MUSCLE RE-EDUCATION

Some New Approaches and Facts

By A. C. PETRICK (Dipl. Physiotherapy (Pta.), R.N.)

(With kind permission of Dr. (med.) W. Zinn, Bad Ragaz, Switzerland)

Muscle re-education is one of the most important facets of the physiotherapist's work, irrespective of whether it is a case of weak, paralysed, injured or diseased muscle. During her training the physiotherapist is taught all the essentials, but there are a few facts that are either just skipped or never specifically mentioned. Some of these will be considered in this paper.

Main Causes of Muscle Atrophy are:

1. Neurological conditions: central and/or peripheral.
2. Operations: e.g., the Facial Nerve may be injured in mastoidectomy.
3. Trauma: to muscles, joints, bones and nerves.
4. Post-natal injuries and conditions.
5. Ill-use or disuse:
   (i) when a limb is immobilized for a long period, without sufficient sustaining exercise;
   (ii) the small intrinsics of the feet atrophy severely due to disuse causing dropped arches.

The above conditions all necessitates muscle re-education by ACTIVE TRAINING! The value of passive movements, especially in the earlier stages, to keep the joints and tissues mobile and to maintain the circulation, should certainly not be forgotten in the enthusiasm for active training.

Muscle re-education by active training is mainly based on neurophysiological, physiological, anatomical and clinical considerations and facts. The most important of these are:

1. The Motor Nerve Structure.
2. The physiology of a muscle contraction.
3. The Muscle Groups.
4. The Muscle arrangement in the body.
5. The Motor Unit.
6. The Muscle Unit.

1. The Motor Nerve Structure:

A true Motor Nerve never consists of only motor nerve fibres, but rather:

(i) 40 per cent sensory fibres (to the muscle spindle)
(ii) 20 per cent motor fibres (of the alpha type)
(iii) 35 per cent motor fibres (of the gamma type)
(iv) few sympathetic fibres.

2. The Physiology of a Muscle Contraction:

A muscle contraction is always the combination of a voluntary movement and a reflex reaction. Use this knowledge in muscle re-education, i.e., give a short sudden overstretch just before the exercise (reflex) and give a clear command (voluntary).

3. The Muscle Groups:

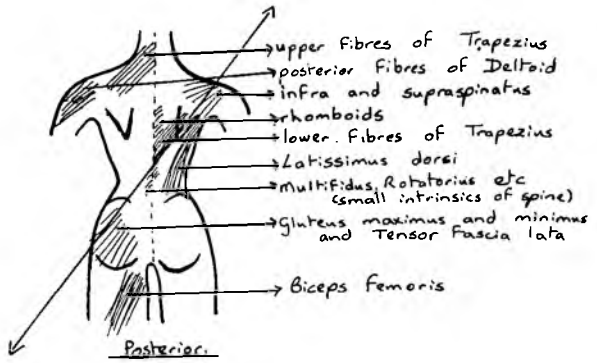
It is known that hard work to one group of muscles (e.g., the fingerflexors) causes the proximal and/or distal muscles (e.g. the elbow and shoulder flexors) also to come into play to strengthen the action.

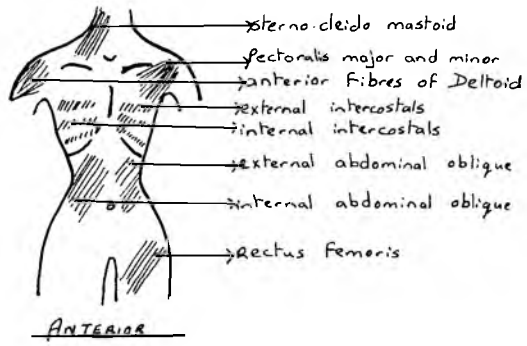
4. The Muscle Arrangement in the Body:

The general arrangement of most muscles and even various other tissues in the body, lies in an oblique line. This type of arrangement is noted in the trunk and the limbs. Therefore the most natural and vigorous actions take place obliquely or with a small initial rotation, e.g. when chopping wood.

5. The Motor Unit:

This consists of the motor nerve from the brain to the muscle fibres via the spinal cord. Each muscle fibre of a particular muscle, e.g. gastrocnemius, is synchronously innervated by the nerve. This ensures that either the contraction has a maximum value or else there is no contraction at all (depending on whether the innervation is intact or not). Another interesting but logical fact, is that the innervation depends entirely on the number of muscle fibres comprising a muscle, e.g. the eye-muscle has about 100 fibres and gastrocnemius, about 2,000 fibres to be innervated, all by the same nerve, or rather axon!



