PART IV

CHAPTER

16

Muscle Strength

LEARNING OBJECTIVES

On completion of the chapter, students will be able to:

- Identify structural features contributing to muscle strength.
- Describe types of muscle work with examples.
- Discuss the ranges in which a muscle works.
- Describe the group action of muscles.
- Enlist causes of muscle weakness or paralysis.
- Enumerate measures used to initiate muscular contraction in early re-education.
- Mention the principles of treatment for preventing muscle wasting.
- Explain the principles of treatment to increase muscle strength and re-educate function.

CHAPTER OUTLINE

INTRODUCTION

Active movement of the skeleton is brought about by the contraction of voluntary muscle. This muscle tissue has contractile properties which are activated by nerve impulses, to supply the effort required to move or stabilise the body levers.

STRUCTURAL FEATURES

Muscle Fibres

The structural unit of voluntary or skeletal muscle is the **muscle fibre** (large extrafusal), which is cylindrical in form and averages from 20–40 millimetres in length, and 1/10 to 1/100 of 1 millimetres in diameter. It is enclosed in an elastic sheath called the **sarcolemma**.

Some fibres appear '**red**' due to a rich blood supply and the presence of a pigment. Their contraction in response to stimulation is slow, but can be sustained for a considerable time without fatigue. This type of fibre, therefore, predominates in the anti-gravity muscles which are primarily concerned with the maintenance of posture, e.g., soleus.

Other fibres, paler in colour, and called '**white**', respond rapidly to stimulation but are easily fatigued. These form the greater part of muscles which are primarily responsible for movement, e.g., gastrocnemius.

Muscle fibres, lying parallel to each other, are grouped together and surrounded by connective tissue to form **bundles**, and many bundles are bound together by denser connective tissue to form the substance of a muscle.

Connective Tissues

Muscles are attached at both extremities to bone, cartilage, or fascia, by fibrous tissue which is continuous with the connective tissue investing the muscle. This fibrous tissue contains elastic non-contractile elements and may be concentrated to form a narrow cord, or spread out to form an **aponeurosis**.

Body Levers

The more proximal of these attachments, which usually remains relatively fixed when the muscle contracts, is known as the **origin**, to distinguish it from the **insertion**, which is the attachment at which the power of contraction is concentrated to produce movement of the **body levers** (Ch 1, p. 12). Either attachment, however, may be free to move toward the centre of the muscle, or the insertion may remain relatively fixed and the structure of origin moved, in which case the muscle is said to work with reversed origin and insertion.

The form of a muscle varies according to its function. A wide range and speed of movement is produced by the contraction of long fusiform muscles in which the fibres are all relatively **parallel** to, or **in series** with, each other and the tendon of attachment. By this arrangement the number of muscle fibres included is relatively few and limited by the length of the muscle, with the result that no great power can be exerted, as the power of muscle contraction is directly proportional to the number of fibres stimulated. The **number of fibres** is much increased, in the case of muscles designed primarily for powerful contraction, by the inclusion of fibres arranged obliquely or at right angles to the line of action of pull of the muscle as a whole (Ch 1, p. 14). The forces of contraction are compounded at the point of attachment, but the range of movement is obviously limited.

Neural Connections

Muscles are supplied by **nerves** which contain both **motor** and **sensory** fibres. Each motor fibre has a cell in the anterior horn of the Spinal Cord or in the nucleus of a Cranial nerve which can be influenced from a variety of sources. The fibre or axon of this **lower motor neurone** divides on reaching the muscle into 5–150 branches each of which terminates in a **motor end-plate** beneath the sarcolemma of a muscle fibre.

A motor neurone and the muscle fibres it supplies constitute a **motor unit** (Fig. 2.1). The unit is activated by stimulation of its cell which discharges impulses for transmission to the muscle fibres which respond by contracting.

Receptors

Sensory **receptors**, which record the tension of passive stretching, the degree of contraction, pain and deep pressure, are found in muscles and tendons, and impulses recording these are conveyed to the central nervous system. The receptors sensitive to stretching of the muscle are component parts of the **muscle spindles** which lie between and parallel to its fibres and the muscle responds to stimulation of its stretch receptors by an increase in intramuscular **tension**. The functions of the spindles and their nervous connections also serve to increase the efficiency of motor unit activity. Stretch receptors in tendons are stimulated by prolonged stretching which results in inhibition of muscle contraction. Sensory fibres from receptors in the fibrous tissue which surrounds joints, travel in the same nerves which supply the muscles which pass over the joints, and a reflex contraction of these muscles in cases of strain is an important factor in preventing joint injury.

Must Know

When stimulated, the muscle fibres contract to their maximum capacity in the circumstances, i.e., the maximum contraction which results from a single stimulus is summated by subsequent stimuli arriving at a sufficiently high frequency. The number of motor units activated at any one time determines the **strength of the contraction** of the muscle as a whole and the strength of the contraction is determined by the **resistance** offered to the contraction.

