THE PRINCIPLES OF EXERCISE THERAPY

BY

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WITH A CHAPTER ON
PROPRIOCEPTIVE FACILITATION
BY
MONICA MARTIN JONES, M.C.S.P.

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This book
is dedicated to

THE STUDENTS OF THE LONDON HOSPITAL SCHOOL
OF PHYSIOTHERAPY

whom it has been my privilege to teach, and to the memory of Cicely Read and Helen Heardman, both of Bedford Physical Training College, who never failed to give help and encouragement to all who were willing to learn

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FOREWORD

by

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PHYSIOTHERAPY is no static art. Methods of treatment constantly change and many that were once prominent and popular have lost popularity. In this way many treatments involving the use of electrical currents have gone out of fashion, massage itself is looked at with a cold scientific eye and does not emerge unscathed from the appraisal, and passive treatments of inert patients making no effort to help themselves are regarded as possibly prolonging rather than cutting short invalidism. Yet in spite of all this more patients are referred for physiotherapy than ever before. The gospel of activity has been widely preached and the prescription of activity and movement has taken the place of the passive treatments so widely advocated before the second world war. There seems little doubt that this phase of activity is a notable advance and that patients are reaping the benefit of it.

No one could be better qualified than Miss Dena Gardiner to write on the Principles of Exercise Therapy, for she holds both a Diploma in Physical Education and the double teacher's qualification of the Chartered Society of Physiotherapy. She has a deservedly high reputation as a teacher and demonstrator and, as this book will show, she has succeeded admirably in setting out the principles that govern the therapeutic value of activity.

PREFACE

THIS book has been written for all those who are interested in the use of exercise to promote physical rehabilitation. It is, however, primarily designed to provide students training in physiotherapy with a simple theoretical background for the practical instruction they receive in the performance and use of movement and exercises for therapeutic purposes.

I have attempted to collect and integrate the various techniques now in common use and to arrange them according to the purpose for which they are designed. To do this I have drawn freely upon the ideas and experience of others as well as my own but, except in the case of forced passive movements which have only rarely been ordered by any doctor for whom I have worked, I have included only those procedures which I have tried out and found to be of value in the treatment of patients at one time or another.

New and widely varying techniques are constantly being developed and no one of these can claim to be suitable for all patients or all physiotherapists. A sound knowledge of basic principles, an open mind and a spirit of enquiry are essential to progress and the discovery of the methods most suitable to achieve results.

> I keep six honest serving men,
> (They taught me all I knew)
> Their names are What and Why and When
> And How and Where and Who.
>
> KIPLING'S *The Elephant Child*

Although there are a considerable number of male physiotherapists, to facilitate description throughout the text I have referred to the physiotherapist as 'her' and to the patient as 'him'.

I would like to express my gratitude to all who have helped me in the preparation of this book. In particular my thanks are due to Dr. W. S. Tegner, B.M., B.Ch., F.R.C.P., who not only read my manuscript and gave me valuable advice but has kindly written the foreword.

I am deeply indebted also to Dr. L. A. W. Kemp, B.Sc., F.Inst.P., physicist to the London Hospital, for his interest and patience in helping me to prepare the chapter on Mechanical Principles and to Dr. M. Partington, M.B., of the Physiology Department, for many helpful suggestions.

Miss Y. Moyse, M.A., who was at the time Public Relations Officer

for the Ling Physical Education Association, encouraged me to undertake the task of writing this book, and she has at all times advised and helped me in the preparation of the manuscript. I would like to take this opportunity of expressing my appreciation and thanks for the time and energy she has given to help me.

My colleagues in the Chartered Society of Physiotherapy have always been ready to discuss controversial matters and to give me advice whenever I asked for it, and I am most grateful to them and to Miss Chatwin, M.C.S.P., who lent me a typewriter for as long as I needed it.

M. D. G.

June 1953

PREFACE TO THE SECOND EDITION

THE techniques of Exercise Therapy are constantly being reviewed and modified, therefore I have thought it advisable to make several alterations and additions in an attempt to keep this book in line with modern thought and practice.

