Chapter 1
INTRODUCTION

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The application of therapeutic exercise to a patient is a process which demands an initial examination of the patient's needs and a constant reassessment of the situation in the light of progress or retrogression. It also demands a knowledge of the condition from which the patient suffers, the potential recovery rate and complications which may arise. In addition the therapist must constantly bear in mind the anatomy of the part being treated and of the whole body; the physiological reactions of the body to all exercise and the particular exercise she is applying at the moment; and the underlying mechanical principles associated with the exercise and/or techniques applied.

Therapeutic exercise is also influenced by a psychological reaction in which the patient may or may not wish to get better. If he wishes to improve he may be overeager to please and do too much or perform badly and in haste. If he does not wish to improve it may be because he is afraid. He may be in pain and fear more pain, he may be afraid his illness or accident may recur, or he may have a fundamental fear of the whole field of medicine and hospitals in particular.

This barrier must be overcome and a rapport established between patient and therapist so that the therapist may initiate the proceedings which will eventually lead to the patient achieving his maximum independent potential.

To this end a few simple but important rules should be followed by the therapist. First, each patient should be known by name and greeted and welcomed at each treatment session. Secondly, fear of more pain can be overcome by working and teaching on parts which are not painful. Each action should be taught on the soundest or least painful part, then on the afflicted part gradually working towards the part he most dreads having treated. In this way he will not only be reassured but there will probably be less pain due to facilitation of inhibition. As he relaxes he will relax his protective painful spasm and so have less discomfort.

Thirdly, his activities must always be harnessed to a goal which is within his potential of achievement. This has two uses: it is a goal for which he can strive and a matter for congratulation when achieved. The objective can be reset each day or each week or with no regularity at all, but it is most important that the early goal is remarked upon when achieved as then the patient will gain confidence in his therapist as well as in himself.

It is said that initially patients have a 'love–hate' relationship with their therapists. This may be so as the therapist may have to insist on the patient performing an uncomfortable manoeuvre and he will not be grateful for it until some time has elapsed. Examples of this situation arise when a patient

ith an ineffective cough must be persuaded cough more effectively to void his chest cretions in spite of the pain of his abdo- inal incision; and when patients have to ntract the quadriceps muscle group follow- g knee surgery. In both these cases patients eely admit later on that they hated the thera- st at the time, but are grateful now that ey were persuaded to do their therapeutic xercise.

Therapists who work in this climate become ccustomed to this attitude from their patients nd learn to use all their manual and psy- nological skills for the improvement of the atient.

With the patient who has a long-term roblem, short-distance goal setting is even ore important, and knowledge of the medical story of the patient, his social background nd his home and work environment will e necessary to determine the sequence of the oals to be achieved. Personal independence hould usually be aimed for initially. This may e toileting, personal care and dressing, feeding r ability to get about. Some go hand in hand. is no use being able to undress and dress in he toilet if there is no possibility of physically etting there.

It is essential that the therapist gradually ithdraws what she does for the patient so at eventually he does every task for himself. this goal cannot be achieved then it is impor- nt to recognize that substitution must occur, g. if independent walking is unsafe and not mproving, the patient must come to terms with e appropriate walking aid. Recognizing the oment when no further progress is being ade is as important as the first assessment of patient. Failure to recognize this fact leads to lse hopes on the part of the patient and his mily and a waste of the resources of the thera- t, the tools of her work and the patient's time d effort.

Physical definitions of muscle performance

Force

The force output of a muscle, usually called its strength, is that which develops tension in the contracting muscle so that it contracts to produce work.

Work is defined as the action of a force over a specific distance in space. In the human body it refers to the product of muscular force exerted through a specific range of movement.

Power refers to a rate of doing work. In muscle action it is the output of the muscles at specific speeds of contraction.

Endurance is the capacity to contract muscles at a specific rate (power) for a specific interval of time.

