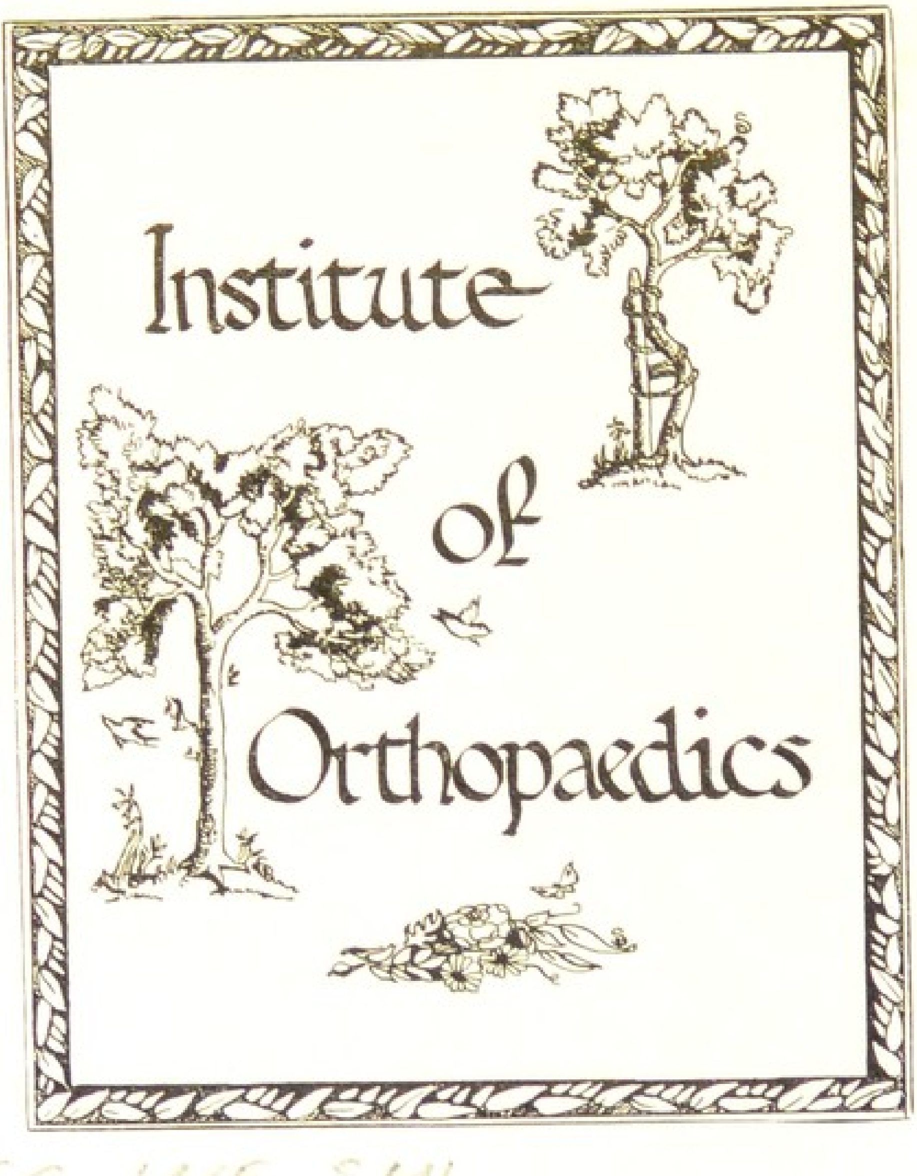
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LATERAL CURVATURE OF THE SPINE, AND FLAT-FOOT

LATERAL CURVATURE OF THE SPINE AND FLAT-FOOT.

AND

THEIR TREATMENT BY EXERCISES

BY

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SIR WILLIAM PURDIE TRELOAR, BART.,

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ON BEHALF OF

CRIPPLED CHILDREN.

With compliments from

[illegible]

PREFACE

THE scope of this book is quite definite, and is sufficiently described in the introductory chapter. Its chief object is to indicate, in what I hope to be a clear and concise manner, the steps necessary for the treatment of those cases of Spinal Curvature which are most likely to present themselves in general practice. High-grade skoliosis, and the method of making and fitting mechanical supports, come under a more advanced category, and are not dealt with in a preliminary work such as this.

Chapter X is embodied because I believe that it conveys several points of interest in the general treatment which the subjects of spinal curvature are likely to require.

I wish to express my thanks to Professor A. M. Paterson, Liverpool University, for the use of material difficult to obtain; and to Dr. F. Strong Heaney, for his kindness in reading and criticizing the manuscript.

J. S. KELLETT SMITH.

15, CAVENDISH PLACE,
CAVENDISH SQUARE, W.

May, 1911.

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INTRODUCTORY.

M. PIERRE DIONIS occupied the professorial chairs of Anatomy and of Operative Medicine at the Jardin-du-Roi from 1673 to 1680, in which latter year Louis XIV. attached him to the Court in the honourable position of Body Physician. In 1707 Dionis published his "Cours d'Opérations de Chirurgie démontrées au Jardin-du-Roi." The book ran through many editions in Paris and Brussels, and was translated into English, German, and Dutch. The language employed is remarkably forceful. The opinions expressed may be taken as representing the highest authoritative teaching of his day, and it is interesting to note therefrom what was the attitude of the profession towards spinal curvature more than two hundred years ago. The lecture on this subject is well worth reading, not only for its quaint merit, but also because it gives evidence that the real understanding of the disease had progressed little since the days of Hippocrates.

Thus Dionis :—

Of Gibbosity

"Gibbosity is a crookedness of the spina dorsi, or backbone, which requires the dexterity of a chirurgeon to correct it. The secret in this case consists in preserving to a man all the parts of this bony pillar, the just proportion which the Creator has bestow'd on it, and in restoring it, when fallen from its perfection. In this machine there are often faults which proceed from nature, and which 'tis impossible to repair.

Description of the Spina Dorsi

"The spina dorsi is compos'd of thirty bones, which are called vertebræ; they are plac'd one above another, and fasten'd together by ligaments, which leave them the liberty to move from one side to the other. The head is situate on the point of this pillar, the ribs and the arms are join'd to its sides, and the thighs to its lower part. 'Tis, as it were, the basis which bears and sustains the whole edifice of the body: 'tis that which by its straightness makes a good shape, and when bent in what manner soever, renders the man deform'd and lame.

The Spine Distorts Five Ways

"'Tis observ'd that the spine bends and jets out five principal ways: (1) Inwards, and then it leaves a hollow place in the middle of the back; (2) Outwards, when it forms a bunch which is called gibbus; or (3) Towards the right, when the right shoulder is higher than the left; or (4) To the left, which raises the shoulder on that side higher than the other; (5) Or lastly, obliquely, and like the letter S, when one part of it jets outwards and another inwards. Of all these distortions, that which most seldom happens, is the curvature inwards, because the structure of the vertebræ, and the impulse of the internal parts are generally from within outwards against the spine.

External and Internal Causes

"A person may become gibbous from an external, or by an internal cause: by an external cause, as a blow, or a fall, not remedied at first, by straining in carrying heavy burthens, by custom, as the labourers in the vineyard, who are always stooping to till the vines or plow the ground, or by an ill custom of making too low complimental bows. The internal causes are a too violent heat, which drying up some of the ligaments of the vertebræ, hinders their stretching themselves out sufficiently to give the spina dorsi its due extent; or an excess of humidity, which soaking the same ligaments in a viscous juice, relaxes them, and suffers them to prolong themselves beyond their bounds; but I believe weakness has a large, or indeed a larger, share in it than all these causes, of which we have a famous instance in a person of quality.*

An Instance

"This person was very straight and well-shap'd, to the age of eight or nine years: 'twas then observ'd, that he endeavour'd to lean on things, and that he inclined to one side, and sustain'd himself on the arms of his elbow-chair: his spina dorsi was examin'd, and was found to bend towards the right, assuming the figure of a crescent: we knew, that being of a very tender constitution, it was the weakness of the spine and its ligaments, which being unable to bear the weight of the parts of the body from the girdle upwards, bent under it. Little bodice of whalebone were made for him, to strengthen his spine; as was a commodious elbow-chair, to rest that part in its whole length: to this chair were added strings, which passing under his arm-pits, supported the whole weight of his body, and eas'd the vertebræ of the weight of the upper parts. But what precaution soever was taken, and what inventions soever were put in practice for several years, it has not been possible to prevent the spoiling of his shape: yet the heart and lungs are not press'd, the vital functions are not incommoded; and nature, weak in this regard, has recompensed this defect, by a thousand excellent endowments of mind, an exalted genius, and a courage and wisdom not to be found in others at his age.

"Gibbosity is not always a hereditary defect which passes from father to child: we see fathers and mothers with this imperfection have straight children: and

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* The Duke of Burgundy.

well-shap'd fathers and mothers have gibbous children; 'tis a misfortune attach'd to each subject in particular, and a deficiency, the cause of which ought never to be sought after, but in him that is afflicted with it. The chirurgeon must not pretend to render a child disposed to be crooked, perfectly straight, he can do no more by all his care, nor all his good conduct, than hinder the vice from increasing to such a degree of deformity, as he would have fallen to without his assistance; wherefore he should not promise the parents any more than he is able to perform, as is practis'd by taylors and steel bodice-makers, who, to get mony, assure them to make them well-shap'd, as if they had never been deformed.

This Imperfection not Hereditary

" 'Tis impossible to prescribe positively, and in particular, what ought to be done to gibbosity: If the spine jets outwards, lay the child on a mattress somewhat hard, keeping it on its back, and without pillow, that the head and the spine may be on the same level; If it jets out from the right leftwards, by the help of little bodice made on purpose, gently compress the part which comes out. The use of iron crosses fixt to the back, the shoulders and neck, is excellent to keep the parts even with one another; 'tis the industrious chirurgeon's task to invent machines capable of engaging this deformity, and correct it as much as he can, especially taking care not to press the parts contain'd in the thorax, which cannot be too free in their motions, which are so necessary to life."

With little alteration and few additions this might serve as an extract from a standard text-book of surgery of thirty years ago. In the interval chirurgeons had certainly been industrious in inventing machines, some of them veritable iron crosses in more senses than one, and looking as though they might have had birth in the imagination of a Thomas de Torquemada. Their very number throws suspicion upon their utility—successful instruments tend to conform to a simple pattern—and the majority of them were no more "capable of engaging the deformity" than was "little bodice of whalebone" in the case of the Duke of Burgundy. The student left off with the impression that spinal curvature was a pretty hopeless kind of thing, and the very name thereof seemed to be associated with some form or other of spinal scaffolding.

The truth was that the correct principles of fitting an appliance were understood by few, by almost as few as understood the proper fitting of a truss in a difficult case of hernia, and a goodly number of cases drifted into the hands of instrument makers who were worthy to be classed in many respects with the "taylors and steel bodice-makers" of M. Dionis.

But there was one gleam of promise. The early case of postural deformity was delivered from the tyranny of steel and leather harness, and a prospect of cure was held out by the employment of exercise.

Thence onward has followed a wordy war between the two schools of thought—the mechanics fighting with great tenacity for their hold, the gymnasts quite as enthusiastic in their claims; each apparently more than a little blind to the merit in his opponent's system, and, in his desire to possess the ground that lies between the two extremes, ignoring the cases especially suited to each.

I do not wish to deny the utility, in fact the necessity, of properly designed and properly used mechanical appliances in the treatment of pronounced spinal curvatures, from whatever cause arising, in which radical changes in the shape of the vertebræ have occurred. This is their rightful sphere. But when used in cases in which the deformity is still capable of correction, then I believe that the good they may do is due in great measure to the fact that the patient receives constant *reminders* from their contact, and so makes constant efforts to hold the body erect. In other words, they bring about, in a very tedious and uncertain way, a result which is obtained infinitely more quickly and definitely by the scientific use of exercises.

I use the words "properly designed" and "properly used" in their full value. An ill-made appliance, or one improperly used, is eminently capable of confirming the deformity it is intended to cure, and this takes place especially when the appliance is unyielding throughout and splints the body so closely that the spinal muscles lose the last remnant of their independence and cease to have any incentive to attempt their proper function.

However, these cases of deformity with advanced bony change are not under review here; nor are those having a pathological basis. I wish to deal with such as are still capable of cure by the cultivation of the natural means of holding the spine straight, or, in other words, with cases in which the spine is still flexible enough, or can be made flexible enough, to enable the patient, by trained voluntary effort, to erect it into something approaching a straight line.

Mention of the flexible curve brings us at once to a question of nomenclature. One writer of eminence, fearful of leaving his opponents any sphere of influence whatever, claims that the term curvature of the spine shall be applied only to those cases in which actual deformity of the bones is present, and that all antecedent to this stage are not cases of curvature of the spine at all. The distinction is a subtle one. But called by any name, qualified by any adjective—postural, flexible, physiological, functional—the fact remains that the deformity is part and parcel of the same vicious cycle that results in the production of the hopeless cripple with the bent trunk and contorted thoracic cage, who has lost all "good shape," and has been rendered "deform'd and lame" for the whole period of life. The fact also remains that it is the most important stage of that cycle; it is the stage when cure is the most easy, and when skilful attention will prevent the overclouding of what ought to be the gladdest years of a young life.

The advocates of the physical exercise treatment lost ground at first by prescribing exercise in an indefinite kind of way, and by neglecting to describe the exact details of the method to be followed. Consequently the cases were left to the professors of calisthenics and deportment, or they drifted to a gymnasium presided over as often as not by an ex-army instructor. In either case the treatment was left to one whose knowledge of anatomy was of the most sketchy kind. Right-handed curves, left-handed curves, double curves, were all lumped together in a class, and the result was largely a matter of luck.

The last decade has seen the growth of systems of exercise without number. Most of them have many good points, and some have very bad ones. The best of them meet with successes, and having no shame of advertisement, promptly claim to be able to cure most of the acquired and inherited ills both of the flesh and of the spirit. But recent teaching is tending in the right direction in condemning the old system in which a pupil was introduced to a gymnasium, was taught the dumb-bells, clubs, and bar-bells, in a musical class, and was then left to roam at will among a profusion of apparatus which tempted him to emulate his elders in acrobatic feats which too often resulted in the production of heart-strain and of hernia.

The lot of the patient seeking remedial exercises is also improved, and the proprietor of a stiff joint, for instance, can usually find somebody capable of carrying out the simple measures necessary for its relief. But it is still otherwise with the unfortunate subject of a spinal curvature. On the one hand, there is the ex-army instructor, or the advocate of a system, who works with a minimum of anatomical knowledge, and who, from his complete ignorance of surgery and of medicine, should never be allowed control of such a case. On the other hand, there is the medical man, very often out of reach of an expert, and whose curriculum has not comprised a course of physical training, who is at a loss how to begin to add this small special field to his already vast province. It is to help him in this difficulty that this little book has been written.

CHAPTER II.

OCCURRENCE—CAUSES.

OCCURRENCE.

LATERAL curvature of the spine occurs in both sexes and at all ages.

Sex.—It is so much more frequent in females than in males that one comes to associate the deformity with the female sex. One authority estimates the proportion as 7 to 1. The reasons for this may be deduced from a consideration of the natural methods by which the spine is held erect.

The spine may be regarded as a column, essentially flexible by reason of its composition of alternate segments of bone and fibro-cartilage, firmly held at its base by being wedged between the iliac bones, and maintained in the middle line of the body by ligaments throughout its length, by the bracing of the ribs and sternum in the dorsal region, and by powerful groups of muscles running approximately parallel to itself. *These muscles have the first and last say in maintaining the spine in a position of unstable equilibrium.* With a column necessarily flexible this is the best result that can be obtained, but the defects of an unstable equilibrium are always present, and any failure in power, or quickness of response on the part of the muscles, will result in its destruction. With the muscles inefficient the spine bends, the ligaments soon stretch with the strain thrown upon them, the pressure on the concave side of the curve interferes with free growth in the case of the young, and finally the bones, both from this cause and from obeying the law of wasting under constant pressure, become altered in shape, and irremediable deformity results.

Girls are, as a rule, less developed muscularly than boys, and they do not obtain the constant and varied exercises necessary to keep their muscles in the same hard condition. Especially do they miss the wrestling and general rough play which supple the muscles as nothing else can, and which, in the shape of resisted effort, have the same foundation for their efficacy as the *jiu-jitsu* system of development. There is no reason whatever why young girls should not participate in sports almost as active and strenuous as those of young boys. It is only upon the near approach of puberty that the female begins to require a more sedate life and to bow to the anabolic tendency which is the concomitant of her sex. As things are, at present, under school and home régime, girls spend long hours over music practice and fancy work, or packed away in easy chairs with enervating cushions, and this means that they have more chances of adopting some faulty posture which may lay the foundation of a curvature.

Girls also undergo a period of physical stress which has no counterpart in the life of the opposite sex. The tables of average weights and heights give interesting information upon this point. They show that between the ages of 10 and 15 years, not only do girls grow more rapidly than boys, but so much more rapidly that, during these years they nearly attain their full stature. The average height of girls at 15 years is 5 ft. 1 in.; at 20 years, when practically the full female growth is reached, it is 5 ft. 3 in. Compare these with the figures for the male, which are: at 15 years, 5 ft. 2¼ in., and at 20 years, 5 ft. 7½ in. Again, from 11½ to 14½ years girls are actually taller, and from 12½ to 15½ years also heavier, than boys.

The process of maturation in the male is more gradual, and during her period of profound change and rapid growth, when she puts forth suddenly from the schoolgirl to the estate of womanhood, the female is apt to suffer from some measure of muscular weakness—she "outgrows her strength." The spinal muscles, along with the other muscles, are not up to their particular work, and she thus becomes especially patent to the onset of curvature.

The peculiarities of ordinary female dress do not in themselves influence the matter. The fit of the garments is of far more importance than their design.

Age.—As might be expected, the greatest number of cases occurs between 10 and 15 years of age, the actual maximum being reached a little before the average period of the change in girls. It is rare in the tender years of infancy, rare also in adults, and is therefore very apt to be overlooked in them. The lustrum 25 to 30 is rather an important one for the female—a "settling down" process seems to occur after the rapid spurt of youth, and the figures show that a diminution both in height and weight takes place. There is quite a type of case associated with patients of this age in which complaint is made of great and persistent pain in the back, generally in the lower dorsal region, attributed to enteroptosis, "kidneys," "internal congestion," or some other vague cause. Nothing is to be made out upon first examination, but after the patient has been sitting a little while, the spine is seen to give way, the lumbar curve vanishes, there is a lateral bending with the convexity towards the more painful side, and she straightens herself out again when asked to do so, with an obvious effort. Such cases are cured by exercises. The pain of overweighted muscles and of stretching ligaments insists upon attention before the set spine of the adult becomes seriously affected. In the softer tissues of the young girl the progress of affairs is more rapid, and deformity often results before any collateral symptoms press for investigation.

The occasional rapidity of onset of a curvature is an important point. It may become quite marked in as short a period as two months.

CAUSES.

(*A*). Predisposing.

1. Weakness of the spinal structures from natural causes or as the result of illness.

2. Feeble muscle sense.

(*B*). Actuating.

<table>
<tr><td>(1). Faulty position in standing</td><td rowspan="2">Due to habit or fatigue in the normal child. Initiated in the abnormal child by deformity of the pelvis, difference in the standing height of the legs (unequal growth, knock-knee, bow-legs, flat-foot, etc.) wry-neck, errors of vision, deafness, etc.</td></tr>
<tr><td>(2). ,, ,, ,, sitting</td></tr>
</table>

(3). ,, ,, ,, lying
(4). ,, ,, ,, extraordinary occupations.

(*A*). **Predisposing.**

1. Hereditary influence has been held to account for the occurrence of lateral curvature in members of the same family. Stiller recognizes as hereditary a condition which he has named general constitutional asthenia (*Asthenia universalis congenita*, *Morbus asthenicus*), and which affects the physical and physiological activities of the tissues, and carries with it a general weakness of muscles, bones, and ligaments. This condition, which may also be acquired through bad hygienic surroundings, is that found in children who have "always been delicate." Again, just as other physical characteristics may be transmitted, there is no

difficulty in accepting the idea of the inheritance of a weak spinal muscle-group. It is a question of physical type: there are whole families who are "stiff-backed," there are others who "slouch." It must be remembered also that children are great imitators, and are quick to copy any peculiarity of those with whom they are in close contact. The frequent assumption of the attitude of a crooked back may speedily lead to the development of the real thing.

The condition produced by what is popularly known as "outgrowing one's strength" is eminently favourable to the development of spinal mischief. The muscles are easily fatigued, the ligaments quickly stretched, and the epiphyses large and soft. A good proportion of patients give a history of noticing their trouble after having passed through this phase.

Rudolf Klapp believes that acute illnesses, such as scarlet fever, produce a degeneration to weakness, not only on the part of the muscles but also on the part of ligaments and of bones. He suggests the loss of calcium salts from the bones, from the fact that, after acute fevers, the latter are often abnormally transparent to the Röntgen rays.

Of all acute illnesses, those involving the chest are especially prone to be followed by lateral curvature, quite apart from the effect of any adhesions or fluid formations which may result from them. This is due to the fact that the patient eases thoracic pain by bending towards the affected side, and continues this posture after convalescence is established.

Anæmia is a frequent cause of muscular feebleness, and is dealt with in the final chapter.

2. The attitude of erect spine is an extremely trying one to maintain for any considerable time, and the greater part of our lives is spent with the spine in a curved position. All the bad habits illustrated hereafter are practised by vast numbers of children, and yet only a small proportion of them suffer from lateral curvature. Moreover, some of

those who do so suffer are quite up to the average of muscular development, and can by no means be classed with the general asthenics. In such children it will often be noticed that the muscle sense is very feeble. From an incorrect posture at the desk, for instance, they will rise with the spine curved and one shoulder raised, and will continue so to hold themselves. Even when their attention is called to it, they do not realize the fact, and when asked to hold themselves erect, will often merely lift the shoulders and even increase the malposition. Their muscle sense is so feeble, their power of establishing an acquired automatism is so unstable, that without question they accept and continue an abnormal posture, and require to be trained to appreciate the proper attitude to an age far beyond that necessary for the ordinary child.

(*B*). **Actuating.**

In describing the various actuating causes of lateral curvature, it will be convenient to discuss at the same time the means of counteracting those which fall within the scope of this book. It is manifestly impossible to illustrate all the bad habits of posture; those dealt with are merely typical examples from which the remainder may be inferred.

1. FAULTY POSITIONS IN STANDING.

Due to Habit.—*Fig.* 1 shows a very ordinary attitude of standing at ease. The muscles are relaxed as far as possible, the ilio-tibial band is brought into use, and the balance maintained by "locking" joints and throwing strain on ligaments. The weight of the body rests on one leg, and the other is thrown out as a strut. It is an attitude of rest natural not only to man but to many quadrupeds; the side-tilted pelvis, with one leg acting as a prop and the other held loosely, is a familiar pose of, for example, the horse.

If adopted by a weak-muscled boy or girl as a habit of standing, the tendency to the production of a spinal curve is manifest.