TYPES OF MUSCLE WORK

Muscle work involves an increase in intramuscular tension; when this is accompanied by a change in the length of the muscle the contraction is said to be **isotonic**. When intramuscular tension is increased without a change in the length of the muscle work is **isometric**.

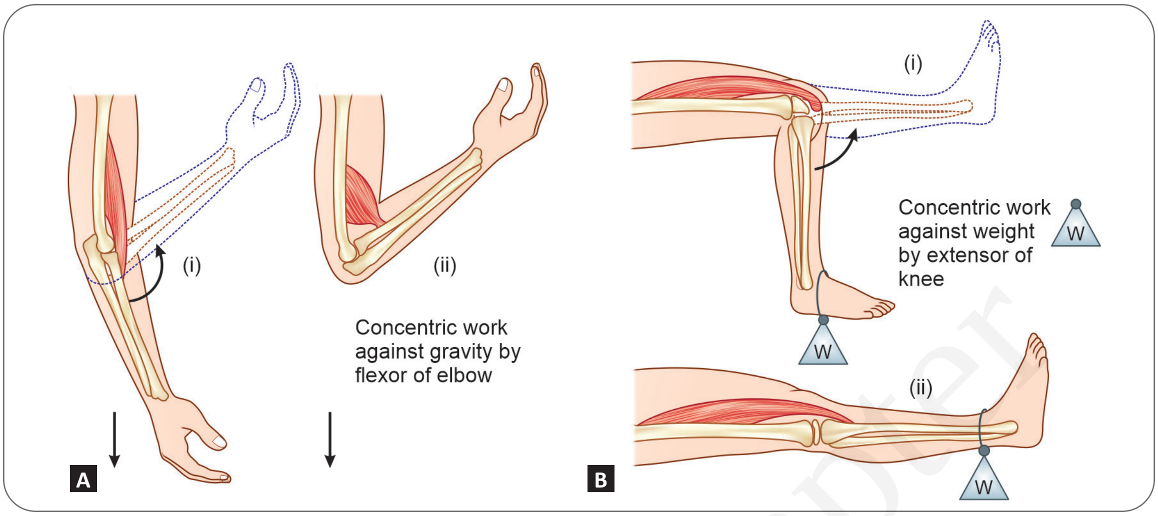
There is a change in the length of a muscle when it works to produce movement in opposition to an external force, and when it works to resist movement produced by an external force which gradually overcomes it. When the attachments of a working muscle are drawn toward the centre of that muscle, it works concentrically, i.e., toward the centre, or 'in shortening' (Figs 16.1A and B). When the attachments are drawn away from the centre, as its resistance is overcome by the external force, the muscle works eccentrically, i.e., away from the centre, or 'in lengthening' (Figs 16.2A and B).

There is no alteration in the length of a muscle which works to stabilise a joint, the power of its contraction being exactly equal and opposite to the forces which oppose it. In this case, the attachments of the muscle remain stationary and it is said to work statically.