Muscles require to be able to do work at varying tempos and to maintain the work for a period of time; failure to be able to produce satisfactory strength of muscle leads to weakness in one or more of the roles in which muscles play their part in normal activities. The roles of muscles are dealt with later in this chapter. Any failure of strength can lead to joint malfunction as well as functional incapacity in any of the daily activities to which the human body is subject during normal living.

Types of muscle work

There are two main ways in which a muscle may work naturally. It may contract and produce no movement, called isometric contraction, or it may produce movement during contraction, called isotonic contraction. Both these types of contraction may be used therapeutically, but a third type of muscle action

may be applied to muscles to strengthen them. This uses *isokinetic* or *accommodative* resistance to achieve isotonic contractions (see Chapter 9).

Isotonic contraction

When a muscle works isotonically it contracts and the part of the body to which it is attached will move. There are two types of isotonic contraction.

Isotonic shortening

When a muscle performs a contraction and its two attachments are approximating to one another, the contraction is known as an isotonic shortening, e.g. when the arm is raised from the side and the abductors of the shoulder contract, the contraction is one of isotonic shortening.

Isotonic lengthening

When the attachments of a muscle move slowly away from one another and the muscle allows this movement to occur in a controlled manner, the muscle action is one of isotonic lengthening, e.g. when the body is in the upright position and the arm is lowered from abduction to adduction, the abductors of the shoulder will control the movement and these abductors will be acting in isotonic lengthening.

Isotonic shortening can take place under any circumstances, i.e. whenever movement takes place in which the attachments of a muscle approximate, the muscle work will be isotonic shortening. Isotonic lengthening, however, may only be brought about if an outside force is applied to the component which is to be moved and the body part is slowly moved so that the attachments of the muscle are moved away from one another.

Gravity may be the outside force which pulls body components towards the earth as in lowering the arm from the abducted position to the side, or in sitting on the edge of a table lowering the outstretched leg to a right angle at the knee. However, under many other circumstances, in order to work a muscle in isotonic lengthening it is necessary for the therapist to be the outside force. The command given is '*resist slightly whilst I move your leg*', or arm as the case may be, to a new position. The patient offers slight resistance, the therapist applies pressure which is greater than the resistance offered by the patient and is on the surface which is on the same aspect as the muscles which are required to be worked in isotonic lengthening. For example, if a patient is in side lying and the quadriceps are to be worked, the leg will be arranged straight at the knee, one hand will be placed as a stabilizing hand on the thigh and to palpate the quadriceps. The other hand will be placed on the anterior aspect of the leg and the command will be given '*resist slightly while I bend your leg*'. The patient resists, the therapist bends the leg and the quadriceps will be worked in isotonic lengthening.

Many other examples of isotonic shortening and isotonic lengthening can be found and therapists should attempt to work out the single movements of each of the joints of the body with and without resistance so that they are able to identify isotonic shortening and isotonic lengthening. When therapists can identify these two types of muscle work they should then try to apply the range of muscle work as described below.

Isometric contraction

When a muscle works isometrically it shortens its muscular length and slightly lengthens its non-contractile components and in doing so no movement occurs at any of the joints over

which that muscle passes. It is easiest and in act usual for an induced isometric contraction o be performed when a muscle is resting at he innermost part of its range, i.e. with the nuscle attachments approximated, but with ractice the skill can be developed so that it is ossible isometrically to contract a muscle or nuscle group at any part of the range. Isometric ontraction can be taught to a muscle by the pplication of a manual resistance which is xactly equal to the contraction which the nuscle produces. The command which the herapist will give will be '*don't let me push or ull that body component about*', e.g. '*don't let ne push you forwards*' with pressure on the ack of the shoulders will initially cause contraction of the extensor muscles. '*Don't let me ull you back*' will cause contraction of the lexor muscles. '*Don't let me push your foot up*' ill cause contraction of the plantarflexors of he foot. '*Don't let me push your foot down*' ill cause contraction of the dorsiflexors of the oot.