A better position of rest in standing is obtained by

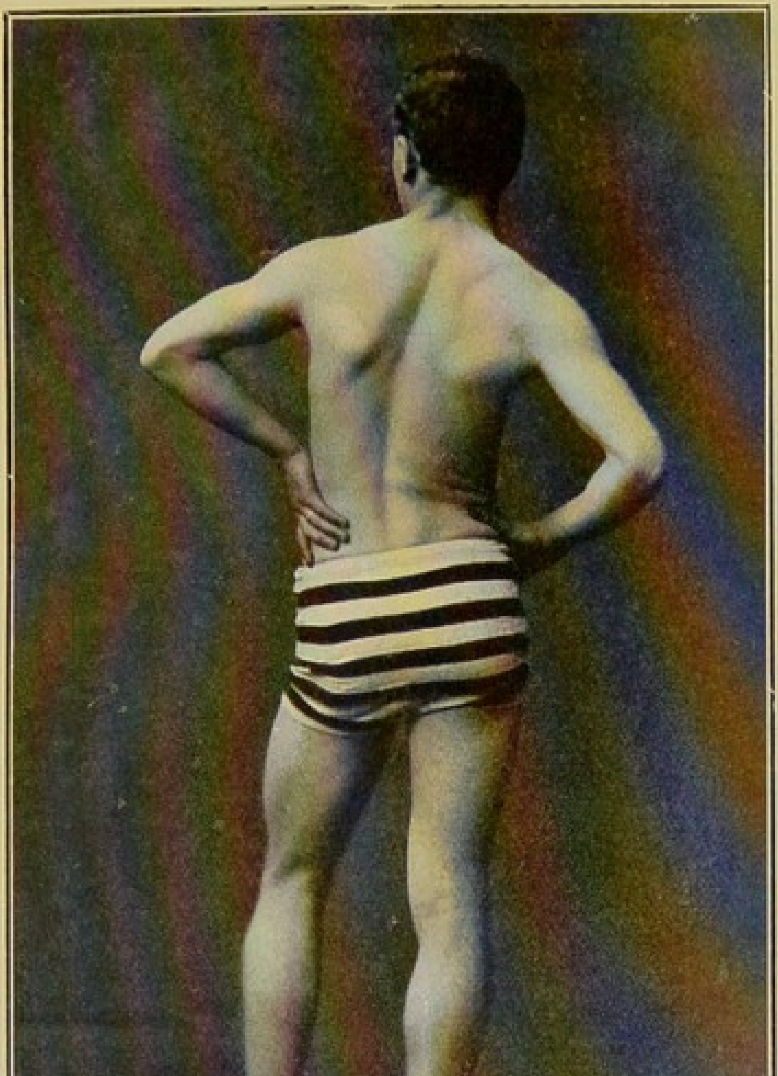

Fig. 1.—Faulty position in "standing at ease."

placing one foot in advance, as though about to take a step forward. In this position the rear leg bears the greater proportion of the weight, and by changing the feet about as they become tired, relief is given to each in turn.

Fig. 2 shows another incorrect position, in which the antero-posterior curves of the spine are affected, resulting in a rounded and stooping back. It is given here because it is so often combined, both in standing and sitting postures,

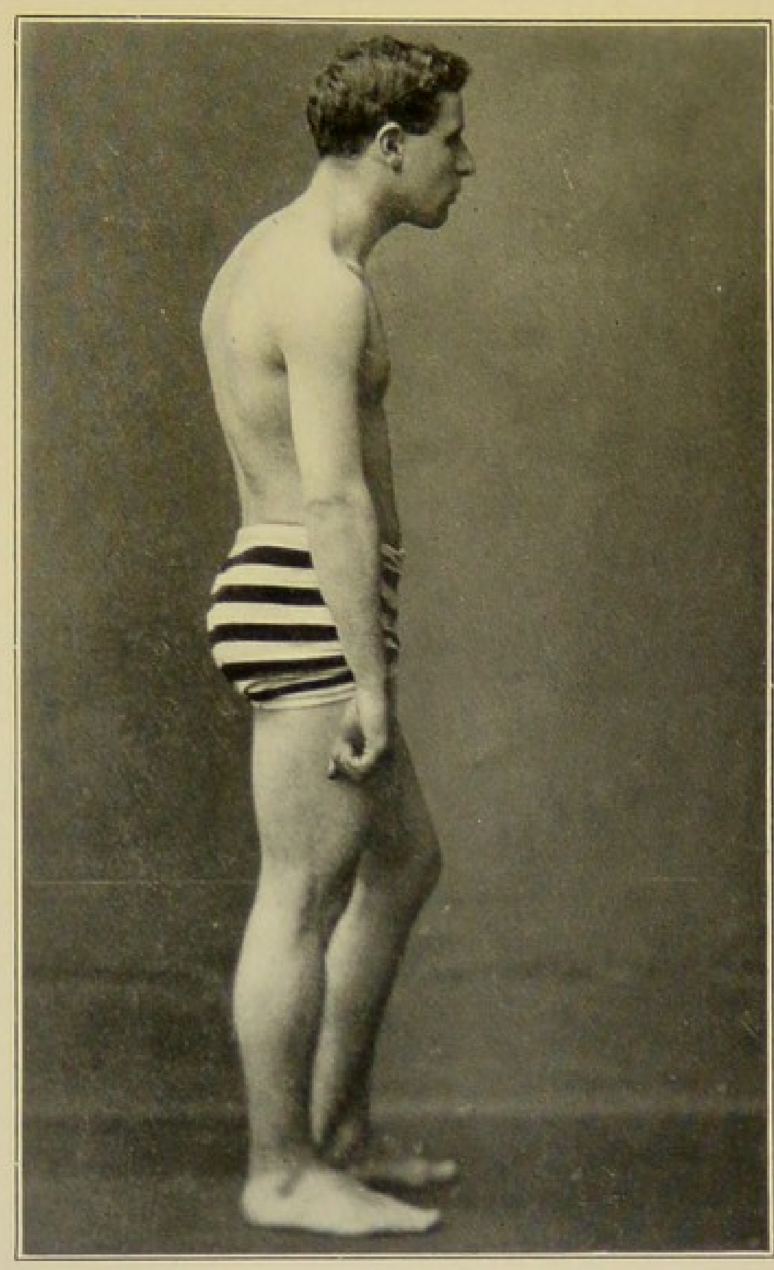

Fig. 2.—Faulty position in standing.

with an attitude producing lateral curve, that it is extremely rare to find a case of the latter in which the antero-posterior curves are not altered, generally in the manner shown in the figure.

Influence of Dress.—In connection with these two figures it will be convenient to discuss the question of clothing. Writers upon lateral curvature have criticized almost every article of attire. This is rather a dangerous thing to do, for dress in its average form is the outcome of centuries of human thought and ingenuity, and each garment may be said to represent the survival of the fittest in comfort and general utility, having regard to the circumstances and climate in which it is used. These writers have been especially harsh upon female dress, but it must be admitted, always disregarding extremes, that the fashion

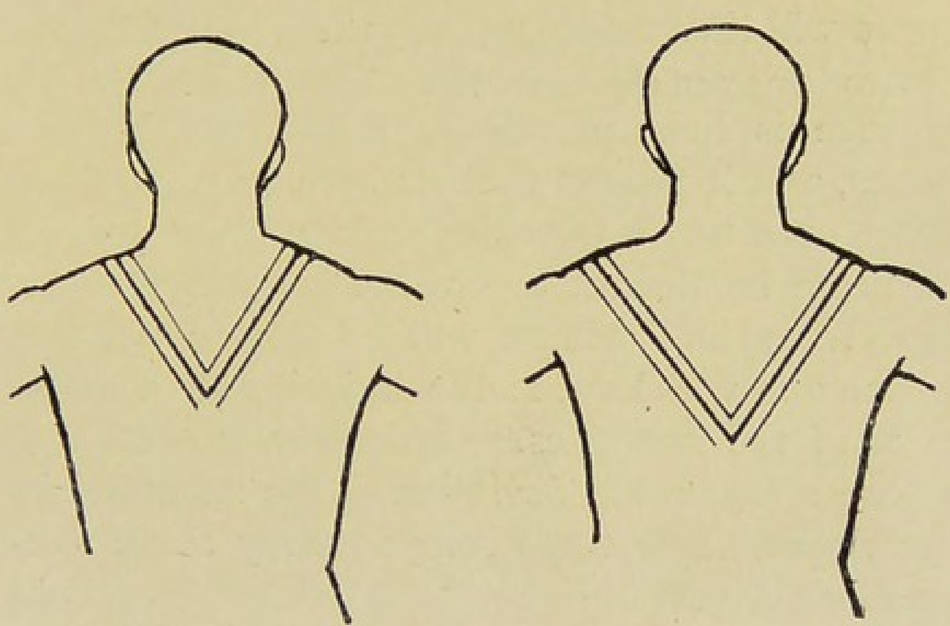

Fig. 3.—Showing correct and incorrect positions of braces on the shoulders.

of late years has generally presumed a symmetrical figure and an upright carriage. Lateral-curvature patients are too young, as a rule, to be the victims of any extraordinary craze in dress, and the important points with regard to the dress of the young are: (*a*) That the clothing shall not restrict expansion of the chest and free movements of the shoulders; (*b*) That as little weight as possible shall be borne on the shoulders, and that braces and straps shall take their bearings near the root of the neck and not far out upon the clavicles and acromions; (*c*) That suspenders shall not be attached to the clothing in such a way as to tend to bend the trunk to one side or other. The outcome of these faults is obvious ; together, or alone, they tend to produce such attitudes as those of *Figs.* 1 and 2, and each patient's clothing should be examined for them. When standing erect—head up, shoulders back, chest out—there must be no restriction in front and no tightness around the arm-holes. Boys' braces are often at fault by spreading too far out on the shoulders ; their point of division at the back must be brought higher up. Better still is it to do away with braces, and have the knickerbockers to fit rather closely round the pelvis. The ordinary back-strap will then suffice to keep them in position.

Due to inequality in the length of the legs.—The sacrum is held practically immovable between the iliac bones, and it follows that its base may be regarded as a platform upon which the spinal column is erected. Should this platform be thrown out of the horizontal to one side or other, the spinal column will be thrown out from the middle line and will lean, in the majority of cases, towards the lower of the two sides.* Moreover, a small deviation at the base means a big deviation at the summit, and calls for a correspondingly large compensatory curve to restore the line of gravity.

Such a tilt of the horizontal may be due to deformity of the pelvis (rare), or to inequality in the standing length of the legs caused by fracture, joint disease, congenital dislocation of the hip, bowing from rickets, knock-knee, infantile paralysis, trophic paresis, etc., or by a disparity in their natural growth. Flat-foot on one side also may produce shortening.

If the shortening is of considerable extent and is accompanied by a stiff joint or by other gross lesion, the case is not likely to come under review primarily as one of lateral

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* In some cases a voluntary over-correction takes place, and the column leans away from the lower side.

curvature. But if there is little interference with natural gait, and the legs, upon casual inspection, present no appreciable difference, then the lateral curvature alone may be the object of consultation.

Few people have legs of exactly equal length, but the variation as a rule is so slight that no mechanical difficulty results. The standing height, however, of the legs of a patient who develops a lateral curvature should always be measured.

Various methods of measuring are employed. I have devised the simple instrument shown in *Fig.* 4. It consists of a thin plate of hard wood, 15 inches long and 2 inches deep in the middle, tapering to 1 inch at either end, curved to suit the prominence of the abdomen, and having its upper edge trued to a horizontal plane. At the centre of its convex face the upper edge expands into a small platform terminating in a convenient handle, and bearing a spirit level.

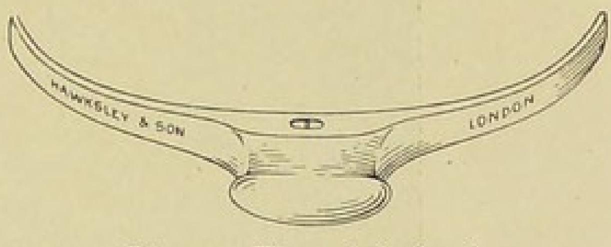


Fig. 4.—The pelvic level.

To use it the patient stands erect, boots off, and with the hips exposed. With a dermatographic pencil a dot is placed over each anterior superior iliac spine. The instrument is then applied so that the upper edge passes through both dots. If the spirit level then indicates horizontal, the two legs are proved equal as regards their standing height. If it does not indicate horizontal, slabs of wood of known thickness are placed beneath the foot of the shorter side until the horizontal is gained. The sum of the slabs used will give the difference between the two legs. A convenient range of slabs is 2 in., 1 in., $\frac{1}{2}$ in., and $\frac{1}{4}$ in. They should be made of well-seasoned wood to prevent warping, and should measure 12 in. by 5 in.

This method of measurement is an extremely accurate one and by far the most simple. It assumes only one thing, viz., that the pelvis is symmetrical as regards the height of the anterior superior iliac spine above the acetabulum. Any vertical measurement taken from the anterior superior spines themselves, with the patient standing on unequal legs, requires correction by a very complex and constantly

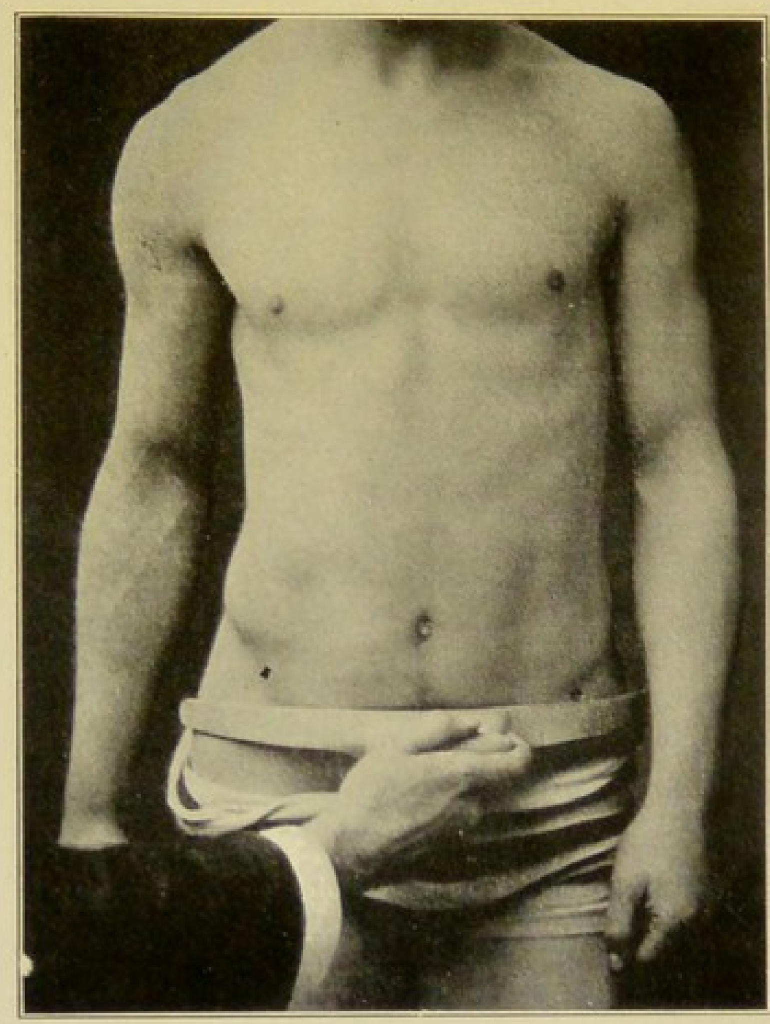


Fig. 5.—Applying the pelvic level. The subject has a slab of wood one inch thick beneath his right foot.

varying formula before it can be accepted as exact, and this for two reasons. Firstly, the distance between the anterior superior spines is greater than the distance between the mid-points of the heads of the femora ($9\frac{1}{2}$ inches to $6\frac{1}{2}$ inches, average measurements), and therefore any difference in the levels of the latter will be exaggerated in the levels of the former (*Fig.* 6). Secondly, when the pelvis is tilted sideways, the anterior superior spines move up or down, as the case may be, not in straight lines but in curves, owing to the ball-and-socket action of the hip joint.

Some surgeons who adopt the use of the slabs of known thickness, trust to mere inspection to tell them when the pelvis is brought to the horizontal. This may suffice for the practised and accurate eye, but otherwise is to be trusted to with caution : the prominent hip on the one side and the filled-in flank on the other confuse the levels.

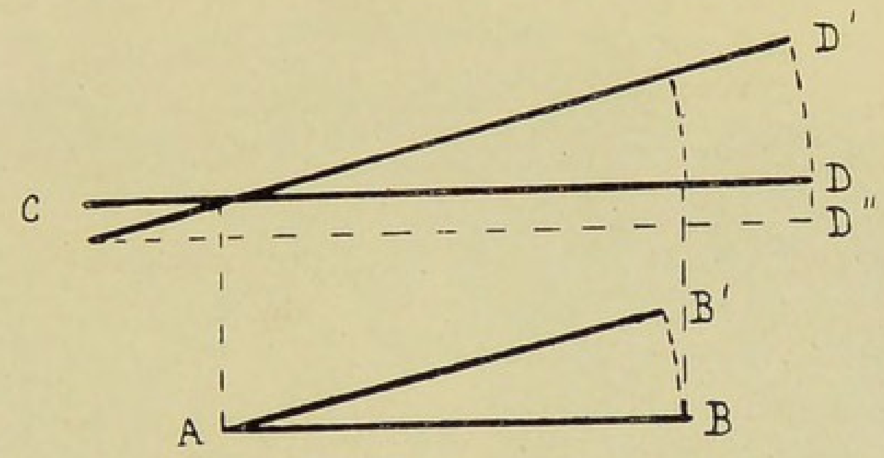


Fig. 6.—Diagram showing how a difference in the length of the legs is exaggerated in the levels of the anterior superior iliac spines. AB represents the distance between the bearing surfaces of the acetabula, and CD the distance between the anterior superior iliac spines. If AB be tilted into the position AB′, then the difference in the length of the legs, represented by BB′, is exaggerated in the levels of the anterior superior iliac spines into D′D″.

The difference between the two legs having been found and measured, the first thing to be borne in mind is that this difference may be due, wholly or partly, to flat-foot on the shorter side. If so, the cure of this defect must be commenced forthwith on the lines indicated later, but should the foot be normal, the question arises of raising the boot on that side by means of a thicker sole or by building it up internally.

Most people naturally object to wearing a thick boot if it can possibly be avoided. Therefore it is asked, *Can a very slight difference in the length of the legs afford to be neglected ?*

Now, the pelvis rests upon the tops of the heads of the femora, and when any side tilt thereof takes place it affects the horizontal plane passing through the bearing surfaces of the acetabula. This plane cuts through the lowest part of the sacrum, as shown in Pirogoff's horizontal section (*Fig.* 7), and the average height of the spine above this point, arrived at by deducting 2 inches for the remainder of the sacrum and coccyx from the total average spine length of 28 inches, is 26 inches.

Fig. 7.—Sectio transversa pelvis, infra spinam anteriorem inferiorem ossis ilei, supra fundum acetabuli, ad $2\frac{1}{2}$ poll. par. a symphysi ossium pubis, per incisuram ischiadicum majorem et per infimam partem ossis sacri . . . instituta.

AA. Os ilei in loco juncturæ cum ramo horizontali ossis pubis, in latere dextro supra fundum acetabuli, in latere sinistro per fundum acetabuli persectum:—*B*, Os sacrum ad 20 lin. par. supra juncturam sacrococcygeam persectum.

The centre of the bearing surface of the acetabulum corresponds roughly with the level of the brim of the true pelvis. Taking 5 inches as the transverse diameter of the brim, and allowing $\frac{3}{4}$ inch on each side for thickness of bone, we may say that the distance between the centres of the acetabular bearing surfaces is $6\frac{1}{2}$ inches.

The position, therefore, is that we have a column 26 inches long fixed at right angles in the middle line of a platform 6½ inches wide. This may be represented by a simple diagram (*Fig.* 8), in which AB represents the acetabular bearing plane, and CD the perpendicular column of the spine. Now if AB be tilted into a new position AB′, it is evident that the column CD will take up a new position, in which its topmost point will be swung away from the middle line to D′. Moreover, neglecting finer mathematical points, the distance BB′ is to AB as DD′ is to CD. This gives an easy method of estimating the effect upon the spinal column of any side-tilting of the pelvis due to inequality in the length of the legs. Thus, proceeding on this formula, and employing the average measurements above given :—

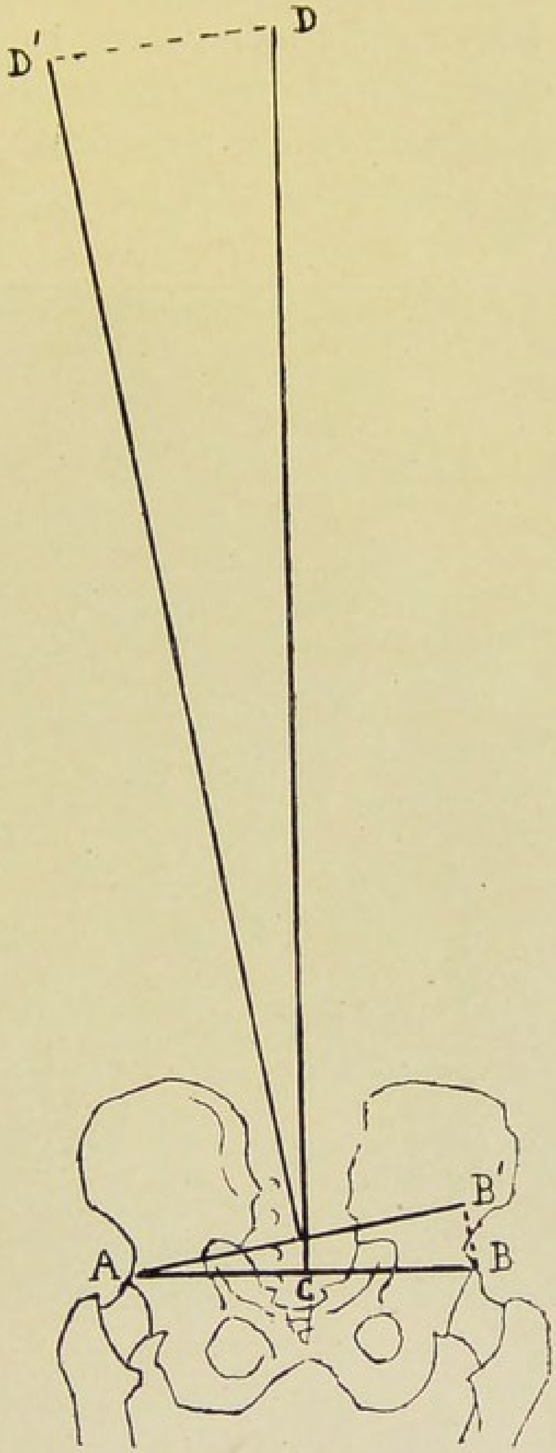
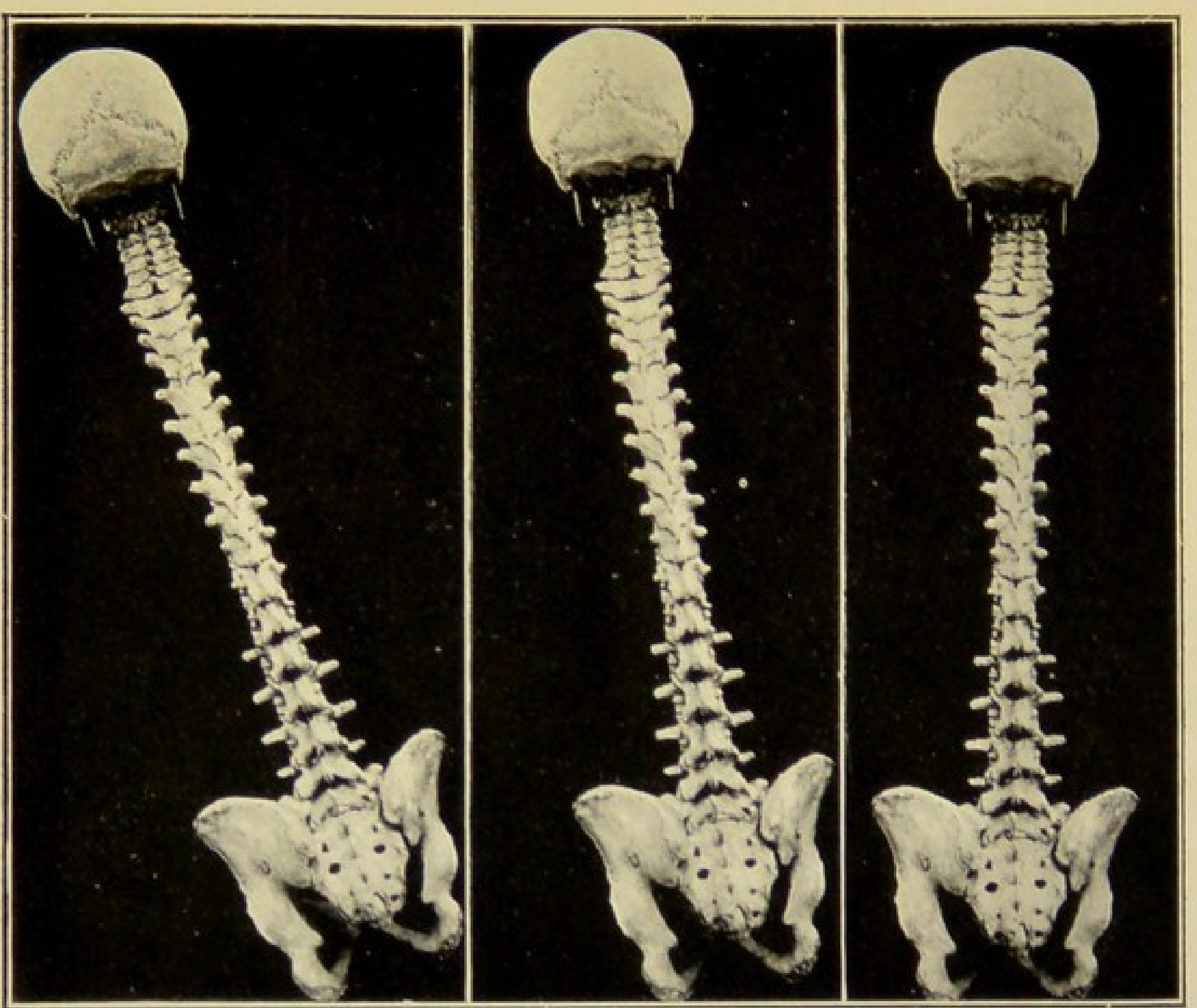


Fig. 8.—Diagram illustrating effect upon the spine of side-tilt of the pelvis.