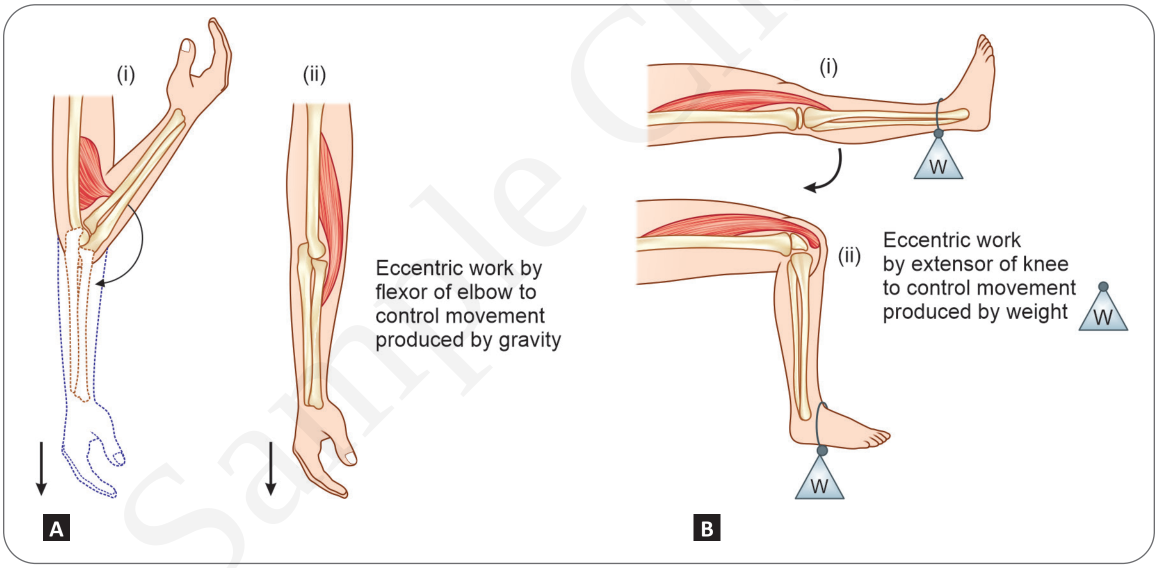
Isotonic

Concentric Muscle Work

Muscles working concentrically become shorter and thicker as their attachments are drawn closer together and joint movement results. A patient doing concentric muscle work performs a movement, and in doing so, he overcomes some force which offers resistance, such as friction, gravity, manual pressure by the physiotherapist, or some form of mechanical resistance.



Figs 16.1A and B: Concentric muscle work



Figs 16.2A and B: Eccentric muscle work

Examples: Flexors of Elbow work concentrically against gravity to flex the elbow (Fig. 16.1A); and knee is extended from a flexed position by the concentric muscle work of the Knee Extensors (Fig. 16.1B)

The **physiological cost** of this type of work is high, as only about a quarter of the energy liberated during contraction is available as mechanical work. Some is used to overcome the initial inertia and some is converted into heat. Concentric muscle work is used to build up muscle power, and although most of the everyday movements involve the use of all types of muscle work, it seems to be more natural and require least concentration, to use the concentric type.

Eccentric Muscle Work

Muscles working eccentrically become longer and thinner as they pay out and allow their attachments to be drawn apart by the force producing the movement.

Examples: Elbow extension from a position of flexion under the effect of gravity is controlled by the eccentric muscle work of the Elbow Flexors (Fig. 16.2A); and to control the knee flexion, that may occur rapidly under the influence of a mechanical weight, Knee Extensors work eccentrically (Fig. 16.2B).

The **physiological cost** of this type of muscle work is low, probably only about a quarter of that required for concentric work, therefore, a muscle recovering from paralysis may sometimes be persuaded to contract to resist before it will attempt to produce movement. Considerable concentration is required during exercises designed to work the muscles in this way. This is probably to control the speed of the movement, as eccentric work in natural movements is usually fairly rapid.

Isometric or Static Muscle Work

The length of the muscle remains the same throughout the muscle work and no movement results.

Static muscle work is more economical than either of the previous types, but it is fatiguing if sustained, probably because of hindrance to the circulation through the muscle, as the result of an increase in the intramuscular tension. Static muscle work against maximal resistance provides the most rapid method for gaining hypertrophy of muscles at a **particular point of the range** because the resistance demands the greatest possible increase in intramuscular tension.

Static work of the postural muscles is used to train the pattern of good posture. **Posture** is maintained by muscle work which is somewhat similar, but is not fatiguing because of the low metabolic rate at which the muscle fibres work, and the special nature of their reflex control.

RANGE OF MUSCLE WORK

The range of muscle work is the extent of the muscular contraction which results in joint movement (Fig. 16.3).

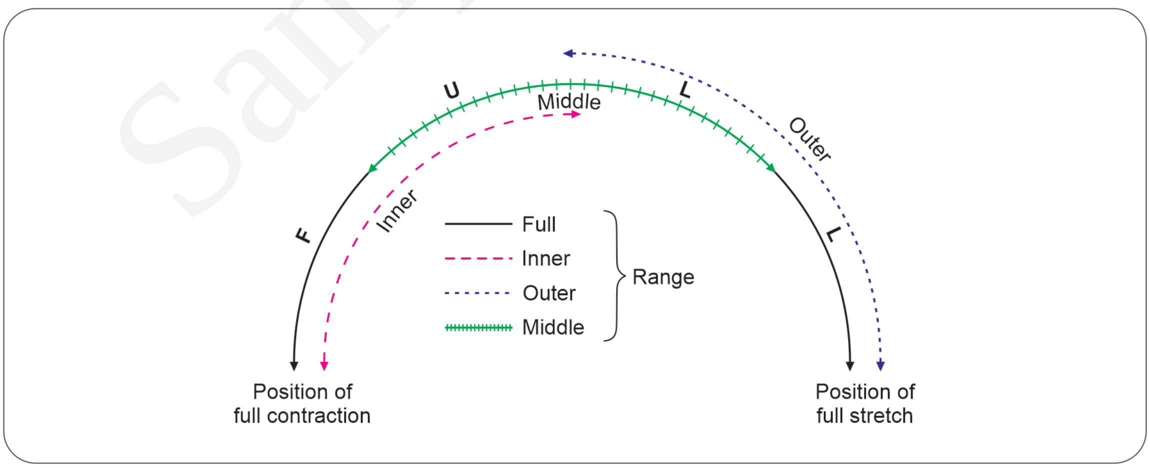


Fig. 16.3: Range of Muscle Work

Full Range

The joint is moved as the muscles work from the position in which they are fully stretched, to the position in which they are fully contracted, concentrically, or, from the position of full contraction, to the position of maximum extension, if they are working eccentrically.