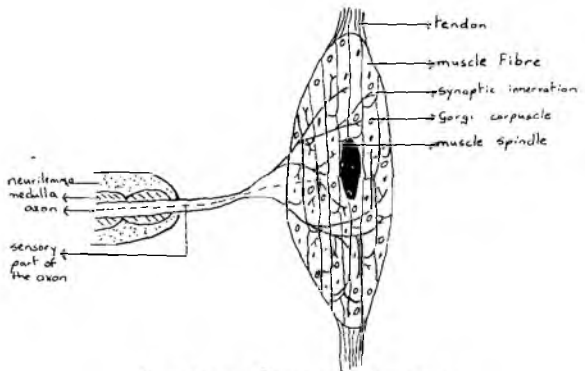


SCHEMATIC REPRESENTATION TO SHOW THE GENERAL DIRECTION OF PULL OF THE MAJOR TRUNK MUSCLES.

6. The Muscle Unit:

A muscle unit consits of:

(i) Muscle fibres.
(ii) Golgi corpuscles in the muscle fibres.
These are sensible to the STRETCH and IRRITATION REFLEX in the fibres, provided that the stretch is short and quick. If the stretch is slow, these corpuscles become inert (Similar bodies "Gorhl Corpuscles" in the tendon's fibres react to the prolonged stretch.)
(iii) The muscle spindle with motor and sensory nerve endings which gives the sensation of tension and pressure in and to the muscle.



SCHEMATIC REPRESENTATION OF A MUSCLE AND ITS MOTOR NERVE.

Physiological Facts to Consider:

1. The Stretch Reflex:
This is initiated by a tesnion/pressure sensation on the muscle spindle and golgi corpuscles. Any stimulus of pressure or overstretch on a muscle, provided it is of short duration—causes a reflex tightening of *that* muscle, aimed at relieving the pressure.

The stretch reflex is perhaps best illustrated in the case of flaccid paralysis (provided that other tests have proved that the innervation is intact). It oftens happens that quite a few stretches are necessary in the beginning to obtain any response, while in a spastic paralysis one obtains a far quicker response very similar to a normal contraction.

2. Alpha and Gamma Fibre:
The Motor Nerve consists of alpha and gamma fibres. If the gamma fibres are injured—even if there is no *direct* central lesion—the result is spasticity!

3. Central and Pyramidal Cell Lesions:
These also cause spasticity.

4. The Motor Nerve
It has to be intact for any contraction to occur at all! The reflex contraction to the stretch stimulus will take place only if the nerve pathway from the anterior horn cell to the muscle exists.

To enable one to obtain a clear picture of a specific case it is advisable to perform certain tests and to perform these again at regular intervals, their object is: (i) to obtain a better judgment of what can and what cannot be done, the stretch of the muscles and the extent of atrophy; (ii) to have a continuous control throughout the treatment, to determine whether there is any improvement or not and thus to establish if a given treatment is beneficial or whether some other method should be tried; (iii) to save time, because attention may be concentrated on muscles that are regenerating (or may possibly regenerate) so as to bring them to full strength; while completely denervated muscles can be neglected, except, of course for continuing with passive movements to keep the tissues and joints mobile and to maintain the circulation.

These well-known tests, include:

(*a*) **The functional muscle test (0-5);**

(*b*) **Testing for any contractures;**
(e.g. testing for flexion contracture of the hips.) The patient is put into a lying position with the hips extended. Flex one leg fully passively out. *The test,* should the other leg also tend to flex, it indicates a a contracture of that hip's flexors (and knee extensors, should the knee also flex).

(*c*) **Power of the muscles:**
For example by using sandbags or special weights the patient can hold for three seconds having the muscle in a contracted position, the limb being in the position of the longest lever possible (e.g. the straight arm abducted to 90 deg.) the weight held on the outstretched hand);

(*d*) **Joint Mobility:**
that is the range of movement the joint is capable of attaining.

(*e*) **Circumference of the Limb and/or Joint:**
Measure over the same level each time, e.g., for the knee-joint and thigh; over the patella 2½ in. above and 6 in. above the base of the patella. The compared measurements of right and left will indicate atrophy, and subsequently the amount of hypertrophy obtained.

(*f*) **Length of the Limbs:**
This is of special importance in the lower limb whether after fractures in a limb or after paralyses, especially in the case of children.

(**Note:** It has recently been found in Europe that the administration of shortwave Diathermy and hot moist packs daily (the latter 3-4 times daily) is of immense value to increase the growing power in the paralysed limbs of children. Since this method of treatment was adopted (about 5 years ago) no severe shortening of limbs has again been noted in treated cases. The period is as yet too short to say whether the method is entirely reliable and whether the result is continuous, i.e., that shortening will not occur later as the children become older. However, the method is harmless and there is no reason why it should not be applied to obtain more evidence.)