A tilt of	½ in.	tends to swing the top of the spinal column	2 in.	from middle line.
,,	1 in.	,, ,, ,, ,, ,,	4 in.	,, ,,
,,	1½ in.	,, ,, ,, ,, ,,	6 in.	,, ,,
,,	2 in.	,, ,, ,, ,, ,,	8 in.	,, ,,
,,	3 in.	,, ,, ,, ,, ,,	12 in.	,, ,,

It will be seen that, taking average measurements, the relation of the distance between the centres of the bearing surfaces of the acetabula, and that portion of the spine above their level, is as 1 to 4. In other words, for every half inch of disparity in the length of the legs, the top of the spine tends to swing out 2 inches from the middle line. This calculation is for the male; in the female it will be



A. *B.* *C.*

Fig. 9.—(*A*) Represents a difference of two inches between the legs; (*B*) A difference of one inch between legs; (*C*) At the normal.

somewhat less ($1\frac{9}{13}$ inch) owing to the relatively shorter length of the spine compared with the base line. The photographs above (*Fig.* 9) will bring home to the eye what these figures mean.

Up to this point in the argument we have treated the spine as a perfectly rigid column, and have also neglected the effect of the weight of the head and upper extremities. It is difficult to realize the great flexibility of the spine under natural conditions, and how it is affected by the weight it has to carry. *Fig.* 10, from the original by Pirogoff, who must have gone to great labour over its preparation, is worthy of very close attention. Pirogoff took the body of a woman and, with the pelvis firmly fixed, allowed it to lean to one side. It was frozen in this position, and then, following the natural curves of the column, he made a coronal section down the spinal column, through the bodies of the vertebræ. In *Fig.* 10 is depicted the face of the posterior section.

This figure illustrates forcibly what tends to happen when the spine is once moved out of its line of balance. The tissues here are in a state as nearly approaching the living state as it is possible to get them ; the ligaments and intervertebral discs are still fresh ; the one thing withdrawn is the power of the muscles, thus showing in unmistakable manner how all-important the muscles are in maintaining the spinal column erect.

The conclusion from this alone is that a small difference in the length of the legs may be neglected only in a subject whose spinal muscle groups are powerful enough to present a wide margin of safety. In the subjects of a lateral curvature, *whose muscles are already overweighted*, even a small difference should be corrected, but the patients with differences of ½ inch or so may be given the hope that, with maturity and greater strength, the correction will be unnecessary.

Fortunately it is now possible to correct shortening without submitting the patient to the distress of the old-fashioned high boot, which proclaimed to all the world the deformity of its wearer.

A small difference of half an inch or so can be met by raising the heel ¼ inch externally and building up the inside

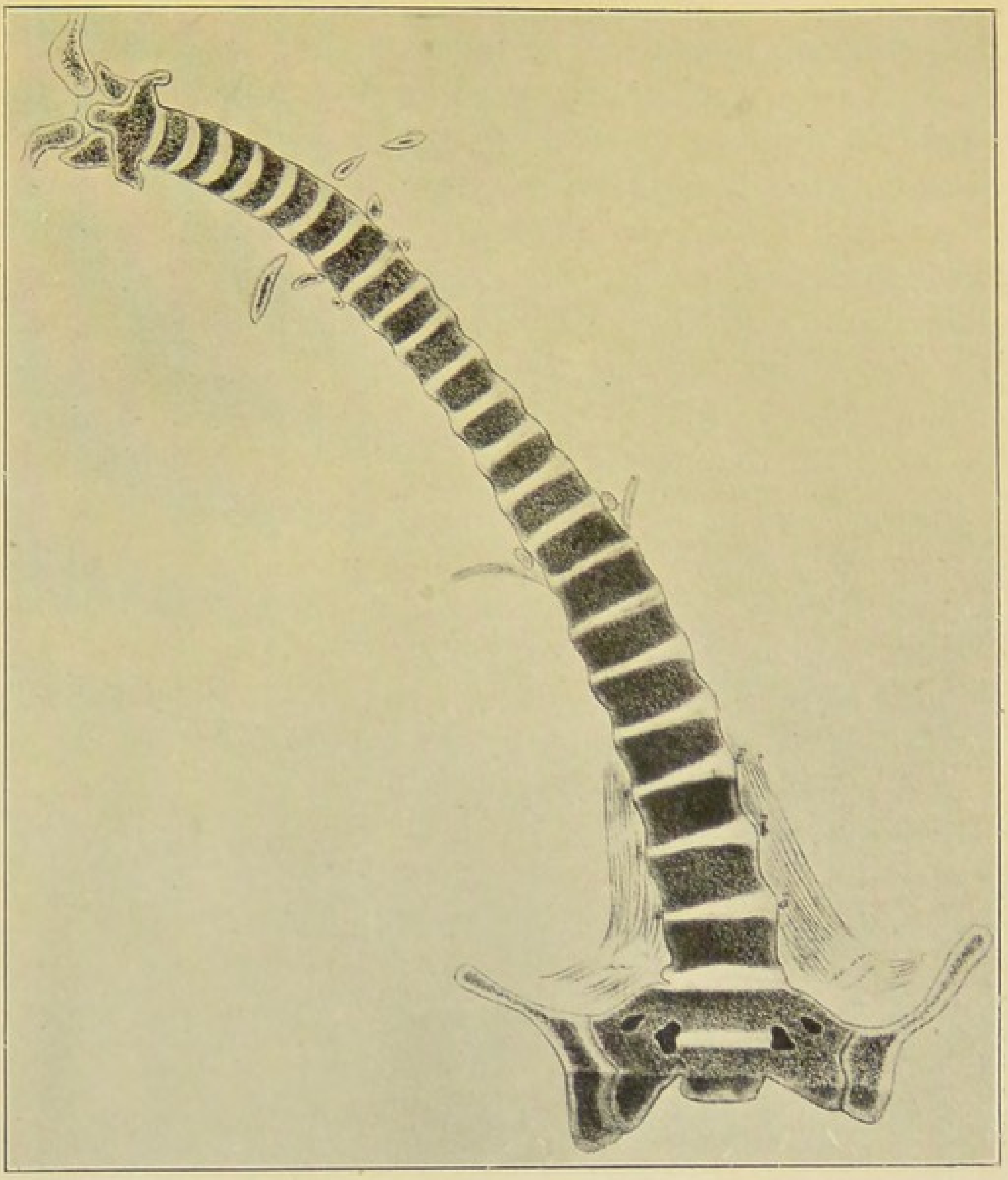


Fig. 10.—Sectionem anteroposteriorem columnæ vertebrarum ejusque ad latus dextrum valde inflexæ adumbrat.

Cadaver mulieris, ita positum est, ut truncus, pelvi in mensam fixa, ad latus dextrum vehementer inclinaretur cadaverque in hoc situ congelatum in discos anticum et posticum diffinderetur.

Linea secans vel in hoc cadavere directionem non rectam, sed tortuosam et flexuris columnæ vertebrarum respondentem sequitur.

Facies anterior disci posterioris.

Imagine hujus sectionis facile probatur, præcipuam motus lateralis corporis sedem in tribus ultimis lumborum vertebris esse positam (a'', b, c). Disci cartilaginei vertebrarum illarum (a,a'', b,b'', c,c''), inclinatione laterali columnæ, prope sinistrum latus (a, b, c) compressæ et angustatæ cernuntur.

of the heel forward to the waist by a leather sock, ¼ inch thick behind and gradually thinning to nothing at the tread. These alterations can be carried out in the patient's ordinary boots.

Larger differences require an internal elevator, best constructed of a tough cork composition, devised on the lines shown in *Fig.* 11. Here again the main thickness is carried well under the heel, and lessens as it passes forward. The upper of the boot requires to be specially constructed to allow room for the insertion of the elevator, and in the more marked cases the sole will require to be prolonged in order to provide a tread further back than normal. Since, however, the foot, being somewhat removed from the horizontal, does not occupy the whole length of the boot, the toes of the two boots appear alike, and the difference in the uppers is masked by the clothing. This device is successful for differences up to 4 inches, or even more, and will cover all cases likely to present themselves for treatment of lateral curvature.

Raising the heel more than the toes would appear on

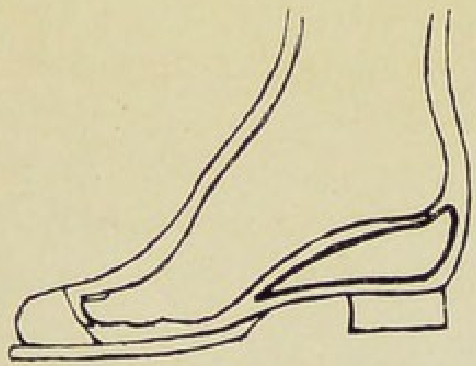


Fig. 11.—Diagram of an elevator worn inside the boot. The unoccupied toe of the boot is filled in.

first consideration to be an uncomfortable method of procedure, but, with a well-designed elevator, it is not so; in fact, the foot occupies a position similar to the one in the high-heeled boots worn by ladies.

CHAPTER III.

OCCURRENCE—CAUSES (*Continued*).

2. FAULTY POSITIONS IN SITTING.

Due to Habit.—*Fig.* 12 illustrates the boy-like attitude of sitting with one leg doubled underneath the body. The result is a side tilt of the pelvis and a corresponding correcting curve of the spine.

A similar position is brought about by sitting with the knees crossed, the pelvis in this case being raised on the side of the leg which crosses over its fellow.

At the Desk.—In the conditions of school life we find the most fertile causes of spinal curvatures. Desk-work involves tasks so artificial to the young human that every care should be taken to favour the easy assumption of a good sitting position at the desk, and to lessen as much as possible the physical strain entailed.

Scholars are grouped into classes according to their knowledge and intelligence; which means, with average children, that the scholars in any one class are more or less of the same age. No attention is given to variations in physical development; the big and little, the long-limbed and the short-limbed, are set down to the same pattern and size of furniture. The result is very much what it would be were an attempt made to clothe a class by ordering so many suits for, say, "children aged 12." A few who happened to be of the stock measurements would be fitted, the others would be inconvenienced.

Long desks and forms, each accommodating several children, are therefore not desirable, but where their use is absolutely necessary they should be provided in several different sizes, and great care should be taken to ensure each child's having ample room for elbow spread. The ideal

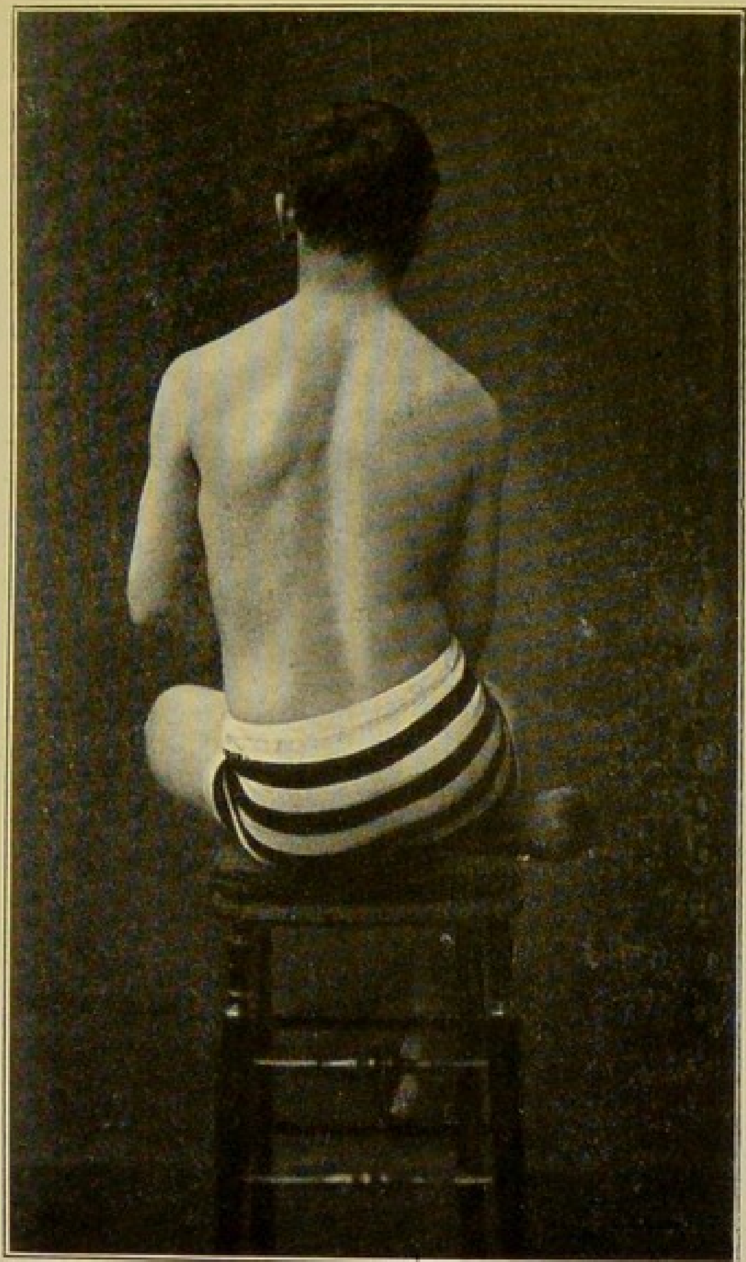
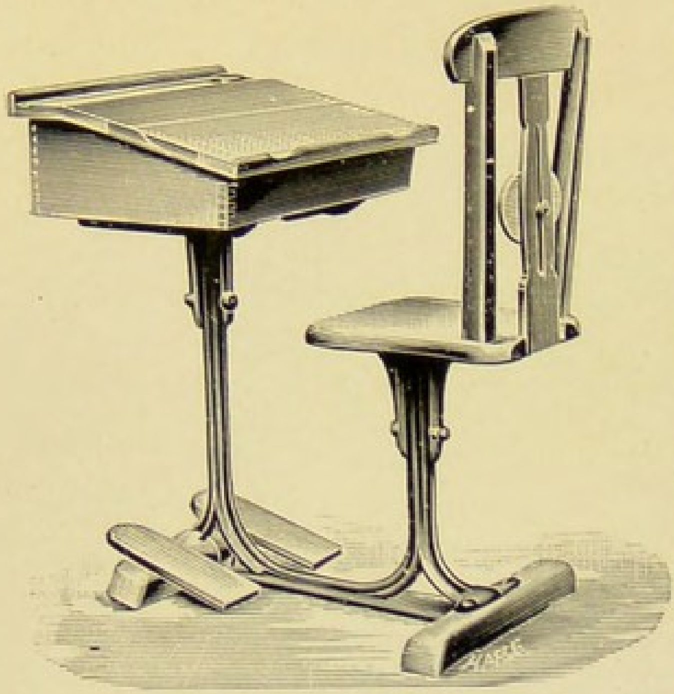


Fig. 12.—Faulty position in sitting.

arrangement is for each child to have a separate desk and seat, so made that they can be readily adjusted to individual peculiarities. Certainly any child suffering from a "weak spine" should be so accommodated.

Fig. 13 shows a design which has been reproduced in various books upon the subject. It meets all the essential requirements. The seat and the desk may each be raised or lowered independently, and the desk top slides horizontally and can be used at the most comfortable working distance for the arms; the writing slope is at an angle of 15°, and there is also a book-support at an angle of 40°; the chair has a deep seat accommodating the proportionate length of the thighs, the adjustable convex pad at the back supports the lumbar spine, and the foot-rests are placed at a good angle.



* *Fig.* 13.—Adjustable desk and chair.

The desk must stand in a good and well-placed light, so that the child may have no need to bend forward or to twist about, either to see its work clearly or to dodge its own shadow.

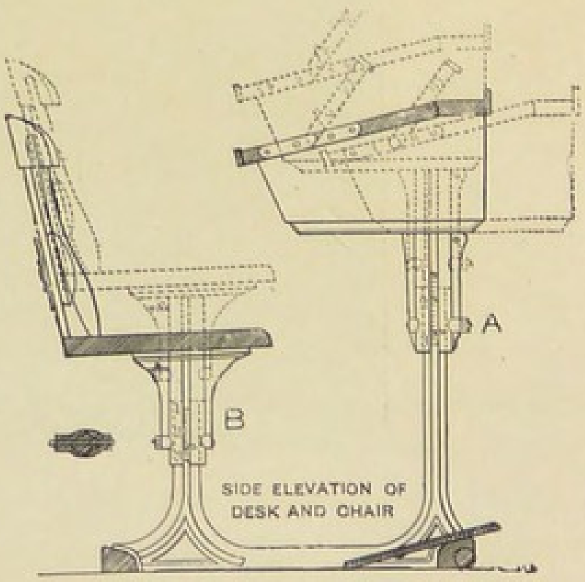


Fig. 14.—Showing the various adjustments.

It now remains to teach the child *how* to work at a desk. The exercise of writing may be taken as an example. The child's natural actions are "large-armed" and free, and it is a matter of much labour for

* The illustrations, *Figs.* 13, 14, 20 and 21 are lent to me by the North of England School Furnishing Co., Darlington.

it to acquire the series of small and highly-specialized movements used in writing. It would be easier if we progressed from right to left of the paper, or in vertical columns, or if we used characters composed of lines and angles. The making of the complicated series of curves habitual with us remains an ungraceful art even for adults, as is evidenced by the strained and awkward positions seen in any writing-room.

The best position for the usual style of writing, in which the letters have a forward slope (*Fig.* 15, upper line), is as follows : The body sits squarely on the chair, with back held stiffly and bending slightly forwards to within an inch or so of the edge of the writing-slope. The feet are placed evenly upon their rests. Both forearms are on the desk, with the elbows pointing outwards. The left hand controls the paper, and the slope of the pen is along the line of the right forearm. The paper is placed opposite the right breast, in order to prevent the right hand obstructing the writing field, and the lines slope from below upwards and to the right to allow the pen hand to move with freedom (*Fig.* 16).

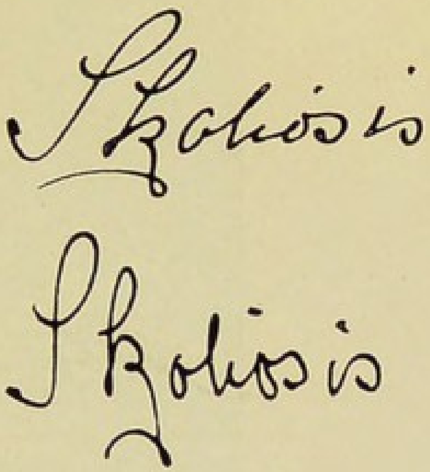


Fig. 15.—" Forward sloping " and " upright " writing.

In this position the weight of the body is comfortably bestowed between the ischial tuberosities and the arms, and there is no tendency in this respect to curving or rotation of the spine. The weak point is the position of the head. Since the paper is not in the middle line, the head rotates to the right and its left side is slightly dropped in order to clear the nose from the line of sight of the left eye and to bring both eyes to the same distance from the pen point. This is not a position of stable equilibrium : it is a position of unequal muscle strain ; and there is a great temptation for the head to increase its displacement until the well-known attitude of *Fig.* 17 is produced.

Here we have a position distinctly faulty, but which is soon assumed by the easily tired muscles of childhood when sloping writing is practised.

The remedy for this is to alter the style of writing and to teach the upright script (*Fig* 15, lower line). In this the position of the body and of the arms is the same as before,

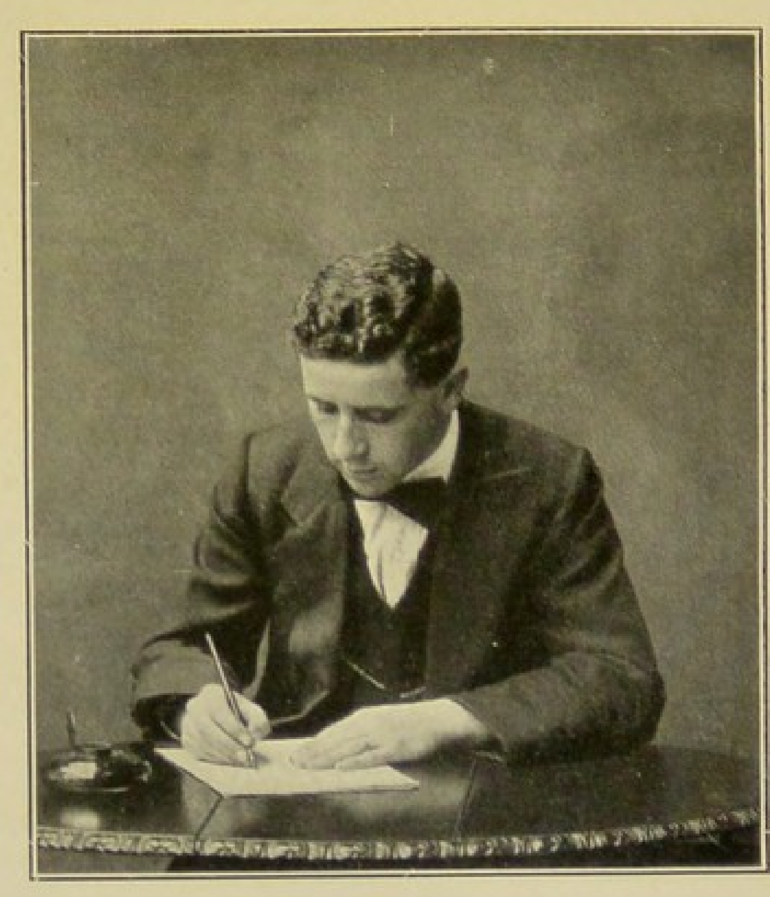


Fig. 16.—Position for "forward sloping" writing.

but the paper rests squarely in the middle line, and the pen hand is turned more over on to its ulnar border. The head remains symmetrical, and the initial stimulus to faulty position is done away with (*Fig.* 18).

Due to Fatigue.—We do not know when man began to walk erect, but however long ago it was, it has not yet been long enough to enable his anatomy to cope successfully with all the conditions of his new posture. His skeleton and circulation have undergone certain accommodating changes, he has developed a big gluteus maximus and big calf muscles, but he still suffers from what Bier has called the "deformities of weight," which include hernia, varix, varicocele, flat-foot, skoliosis in many forms, knock-knee, enteroptosis, etc., and the maintenance of an erect spine for any prolonged period still remains a big task for him, especially during his period of growth.