Example: Hamstrings group of muscles work concentrically in their full range as the knee joint is moved from a position of complete extension (as in standing with a locked knee) to a position of maximum knee flexion (as in a position of heel touching the buttock).

Purpose: Under ordinary circumstances muscles are rarely required to work in full range, but in emergencies they may have to do so. Active full range exercises are used for patients as they maintain joint mobility, increase the circulation and ensure that the emergency reserve of power and mobility is preserved.

Inner Range

The muscle works either concentrically from a position in which it is partially contracted (approximately half-way between the limits of full range) to a position of full contraction, or vice versa if it works eccentrically.

Example: Quadriceps muscle works in its inner range as the knee extends in the swing phase of the gait cycle before achieving heel strike of the foot of the same side (Fig. 12.6).

Purpose: Exercise in inner range is used to gain or maintain movement of a joint in the direction of the muscle pull, and to train some extensor muscles responsible for stabilising joints.

Outer Range

The muscles work concentrically from the position in which they are fully stretched to a position in which they are partially (half) contracted, or vice versa if working eccentrically.

Example: In bending the elbow partially from anatomical position, elbow flexors work in their outer range.

Purpose: The outer range of muscle work is used extensively in muscle re-education as a contraction is initiated more easily from stretch in most muscles owing to the myotatic reflex.

Middle Range

The muscles are never either fully stretched or fully contracted. This is the range in which muscles are most often used in everyday life and in which, generally speaking, they are most efficient.

Example: Elbow Flexors and Extensors work in their middle ranges at the elbow joint as we eat food from a plate.

Purpose: Exercises in this range maintain muscle tone and normal power, but full joint movement is never achieved.

GROUP ACTION OF MUSCLES

Muscles do not work singly, but in groups, and it is the harmonious working together of several groups which results in co-ordinated movement (*see* Figs 2.2 and 18.1).

a. The prime movers, or **agonists**, are the group which bring about the movement by their contraction.
b. The **antagonists**, which are the opposing group, relax and lengthen progressively so that the movement is controlled but not impeded.

c. The **synergists** are the muscles which work or relax to modify the action of the prime movers. They may alter the direction of pull or, in the case of prime movers which pass over more than one joint, they fix or move the joint in which the main action is not required into the position which is most advantageous.

d. The **fixators** are muscles which work to steady the origin of the prime movers or the synergists.

Example: In flexion of the fingers, as in making a fist, the flexors of the fingers work as prime movers to perform the movement. The antagonists, the extensors of the fingers, relax. The extensors of the wrist work as synergists to fix or move the wrist into full extension so that the power of the flexors of the fingers, which can also flex this joint, is not diverted to this purpose, but increased as the extended wrist joint acts as a fulcrum for their action.

The appropriate impulses for contraction or relaxation are conveyed to the muscles concerned in any particular movement, from the Central Nervous System.

PRACTICAL TIP

As movements, and not individual muscles or even muscle groups, are represented in the cerebral cortex, the importance of concentrating on the movement rather than on the contraction of a specific muscle or muscle group in re-education cannot be over-emphasised. The movements which are represented are those to which the patient is accustomed to, i.e., natural movements, hence, these are of prime importance.

Two-joint Muscles

Most groups of muscles include at least one which extends across more than one joint. These muscles are most effective in moving one joint when they are stretched over the other, as under these conditions the latter joint is used as a fulcrum and the stretching of the muscle acts as an additional stimulus to contraction.

Example: To work the hamstrings as flexors of the knee, the hip joint must flex or be flexed by synergic action; alternatively, to work the hamstrings as extensors of the hip, the knee must extend or be extended during the movement of hip extension.

GROUP MOVEMENT OF JOINTS

Most natural movements involve the use of a series of joints controlled by the integrated action of many muscle groups. The control of these movements may be voluntary and conscious, but in many instances, it is unconscious and reflex in character, and controlled from the basal ganglia or reflex centres in the spinal cord. The basic patterns seem to be those of **thrust**, **withdrawal**, **swing** and **strike** (Figs 16.4A to F).

Example: In walking, plantaflexion of the ankle joint and extension in the knee and hip result progressively in response to firm pressure on the ball of the foot, but should there be pain in the foot as the result of injury or ill-fitting shoes, a flexion reaction is often imperfectly inhibited to produce a sagging posture and a limping gait.

