at all, or a muscle may be so tight that attempts to strengthen the agonist fail. Also, even if the agonist can be activated, it will move through more complete range of motion if the stretch reflex of the tight antagonist can be inhibited; therefore, inhibition of the tight muscle should be considered. Inhibition can be developed locally within a limb segment or it can be obtained more generally within the limb and entire body by way of the CNS.

Local inhibition is useful for localized tightness, especially within one muscle group at one joint, such as after plaster immobilization following injury or surgery. Vibration to the opposing muscle group causes reciprocal inhibition to the contracted muscle. Neutral warmth causes decreased gamma motor neuron activity; prolonged icing causes slower nerve conduction and diminished spindle and myotatic reflex activity. The hold-relax and contract-relax techniques of proprioceptive neuromuscular facilitation work by means of successive induction, when a muscle is inhibited after a contraction while its opponent is facilitated. The hold-relax procedure has been found to be more effective than passive stretching in lengthening the hamstring muscles in normal individuals.

General Inhibition

Another approach to passive stretching is based on inhibition of muscle tone throughout the body, which may be accomplished through both somatic and autonomic components of the CNS. Generalized inhibition may be particularly effective when hypertonus or spasticity interferes with normal movement. Inhibition causing a reduction of hypertonus may allow greater active or passive range of motion because the stretch reflex would not respond as readily to movement. Spasticity can be considered a release-from-inhibition phenomenon. Therefore, methods that develop inhibition may decrease spasticity and improve motor control. Inhibitory techniques may also be effective when a patient's neuromuscular control is inadequate (because of age, mental status, or CNS dysfunction) to participate in the activation of the agonist or the hold-relax technique. Bobath and Rood have both developed techniques that use generalized inhibition of hypertonus. Bobath has described particular movement patterns of proximal joints ("key points of control") that affect tone of the trunk and limbs. By these patterns of movement the tight or spastic muscle groups may be inhibited and, simultaneously, normal movement facilitated. This technique enables the patient to develop active agonist control at the same time, enhancing effective-
ness of the treatment. When the spastic limb is inhibited, its muscles will not respond to stretch as readily, permitting the limb to move through more complete range of active motion and preventing the development of myostatic contractures.

Ayres has proposed that slow rocking, which provides vestibular stimulation of low frequency, inhibits the reticular formation of the CNS and has a calming effect. It is a technique employed by parents of infants over the ages and is probably the basis for such calming measures as using wind-up swinging chairs and walking the floor. For the individual with spasticity, slow rocking may help reduce tone to allow normal movement.

Little has been written about several other inhibitory techniques, learned empirically by those therapists working with very spastic patients. One such technique is slow, rhythmical rotation about the body axis, frequently the pelvis rotating on the thorax. It may be done manually by the therapist, and certain spastic individuals may learn to rotate themselves. This slow rotation reduces hypertonus in the limbs and trunk, allowing more freedom of movement and more normal movement. The rationale for this technique has not been described but may be related to Bobath's "key points of control" and elicitation of normal righting reactions.

Another little-described or -explained technique that may empirically be found effective in decreasing spasticity is to treat the patient on a slightly moving surface, such as that provided by a ball, bolster, or equilibrium board. The rationale for this technique is twofold: 1) the slightly moving surface is relaxing, probably like the effect of a rocking chair or other gentle motion and 2) carefully graded and planned movement of the supporting surface requires subtle equilibrium responses as the patient adjusts to being moved. With careful monitoring, normal muscle action to maintain balance may develop and the patient with spasticity may learn to move in a more normal way.

The head-down or inverted position may be useful for general inhibition of tone. Gellhorn describes the influence of increased blood pressure in the head as stimulating the carotid sinus in the neck and causing a generalized parasympathetic effect. Reduction of muscle tone is one result and can be noted in small children during inversion for postural drainage, for they often relax completely, some to the point of falling asleep. Hypertonic or irritable children may be calmed in this position. A person with hypertonus who can tolerate inversion may benefit by the general reduction in tone, for movement may be less restricted, muscles may relax, and potential contractures may be easier to prevent.

**Passive Lengthening**

Three different approaches to avoid eliciting the stretch reflex when lengthening a contracted muscle have been described. There are times, however, when none of these methods may be used, either because the agonist is too weak to respond or because attempts to inhibit the antagonist tone are unsuccessful. In conditions of weakness or paralysis, the neuromuscular mechanism may be so disturbed that the muscle may not respond to stimulation. Advanced stages of muscular dystrophy and peripheral neuropathies are examples of disabilities that may require direct passive lengthening because in each condition the tight muscle and its opponent are unresponsive to other measures of intervention.

If passive lengthening is selected as the appropriate alternative, there are two kinds of techniques from which to choose. One technique is prolonged holding of the desired position at the point of maximum tolerated length of the contracted muscle. The stretch receptors of a muscle will become less sensitive to stretch applied very slowly and maintained for a long time. A variety of methods may be employed. Orthoses and splints may be used to hold joints in desired positions. Adaptive equipment may enable an individual to function in certain positions more readily. For example, a barrel chair for hip abduction in sitting for a person with an adduction tendency or a prone standing board for extension in weight bearing for persons with lower extremity flexor problems may be effective. Individuals can be taught which positions for sitting, sleeping, and other daily activities will be most helpful in correcting muscle shortness. For example, individuals with muscular dystrophy may be taught to use a long sitting position to maintain hamstring muscle length. The advantages of positioning are that it avoids the position of contracture for the duration of the positioning, 2) may be maintained over a long period so that treatment effectiveness is prolonged, 3) may be incorporated into the patient's daily routine, which increases the likelihood of its being done regularly, and 4) is usually painless.

If the above treatment suggestions are inapplicable or ineffective, the technique of manual passive stretching of the tight antagonist may be employed. Passive stretching is likely to be most effective in individuals whose stretch reflex is inhibited, either by cortical effort at relaxation or in paralytic conditions. Very slowly applied passive stretch is likely to be the most effective technique, for it should avoid eliciting the stretch reflex and may cause the muscle to be locally inhibited. An example of the latter is myelomeningocele, in which severe weakness or paralysis
and tightness are often present in the same muscle. Only positioning and passive exercises will be effective in gaining range at those joints that have no active movement.

SUMMARY

Passive stretch to a contracted muscle has several disadvantages. It does not improve active motion of the opposing muscles and may elicit a stretch reflex contraction in the contracted muscle if innervation to the spinal cord is intact. This reflex contraction is undesirable because it interferes with the desired motion. Also, stretching is often painful.

Four approaches to reducing muscle contracture have been described. Ideally, the weak opponent muscle or agonist should be strengthened, if possible, to enable it to move the joint through full range and prevent recurrence or further development of the muscle contracture. Other alternatives that may be used before, or instead of, strengthening the weak agonist include specific local inhibition to the contracted muscle or general inhibition to the limb or entire body. If the stretch reflex can be inhibited, the agonist may contract more easily and the tight muscle may be stretched more easily and effectively. Finally, prolonged maintenance in the desired position by means of adaptive equipment and splints and performing activities of daily living may be more comfortable and more effective than passive manual stretching because the procedures are carried out for longer periods.

The variety of techniques available for treatment of muscle contractures challenges physical therapists to gain an understanding of the principles on which the techniques are based and to develop skill in their application. Research is needed to establish which procedures are most effective for what kinds of problems, as well as to determine the scientific rationale of procedures empirically found to be effective. Research may also lead to development of additional techniques.

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