(*g*) **General Functional Ability of the Limb:**
Can the patient walk, ascend and descend stairs, wash his face, eat, dress, etc., by himself? What does he need? Does he use trick-movements? (This, however, does not matter at all.) Consider the gait carefully and measure the length of the steps. Find out the amount of activity the patient has during the day. Encourage him to do as much as possible for himself.

(*h*) **Electro diagnosis:**
Determine the rheobase, i.e., the smallest milliamperage with the longest impulse still allowing a contraction.

(*i*) **Electromyography:**
This test is usually done by a doctor. Unfortunately it is not as yet been used much in South Africa. It has the same principle as an electrocardiography. During contraction each muscle gives rise to an electrical impulse (demonstrated by a wave in a graphic representation). A needle is inserted into the belly of the muscle to be tested and a graphic recording is made of these electrical impulses.

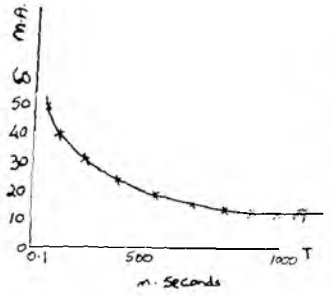
Diagrammatic Representation of such a Graph:
Time

Normal:
at rest: Graph represented by a straight line.
active: Definite contractions with rest periods.

Denervated:
at rest: Fibrillating.
active: Fibrillating, no definite contraction and relaxation indicated.

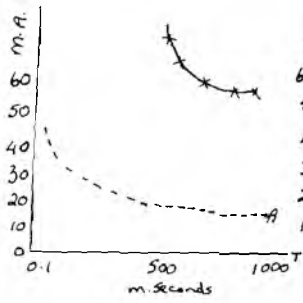
Regeneration:
at rest: Fibrillation less, though still noticeable.
active: Fibrillation less harsh. Few definite contractions and rest periods are distinguished.
This test is influenced by:
Temperature of the surroundings;
Obesity;
Fatigue.

Note: One can never really fully isolate a muscle contraction as it is always combined with that of other muscles!



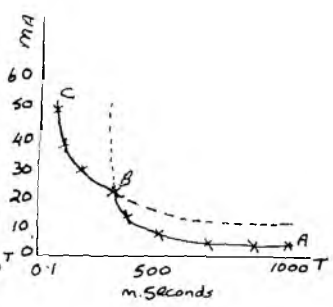
Normal

A: Rheobase



Denervated.

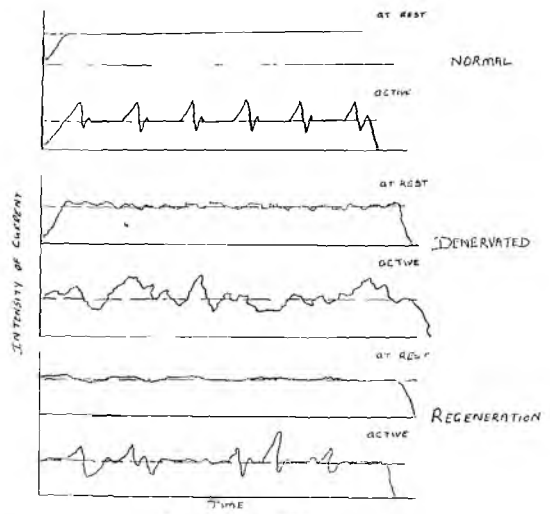
The graph is lower than normal initially. Later it moves up and to the right, till it completely disappears.



Partial Denervated.

The first part of the graph is lower and more to the right. The second part is like that of a normal graph. Muscle contractions are slow (A→B) then suddenly start to become short and sharp (B-C)

SCHEMATIC REPRESENTATION OF THE GRAPH TO BE SEEN IN DIFFERENT CASES WITH THE ELECTRO-DIAGNOSTIC TEST.



ELECTRO-MYOGRAPHY

NORMAL : AT REST: GRAPH REPRESENTED BY A STRAIGHT LINE.
ACTIVE : Definite contractions with restperiods

DENERVATED. AT REST: FIBRILLATING
ACTIVE: FIBRILLATING; no definite contraction and relaxation indicated.

REGENERATION AT REST: Fibrillation less marked (still noticeable)
ACTIVE: Fibrillation less harsh. Few definite contractions and restperiods are distinguished

Muscle Action depends on:

1. Stimulus in the brain:
   (i) the will of the patient;
   (ii) vocal command;
   (iii) the perfect understanding of a required exercise.
2. Learnt movement of the pattern: The aim should be to make this virtually automatic.
3. Full proprioceptive and sensory information to the brain and central nervous system.
4. The intactness of the motor pathways to the anterior horn cells.
5. The continued existence of primary reflexes (even in spastics) which promotes special basic models of movement.