MUSCULAR WEAKNESS AND PARALYSIS

Weakness or paralysis in any muscle or group of muscles not only results in loss of movement or stability of a particular joint, but also creates a state of muscular imbalance which affects all the groups concerned in the production of co-ordinated movement. If the weakened muscles are to recover their full function, they must be protected while they are ineffective and encouraged by re-education, until they are finally able to take their

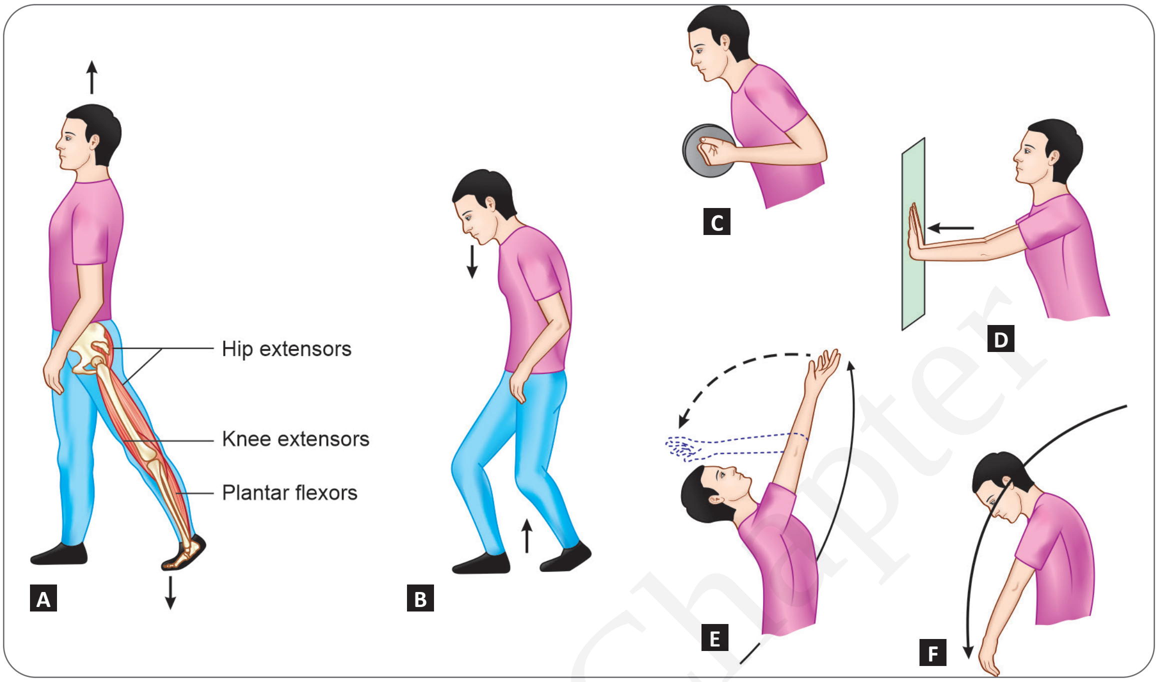


Fig. 16.4: Thrust, Withdrawal, Swing and Strike

place once more as effective members of the teams of muscles, which work together to perform natural and skilled movements.

CAUSES OF WEAKNESS OR PARALYSIS

As contraction is the only means by which muscle power can be maintained or increased, any lesion or habit which prevents or limits contraction will result in muscle wasting. Complete loss of ability to contract is known as paralysis, partial loss as paresis, or a muscle may be merely weak or sub-normal.

Lesions Affecting the Anterior Horn Cells

Destruction of the Anterior Horn Cells results in permanent inactivity of the motor unit, i.e., flaccid paralysis. Damage to these cells, short of their destruction, may increase their threshold to such an extent that they remain dormant.

Lesions Affecting the Motor Pathways

Interference with the passage of impulses along motor pathways causes paralysis. Spastic paralysis results from upper motor neurone lesions and flaccid paralysis from lower motor neurone lesions.

Lesions Affecting the Muscle Tissue

Degeneration of the muscle tissue results in loss of strength which is usually progressive, i.e., muscular dystrophy. Ischemia causes structural changes, i.e., Volkmann's ischemic contracture, and extensive scar tissue may replace contractile tissue as the result of deep flesh injuries.

Disuse of Normal Nerve and Muscle Tissue

Loss of strength and wasting from disuse is quite common. A patient may not use his muscles in the following scenarios:

a. Because he cannot

As contraction is inhibited by pain or protective spasm of antagonistic muscles, the patient is not able to use his agonistic muscles.

b. Because he does not need to

Joints fixed by splintage are stable and unable to move, therefore, there is no necessity for the patient to contract his muscles unless he is compelled to by strong resistance offered to other strong muscles in the same series or by his own voluntary effort. Static muscle work is essential to maintain circulation, muscle power and the movement of tendons passing over the temporarily immobilised joints, which are essential for recovery of function when splintage is removed.

c. Because he will not

Some patients resist all efforts to make them do sufficient muscular contraction to prevent disuse atrophy.