When isometric contractions are done to ne group of muscles only, they are usually aught in order that the patient might prac- ise these contractions alone without the thera- ist. Indeed isometric contractions are the nly contractions which are possible when the atient is wearing a support such as a plaster r a fixation splint. This is the type of muscle ork which is used when the joint is so nflamed that movement would be both pain- l and inadvisable. The strength and tone of he muscles working over that joint may be naintained by teaching the patient isometric ontractions. When a patient is initially inca- ble of performing an isometric contraction n a damaged part, the technique may be ught on the opposite limb or may be taught any part of the patient, and if this is com- etely impossible the contraction *per se* may taught with the use of a faradic type current applied in such a manner that it merely teaches the patient what to do and is immediately followed by patient participation. In other words the current is used for re-education of contraction.

Range

The word range may be used in two senses. First, it may refer to the amount of movement which occurs in a joint. Secondly, it may refer to the amount of shortening or lengthening of a muscle as it acts to produce or control movement.

Range of movement at a joint This is the total quantity of movement when a joint is moved to its full extent. The names of the movements are those anatomical names which are normally applied (see Chapter 3) and the method of recording range is well laid down in the book *Joint Motion* published by the American Orthopaedic Association.

One may measure and record the amount of range of movement in a certain direction, e.g. the range of abduction of the shoulder joint is 90°. The range of adduction of the shoulder joint is 90°. This is normal range. If, however, the range is limited the available range can be recorded when a zero starting point is necessary and the recording could be from 10° of abduction to 80° of abduction, i.e. the first 10° and last 10° of movement are absent and the available range is 70°.

Muscle

When a muscle contracts and performs a movement it is said to have acted through a certain range. When a muscle is fully stretched and contracts to the limit of its normal capacity it is described as having contracted and produced a movement in *full range*. For purposes of description full range is broken down into three components which overlap (Fig. 1.1).

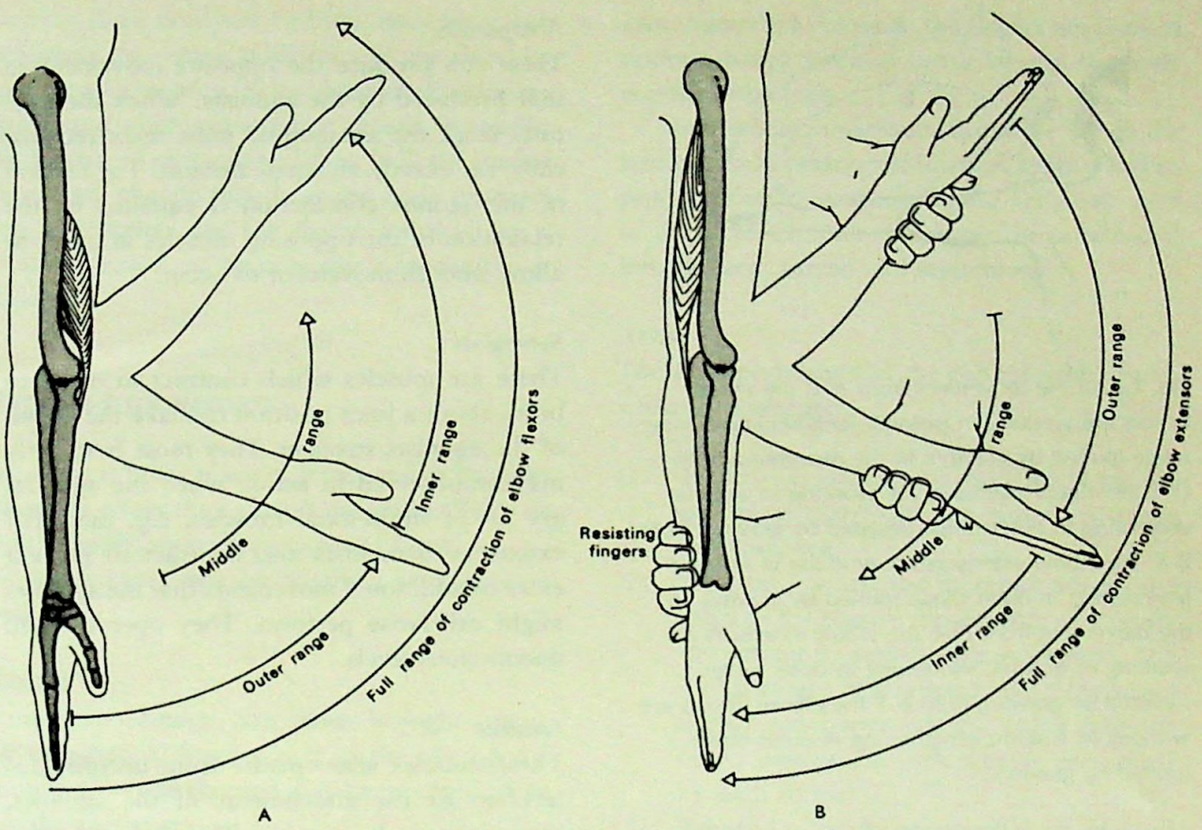
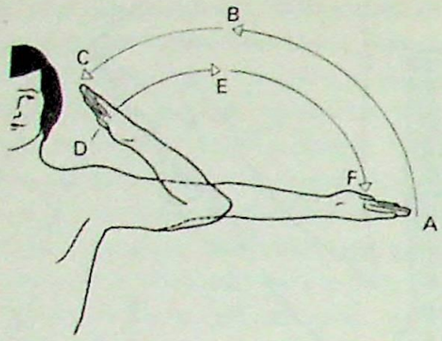