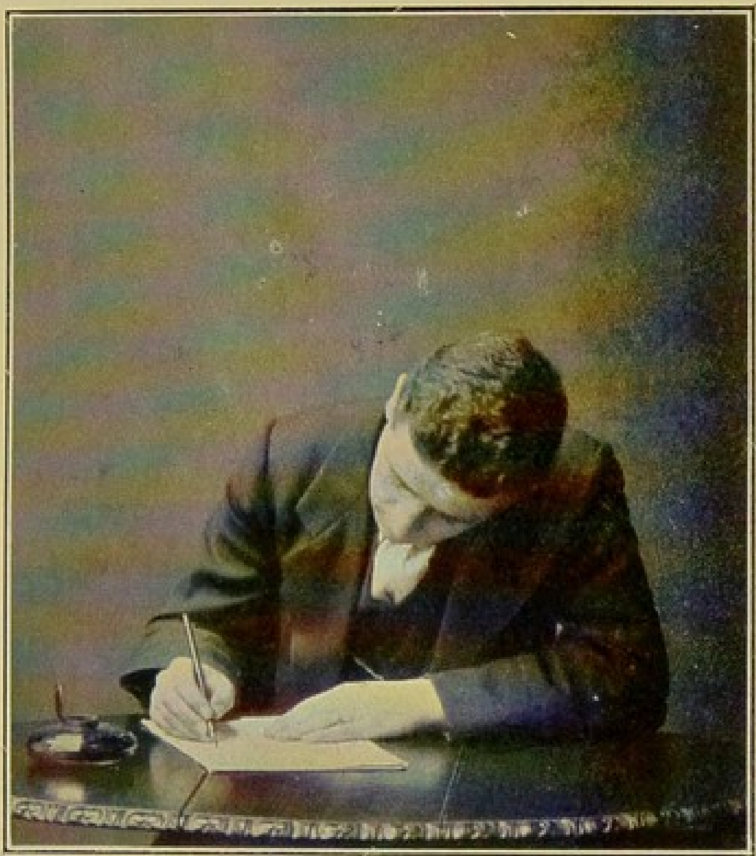


Fig. 17.—Fatigue posture in "forward sloping" writing.

The muscles are powerful agents in promoting the circulation of both the lymph and blood. During contraction their vessels and lymph spaces are squeezed comparatively empty; during relaxation they are flushed with an ample supply of blood, which not only brings oxygen and food-material to supply fresh energy, but is ready also to carry away with it upon the next contraction the poisonous products of tissue activity. When a muscle is kept in a state of contraction without sufficient periods of relaxation, it suffers in two ways, viz., from poor supply of refreshment, and from accumulation of its own waste products, with the result that fatigue is induced. A familiar example of this is the fatigue caused by working (putting in a screw, for instance) with the arms overhead, when gravity intensifies the other factors.

Fig. 18.—Position for "upright writing." (The position is somewhat exaggerated owing to a low, flat table having been used in order that the paper might be shown clearly.)

Again, when only a certain mass of muscle tissue is working, as in sitting at a desk, the body heat tends to fall and blood accumulates in the splanchnic veins and large abdominal glands, so that the working muscles are starved in still another way by the lessening of the total quantity of blood available for them.

The young get over both these difficulties by *restlessness*, which is a perfectly natural method of relief, and might almost be called a physiological necessity for them.

The deductions are that the schoolroom should be of a comfortable heat, and that desk-work should be frequently interrupted. Otherwise the erector spinæ muscles pass into a condition of fatigue, which induces faulty positions.

The interruption of desk-work is very important. Young pupils should not be given continuous exercises which take long periods to carry out. It is better to divide the lesson, and give them opportunities for sitting back in their seats every ten minutes or so to listen to instruction from their teacher. And in addition to the intervals for play, it would be an excellent method to give them two breaks of a few minutes each in both morning and afternoon school, during which arm-extension and body-bending movements could be carried out in the schoolroom.

1 and 2. FAULTY POSITIONS INDUCED BY WRY-NECK, DEAFNESS, AND ERRORS OF VISION.

These causes, operating upon the upper end of the spine, are active both in the standing and sitting positions. As a rule the postures induced are such as to affect the whole length of the spine equally with causes acting directly upon the lower end thereof; but in some instances, especially of wry-neck and astigmatism, the effect is more localized towards the cervical and upper dorsal regions, in which case their action upon the main length of the column is not so direct and ample: firstly, because the movements between the occiput, the atlas, and the axis render a certain amount of head motion possible without disturbance of equilibrium, and secondly, because the superincumbent weight displaced is not so great.

In wry-neck, faulty posture is part of the defect, and the patient curves the spine in an effort to bring the eyes to the same horizontal level.

In total deafness on one side, the faculty of locating sound is lost, and both in this and in partial deafness the twisting, peering attitudes of the sufferer are too well known to need description.

Errors in vision are at the bottom of many of the bad positions assumed in desk-work, etc., and their development is very often the result of bad lighting, ill-fitting school

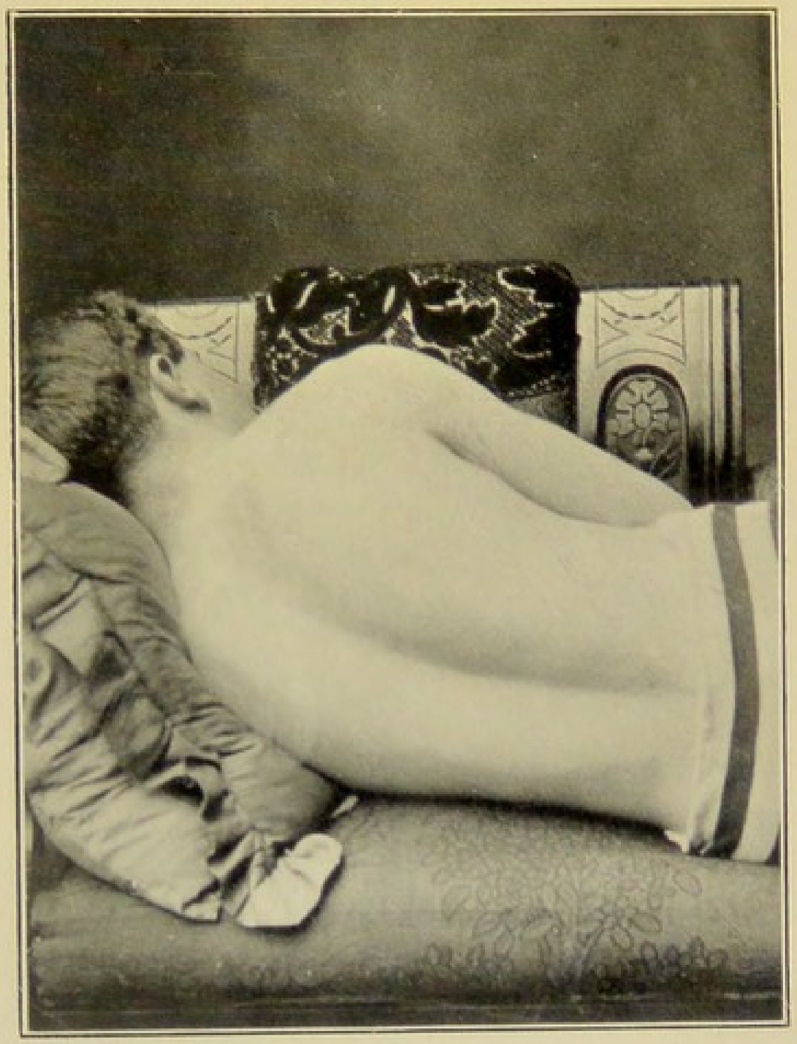


Fig. 19.—Curve of the spine in an ordinary lying position.

furniture, and too long lessons. Their correction is so distinctly a matter for the specialist that nothing further need be said in this place.

3. FAULTY POSITIONS IN LYING.

These are not such powerful agents as the preceding ones, partly because in recumbency weight is taken away from the spine, and partly because the ribs on the convex side of the curved spine are not allowed free play, and so do not become much elevated. The influence of this is discussed in the following chapter.

Fig. 19 shows a common position in sleep. Since most people who are not doctors spend well over a third of their lives in some such position, it is clear that it can have no permanent effect upon the average spine. At the same time, in unfolding a curved spine, especially in the "rigid" type of single curve, advantage may be taken of it in patients who find a side position more comfortable than sleeping on the back. They should lie on the side of the dorsal *concavity*.

4. FAULTY POSITIONS IN EXTRA-ORDINARY OCCUPATIONS.

Piano-playing.—Piano-playing has been placed first in order that especial attention may be drawn to it. It presents in a very aggravated form all the bad conditions liable to be present in desk-work. The height of the keyboard is fixed, and is calculated for grown-up measurements, and not for

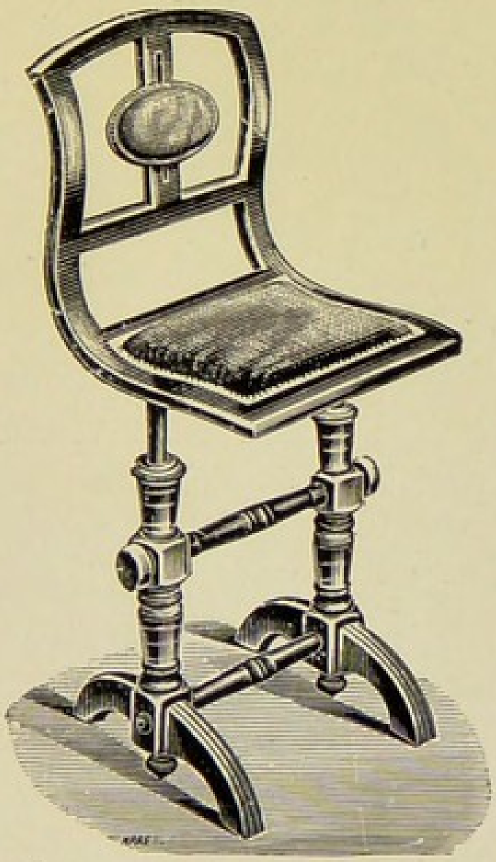


Fig. 20.—Music chair with adjustable back support.

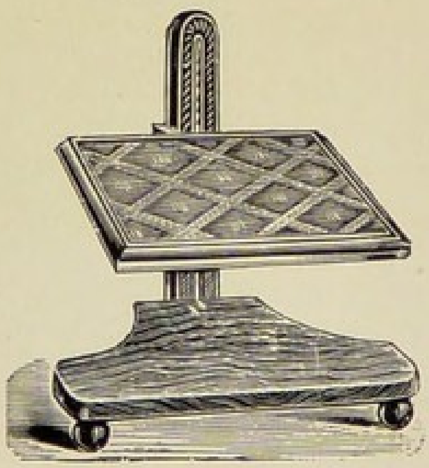


Fig. 21.—Adjustable foot-rest.

children. The piano-stool certainly is adjustable, but it affords no back support for occasional rest, and when it is screwed up to bring the keyboard within reach, the feet of a small pupil cannot touch the pedals and are left without support. Curved positions have to be adopted in order to reach the notes at the treble and bass ends. The light is generally bad in the daytime, since pianos are usually arranged for the artificial lights and not with regard to the windows. The music-rest is often too far away, and the common printed music is too small for children. Experts read the notes as we read printed words—by "look of their faces"—but the unravelling of chords before this stage is reached is a hard task for the young eye.

The remedies are obvious. A suitable music-chair should be provided, and also, when the feet do not reach the pedals, an adjustable foot-rest (*Figs.* 20 *and* 21).

Large-note music must be used, with correct distance of the music-rest, and proper lighting provided. The use of the digitorium in a comfortable position is to be commended, as also short practice periods for all new work requiring the dissection of chords note by note.

Violin Playing.—Few but those who have been through it realize the severe physical strain that violin practice involves. A faulty position is shown in *Fig.* 22.

Practice in the sitting position relieves the strain to a great extent, but even then harm is often done by the efforts of a short-armed or large-breasted girl to hold a full-sized violin in the correct position, in which the left elbow must be brought well under the instrument in order to enable the fingers to have full power over the strings.

In orchestral playing the pupil must be able to sit comfortably, with ample bow-room, and to have a separate, well-lighted music stand.

Horse-riding.—*Fig.* 23 illustrates a faulty position on side-saddle.

The bad effects of such a position are emphasized by the repeated concussions of the spine, especially

Fig. 22.—Faulty attitude in violin practice.

during cantering, and a weak-muscled girl is not able to save herself much by using her legs. Riding astride and riding on alternate sides have been suggested as means of overcoming the tendency to faulty posture induced by the side-saddle. The former is a good plan for young girls, who may assume the more graceful side position when greater muscular strength enables them to cope with its difficulties.

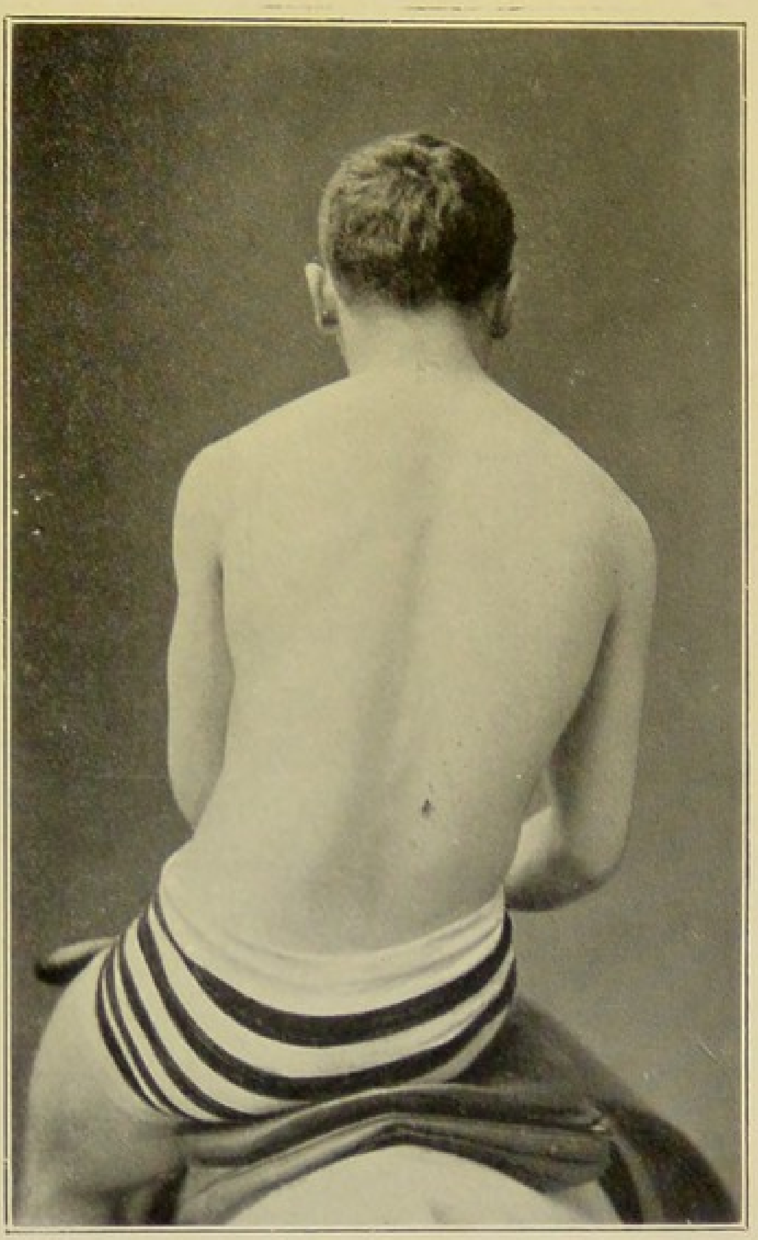


Fig. 23.—Curve of the spine in faulty side-saddle riding.

Carrying Weights.—Pupils frequently have to take bags of heavy books to and from school, and girls generally carry them in their hands. *Fig.* 24 illustrates one fatigue attitude produced by this. In another posture the trunk is inclined to the opposite side to act as counterpoise to the weight carried.

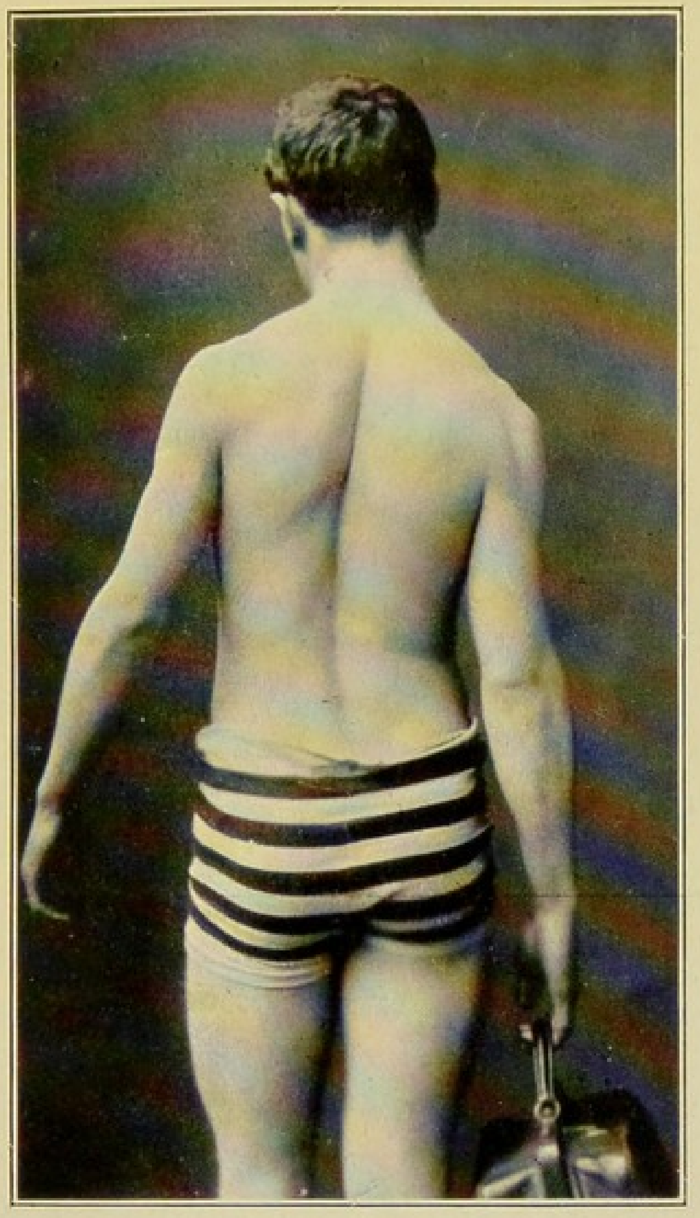


Fig. 24.—Curve of the spine induced by carrying a weight.

Amongst the classes attending hospital cliniques, "carrying the baby" is often responsible for a similar result.

CHAPTER IV.

ANALYSIS OF THE DEFORMITY.

λόρδωσις, a curvature which is convex in front.
κύφωσις, a being humpbacked.
σκολίωσις, crookedness, obliquity.
σκολιός, ά, όν, twisted.

—*Liddell and Scott.*

LATERAL curvature of the spine has come to be almost synonymous with skoliosis of the spine, because, in its typical form, it presents not only a deviation from the middle line, but also a twisting or rotation of the vertebræ involved.

The lateral deviation is the result of gravity, and represents the effort to balance the weight of the head and shoulders on the top of a spine whose muscles are too weak to maintain it erect, and which therefore yields, and forms a curve or curves calculated to preserve equilibrium.

Classification of the Curves.—The following forms are recognized, and those most common are represented in the diagram on the next page.

The percentage figures are taken from Roth's valuable analysis of 1,000 consecutive cases from which the extreme deformities due to severe infantile paralysis were eliminated.

It will be seen that Forms I. and II. represent between them 85·2 per cent of the whole. This is due to the fact that we are a right-handed people, and the majority of our faulty postures are such as to produce these curves. Were we left-handed, Forms III. and IV. would take the place of

Forms I. and II. This statement in no way means that Forms III. and IV. occur necessarily in left-handed people; it means simply that the predominant side determines the majority of faulty postures.

Form II. is often a later development of Form I., the dorsal curve appearing as a secondary or compensating curve; but frequently it occurs independently, the spine

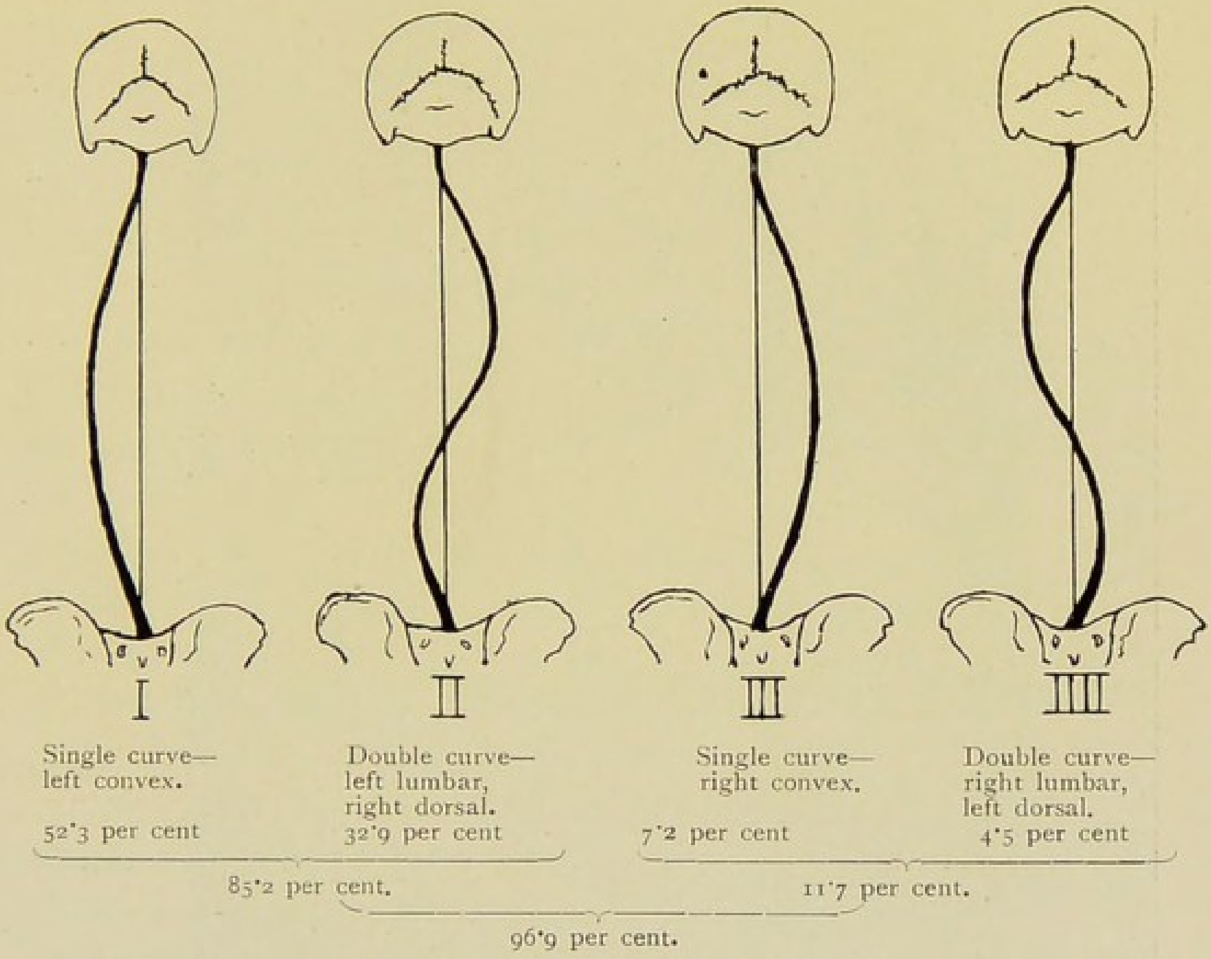


Fig. 25.—Classification of Curves.

assuming the double curve from the very commencement of the mischief.