Some Constitutional Diseases

A marked degree of muscle wasting, which cannot be put down entirely to disuse, occurs in some diseases, notably in rheumatoid arthritis.

Functional

There is no organic cause, but the muscles do not function, although they may be made to contract by electrical stimulation of the nerve or by methods of facilitation.

THE PREVENTION OF MUSCLE WASTING

IN FLACCID PARALYSIS

Muscles deprived of their motor nerve supply are limp, hypotonic and unable to contract. Rapid wasting takes place and cannot be prevented, although it is thought that it can be arrested by improving the blood supply to the area by stimulation of the muscle fibres by electrical means. Although little can be done to prevent wasting in these cases, measures are taken to keep both the muscles and the joint structures in as good a condition as possible in preparation for a return to normal function.

Principles of Treatment During Flaccid Paralysis

1. Protection of Affected Muscles from Prolonged Overstretching by Support and Splintage

Normal muscles protect themselves from overstretching by a reflex contraction, but those suffering from flaccid paralysis are unable to do so, as they are incapable of contraction; consequently, they may become

stretched beyond their physiological limit and injured by the force of gravity or the unopposed action of healthy antagonistic muscles.

Example: A lesion affecting the Anterior Tibial Nerve results in a dropped foot, as gravity and the unopposed action of the Calf Muscles plantaflex the foot. To prevent injury to the Anterior Tibial Muscles a splint or toe-spring must be worn until their power of contraction is sufficient to restore muscle balance.

2. Maintaining Circulation of Affected Area for Nutrition to Paralysed Muscles

The circulation to the area must be maintained to ensure adequate nutrition to the paralysed muscles by active exercise for other normal muscles in the area, contrast baths, etc.

Paralysis leads to coldness and blueness of the area, indicating poor circulation. The arterial blood flow to muscles is much increased during active work to supply the oxygen and nutrition essential for repair and at the same time, the local venous return is assisted by the intermittent pressure exerted on the vessels, by the contracting muscles, and by the movement of joints.

3. Maintaining Range of Movement in Joints and Extensibility of Affected Muscles by Passive Movements

The fibrous tissue which constitutes the sheaths of muscles, ligaments of joints and fascia, undergo adaptive shortening if subjected to prolonged immobilisation. One full-range movement at frequent intervals is sufficient to prevent this and in practice, two full-range passive movements performed twice daily are found to be adequate. Where muscles work over more than one joint they must be stretched over these joints at the same time.

Example: For stretching wrist and finger flexors, wrist and fingers must be fully extended in one movement.

4. Stimulating Remembrance of the Pattern of Movement

Movement is associated in the brain with numerous sensory impulses from the joints, muscles, skin and eyes. In the absence of voluntary movement, stimulation of these sensory impulses by passive movement may remind the brain of the pattern of movement, in preparation for the time when the motor pathway will once more be intact. In this way co-ordinated movement, made possible again by the return of power to the affected muscles, is remembered and does not require to be re-learnt or re-developed.

The passive movements used for this purpose must obviously follow the natural pattern of movement with regard to the group movement of joints.

5. Maintaining Strength of Normal Muscles in the Area by Resisted Exercises

Unless the limb is flail (all muscles paralysed), all possible activity is encouraged. Thus wasting from disuse is prevented and circulation to the part is improved.

Example: A man with Anterior Tibial paralysis is able to walk about provided he wears a toe-spring, and the advantage of his being able to work is obvious.

IN SPASTIC PARALYSIS

Muscles which receive a motor nerve supply only by means of a spinal reflex, since they are cut off from the higher centres by a lesion affecting the upper motor neurone, are tense, hypertonic and incapable of voluntary contraction or relaxation. This condition is known as spastic paralysis and wasting is not marked. When a limb or segment of the body is 'locked' in spasm, circulation is impeded and muscle and joint contractures may develop over a period of time. The aim of treatment is to initiate movement to maintain normal joint range and muscle extensibility and at the same time improve the circulation. While the limb remains immobile any potential for voluntary control is masked by the spasm. Reflex movements initiated by means of Proprioceptive Neuromuscular Facilitation techniques, i.e., the stretch stimulus coupled with a command for voluntary effort, develop any voluntary control which remains and may lead to a permanent reduction in spasm. Controlled sustained passive stretching also inhibits spasm sufficiently to permit movement.

Must Know

Active or passive mobilisation may be preceded by massage or packing with ice to reduce spasm and make movement easier.

IN PRIMARY LESIONS OF THE MUSCLE TISSUE

In this case, loss of power cannot be arrested, although a temporary improvement often follows light exercise in the cases which have not previously received treatment. This is probably the result of making the best use of muscle fibres which still function.