Active Training:

This can be defined as the adaptation of a muscle to exercise and rest.

Effects:

1. Hypertrophy:

Not only do the individual fibres hypertrophy, but it has also been proved recently that there is actually formation of more fibres. Only exercises against strong resistance lead to hypertrophy. Often it is even better to give isometric (static) exercises although the patient finds them more difficult than the more primitive type of exercises (isotonic, i.e. concentric muscle work) with actual movement.

2. Adaptation of the enzyme activity in the muscle fibres:

3. Formation of a reflex arc:

If the exercise is repeated often enough, a reflex arc may be formed even if the muscle is completely denervated.

4. Improvement in the Blood Supply:

Active training increases the blood supply up to ten times more than any other method (ice, heat, etc.). This is especially seen in the case where isometric exercises are done.

5. Better Oxygenation:
Due to the improved circulation better oxygenation is possible, which again increases the endurance.

Improvement Points to Watch During Treatment:

1. Always aim at making the exercises FUN for the patient! Let him realise their objective; praise him when he does well so as to stimulate his perseverance. Do give him time to rest and recuperate in between—for short periods of course. Your treatment should not become a chatting session!
2. Avoid giving him PAIN. It will only break down what has been achieved already, will cause muscle spasm and lessen the co-operation from the patient. If the treatment causes no pain, the patient does not dread his treatment. Use ice or heat, or any other method you and any member of the medical team can think of (e.g., pain-relieving tablets, procaine infiltrations, etc.). Look for the *actual* cause of the pain. THERE IS ALWAYS A WAY! (Slogan of Margaret Knott and Dena Gardiner.)
3. Regulate the speed of the exercise and watch the patient's co-ordination during his treatment.

Physiotherapy:

1. Do all the tests available.
2. **Electrotherapy.**
   Use it as an aid only! Try to get along with as little electrotherapy as possible. Electrical stimuli *do not* (contrary to general belief) prevent atrophy, or maintain joint and tissue mobility, neither does it increase the circulation much. It often is unpleasant and even painful. The main use is to give the patient an idea of what he is expected to do during active training. Use it with discretion, though.
3. **Exercises:**
   (i) Give passive exercises to keep the joints and tissues mobile and to increase the circulation.
   (ii) Always start an exercise with a slight to definite stretch of the particular muscle to be trained never train a muscle in its shortened position, because the muscle spindle is not stimulated at all).
   (iii) P.N.F.: Use all the principles: stretch, vocal command, maximal resistance, manual touch, traction and compression. Remember particularly the muscles with double function, e.g., the biceps.
4. **Use all the Reflexes:**
   (i) Balance reflex (especially in athetosis);
   (ii) Stretch reflex (especially in paralysis);
   (iii) Flexion reflex (especially in ankylosing spondylitis.)
   Note: The quick stretch is NOT used on spastics. Use a slower stretch, avoid sudden touch and pain. Use spastic relaxing positions (e.g., stride sitting) and other spasm reducing methods (e.g., ice).
5. **Trick Movements:**
   Train the synergists—train trick—or rather compensatory-movements when a muscle is completely denervated to allow a certain function to be done, e.g., to abduct and elevate the shoulder.
6. Do not forget to attend to the patient's posture gait, possibility to ascend and descend stairs, and his functional activities daily (e.g., dressing, getting into and out of a bath, etc.). This is not only the occupational therapists work!
7. Join the patients in invalid sports groups. It is stimulating and encouraging to them; arouse a competitive atmosphere. Play various games (e.g. badminton) even if modified positions, like sitting on the floor or in a wheelchair are used. Archery is very much enjoyed by everybody. The groups may be very mixed, e.g., paralytic cases of all types and various limbs or fracture, muscle and other injuries, and various bone and muscle disease cases may be grouped together with no harm, as long as each patient benefits from the group, each one aiding the other.
8. **Mechanical Aids:**
   Sticks, splints, calipers, crutches. See that they fit correctly. Preferably teach the use of ELBOW CRUTCHES with which they are much more independent. Even P.O.P. cases benefit more from elbow crutch use. See that these aids are correctly used.
9. **Operations:**
   If operations are necessary, carry on with the usual pre- and post-operative treatment. Resume active training as soon as possible.
10. **Water Therapy:**
    It is a fantastic aid to active training, when strongly resisted active work is given in the pool.

Results: The results to be obtained will depend on:
(i) the muscle power at the commencement of the treatment;
(ii) Oedema (wehther it occurs or not);
(iii) at what *stage* exercises are started.
(iv) duration of the treatment and exercises each day;
(v) technique and quality of the treatment.

These are the general principles of active training in muscle re-education. The physiotherapist, with her knowledge of physiology and exercise must endeavour to get from the patient his fullest co-operation. His recovery will be the greatest reward one can get.