I am very glad to be able to include a chapter on Proprioceptive Facilitation written by Miss Monica Martin Jones as an introduction to this method of neuromuscular re-education. I am most grateful to her for making this contribution and for completing it in spite of the fact that she left England at very short notice to help in the rehabilitation of poliomyelitis victims in Argentina. I am well aware that at present there are only very few physiotherapists in this country who have had the opportunity to learn enough of these techniques to practise them even in their most simple form, but I am convinced that the physiological principles on which they are based are of such importance that this method of applying them should be more widely known and understood. This chapter, in common with the rest of the book, is intended to stimulate interest and to provide a simple theoretical background as an adjunct to practical instruction whenever and wherever this is available.

It is of great importance that methods new to this country should be examined and tried out, as each one contributes, in a greater or lesser degree, something of value to the physiotherapist for use in the treatment of patients.

M. D. G.

July 1956

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PART I

I

MECHANICAL PRINCIPLES

THE mechanical principles utilised in Exercise Therapy are defined here to ensure that they are understood and applied correctly.

FORCE

Force is that which alters the state of rest of a body or its uniform motion in a straight line.

Composition of Forces

The application of a force to a body is specified by—

(*i*) the direction of the force; this may be represented by the direction of an arrow,

(*ii*) the magnitude of the force; this may be represented by the length of the arrow.

The tail of the arrow drawn to represent a force can be taken as the point of application of that force.

FIG. 1

A single force applied to a body, which is free to move, causes movement in the direction of the force. (Fig. 1).

a. Two forces acting in the same direction and at a common point

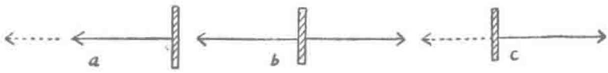

FIG. 2

are equivalent to a single force acting in that direction, whose magnitude is equal to the sum of the magnitudes of the individual forces.

b. Two equal forces acting at a common point, and in opposite directions, will result in a state of equilibrium.

c. Two unequal forces acting at a common point and in opposite directions will result in movement in the direction of the greater force, the magnitude of the force producing this movement being equal to the difference between the magnitudes of the two unequal forces which oppose each other.

Sometimes it is inconvenient to apply force in a particular direction and in these circumstances two forces acting at an angle to each other may be compounded to produce the desired effect.

If two forces represented by the lines AB and AC act at A, then the

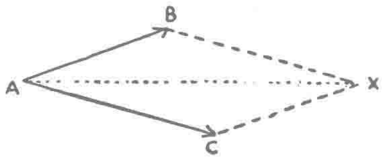

FIG. 3. The Parallelogram of Forces

diagonal AX of the parallelogram ABXC represents the force to which they are equivalent. One example of this occurs when the Deltoid Muscle contracts during shoulder abduction, the action of the anterior and posterior fibres of the muscles being compounded to work with the middle fibres and so vastly increasing their power.

The principle of compounding forces is also employed in some arrangements for balanced traction.

MECHANICS OF POSITION

GRAVITY

Gravity is the force by which all bodies are attracted to the earth. Newton concluded from experiments and observations that a force of attraction existed between all material objects, and that the magnitude of this attraction was directly proportional to the mass of each body and inversely proportional to the square of the distance between them. The gravitational attraction of the earth for every other body is directed towards the earth's centre.

The force of gravity acts continuously upon the human body, and if unopposed the latter will fall to the ground. The effects of gravity can be counterbalanced when a force equal and opposite to it is employed, such as the support of a plinth, the buoyancy of water, or a static muscular contraction. If, however, gravity is opposed by a force which is greater, movement will occur in the direction of that force.

For example:—

a. From the standing position the heels can be raised from the ground by the contraction of the calf muscles, working in opposition to the resistance of gravity, provided the force of their contraction exceeds the force of gravity.

b. The heels will remain raised as long as the force of the static contraction of the muscles is equal to that of gravity.

c. The heels will be lowered to the ground by the action of gravity if the muscles relax.

Movement of joints may occur as the result of gravity or of muscular action, and each may control the effect of the other. In the erect position balance is maintained by the reciprocal contraction of many muscles, called the anti-gravity muscles, while true relaxation can only occur under conditions in which the muscles are no longer required to work against the effects of gravity, as the latter are cancelled out by adequate support.