Fig. 1.1 A, The range of movement produced by contraction of brachialis. Gravity resisting; B, The range of movement produced by contraction of triceps. Manually resisted.

Outer range of contraction is from full stretch of the muscle to mid point of the full range. Inner range of contraction is from the above-mentioned mid point to full contraction. Middle range of contraction is any distance between the middle of the outer range and the middle of the inner range. Middle range of contraction is that in which many muscles work most of the time when they are producing movement.

Extreme inner range is more difficult to perform because it requires a contraction of a greater number of motor units of which a muscle is composed and usually also the muscle is pulling with an adverse angle of pull which diverts some of the effort to distracting the two joint surfaces.

Extreme outer range is also difficult because usually the angle of pull is adverse and some of the effort is diverted to compressing the two joint surfaces and, in addition, the muscle may have to overcome inertia and be working against a long or heavy weight arm. It is possible when some movements occur that in moving from full outer to full inner range, with the body in certain positions, gravity may resist the movement when outer range is performed and assist the movement when inner range is performed. When this occurs the same muscles will not be working througout



1.2 In the movement from A–B the elbow ors are working in isotonic lengthening in outer ge (pulled by gravity). In the movement from the elbow extensors are working in isotonic rtening in outer range (resisted by gravity); from the elbow extensors are working in isotonic gthening in outer range (pulled by gravity). In movement from D–E the elbow extensors are king in isotonic shortening in outer range isted by gravity); from E–F the elbow flexors are king in isotonic lengthening in outer range led by gravity).

range of movement. The last part of range of movement (gravity assisted) will controlled by the antagonists working in ir outer range but working in isotonic gthening. It is thus possible to describe scle work by mode of action, i.e. type of scle activity (isotonic shortening or length- ng or isometric) and, in the former case, describe the range of the muscle work (Fig.).

oup action of muscles

scles do not work in isolation. They must, smooth co-ordinated movement to occur, erate in one of the following roles.

e movers or agonists

is case they are those muscles which initiate perform movement.