Form IV. bears a similar relation to Form III.

These single and double curves account for all but a small proportion of the cases in this analysis, which, it must be remembered, excludes the worst deformities having a pathological basis. The remaining 3·1 per cent consists

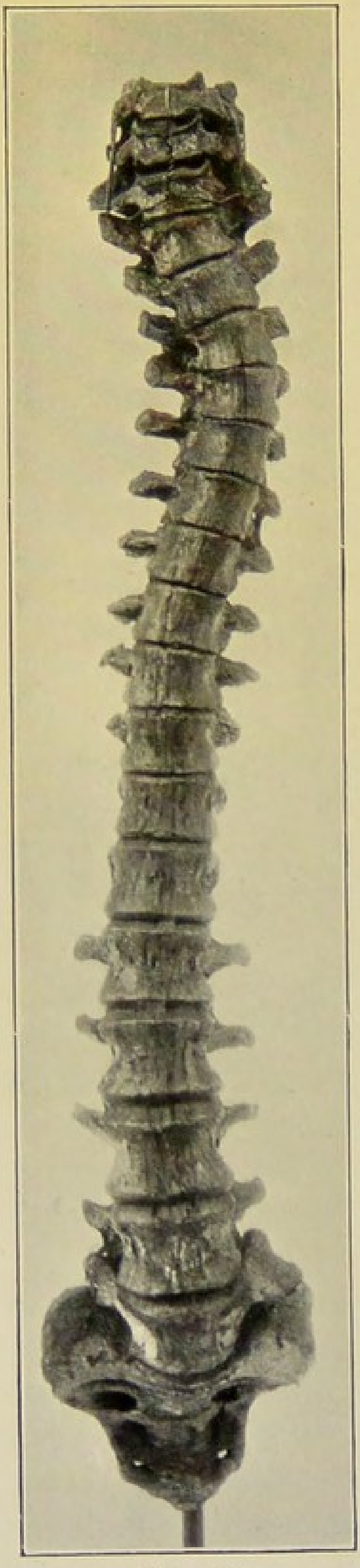


Fig. 26.*

of cases which are later developments of the more simple forms and which present three or more curves.

Fig. 28 represents an advanced example of multiple curves. In some of the worst specimens the distortion is so extreme that it seems mechanically impossible for the dislocated internal organs to support life. In No. 1900 in the Virchow Museum, for example, the main curve is so severe that the upper and lower parts of the dorsal spine almost meet.

A consideration of the two preceding chapters will show that the great majority of faulty postures affect primarily the lower end of the spine—that they act by producing side-tilt of the pelvis—and this is true also of most of the faulty attitudes at the desk induced by errors of vision, etc. In such cases the lumbar curve is the primary curve, and the secondary or dorsal curve, when developed, is widely distributed, with its centre about the mid or lower dorsal region. But as remarked in Chapter III., a few cases will show an effect operating

* The curves in *Fig.* 26 can be well seen by placing a strip of thin card perpendicular to the page, with its edge running through the middle of the cervical and last lumbar vertebræ.

Notice the wedge-shaped deformity of the 3rd and 4th dorsal bodies. Rotation is present, but is better demonstrated on more advanced specimens.

most strongly upon the upper end of the spine, and these generally exhibit a primary curve high up in the dorsal region. In these the long gradual dorsi-lumbar curve is the secondary one (*Fig.* 26).

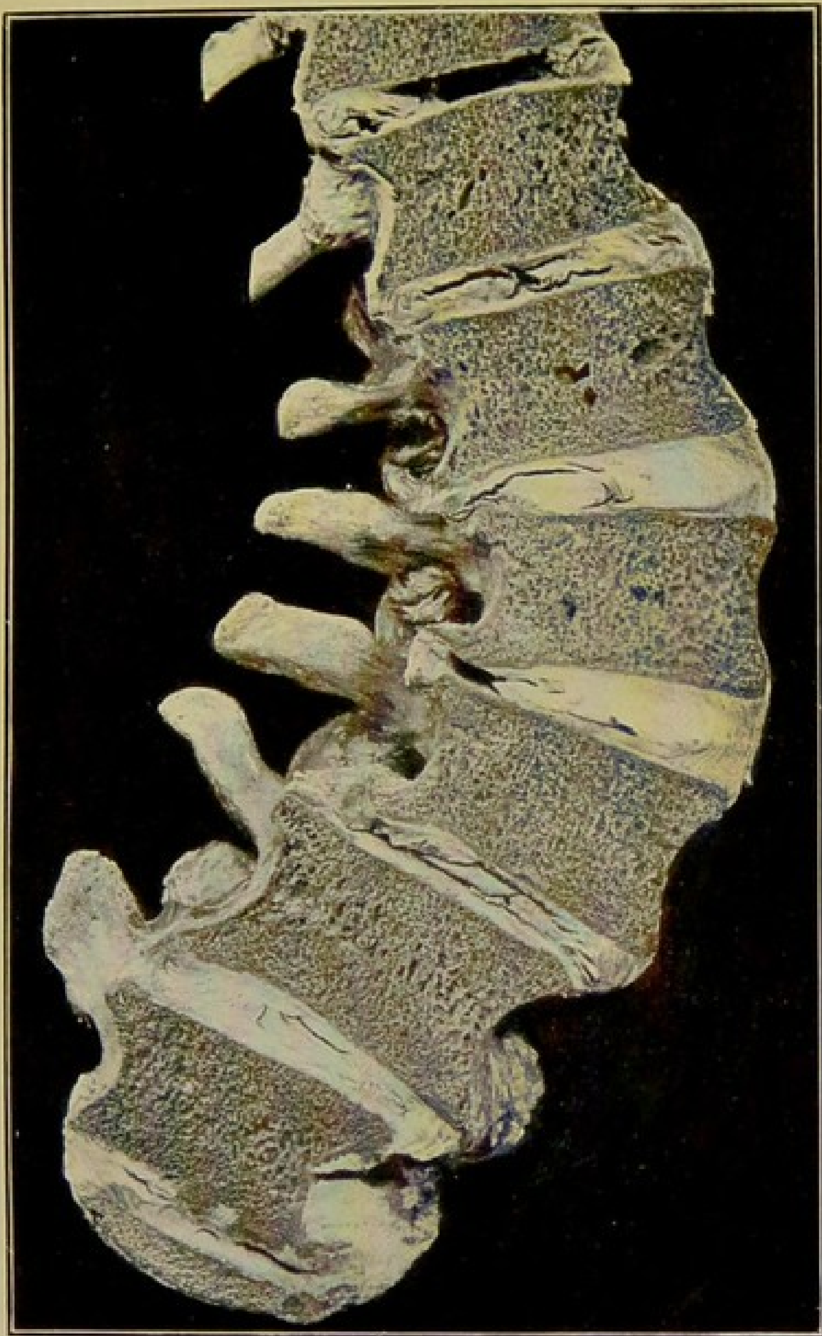


Fig. 27.—Section of the lumbar spine showing wedge-shaped deformity of the bodies and compression of the intervertebral discs.

Wedge-shaped Deformity of the Bodies.—It is very evident that the effect of a lateral curvature will be to compress the bodies of the vertebræ on the concave side of the curve. In the young spine, not only is growth checked by the pressure, but compression and absorption of the soft bone also take place. Of these two factors the checking of the growth is probably the more important. I am unable to find, by actual measurement of specimens, that there is any relative increase of growth on the convex side of the curve. The total result is a wedge-shaped deformity of the vertebral bodies, those at the centre of the curve showing, as might be expected, the greatest alteration in shape.

Fig. 27 shows a transverse section of the lower end of the spine. The wedge-shaped deformity is well seen in the bodies of the second and third lumbar vertebræ, as is also the alteration in the shape of the intervertebral discs. The cancellous tissue appears normal, but in some more severe cases it presents a rearrangement of its structure corresponding to the new forces of stress and strain. There is marked lipping at the thin end of the bodies; in some specimens of advanced curvature, new bone on the concave side produces an actual fusion of the vertebræ about the centre of the curve (*Fig.* 28).

Wedge-shaped alteration of the bodies occurs late in the history of the more severe cases. Naturally, its development is very slow, and is the result of greater pressure than the intervertebral discs can dissipate. Once established, it is certainly the most serious factor in rendering the curve permanent.

Rotation of the Vertebræ.—The lateral deviation of the spine and the wedge-shaped alteration of the bodies are both easy to understand, but not so the third, and most important, element of the deformity, viz., the torsion. Briefly stated, it may be said that when the spine curves laterally the bodies of the vertebræ rotate to the convex side of the curve. Why should they do so?

The spine is an exceedingly complex structure, and its mechanics are very different from those of a simple flexible

Fig. 28.—Shows the rotation of the bodies of the vertebræ to the convex side of the curves; also the wedge-shaped deformity of the bodies, which are fused together on the concave side of the main dorsal curve by exostoses.

rod of homogeneous matter. Thus, the anterior part of the column, designed for bearing weight and absorbing shock, is composed of alternate segments of rigid and elastic material which decrease in size from below upwards. This decrease, however, is not by exact gradations, and the proportion of elastic to rigid material varies in different regions of the spine. The posterior part consists of a series of bony arches, varying in shape and articulating with one another to accommodate, and also to control, the movements of the spine. On account of their shape, and also because of the attachment of the ribs, the dorsal region is less capable of free movement than either the cervical or the lumbar, the range of flexion and extension being small, and lateral bending, although free in the flexed position, being almost entirely lost when the trunk is held in the position of extreme extension. Also, the spine presents naturally certain curves, forwards in the lumbar region, backwards in the dorsal region, and very often slightly convex to the right where the base of the heart comes into relation with the vertebræ. When all these things are considered, it is evident that the explanation of one constant feature of an abnormal condition is not simple

Certain experiments are often quoted in which weights were added to the top of a human spinal column, with the result that, at first, the normal antero-posterior curves were increased, then a lateral curvature made its appearance, and, when the weight was shifted from the centre and applied obliquely, rotation occurred. The weight used was excessive (over 80 lb.), far beyond that which the spine of the average spinal-curvature case is called upon to bear, and the salient fact demonstrated was that rotation in the spine could be produced by vertical force unevenly applied. The experiments did not provide an explanation as to how the equilibrium of forces is disturbed in the living subject, and since rotation is a very early accompaniment of lateral curvature, the causes leading to its commencement are of great interest.

I believe that in this connection the presence of the ribs in the dorsal region has not been taken into sufficient account. Theoretically, the argument may be stated in this way: When a rib is raised from an oblique position to one which is less oblique, the situations of its extremities must become further apart in an antero-posterior direction. Thus, in deep costal inspiration, for example, the sternum is carried forwards and the spine slightly, but distinctly, backwards, with a movement which is perfectly evident

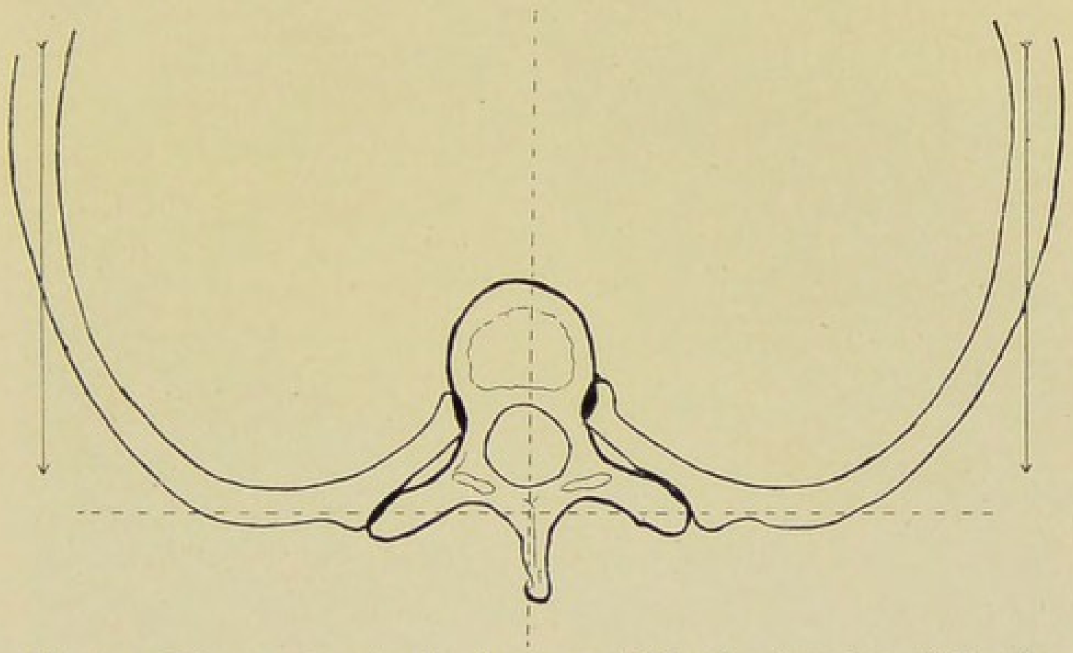


Fig. 29.—Diagram showing the force created by the elevation of the ribs resolved along a horizontal plane and pressing the spine backwards.

to a hand laid upon the middle of the dorsal region. The force moving the spinal column backwards, which is brought into being by the elevation of the ribs, is the result of complicated lever movements modified by the elasticity of the ribs themselves and by the considerable amount of play allowed in their articulations with the vertebræ. It is represented in the diagram (*Fig.* 29) as a simple backward pressure along the shafts of the ribs. Its effect will be to lever the heads of the ribs away from the vertebræ as far as the ligaments of the articulations will allow, and then to move the spine backwards by pressure exerted upon the tips of the transverse processes. If for any reason the ribs on one side only be elevated, it is evident that the transverse processes on that side will be pressed back, and that rotation of the vertebræ will take place (*Fig.* 30) around an axis situated at the meeting-point of lines produced inwards along the transverse processes themselves (*Fig.* 34).

Now this condition occurs in early lateral curvature of the dorsal spine. The ribs on the convex side "fan out,"

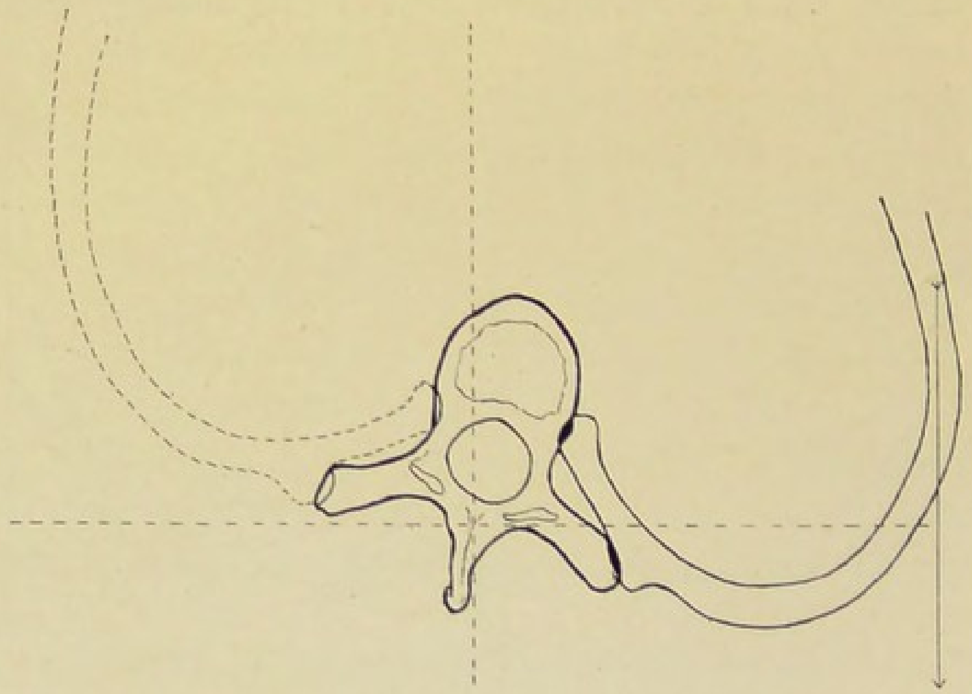


Fig. 30.—Diagram showing the force created by the elevation of the ribs resolved along a horizontal plane and acting upon one side only of the spine.

and those about the crown of the curve are held more nearly approaching the horizontal than are those on the concave side. They must exert, therefore, a pressure backwards against the transverse processes which is not balanced upon the opposite side, and which will tend to start a rotation of the vertebræ, carrying their bodies towards the convexity of the spinal curve.

Experiments to test this theory were made on the spine and thoracic framework of a young man aged twenty-four years. The cartilages were perfectly soft, and all the articular movements free. The sternum, which had been divided down its length, was lashed together firmly. The last lumbar vertebra was held fast in a vice, with the spine laid almost horizontally in order to get clear photographs of the results. Since there was no weight of head or upper extremities to over-extend it, the conditions were, from

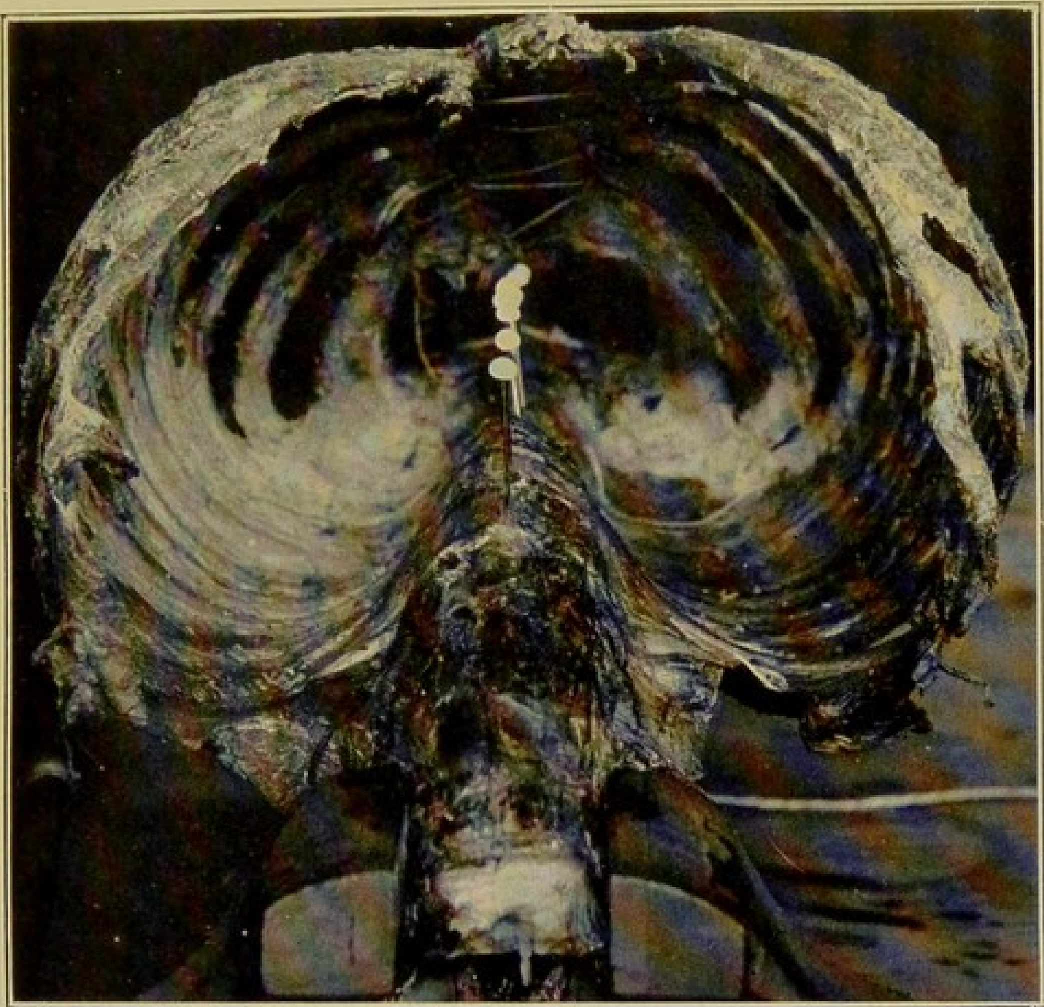


Fig. 31.—Specimen prepared for testing the effect of elevation of the ribs upon the spine.

the experimental point of view, similar to those in the erect position. Finally, a long glass-headed pin was driven into the centre of each dorsal vertebral body in order to exaggerate any movement and to provide an easily interpreted record (*Fig.* 31).

In *Fig.* 32 the spine was prevented from curving by means of a counterpoise at its upper part. The ribs on the

Fig. 32.—The ribs of the right side are strongly elevated. Rotation of the spine ensues even when, as in this experiment, lateral curvature of the spine is prevented by a counterpoise.

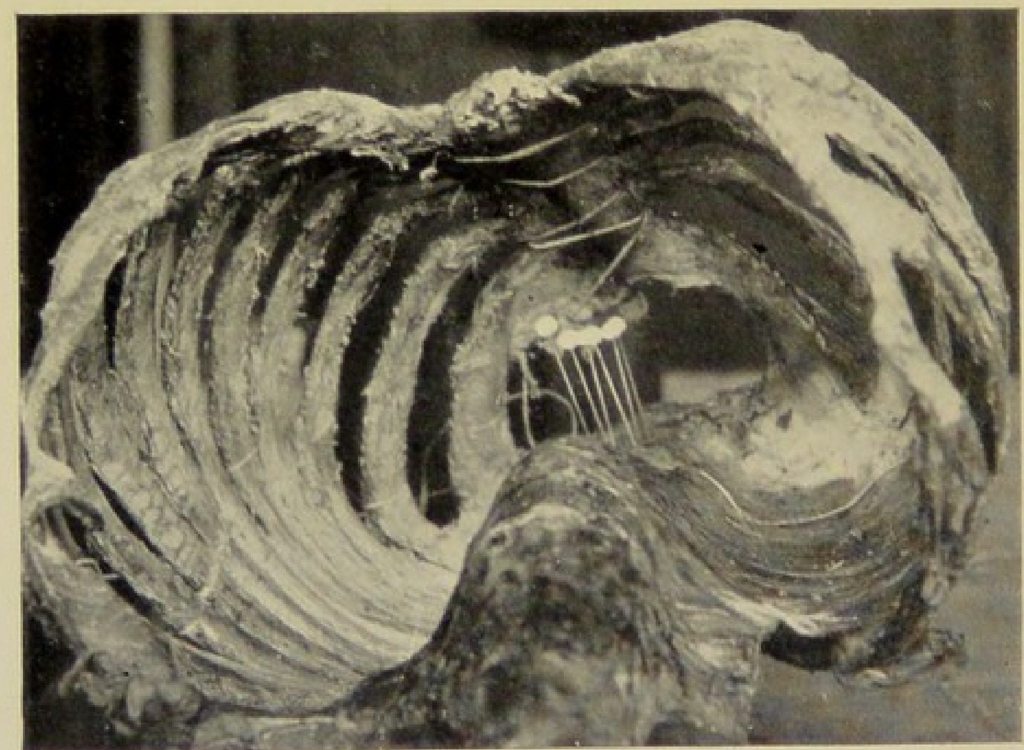


Fig. 33.—The ribs of the right side are strongly elevated. Rotation and lateral curvature of the spine ensue. An exactly similar result is obtained in producing a lateral curvature of the spine by manipulating its upper part.

right side were then elevated by weights working over a pulley. It was found that a certain amount of elevation, quite enough to provide for ordinary breathing, was allowed to take place by reason of the play at the costo-vertebral articulations, without any effect whatever upon the spine. When elevation was increased past this point, the vertebræ rotated. It was found that this rotation was absent in the lower part of the dorsal region, where the costal articulations allowed the most play, the slight deviation of the pins here being due to the twist of the spine produced higher up.