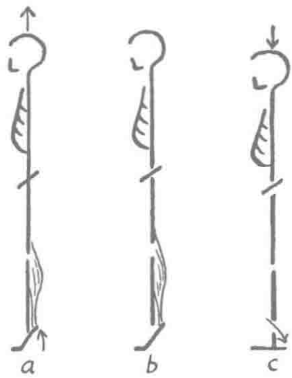

FIG. 4

THE CENTRE OF GRAVITY

The centre of gravity of a rigid body is the point in it through which the earth's attraction effectively acts whatever the position of the body, i.e. the point through which the line of action of the weight acts. A rigid body will balance when it is supported only at its centre of gravity.

a. A uniform rod will balance at a point exactly half-way along its length.

b. The centre of gravity of an irregular piece of cardboard can be discovered by suspending it consecutively from at least two points at its margin, and marking on it the line taken by a plumb line when the latter is attached at the point of suspension in each position. The point of intersection of the two lines will be the centre of gravity (Fig. 5*c*), which need not necessarily lie within the body, as in the case of a ring or a boomerang.

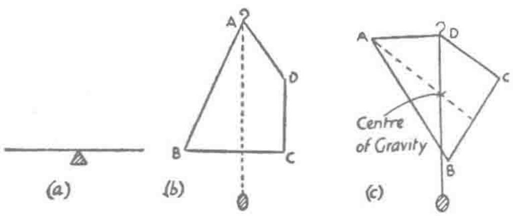

FIG. 5

The centre of gravity of the human body in the anatomical position is reputed to be in the vicinity of the body of the second sacral vertebra. Its position must vary, however, according to the anatomical structure of the individual, being higher in men and children than in the average woman, because of the greater amount of weight they carry in the upper half of the body. Direct support at the centre of gravity of the human body is obviously impossible and its exact position is merely of interest in assessing the distance between it and the point of support.

The location of the centre of gravity will vary with each of the many and varied postures the body assumes.

LINE OF GRAVITY

The line of gravity is a vertical line through the centre of gravity.

When the human body is in the fundamental standing position the line of gravity through the body of the second sacral vertebra passes through the vertex and a point between the feet, level with the transverse tarsal joints. The relationship of body structures to this line is subject to considerable variation in accordance with individual differences in posture and anatomical structure. It is estimated that on an average when posture is good the line passes through the mid-cervical and mid-lumbar vertebrae and in front of the thoracic vertebrae. The external ear and the point of the shoulder are in the same frontal plane and lie lateral to the line, and the central axis of the knee joint and the ankle joints are postero-lateral.

BASE

The base, as applied to a rigid body, is the area by which it is supported. In the case of a cube the face on which it rests is the base,

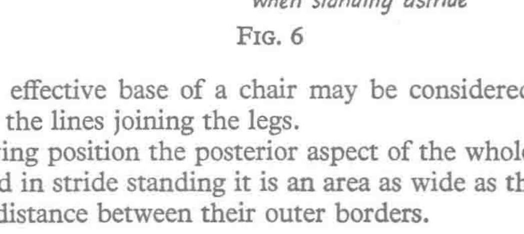

FIG. 6

whereas the effective base of a chair may be considered as the area bounded by the lines joining the legs.

In the lying position the posterior aspect of the whole body forms the base, and in stride standing it is an area as wide as the feet and as long as the distance between their outer borders.

EQUILIBRIUM

Equilibrium results when the forces acting upon a body are perfectly balanced and the body remains at rest.

Stable Equilibrium. If the forces acting upon a body at rest tend to restore it to its original position after it has been displaced, the body is said to be in stable equilibrium. The condition of equilibrium is most stable when the centre of gravity is as low as possible and the line of gravity falls near the centre of an extensive base. It becomes progressively less stable as the centre of gravity is raised and the line of gravity falls nearer to the margin of the base.