Antagonists

These can produce the opposite movement to that produced by the agonists. When the agonists work the antagonists must relax reciprocally, i.e. exactly an equal amount. The tension of the agonist contraction is equalled by the relaxation of the opposing muscles in order to allow smooth movement to occur.

Synergists

These are muscles which contract in order to bring about a joint position to make the action of the agonists stronger. They most frequently may be observed in action when the agonists are bi- or multi-axial muscles, e.g. the wrist extensors. Synergists also contract to prevent extra or additional movements that the agonists might otherwise perform. They operate from unconscious levels.

Fixators

These muscles also operate from unconscious level to fix the attachments of the agonists, antagonists and synergists. This does not mean that they fix a component of the body and keep it there throughout the whole of one particular muscle action; rather their role is dynamic as is that of the synergists. Fixator muscle work probably constitutes about 75% of normal daily muscle action. Their role is not isometric except for very short periods; it becomes isotonic in alternating patterns so that movement is smooth. In the example quoted above the fixator muscle work would be those around the elbow to fix the forearm and hand, the shoulder to fix the arm and shoulder girdle and of the remainder of the body to fix such parts as are not totally supported.

The fixator muscle work of an action such as threading a needle will be very different from that in throwing a heavy ball, both in quantity and quality. In the former case the starting position may be sitting and therefore the fixator

work will be confined to those muscles which maintain the sitting position and the shoulder girdle and arm muscles involved in a fine pincer grasp and approximation of thread to needle. In the case of throwing a heavy ball, the fixator work will change rapidly as the body prepares for and carries out the throw followed by a braking action to prevent loss of position or balance.

Types of movement

Movement takes place at joints and is brought about by either the patient's muscular efforts or by the application of an external force.

Movements may be classified as passive or active.

Passive

Passive movements are those brought about by an external force which in the absence of muscle power in the part may be mechanical or via the therapist:

(1) Mechanical – the pull of gravity causing 'flopping'.
(2) The therapist performing movements. The therapist may produce accessory or anatomical movement at joints.

Accessory movements occur when resistance to active movement is encountered and fall into two types. The first type is seen when the metacarpophalangeal joints, which do not normally do so, rotate when grasping an object such as a hard ball. The rotatory movement is not possible unless resistance is encountered.

The second type of accessory movement can only be produced passively. It is produced when the muscles acting on the joint are relaxed and cannot be performed actively in the absence of resistance. An example is distraction of the glenohumeral joint when the fingers are hooked under a heavy piece of furniture and the body is pulled upwards.

Anatomical movements are those which the patient could perform if his muscles worked to produce that movement. These are dealt with in detail in Chapter 5 but can be subdivided into relaxed, forced and stretching.

Active

These are performed by the patient either freely, assisted or resisted.

(1) Freely – in which case mechanical factors will play a part offering either resistance or assistance.
(2) Assisted – when the therapist adopts the grips as for passive movements and assists the patient to perform the movement. The disadvantage of assisted active movements is that it is impossible for either party to detect how much work is being performed by each of them.
(3) Resisted – when mechanical or manual resistance is applied. The mechanical resistance may be in the form of weights, springs, water, auto loading or the mode of performance of the activity.

All these types of movement are described in the following chapters but it must be remembered that the human being is subject to most of the laws of mechanics and to physiological factors which make it able to react to stimuli in accordance with the state of development of the neuromuscular system and with the integrity of both the mechanical and neuromuscular systems of the body. A broken bone, a torn ligament, a ruptured muscle or damage to the nervous system will each have their detrimental effect on the normal activity of the body.

In some of these cases rest may be an essential prerequisite to recovery with the

consequent deterioration in muscle power; in others the muscles will react in an abnormal manner due to the abnormal impulses impinging on the central nervous system.

It is not the intention of this book to outline all the rapidly advancing frontiers of knowledge of the present day in respect of the neuromuscular system nor of the well understood mechanics of normal motion, but a fundamental study of anatomy, physiology and mechanics must proceed at the same time as this text is being used.