In *Fig.* 33 the spine was quite free, and curving as well as rotation took place when the ribs were elevated. The conditions shown in this figure were produced also by acting upon the spine alone, spreading of the ribs resulting from the formation of a lateral curve. In handling the specimen in such a way as to produce the latter condition by manual efforts, great information was gained through the sense of touch. It was quite easy to produce the lateral curve, and to elevate the ribs on the convex side, up to that point when all the play at the costo-vertebral articulations had been taken up. It was then immediately felt that the ribs began to offer strong resistance, and that a rotatory movement would facilitate the side bending. With the employment of reasonable force an increase of the lateral curve could be made only by giving a screw-like movement to the spine. This sensation was quite unmistakable, and was entirely absent when a lateral curve involving the lumbar and lowest dorsal regions was produced. Here the movement was not checked in the same emphatic manner, and no "path of least resistance" was evident to the touch throughout the range of the parts.

The forces in action at this stage of the experiment may be represented in diagram as on following page (*Fig.* 34).

Force *A*, created by the elevation of the ribs. The possibilities of this force must not be over-estimated, for its range of action is strictly limited. That it is able, at its maximum, to actually move the spine, is shown during full costal inspiration, and therefore it must be able to rotate the vertebræ when exerted on one side only. In lateral curvature it initiates the rotation by pressing the tuberosity of the rib against the transverse process as soon as all play in the costo-vertebral articulations has been taken up.

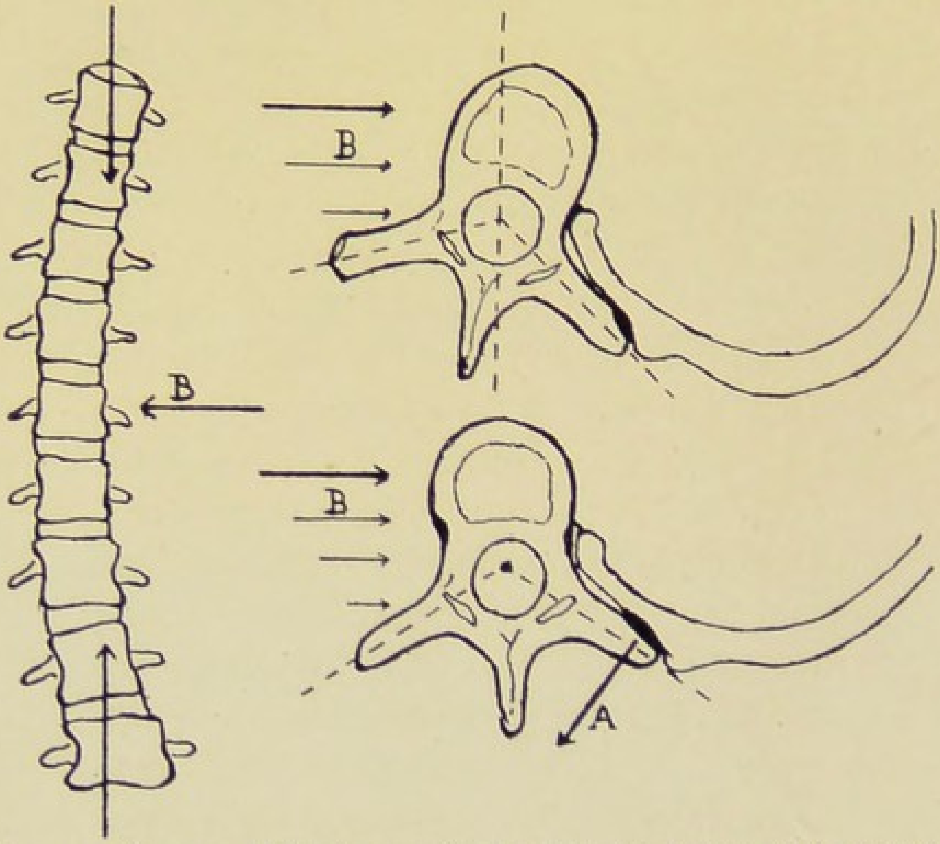


Fig. 34.—Diagram of the forces which rotate the bodies of the vertebræ to the convex side of a curve in the dorsal region.

Force *B*, derived from the forces bending the column outwards. The weight carried by the spine enters largely into this in the natural condition. In the dorsal region, owing to the backward curve of the spine, the weight is borne well forwards on the bodies of the vertebræ and on that side of them towards the concavity of the curvature. This outward bending force, therefore, will act most strongly upon the anterior part of the column.

Force *A*, as an active agent, disappears as soon as the ribs have been elevated to their utmost, but by this time the rotation has been commenced, and Force *B* becomes an overpowering factor. The ribs, however, remain with their tuberosities firmly applied to the transverse processes,

Fig. 35.—Specimen of advanced skoliosis. The tuberosities of the ribs on the convex side of the curve are firmly butted against the transverse processes, which are pressed backwards.

thus resisting outward movement of the posterior part of the column. The result is that every effort to increase the outward bending increases the rotation. Evidence of this mechanism is afforded by pressure results in specimens of high-grade skoliosis. In *Fig.* 35 the three lowest segments especially should be carefully examined with a magnifying glass, and the two sides contrasted. On the right side the necks of the ribs are quite bent, the tuberosities are firmly butted against the transverse processes, and these in their turn are pressed back in striking contradistinction to their opposite fellows. The rotated bodies of the vertebræ show up as a dark mass in their background.

Effects of Rotation.—It has been shown that lateral movement of the spine, without any tendency to rotation, is easy up to the limits of play in the costo-vertebral articulations, and such cases occur in practice, especially in individuals of the loose-jointed type. They are cases of simple curvature or deviation, and in this stage should not, strictly speaking, have the term skoliosis applied to them.

The early stages of rotation in the dorsal region have been described rather fully because the torsion of the thoracic framework resulting therefrom is the most important point in the history of a skoliosis. Setting aside the probability that *the mechanism of rotation in this region has some intimate relation to the formation of the secondary curves and to compensatory lumbar rotation*, the great fact to recognize here is that the bending of the ribs by the "screwing-round" process results in fixing the curvature long before any wedge-shaped alteration of the vertebræ is produced. Owing to the attachments of the sternum, the thoracic cage does not move round as a whole. Even in late cases the displacement of the sternum is not great; its lower end is pushed over to one side or other, but the upper end remains anchored by the clavicles and the first and second ribs. Therefore the brunt of the torsion falls upon the longer ribs on either side, and the final consequence is shown in *Fig.* 36.

When it is remembered that the ribs on the convex side of the curve are elevated, there will be no difficulty in understanding the appearance of the patient. On the side of the convexity the shoulder is raised, the ribs by the side of the spine bulge more than normal, the scapula thereby being rendered more prominent ("shoulder growing out"), and the chest in front is flattened. On the side of the concavity the back is flattened, and the chest protrudes in front. The hip from which the trunk leans away appears prominent ("hip growing out") (*Fig.* 40).

In the beginning the side movement and rotation of the spine are accommodated by the general mobility of the thorax, derived from the elasticity of the ribs and their cartilages, but when the extent of this is reached the

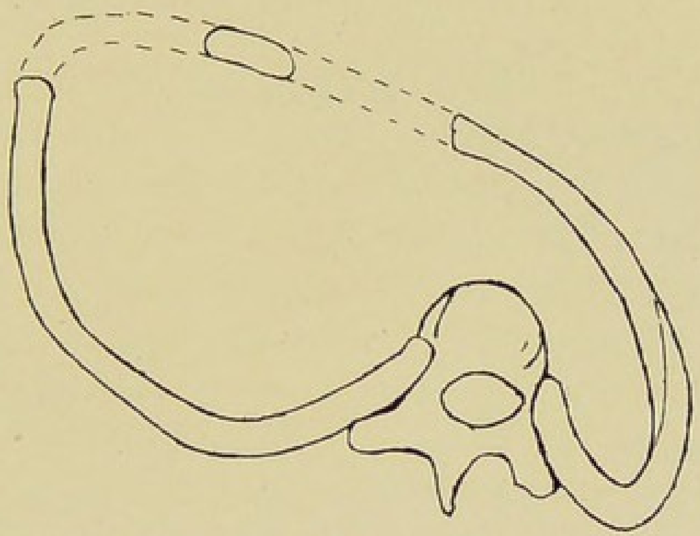


Fig. 36.—Horizontal scheme of advanced skoliosis. (Modified from von Bergmann.)

ribs yield, and permanent bending, with fixation of the deformity, takes place. The progress of events may be divided into three stages: (1) Lateral curvature before rotation; (2) Curvature and rotation, with bending of the ribs up to the limit of their natural "spring;" (3) Fixation of the bends as a bony deformity. The first stage, as before said, is generally very brief. The second stage passes by imperceptible gradations into the third. Both the first and second stages are curable, and even from the third stage a certain limited amount can be reclaimed, i.e., the ribs, by exercises which restore the mobility of the thoracic skeleton, can be unbent if the case is a recent one and not far advanced, and if the patient is of a good type.

It will be gathered from the foregoing that the curvature in the rib-bound dorsal region is more dangerous than the curvature in the freer lowest dorsal and lumbar regions, and with certain exceptions this is true. On this is based a golden rule of practice : In cases of more than one curve, when there is any doubt as to the method of employing any exercise, *treat the dorsal curve.*

CHAPTER V.

EXAMINATION OF THE SPINE—CLASSIFICATION OF CASES—TYPES OF PATIENT—GENERAL DIRECTIONS.

EXAMINATION OF THE SPINE.

THE patient should be stripped down to below the iliac crests, so that the full length of the movable spine is exposed. The boots should be removed.

The first step is to see that the standing height of the legs is equal. If not, a book or wooden slab of the requisite thickness must be placed beneath the shorter leg.

1. *Examine from the front.* Notice any inequality of the chest. In girls with mammary development such inequality is very evident to the eye, even when the difference is quite small, the breast on the concave side of the dorsal curve being the prominent one.

2. *Examine from the side,* in order to estimate the alteration of the normal antero-posterior curves. A marked kyphosis will call for the use of Exercise III. in the " creeping " series.

3. *Examine from the back.* (*a*) Let the patient stand in the usual attitude. Note the kind of curve (single, double, etc.), and estimate its stage of development by the prominence of the angles of the ribs on the convex side, the protrusion of the lower angle of the scapula, and the raising of the shoulder. (*b*) Let the patient cross arms in front of the chest, resting the hands on the shoulders. Confirm the previous observations as to the kind of curve

and alteration in the ribs. (*c*) Let the patient assume the best attitude by standing up straight. The results of this effort will be variable, and will depend to some extent upon how far the sense of correct position has been lost. (*d*) Improve the patient's best *voluntary* position by manipulating the arms, thus arriving at the best *possible* position in the standing attitude. The principle upon which the arms are manipulated will be understood after a study of the principles underlying the exercises in the following chapter. Generally the arm on the concave side of the dorsal curve will require to be stretched above the head, and that on the convex side held straight out or kept low; but both arms above the head to varying heights, or both straight out, will sometimes give a better result. Except in very thin patients, it is really difficult in this test to estimate by sight alone the exact position of the spine, and the surgeon will require to use his fingers to confirm the evidence of his eyes. The surest method of estimating the best possible position of the spine in the erect attitude can be carried out only after the patient has had some experience of the "straight-work" exercises. The attitude of *Fig.* 48 is then assumed, with the body bent a little more forwards. The surgeon's left hand steadies the nape of the neck and receives the strongly retracted occiput in the expanded cleft between his thumb and index finger, whilst the fingers of his right hand travel down the spine with a stroking movement, thumb on one side and fingers on the other side of the spinous processes.

4. *Examine the bent back*. The patient stands with the knees stiff, and bends forwards from the hips to a right angle, the back being loosely held and the arms hanging by the sides. In this flexed position, lateral bending in the dorsal region is free. The surgeon sits behind the patient, and guides the body from side to side until the spine occupies the straightest possible position in the middle line. He then looks along the back, and notices the

prominence of the ribs on either side of the spine. If rotation is present, the prominence on the convex side will be greater than that on the concave side of the curve. Similarly, rotation in the lumbar region will be shown by a greater prominence of one mass of the erector spinæ. This is a most valuable test, and gives information, not only of the mobility of the spine and the extent to which a curve may be corrected, but also of the existence and amount of rotation.

The points to make sure of are the state of the spine and the thoracic walls in the ordinary attitude (1, 2, and 3 *a*, *b*), the best possible position of the spine under manipulation (3 *d* and 4), and the amount of rotation, if any, remaining in this position (4).

It may be laid down as an axiom, that when a skoliosis of the spine is entirely corrected, all the concomitant physical signs vanish. Not only does the spine occupy its normal place in the middle line of the body, but all distortion of the thoracic cage, due to curving and rotation of the column, disappears, and a look along the "sky-line" of the back shows no inequality in the curves on the two sides, either in the dorsal or lumbar region.

On the basis of this examination it is convenient to divide all cases into three grades :—

CLASSIFICATION OF CASES.

Grade I.—Those in which the spine may be straightened out to normal by posture.

Grade II.—Those in which the spine may be straightened out to some extent by posture, but in which some measure of the deformity still remains.

Grade III.—Those in which the deformity is so confirmed that radical changes in the shape of the ribs, and inferentially of the vertebræ, are palpable, and in which the alteration produced by posture is inconsiderable.

These three grades pass imperceptibly from one into the other, but as a rule there is little difficulty in relegating any one case to its proper grade. The borderland between Grades II. and III. presents some cases occurring in individuals of the " rigid " type, of which a correct estimate cannot be formed until the spine has been rendered mobile by means to be described later.

Cases of the second grade are those that most frequently come under treatment, for it is usually at this stage that patients are found by their friends to have one shoulder or hip " growing out."

The prognosis in Grade I. and early Grade II., with which we are chiefly concerned, is *very good indeed.* Given patients of any " fibre " at all, treatment may be undertaken with much faith.

The prognosis in Grade III. is naturally not so bright, but even here a surprisingly large number of cases are saved by exercises from drifting into a helpless state of corsetted crippledom, and are enabled with the help of a light appliance to lead lives of comparative activity.

TYPES OF PATIENT.

The surgeon of practical experience will recognize also various types of patient, and will be quite aware of how the type will influence the result :—

Type I.—The average normal patient passing through a period of weakness due to too rapid growth, over-study, convalescence after illness, etc.

Type II.—The small-boned, " wiry " type, active physically and mentally, carrying little subcutaneous fat, and often presenting a curvature which is unduly rigid considering its extent.

Type III.—Well-grown and of rather sluggish temperament, having not much mental or physical initiative; big-jointed, with loose ligaments, often presenting over-extension of the elbow joints, weak ankles, flat-foot, etc. Certainly the type that Dionis describes picturesquely as having " an excess of humidity, which soaking the ligaments in a viscous juice, relaxes them, and suffers them to prolong themselves beyond their bounds." It is possible that this type may be associated with some inefficiency of the thyroid gland. Some of them certainly brighten up and show more interest in their case when treated with thyroid extract. It is in this type that the "muscle sense" is apt to be feeble.

Type IV.—A very frequent type and the most doubtful in its results—the type of general constitutional asthenia before alluded to. These cases present themselves young, generally show signs of early rickets, and are altogether poor stuff. Great attention to general hygiene and nutrition, and exercise carefully regulated to the strength of the patient, are necessary. At the same time these patients are apt to be " baby'd " too much at home, and it needs all the tact of the surgeon to steer such cases aright.

GENERAL DIRECTIONS.

It is unnecessary to recapitulate here all the details that enter into the examination of a case. Most of them have been already sufficiently indicated, and some further points, bearing upon general health, are given in a chapter upon anæmia and the action of some oils in malnutrition, to be found at the end of the book. Suffice it to say that the examination must be very thorough, and, having eliminated the physical causes—unequal standing height, errors of vision, etc.—an inquiry must be made into all the habits and occupations of the patient's life. Generally such an inquiry will reveal some faulty habit of posture which is the actuating cause of the mischief. Having in mind the great evils of desk-work, it is well to investigate thoroughly the patient's attitude in this respect. Roth first pointed out that if a patient with lateral curvature, presenting no obvious cause for the deformity, be asked to sit down and write at an ordinary desk, the actuating habit will be revealed thereby in nine cases out of ten.

In discussing a case of lateral curvature, the surgeon, without being an alarmist, has to bear in mind the possible disastrous results of neglect. A skoliosis gone to the bad is one of the most pitiful deformities of mankind. It may be admitted that some cases of Grade I. and early Grade II. grow out of it. This "growing out of it" means that a natural increase of strength, coincident perhaps with the establishment of puberty, and prompted by an access of fitting personal vanity in the girl or by military or athletic ardour in the boy, enables the patient to overcome the trouble, but the surgeon, knowing the alternative, has no right to take the chance of this. He should interest the parents in the nature and causes of the deformity, and enlist them as his intelligent assistants. He should make no compromise, but claim the whole life of the patient for a period of from three to six months. This is the period of full training, and varies with both the grade of skoliosis and the type of patient. Grade I. in a good patient will usually be restored well before the minimum quoted: advanced Grade II. in a poor subject will probably take much longer than the maximum. But with the average patient the surgeon will be able to show such a result between the third and sixth months that a modification of the treatment will be allowable, together with a return to a fuller life.

During the period of full training the patient has only one thing to do, and that is, to get the spine straight.

Piano-playing, violin-playing, horse-riding, all occupations involving fatigue or promoting faulty posture, must be left off entirely.

School, in the ordinary sense of the word, is prohibited. A certain amount of reading may be allowed, but it must not be of a character to cause brain-fag, and must be carried out in the approved resting posture (*Fig.* 38) or in the supporting chair. For this the folding deck pattern made of wood laths or cane—not the canvas-hammock type—with a slightly inclined seat, and a long back at an angle to correspond, will suffice, and any carpenter will provide a foot-rest and a stand to hold a book. A cylindrical cushion supports the lumbar curve, and it is a good plan to fix a rail along the top of the back, from which can be hung two canvas or leather loops adjustable as to height by strap and buckle. By slipping the arms through these so that they come under the armpits, the patient is able to take weight from the spine, and so avoid fatigue of the muscles. Also, by using the loop on the lower shoulder side, i.e., the side of the dorsal concavity, a position which tends to correct the curve will be taken up. The loop on the higher shoulder side, i.e., the side of the dorsal convexity, must, of course, not be used alone.

The chair used at meals must not be so long in the seat as to prevent the patient's sitting right back in it. The feet must touch the floor or be supported by a footstool. A cylindrical cushion is hung over the back of the chair to support the normal lumbar curve. An upright position at table must be insisted upon.

The daily walks are treated as drills. The skoliotic patient has lost the sense of good walking posture: the abnormal has become the normal, and the muscles have to be educated by practice into holding the new balance automatically. It is important that the common actions of life, such as sitting and walking, be performed with the spine held in the best possible position, and it is especially important that the curative exercises be carried out with a like precaution. *Fig.* 37 is inserted here to show that exercise taken with the spine in faulty posture will serve to establish a curve whatever may be the muscular development. It is taken from a photograph of a famous fighting man, who adopts a crouching attitude in which the spine is held convex to the left. This curve has now become fixed with him.

Exercises are taken for one hour in the morning, and for any time up to one hour in the afternoon. Each course is followed by five minutes' massage of the back, after which the patient rests for some time in the position shown in *Fig.* 38.

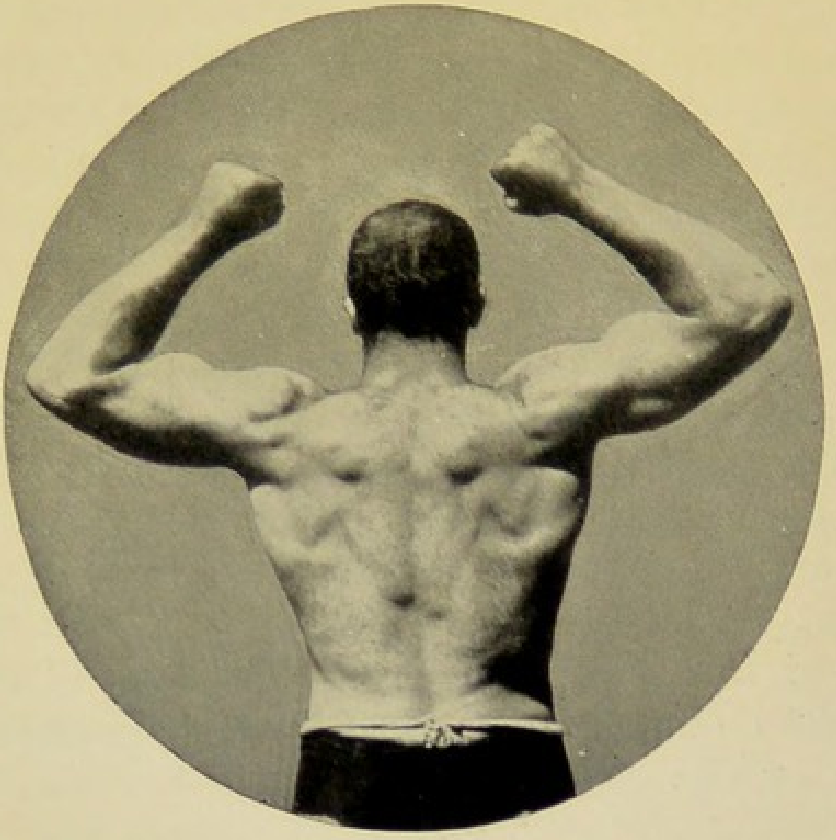


Fig. 37.—A lateral curvature confirmed through taking exercise in a faulty position.

If this position becomes irksome, the patient may change to the back, with both arms, or with the arm on the lowered-shoulder side, above the head, or may lie on the side of the concavity of the dorsal curve.

The patient, who is generally a weakly girl, cannot be expected to take the full time of exercise to begin with, but with the system advocated here the capacity to do so is soon gained. At first, not only the physical but also the mental processes become fatigued, and it must be remembered that a short cycle of exercises carried out with full intent is worth many hours of perfunctory movements. It is better, as a matter of training, to occupy the full hour, interrupting the exercises with occasional rests, than to shorten the total time occupied. The surgeon must regard the exercises as a therapeutic remedy, and must beware of an overdose. Overworked muscle becomes as feeble as disused muscle, and should the condition of "staleness" arise, the patient must be given a holiday for a few days.

As the patient grows stronger, part of the second exercise

Fig. 38.—The resting position.

hour may be occupied by singing or by swimming, and cycling may be allowed as an outdoor exercise.

Singing is to be highly recommended. Practised under able tuition it tends to make the whole thoracic framework more mobile, and thus helps in the restoration of the normal shape. A useful breathing and singing exercise is carried out as follows :—

Patient on back : arms to sides.

(*a*). Inhale slowly through nose. At the same time the arms describe a semicircle in the vertical plane until they are stretched to their utmost above the head.

(*b*). Sing the scale slowly, sweeping the arms in the horizontal plane back to the sides, taking care that the shoulders do not remain "shrugged up" after the upward stretching.

The two parts of the movement occupy a single inspiration and expiration respectively. A similar exercise may be carried out in the standing position.

In swimming, the breast stroke is employed chiefly, and great attention must be given to proper breathing. A complete respiration is taken with each stroke, inspiration being made as the arms sweep outwards. When sufficiently expert the patient may practise the fancy stroke known as "swimming like a dog." In this a leg moves with the arm of the opposite side, and many of the movements of the regular exercises may be imitated in the water.

Cycling should be done on fairly level roads and not in high winds. The saddle and the handle-bars must be arranged to give an upright seat, and the patient *must* use ankle-action (described under exercises for flat-foot) which enables all the work to be done from the hips downwards and prevents awkward side-positions of the trunk.

Finally, there must be plenty of bed—the patient should be given the opportunity of "sleeping the clock round." The best sleeping position is on the back; failing that, on the side of the dorsal concavity.

When, in the surgeon's opinion, the patient is strong enough to resume school and a greater measure of ordinary life, great care must be taken to avoid overstrain and fatigue, and all precautions must be adopted against faulty postures during work. It is well to encourage ambi-dexterity. Continued attention must be given to correct walking and sitting. Exercises, which by now will be chiefly or entirely of the "straight work" series, must be carried out daily in two short sessions. At intervals the patient must be presented for inspection and to receive directions, and the surgeon must satisfy himself, not only that the spine is in good state, but that the muscles are being kept in fine, hard condition.