Unstable Equilibrium. If a body is given an initial displacement and the forces acting upon it increase this initial displacement, however small the latter may be, the body is said to be in unstable equilibrium. A centre of gravity which is as high as possible and a small base result in *relatively* unstable equilibrium, because even very small displacements cause the line of gravity to fall outside the base, and the body will fall to the ground.

Neutral Equilibrium. If, in spite of displacement of a body, the height and position of its centre of gravity remain the same in relation to the base, the body is said to be in neutral equilibrium, as, for example, when a ball moves on a plane surface.

The stability of the human body is greatest in the lying position. It becomes progressively less stable as the centre of gravity is raised and the base is reduced, as in the sitting and standing positions.

FIXATION

Fixation or stabilisation of bones or joints is achieved by a balance of the opposing forces acting upon them. These forces may be provided by muscular contraction, manual pressure or by mechanical means such as splints.

Contraction of a muscle group is most effective in the performance of movement when the bone or bones of origin are stabilised so that contraction results in movement of the bone or bones of insertion (or vice versa when the group works with reversed origin and insertion). This stabilisation (or fixation) is normally achieved by other muscle groups working to control movement in neighbouring joints. If, however, the power or co-ordination of these 'fixator' muscles is inadequate, an additional force or forces may be applied to compensate for their deficiency.

In giving forced passive movements fixation of the bone proximal to the joint to be manipulated is essential to ensure localisation of the movement.

Fractures, joint injuries and disease necessitating long-term immobility of joints usually require fixation by mechanical means such as splintage, balanced traction or operative measures, e.g. bone grafting or plating.

MECHANICS OF MOVEMENT

Axes and Planes

An axis is a line *about* which movement takes place and a plane is the surface which lies at right angles to it and *in* which the movement takes place. The terms are used to facilitate the description of movement or direction, and as far as axes and planes of joint movement are concerned, they are described with the body in the anatomical position.

a. A sagittal axis lies parallel to the sagittal suture of the skull, i.e. in an antero-posterior direction, as an arrow might have pierced a yeoman in attack or in flight. Movement about this axis is in a *frontal plane.*

b. A frontal, or transverse, axis lies parallel to the transverse suture of the skull. It is also horizontal and at right angles to the sagittal axis. Movement about a frontal axis is *in a sagittal plane.*

c. A vertical axis lies parallel to the line of gravity and movement about it is in *a horizontal plane.*

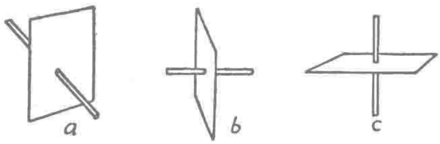

FIG. 7

The hands of a watch moving about the central pin and over the watch face, or a pencil thrust through a sheet of paper and turned to represent the three axes, are convenient examples to demonstrate axes and planes.

Movements of the body occur at joints, therefore axes pass through joints and the part moved is in the plane which lies at right angles to the axis of the movement.

Abduction and adduction (except of the thumb) and side flexion movements take place about a sagittal axis and in a frontal plane, flexion and extension (except of the thumb) about a frontal axis and in a sagittal plane, and rotation occurs about a vertical axis and in a horizontal plane.

The Plane of Movement and Gravity

Movement in the Horizontal Plane. Movement in the horizontal plane is in no way affected by gravity and is therefore stated to be 'gravity free'. Weak muscles which are unable to produce movement against gravity can often succeed in doing so when the part moved is supported horizontally.

Movement in the Inclined Plane. Movement in this case can be up the incline or downwards. When muscles work to produce movement up the incline, the resistance offered to them by the force of gravity is modified and reduced by the reaction of the plane. The latter is greatest when the incline is nearly horizontal, therefore the resistance to the muscles is least when the incline is nearly horizontal

FIG. 8

(*a*) Movement about a Sagittal Axis and in a Frontal Plane

(*b*) Movement about a Frontal Axis and in a Sagittal Plane

(*c*) Movement about a Vertical Axis and in a Horizontal Plane

and increases as it approaches the vertical. Movement downwards is produced by the force of gravity, the magnitude of its force increasing as the inclination approaches the vertical and the reaction of the plane decreases.