IN DISUSE ATROPHY

Provided there is no constitutional disease, e.g., Rheumatoid Disease, muscle atrophy from disuse can be prevented or controlled by strong and frequent contraction against resistance as wasting occurs because an insufficient demand is made to elicit a strong enough contraction. Exercises must be carried out within the limits of the disability but with skill and imagination this can be organised. Any type of active work is suitable, provided the right muscles are activated sufficiently to maintain or improve their normal strength and endurance.

PRACTICAL TIP

Exercises with manual resistance are advisable in the early stages to make sure that the contraction is pain-free and satisfactory and to give the physiotherapist the opportunity to assess patient's capacity for activity and to give instruction in those activities he must practice on his own.

Whenever possible, the patient should continue with his normal work, when this is impossible, other **occupational activities** suited to his abilities can be substituted. Suitable **games** and **sports** of a competitive nature supply a demand for activity but need careful supervision and control to avoid development of 'trick' movement, e.g., development of a faulty pattern of walking in order to move rapidly.

The wasting of muscles in Rheumatoid Disease is not entirely due to disuse. **Isometric** muscle work in the **pain-free range** helps to prevent atrophy and often leads to increased pain-free movement which can be used for functional activities.

Must Know

> It is important that the patient should fully understand and appreciate the need for his own effort to ensure his co-operation in carrying out a regime of **free exercise**, the slogan for which is, **'Five minutes in every hour'**. If his co-operation is doubtful or his ability to exert voluntary effort is reduced, he will require constant supervision of individual treatment.

THE INITIATION OF MUSCULAR CONTRACTION (EARLY RE-EDUCATION)

Denervated muscles are incapable of contraction except by direct stimulation of the muscle fibres through suitable electrical means.

Must Know

> Innervated muscles contract in response to a demand for activity, provided the demand is sufficient. As contraction is the only means by which muscles regain their normal function, it is essential that a response is obtained as soon as possible from muscles affected by paralysis.

The lesion causing paralysis and the inactivity which follows both, increase the threshold of excitability of the anterior horn cells (AHC). Once the **acute phase** of the lesion has passed, reactivation of the motor unit is possible except when there has been permanent damage, e.g., death of the cell or lack of continuity of its axon. The AHC is much more difficult to stimulate, when its threshold is increased, therefore, it fails to react to the normal level of stimulation, in which case the patient's maximal voluntary effort of contraction is insufficient to gain a response. An increase in the demand is required and supplied by stimulation of sensory receptors, i.e., proprioceptors and exteroceptors, which discharge impulses to the AHCs to increase central excitation and lower the threshold of the cells. With a lower threshold, the AHCs are more easily stimulated and the arrival of repeated stimuli reduces the threshold furthermore and facilitates the passage of impulses along all the nervous pathways used. When stimulated, the AHCs discharge impulses to the muscle fibres which respond by contracting. A single discharge of impulses results in a muscle twitch, but discharges repeated sufficiently frequently lead to summation and a sustained contraction.

MEASURES USED TO OBTAIN INITIATION OF CONTRACTION

Warmth

The area affected must be warm, as moderate warmth improves the quality of the contraction. Any method designed to improve the circulation in the area is effective; active exercise of unaffected muscles against strong resistance is the method of choice.

Stabilisation

Stabilisation of the bones of origin of the affected muscles and of joints distal to those over which these muscles work, improves their efficiency. Whenever possible, stabilisation should be achieved by isometric contraction of strong synergic muscles working against maximal resistance as their effort reinforces that of the muscles in question, e.g., for initiating elbow flexors, the shoulder and wrist are stabilised by their flexors working against resistance applied by the physiotherapist's hands.

Grip or Manual Contact

The physiotherapist's hands give pressure only in the direction of the movement, to direct the patient's effort and give sensory stimulation.

Stretch

Stimulation of the muscle spindles elicits reflex contraction of that muscle, provided the reflex arc is intact. Sharp but controlled stretching of the affected muscle at the limit of its extended range is followed immediately by the patient's maximum effort of contraction thus:

NOW (Stretch) – PULL! (Let it move)

The muscles must be stretched in all their components of action and the more accurate the stretch the greater is its effect for producing a contraction. Prolonged stretching or failure to allow the muscle to shorten inhibits the contraction.

The command for voluntary effort must be brief, forceful and timed to coincide with the **stretch reflex**. The stretch reflex is applied several times in quick succession and then repeated after a short rest for as long as a satisfactory response is obtained.

Some muscles do not respond to the stretch reflex applied from the lengthened range as well as others, e.g., triceps. Once the ability to initiate contraction is established, muscle strengthening continues until normal function is restored.

Irradiation

i. The use of resistance to functional movements of the opposite limbs which normally produces fixator action on the other side can assist initiation of contraction in the affected muscle. For example, resistance to the extension- abduction pattern of one arm results in extension and abduction of the other arm to prevent the body rolling toward the moving arm.
ii. The use of resistance to strong groups which normally work with the affected muscle also encourages contraction of that muscle. For example, the eating pattern involves flexion of the shoulder, elbow, wrist and fingers. Therefore, strong resistance given to the shoulder, wrist and fingers flexors will stimulate the flexors of the elbow to contract.