The question as to how long the patient must continue "under the doctor" depends so entirely upon the grade of skoliosis and the type of patient that no general answer can be given. The period of full training has already been discussed (p. 64), and in addition to this, what may be called the period of half-training, when the patient is doing exercises regularly, as well as leading a life of comparative liberty, will probably last for six months before the surgeon will feel safe in relinquishing frequent supervision. When he considers the case beyond need of him, it will be his duty to advise a periodical inspection until the patient be at least sixteen years of age, and to warn the parents, in order that they may continue to check slack physical habits and to watch the effects of any period of illness, that the fact of the condition having once occurred somewhat favours a relapse, even to the time of full growth.

CHAPTER VI.

THE CREEPING EXERCISES.

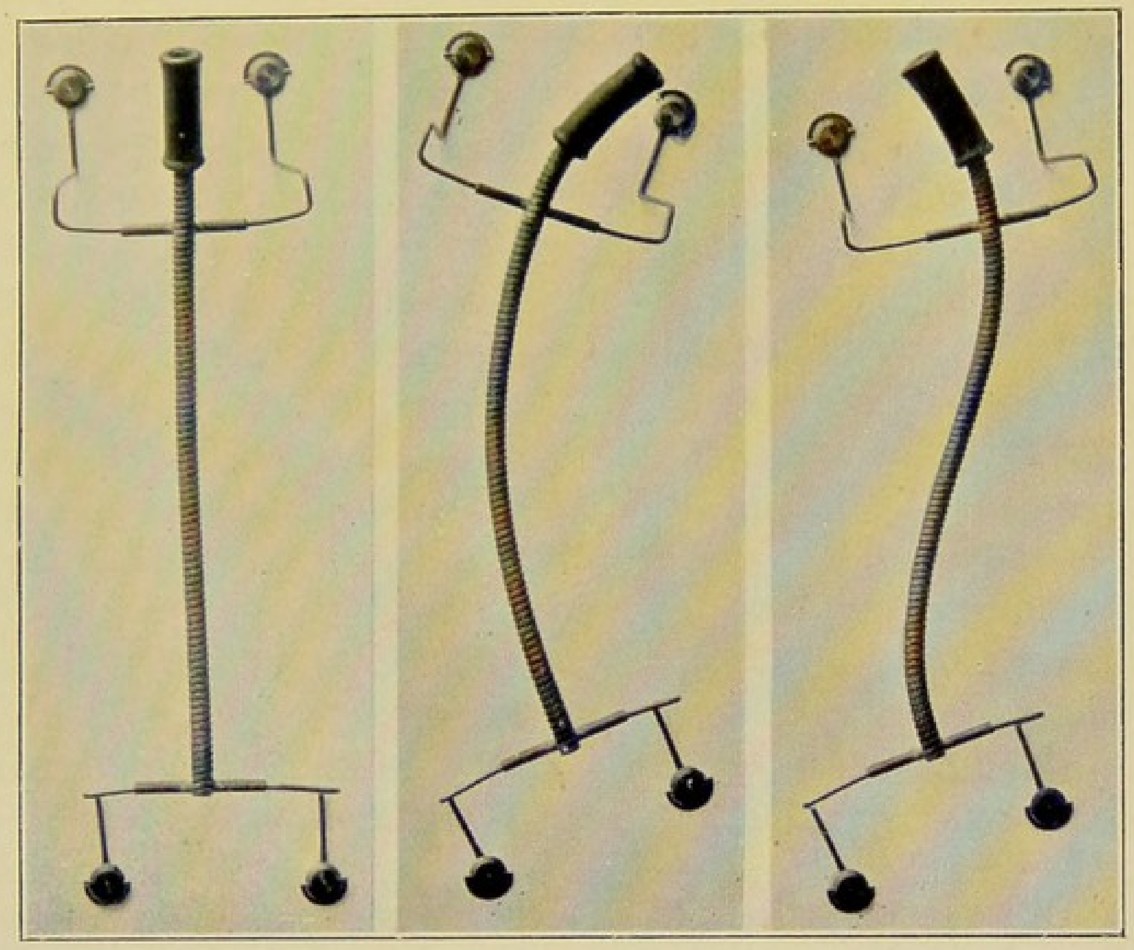
We now come to the important question of deciding which exercises shall be employed in the treatment of skoliosis.

The number of exercises devised for "strengthening the back" is legion, for the simple reason that the spinal groups of muscles are brought into action in the vast majority of the movements of the body. In making choice, it is wise, therefore, to consider the exact objects to be attained, and to this end a typical case of Grade II. will best serve the purpose. Here the spine can be straightened up to some extent by posture; beyond that extent it remains curved. This means that not only the spinal column, but also in consequence the whole thoracic framework, are fixed in an abnormal and distorted position, which all the force at the patient's command is unable to rectify. The first object of exercise is to overcome this fixity, and to render the thoracic skeleton so mobile as to be capable of being completely or partially restored to its normal position. The second object is to strengthen up the spinal muscles to such a degree that they are capable of maintaining this improved position.

By far the most important method of obtaining the first object, and at the same time laying the groundwork for the second, is that devised by Prof. Rudolf Klapp, and elaborated by him and Dr. Fränkel. It has been called the *Creeping* method, and is best explained by considering the movements of the spines of quadrupeds.

In order to illustrate such movements in the most simple way, I have constructed a model, of flexible metal gas-tubing and copper wire, which can be fastened down to a board with drawing-pins.

In *Fig.* 39A the straight tubing represents the spine, and the rubber junction the head, of the animal. The wire



A B C

Fig. 39.—Models to illustrate the creeping movements.

(*Fig.* 39B illustrates the effect upon the spine of moving the limbs in diagonal sequence. *Fig.* 39C illustrates the effect upon the spine of the "pacing" movement.)

bridges represent the pelvic and shoulder girdles respectively.

The usual method of progression in quadrupeds is that in which the limbs move in diagonal sequence—one hind-foot is moved forwards, and immediately the fore-foot of the *opposite* side is advanced. This is shown in *Fig.* 39B.

The effect upon the spine through the assumed obliquity of the pelvic girdle is very evident, and that through the looser shoulder girdle may be intensified by inclination of the head, neck, and upper part of the trunk towards the side of the stationary fore-foot. The total effect is the production of a simple curve in the manner illustrated.

A second, but less usual, method of progression is that in which the limbs of one side are moved forwards almost simultaneously. It will be seen from *Fig.* 39C that in this method of progression the effect upon the spine is the production of a double curve.

The young human in its days of infancy employs both these methods, and by their use prepares the spinal muscles for their part in maintaining the erect posture. In their practical application to cases of skoliosis, the patients become again creeping infants, with the advantage that their efforts are directed by intelligence towards the attainment of a certain end, and are so arranged that the best results are produced.

The advantages of the system may be summarized as follows :—

In the all-fours position the spine is relieved of weight, and is automatically straightened out as much as possible, both lateral and antero-posterior curves being affected. The rule previously laid down that all exercises are to be performed with the spine in the best possible position is thus obeyed.

The movements are kept within the limits of the physiological excursion of the parts. There is no acrobatic distortion, no muscles are asked to perform other than what ought to be within their normal capacity, and no ligaments are unduly stretched.

The muscles on both sides of the spine are dealt with—those on the convexity of the curve which, hypertrophied at first by their efforts to restore the spinal balance, finally become stretched and weakened ; as well as those on the concavity of the curve, which become contracted. The exercise is a gentle one, and patients, after a little practice and with short intervals of rest, keep it up for quite a long time without fatigue or muscle-soreness.

It is efficacious : the spine is acted upon at both ends.

It is comparatively easy of supervision, and lends itself to the treatment of a large number of children in class. Moreover, parents of middle circumstances, who cannot afford a daily visit of the surgeon, and who yet object to their child attending a hospital *clinique*, or who do not live within reach of one, are able to give help in the treatment, and to carry it out successfully under instruction. In this matter the surgeon must exercise his own discretion. He must initiate every new movement and satisfy himself that it is thoroughly understood, and he must critically revise the whole programme at frequent intervals.

The exercises may be carried out in a room, corridor, or any place, in short, with a smooth floor free from splinters. The patient is provided with a loose gymnasium costume, the knees are protected by knee-caps of thick boiler-felt tied on with tapes, and the hands may be similarly protected by a pad of felt worn on the palmar aspect. Gymnasium shoes, the toes of which may be strengthened up against friction by a cap of leather, complete the outfit.

EXERCISE I.

This is founded upon the principle of *Fig.* 39B, and is quite the most useful of the series. It is illustrated by *Figs.* 40 and 41, which depict the subject of a double curve (Grade III.) carrying out the exercise, and which should be most carefully studied in connection with the following description.

The patient goes down upon hands and knees. The right knee is advanced. Then the left hand is taken forwards in a wide, upright sweep, the trunk being at the same time pitched sideways, and strongly inclined towards the stationary right hand. This part of the movement up to the point shown in *Fig.* 41 is done with somewhat of a jerk, the patient making a strong effort to unfold the dorsal curve, and a slight pause is made when the arm is stretched out to its maximum. The hand is then brought to the ground, being placed rather wide of the body (note the position of the right hand in the figure) in order to give proper balance for the next phase. This consists in

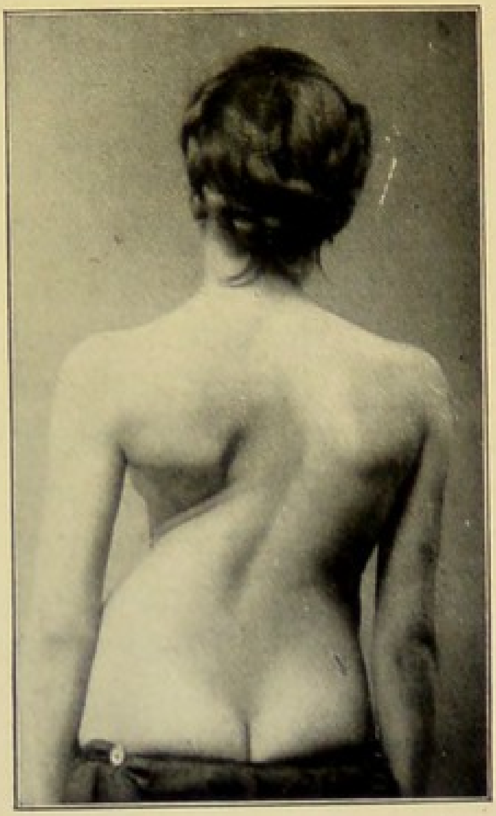


Fig. 40.*—Skoliosis. Grade III.

advancing the left knee and repeating the arm and body movements towards the left side.

The movement which unfolds the all-important dorsal curve is made more energetically, and is dwelt upon a little longer than its fellow. For this reason, when the exercise is done in an ordinary room, the patient should always creep round with the dorsal *convexity* towards the centre, the

* *Figs.* 40, 41, 42, and 43 are reproduced, with his permission, from Prof. Klapp's "Funktionelle Behandlung der Skoliose."

more important movement being given more space thereby and being favoured by the curve of the body as it progresses around the circle. The patient illustrated here, for example, would have her right side—the side of the dorsal convexity—towards the centre of the room, and would travel in the direction of the hands of a watch. A

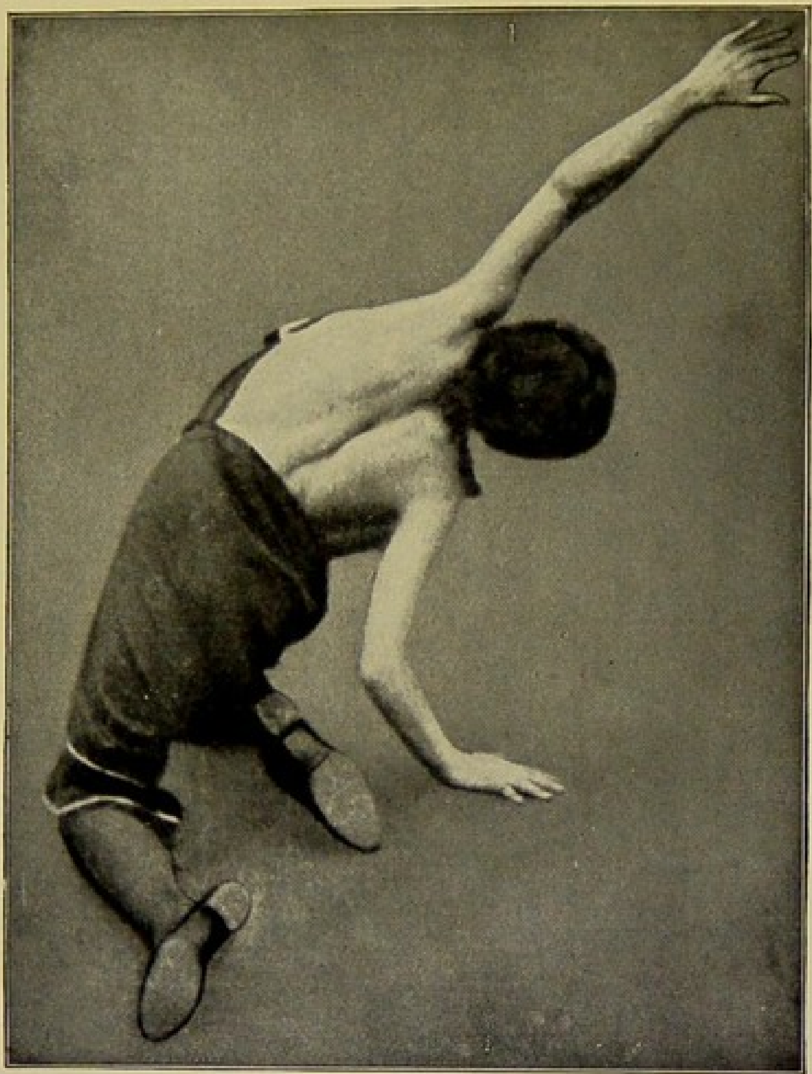


Fig. 41.—High creeping movement correcting the dorsal curve in the above case.

patient with a left dorsal convexity would travel in the opposite direction.

Patients who are learning this exercise should be placed, to begin with, in the hands-and-knees position, and allowed to shuffle along the floor quietly until they become familiar with the correct sequence of the movements of the limbs.

The next thing is to teach them to bend the trunk from side to side as the corresponding steps are taken, and when this is acquired, the full exercise, with the wide-arm movements, presents no difficulty.

EXERCISE II.

This is a variation of No. 1, but places more strain upon the erector spinæ muscles. The hands rest upon the iliac

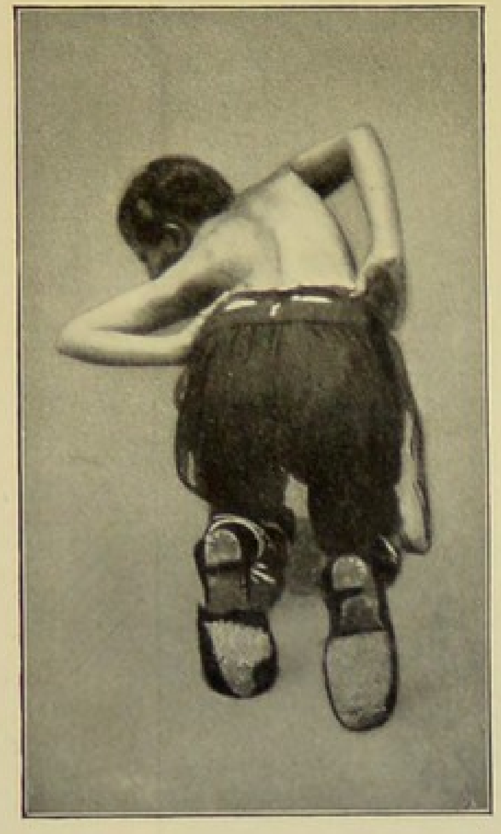


Fig. 42.—Movement to the left in Exercise II (Creeping Series).

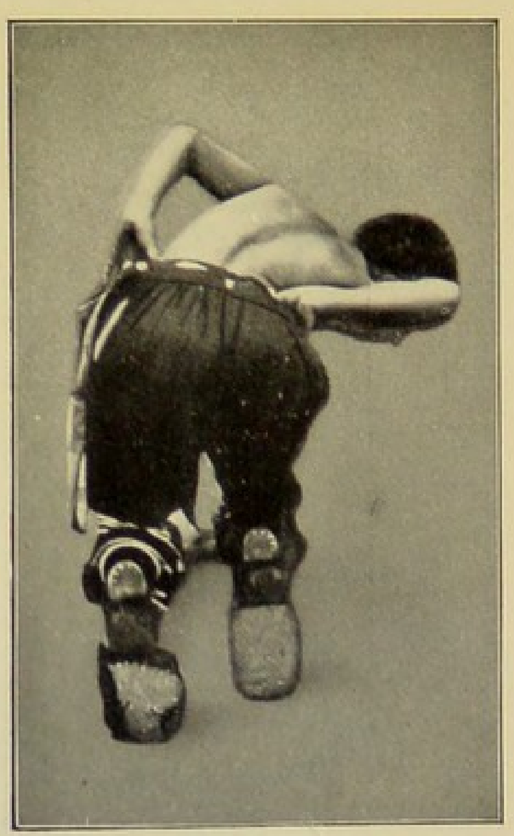


Fig. 43.—Movement to the right in Exercise II (Creeping Series).

crests, and the shoulders are kept braced well back. The trunk leans forwards from the hips, and as the patient progresses on the knees, is inclined laterally towards the side of the advancing foot (*Figs.* 42 and 43). In this exercise also the movement which unfolds the dorsal curve is made more strongly than its fellow, and the same rule, as laid down above, of travelling with the dorsal convexity towards the centre of the room, applies.

Preparation for this exercise consists in the patient's kneeling in the correct position, and practising the lateral inclinations of the trunk without moving the knees. When the trunk swayings are familiar, they are combined with forward progression.

These two exercises, with now and then a short rest in the proper position (*Fig.* 38), will fill in about forty minutes of the hour, the greater part of the time being occupied by Exercise I., and an occasional few minutes by Exercise II. The remainder of the hour is devoted to "straight work" calculated to act more directly upon the spinal muscle groups. As the patient improves, and the thoracic framework grows more flexible and more capable of being held in correct position, this "straight work" becomes the more important part of the programme, and the afternoon period of exercise may be devoted entirely to it, combined with a singing or swimming lesson, or with the flat-foot exercises should the patient require them.

In cases of Grade I. where there is no fixed distortion of the thoracic framework, the straight exercises are the more important from the beginning, but the creeping method is highly advisable at first in order to strengthen up the muscles by gentle means, and so prepare them for the more strenuous efforts demanded by the straight work.

EXERCISE III.

This exercise, although it does not apply so directly to the class of case under discussion as do the two previous ones, is introduced here for the purpose of completing the series. It is intended for use in advanced cases where it is desirable to employ the maximum of power, and in cases where the patient presents much kyphosis. It is founded upon the principle of *Fig.* 39C, and attacks both curves at the same time. In its fullest extent the movement is rather intricate. *Figs.* 44 and 45 represent two simplified poses in which most attention is paid to the leg action, but to illustrate it adequately would almost require a cinematograph film.

The first thing to notice is that it is carried out with the thorax kept low to the ground. Hence it is known as the *low-creeping* movement, in contradistinction to Exercise I., which is the *high-creeping* movement (*Fig.* 41). The object of keeping the thorax low is to attack the kyphosis which is so marked a feature of many advanced cases. With the pelvis high and the shoulders low the spine sags in such a way as to correct this kyphosis, and this effect may be increased by holding the head well back.

Fig. 44 represents the strong corrective movement in

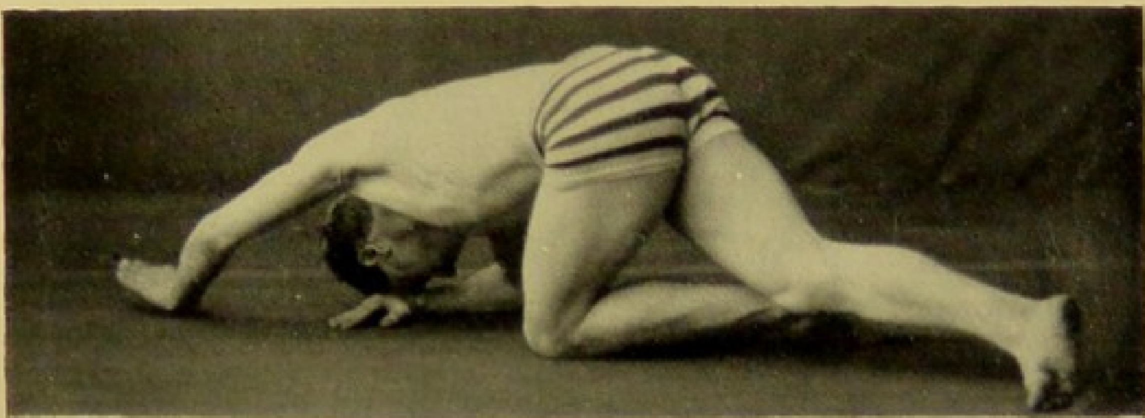


Fig. 44.—Illustrating the low creeping movements employed chiefly in double curves with marked kyphosis.

a case of double curvature convex to the *right* in the dorsal region, and reference to *Fig.* 40 will help the student considerably in its interpretation. Starting from the hands-and-knees position, the left knee is first moved forwards, and the right leg is then stretched backwards and swung across to the left as far as it will go. The result is to side-tilt the pelvis in such a fashion as to unfold the lumbar curve. The left arm is then advanced and the trunk strongly bent to the right. This movement unfolds the dorsal curve. Thus the total effect is to correct the deformity by reversing both curves by movements which, in a normal spine, would produce a double curvature convex to the *left* in the dorsal region (*Fig.* 45).

The patient makes both phases of the movement very strenuously, the right leg being stretched backwards and to the left as much as possible, and the whole shoulder-girdle being strongly turned to the right, and this position is maintained for a few seconds.

The next pace forwards is a simple one, and is made by advancing the right knee and right hand without any crossing of the legs or much curving of the trunk, its object being merely to relax the tension on the spine for the time being and to bring the patient into position to repeat the stronger corrective movement.

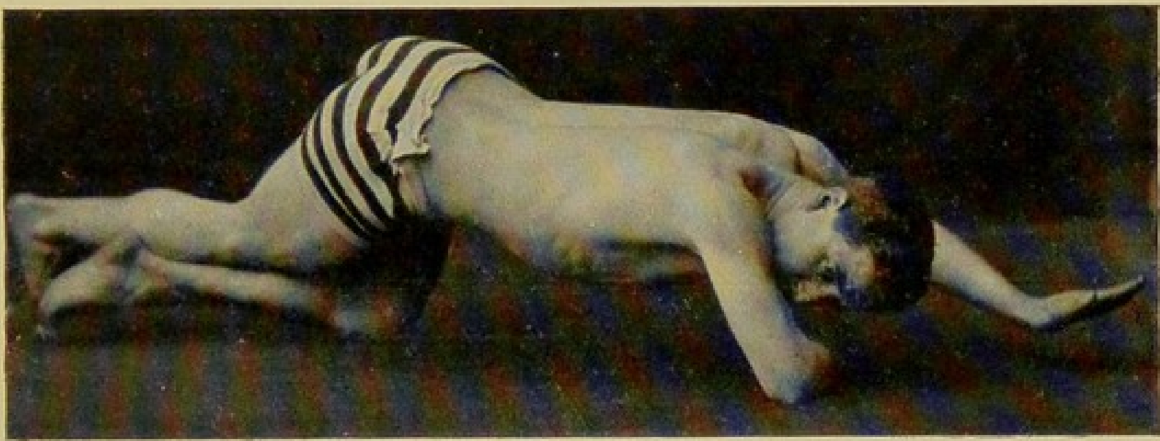


Fig. 45.—Illustrating the low creeping movements employed chiefly in double curves with marked kyphosis.

In dealing with a case of double curvature convex to the *left* in the dorsal region, the sides of the strong and weak movements in the above description would, of course, be reversed.