Movement in the Vertical Plane. Upward movement is produced by a force such as that of muscular contraction which exceeds the force of gravity. Downward movement is produced by the force of gravity and occurs at a specific speed which can be modified and controlled by muscular action.

SPEED

Speed is merely the rate at which a body moves, and takes no account of the direction, i.e. a car has a speed of forty miles an hour. Speed is uniform if the car travels the same distance during every second that it moves, but if it slows down at a turning and then increases speed along a straight road to make up for lost time, its speed is variable, but the average speed for a given time can be calculated.

Speed of Relaxed Passive Movements

The speed at which a passive movement is performed must be slow and uniform so that relaxation can be maintained.

Speed of Active Exercises

Natural Speed. There is a natural speed for every exercise which varies to some extent for each individual and, in general, this is the speed at which exercises should be done. The effect of many exercises can be modified, however, by an alteration in the speed of their performance.

Reduced Speed. Exercises done more slowly require greater muscular effort and more control. Decrease in the speed of repetitive movements ensures time for full-range movement.

Increased Speed. Rapid movement also requires strong muscular effort but momentum is gained and this may help to increase the range of joint movement provided the direction is not reversed before the free limit is reached. Exercises performed rapidly are stimulating but frequently lead to inaccurate or 'trick movements' and full-range movement is rarely achieved.

VELOCITY

The notion of velocity incorporates not only the rate of motion but also the *direction*, e.g. an aeroplane travels at 500 miles an hour *in an easterly direction.* A change in either speed or direction is said to alter the velocity.

ACCELERATION

Acceleration is the rate of change of velocity. A positive acceleration causes an increase and a deceleration, or retardation, a decrease in velocity.

Movement under Gravity. Galileo dropped heavy bodies from the leaning tower of Pisa and established the fact that all bodies, irrespective of their weight, are subject to the same uniform acceleration as they fall freely under gravity.

MOMENTUM

The momentum of a body is the quantity of motion it possesses, and it is represented by the product of mass and velocity. The force responsible for the momentum will generate movement slowly in a relatively heavy body and more rapidly in a lighter body.

INERTIA

Inertia is the resistance of a body to any change in its state of rest or motion. A body at rest tends to remain at rest indefinitely, while a moving body tends to continue moving at a constant speed and in a straight line unless acted upon by a force.

A railway truck in a goods yard requires considerable force to start it moving, but once it gets going it continues until another force, such as collision with the buffers of another truck, impedes it. If there was a man standing in the first truck he would be thrown forward at the moment of collision, as his body would continue moving, owing to inertia.

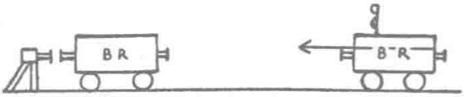

FIG. 9

Once the inertia of the body is overcome and movement is initiated, it is more economical to continue moving, as in a well co-ordinated swimming stroke or running action, to avoid the additional expenditure of force which would be required to overcome the inertia on stopping, starting or altering speed. Weak muscles may be unable to exert sufficient force to overcome inertia, yet may be able to produce movement or control with assistance at the right moment.

FRICTION

Friction is the force which opposes motion when one surface slides upon another. It may be sufficient to prevent movement altogether, e.g. as in the case of rough surfaces or substances, such as rubber, when they are in contact with one another. The frictional resistance obtaining during movement (dynamic friction) is slightly less than the so-called limiting friction, i.e. the friction obtaining just as sliding is about to set in. Dynamic friction may be further reduced during movements of a limb, while the latter remains supported by a plane surface, by the use of a polished surface such as a table or plinth on which the limb will slide. The use of talcum powder or oil on the supporting surface will further reduce friction and make the movement easier, whereas suspension of the part to be moved virtually eliminates all frictional resistance.

SIMPLE MACHINES, PENDULUMS AND ELASTICITY

A machine is a contrivance which enables an applied force to overcome a given resistance. The use of a machine usually makes it possible for the magnitude of the applied force to be less than that of the resistance which it overcomes, or when this is not so, it enables the force to be applied more conveniently.

Levers and pulleys are examples of simple machines in common use in everyday life and their principles are also utilised for the production of movement in the human body.