STRENGTHENING METHODS (RE-EDUCATION)

The art of training or strengthening muscles lies in creating the conditions under which they are called upon to work to full capacity against an ever-increasing resistance. Increase in strength and hypertrophy occurs in response to an increase in intra-muscular tension set up by the factors which oppose their contraction. It is, therefore, essential that these opposing factors, which constitute the resistance, must be increased as the strength of the muscles improves.

Must Know

> An increase in resistance which is too rapid results in overloading, which prevents contraction and may damage the muscles. Under-loading will not increase strength, but may be sufficient to prevent wasting of muscles.

At the beginning of treatment, **assessment** of the strength of the muscles is essential. A suitable **resistance** is then selected, which includes consideration of the poundage of the resisting force, the leverage, the speed, and the duration of the movement. As treatment continues, progressions of one or all of these factors is made as muscle strength develops. Account must be taken of all work the muscles in question are called upon to do, whether it be exercises in the physiotherapy department, occupational therapy, specific home exercises, work, or the ordinary activities of everyday life.

Re-education may be regarded as a continuous process which begins, while the muscles are still paralysed, in the form of an attempted initiation of contraction, and extends until maximum function is achieved. The exact stage in this re-education process at which any particular muscle group begins is determined by the findings at the assessment made when treatment begins.

TREATMENT TO INCREASE MUSCULAR STRENGTH AND FUNCTION

Once the power of contraction has been regained, the muscles are strengthened progressively until maximum function is obtained. Passive movements, support, and artificial methods of assisting the circulation are discontinued gradually and are replaced by active exercise.

Principles of Treatment to Increase Strength and Function

Resisted Exercises

The affected muscles must be strengthened progressively by Resisted Exercises, which are specific for the group to which the muscles belong.

Range

The range of movement is increased.

Type of Muscle Work

Concentric, eccentric and static muscle work are elicited.

Resistance

The resistance is increased by:

i. Increasing the poundage of the resistance;
ii. Increasing the leverage of the resistance.

Speed

Increase or decrease in the speed of movement is a progression for concentric work. Decrease in speed is a progression for eccentric work. Lengthening of the contraction period is a progression for static holding.

Duration

Increase in the number of times an exercise is performed or decrease in the rest period between each series of exercises, or a combination of both according to circumstances, makes more work for the muscles.

Function

Full function of the affected muscles as members of the teams of muscles which work to produce skilled and co-ordinated movement, must be restored by free activities, natural and skilled movements.

Progression of these exercises follows on lines similar to those stated above for resisted exercises.

Pendular Movements

These require relatively little power and are used at first to assist in the restoration of muscle balance.

Rapid Movements

Progression to slow, sustained or rapid movements requires more power.

Small-range Movements

Movements in which many joints must be controlled are the most highly skilled.

TYPES OF EXERCISES TO STRENGTHEN MUSCLES AND RESTORE FUNCTION

All active exercises maintain or increase muscle strength, providing intra-muscular tension is increased sufficiently by the demands of the resisting forces. Weak muscles are provided with work suitable to their capacity by the use of Assisted- Resisted, Free, or Resisted Exercises (Chapter 6); while Objective, Recreational or Occupational Activities ensure their return to functional use.

It cannot be over-emphasised that the choice of a particular exercise does not necessarily ensure the desired effect: it is the manner and speed with which the exercise is performed which determines the effect it produces. In general, strengthening exercises are slow and precise.

Assisted-Resisted Exercises

These are rarely used to strengthen muscles except in the cases of marked weakness when strength is insufficient to complete the range of movement.

Free Exercises

Free exercises are valuable as they can be practised at regular and frequent intervals and at home. Careful selection of the starting positions and accurate teaching ensures the use of the muscles in question and grade the exercise to match their capacity for work.

Resisted Exercises

These exercises create the tension in muscles essential for increase in power and hypertrophy. Emphasis on the activity of the affected group restores the balance of muscle strength rapidly and so prevents trick movement and strain elsewhere. Proprioceptive neuromuscular facilitation is most effective in this context. Repeated contractions, slow reversals and rhythmic stabilisations are all suitable techniques.

Activities

These are essential to ensure integrated action of muscle groups in the production of movement. They also restore confidence and general health.

ASSESSMENT OF PROGRESS

Re-assessment of the patient's abilities is essential and made at frequent intervals to guide progression of activities and estimate progress.

CONCLUSION

Muscle strength is a result of various anatomical and physiological factors. Precise quantitative measurement of muscle strength is a subject of constant research. However, some of the concepts which are globally accepted and used to practice and discuss muscle work pragmatically have been discussed.