This exercise is a difficult one, and the patient requires a good amount of practice in Nos. I. and II. before proceeding to it. When carried out to perfection, the front part of the body travels along quite close to the ground, with the arms spread out and elbows up, much in the same style that a crocodile's body is carried along between its own forelegs.

CHAPTER VI—(Continued).

SUPPLEMENTARY EXERCISES.

THE importance of the flexing exercises has already been insisted upon, and adequate reasons have been given for recommending the creeping method of treatment. But occasionally, and especially in patients of mature growth, this method will be found inconvenient, and other lateral bending movements must be substituted. If the surgeon has a thorough understanding of the principles underlying *Fig.* 39B and C, he will have no difficulty in devising such movements. The following—illustrated and described as used to unfold a left convex dorsal curve—may serve as examples :—

EXERCISE A.

The patient sits across a chair or stool, feet on ground, arms by side.

To perform the exercise the arm on the *convex* side of the dorsal curve is stretched downwards, the arm on the *concave* side is flung upwards over the head by a circular sideways movement, whilst at the same time the trunk, together with the head and neck, is bent laterally to correspond (*Fig.* 46). The whole movement is carried out with a certain amount of vigour, the spine being, as it were, wrenched over. This attitude is kept at its maximum for five seconds, and the starting position is then resumed by reversing the actions.

This exercise may be repeated in standing position, the knees being held extended and the feet placed apart to give steadiness.

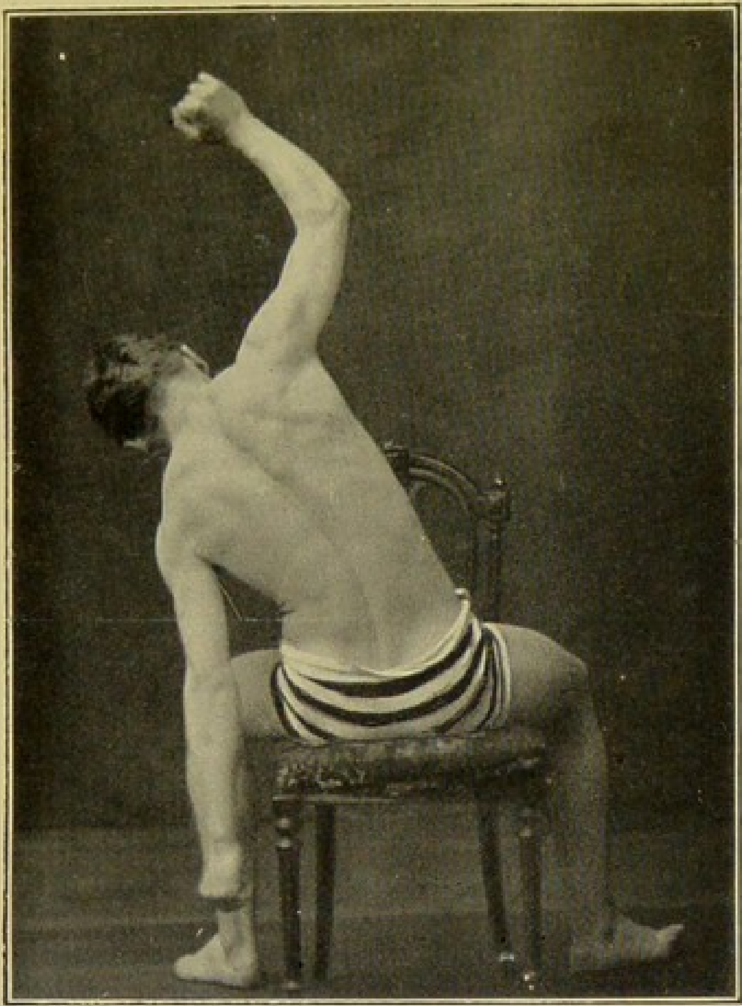


Fig. 46.—Simple lateral bending (sitting).

EXERCISE B.

The patient stands. A book or block is placed beneath the foot on the *convex* side of the deformity. The knees *must* be kept extended in order to side-tilt the pelvis. The possible range of side-tilt is restricted, and the greatest care must be taken to ensure the patient's being able to do the exercise freely and with comfortable equilibrium without bending the knee on the raised side. A block two inches thick generally forms the limit, even with a tall, supple patient.

The arm and body movements are similar to those of Exercise A.

This exercise embodies the principle of *Fig.* 39B.

Fig. 47.—Simple lateral bending with pelvis side-tilted.

EXERCISE C.

This exercise embodies the principle of *Fig.* 39C, and is employed in cases of double curves when it is advisable to control the lumbar spine. The starting position and movements are as in the previous exercise, except that the block is placed beneath the foot on the *concave* side of the dorsal deformity.

The control of the lumbar spine is by no means so great as in Exercise III. of the creeping series, but it is considerable enough to be of use. This may be seen by carefully examining *Fig.* 48 and contrasting it with *Fig.* 47. Even in these small photographs a distinct difference is apparent,

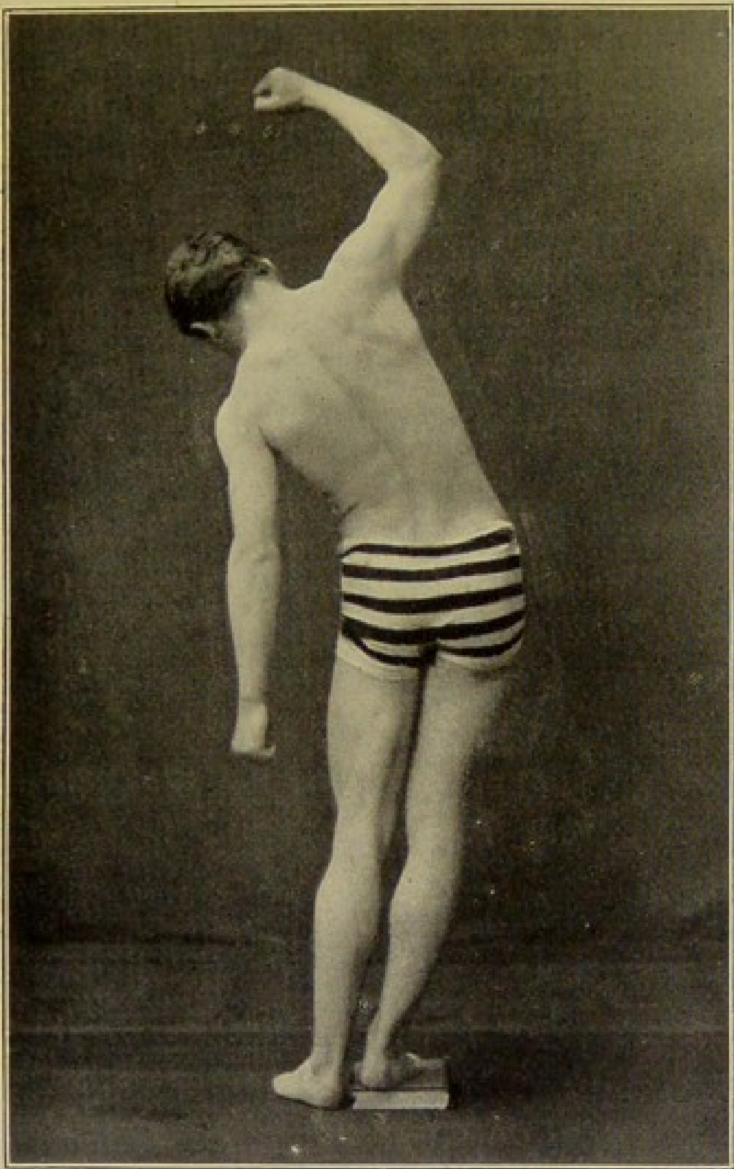


Fig. 48.—Simple lateral bending with pelvis side-tilted to control lumbar spine.

although, in this particular instance, the book beneath the foot is little more than one inch in thickness.

A twice-repeated series of six times A, sitting and then standing, followed by six times B or C, with a rest between each group of movements, will form an efficient session.

These exercises (A, B, and C.) are not suggested as equally valuable alternatives to the creeping series, which have a character and an efficacy all their own, but are meant to be employed when circumstances render the use of the creeping series highly inconvenient or impossible. Their inferiority is due to the facts that the spine is not relieved of superincumbent weight, that it is acted upon strongly from one end only, and that they cannot be repeated with comfort so continuously as the creeping movements. On the other hand, they have an individual value in helping to restore the patient's sense of erect carriage of the body, and they may often be prescribed with advantage for this purpose alone.

The surgeon should bear in mind that it is often possible to modify the movements of the creeping series in cases in which circumstances forbid their full use, and to still preserve much of their particular action. Thus, the essential movements of Exercises I. and II. may be carried out without the patient's actually travelling along the floor, by allowing each lateral bending of the trunk to be followed by a return to the original starting position.

CHAPTER VII.

THE STRAIGHT WORK EXERCISES.

THE "straight work" is devoted chiefly, and in a very direct fashion, to the muscles of the back, and its value in enabling the patient to retain all the advantage derived from the flexing exercises has already been insisted upon.

The exercises about to be described have each the same root idea, viz. : *the spine being stiffly held*, the trunk is made to perform movements of flexion and extension at the hip joints, and these movements are varied by the positions, or by additional movements, of the arms.

They are carried out standing, sitting, prone on the floor or on a bench ; but whatever position may be taken as the initial one, the programme is just the same as regards details of the movements, which may be listed in the following way :—

	TRUNK	ARMS
(1)	Flexion and extension	By sides.
(2)	Flexed, if standing or sitting. Extended, if prone.	Fists to shoulders. Shoot fists forwards. Recover.
(3)	Flexion and extension.	Hands to back of ears.
(4)	Flexed, if standing or sitting. Extended, if prone.	Fists to shoulders. Shoot fists outwards. Recover.
(5)	Flexion and extension.	Stretched above head.
(6)	Flexed, if standing or sitting. Extended, if prone.	Swimming movements (breast stroke).

It will be noticed that when the arms are still the trunk is bent backwards and forwards (1, 3, *and* 5), *and that when the arms are active the trunk is kept still in the position of strain, i.e., bent forwards if standing or sitting, bent backwards if lying in the prone position* (2, 4, *and* 6).

Each exercise is carried out six times. There must be no hurrying, and each phase of an exercise must be marked by a slight pause. This is insured by the instructor giving words of command for the slower movements and counting the quicker movements in seconds time. For example, No. 2 in standing position would be conducted thus :—

Instructor.		Patient.
Attention.		Assumes starting position (*Fig.* 49).
Forwards bend.		Trunk forwards.
Prepare.		Fists to shoulders.
In seconds time. Repeat movement six times	One.	Fists shoot forwards (*Fig.* 50).
	Two.	Fists back to shoulders.
	One.	Fists shoot forwards.
	Two.	Fists back to shoulders.
As you were.		Patient drops hands and stands erect.

Again, No. 3 on the bench would be as follows :—

Instructor.		Patient.
Attention.		Rises from the resting position (*Fig.* 53), and at once assumes the position of exercise (*Fig.* 55).
Repeat movement six times	Downwards.	Trunk is flexed at hip joints.
	Upwards.	Trunk recovers.
	Downwards.	Trunk is flexed at hip joints.
	Upwards.	Trunk recovers.
As you were.		Patient resumes attitude of *Fig.* 53.

In the swimming movements (No. 6) the instructor times the quick forward dart of the hands and allows a suitable period for the deliberate backward sweep. Respiration must be carefully trained in this movement. Inspiration is made through the nostrils, with closed mouth, as the arms go backwards. Expiration is made forcibly and audibly with the mouth open as the arms shoot forwards.

A rest of a few moments is given after each exercise.

The patient is trained to these exercises by learning them in the standing position, and then taking them in the following order :—sitting ; prone on the ground ; and on the bench. When proficient in all, a series in one vertical and one prone position—e.g., standing and on the bench, or sitting and on the ground—is gone through at each exercise time.

It goes without saying that the utmost value must be extracted from each movement. In Nos. 2 and 5, for instance, the shooting forwards of the fists and stretching of the arms must be done to the very fullest extent. In all the exercises the spine must be stiffly held ; all the time the patient is working, the erector spinæ muscles should feel quite hard. The object is not only to exercise the muscles to the full, but also to hold the spine over-extended, in which position lateral movement in the dorsal region is checked.

This series of exercises is a very simple and, at the same time, a highly effective one. A study of the table given, in conjunction with the paragraph in italics which follows it, will enable its main points to be gathered in a very short time. It now remains to note certain details of each position.

STANDING.

Fig. 49 gives the starting position, which must be carefully considered. The feet are placed apart to give a firm stand. The knees are kept absolutely stiff. The trunk inclines slightly forwards, with the back arched, so that the buttocks are thrown into prominence. The arms are by the sides, with the shoulders well down, and the head is erect.

In Exercises 1, 3, and 5, the trunk bends forwards and backwards from this position with the arms by the side, to the back of the ears, or stretched above the head, as the case may be. *Fig.* 51 illustrates No. 3, and shows the

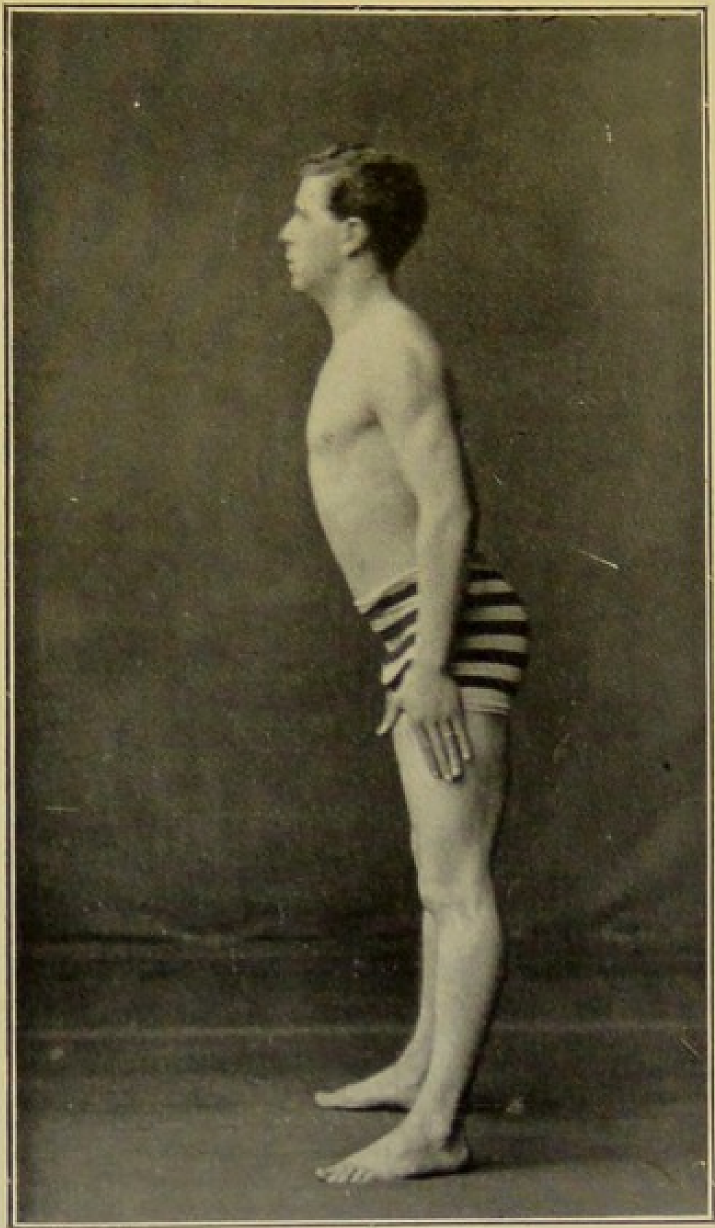


Fig. 49.—The starting position for straight work (standing).

patient during the act of bending forwards. Notice that the knees are rigid, the back is well arched, and the erector spinæ thrown into prominence.

In Exercises 2, 4, and 6, the arm movements are made with the trunk held inclined forwards. *Fig.* 50 illustrates

No. 2. Notice again that the knees are rigid and the back is well arched.

SITTING.

The patient sits forward on the edge of a chair or stool, with the feet on the floor and the back held stiff. The

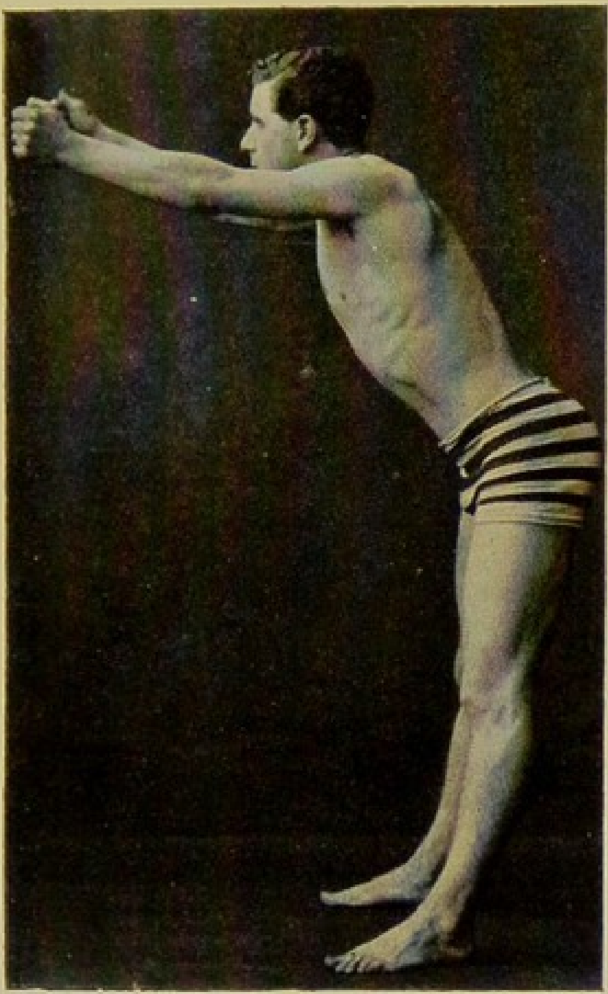


Fig. 50.—Fists forward in Exercise No. 2.

Fig. 51.—Bending forward in Exercise No. 3.

movements are made exactly like those in the standing position, but in Exercise 1. with the arms down, the hands grip the edge of the front or sides of the seat.

PRONE ON THE GROUND.

The patient lies on a rug, and the feet are kept down by a strap or by the instructor's hands.

In Exercises 1, 3, and 5, the trunk movements are necessarily confined to a "rearing up" from, and a return to, the prone. This is done with the arms in their appropriate positions—by the sides, with the hands to the back of the ears, or stretched forward to fullest extent, as the case may be.

In Exercises 2, 4, and 6, the trunk is held as in *Fig.* 52, which illustrates the swimming movement.

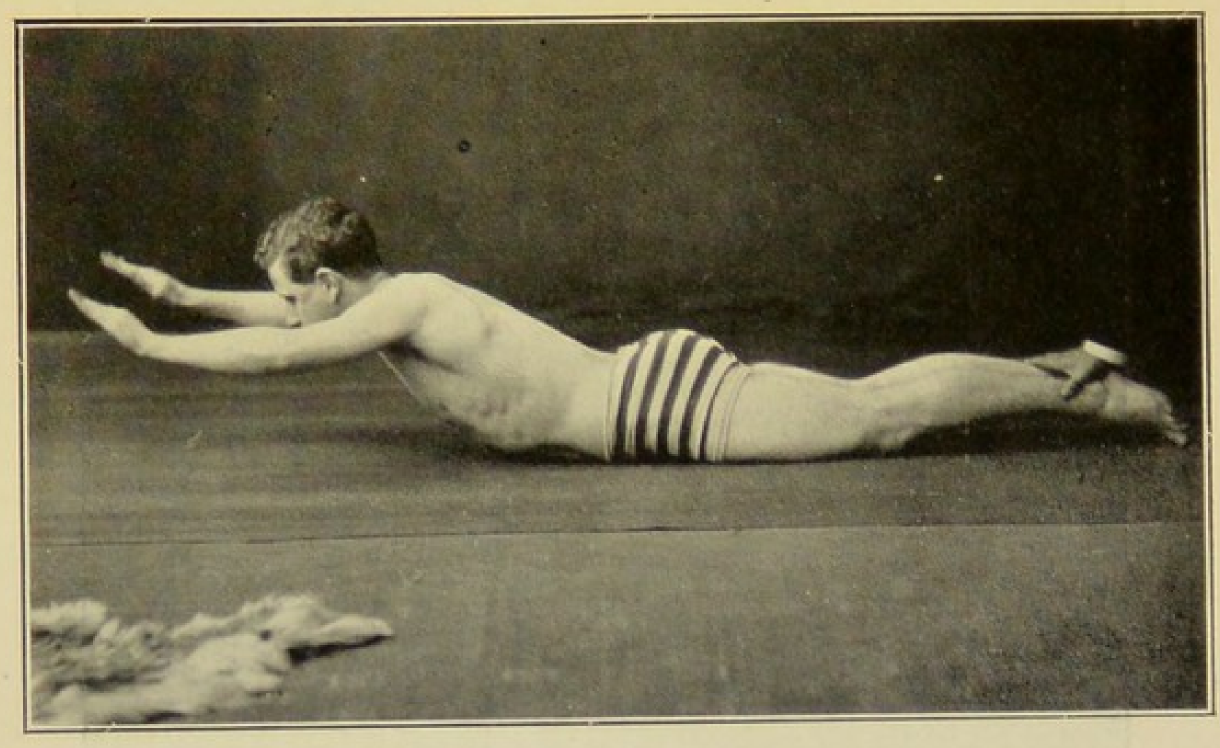


Fig. 52.—The swimming movement in the prone position.

ON THE BENCH.

The bench, or plinth, should be about twenty inches high. The patient lies in prone position with the pelvis at the edge thereof, and the feet are kept down by a strap—a surcingle does well—passing over the ankles.

Fig. 53 shows the resting position which the patient assumes between the exercises, and from which the starting position of any particular exercise is taken up upon the word of command.

Figs. 54 and 55 illustrate the starting positions of

Exercises 1 and 3, and from these positions the trunk, held stiffly all the time, is bent from the hips towards the ground as far as possible, and then restored.

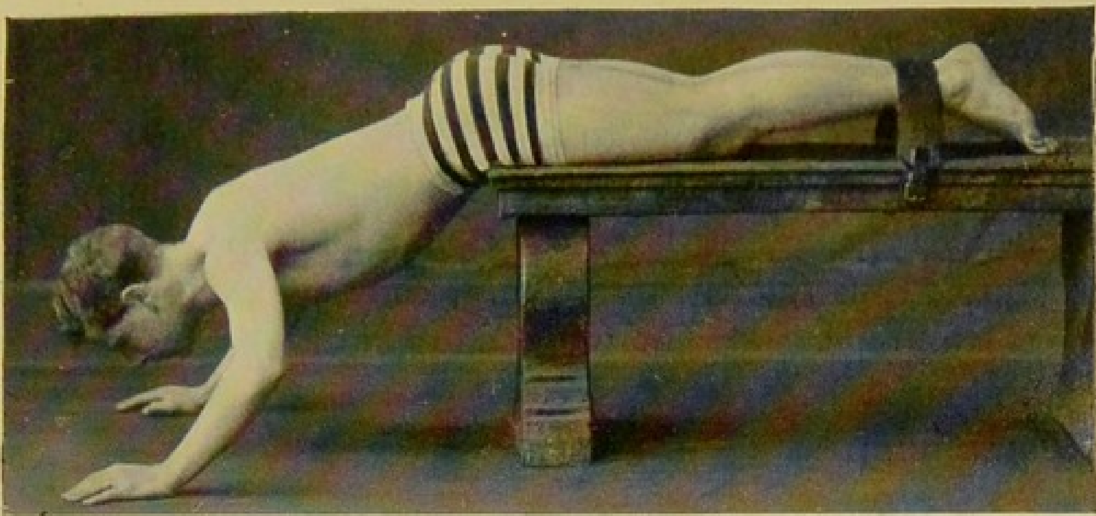


Fig. 53.—The resting position on the bench.

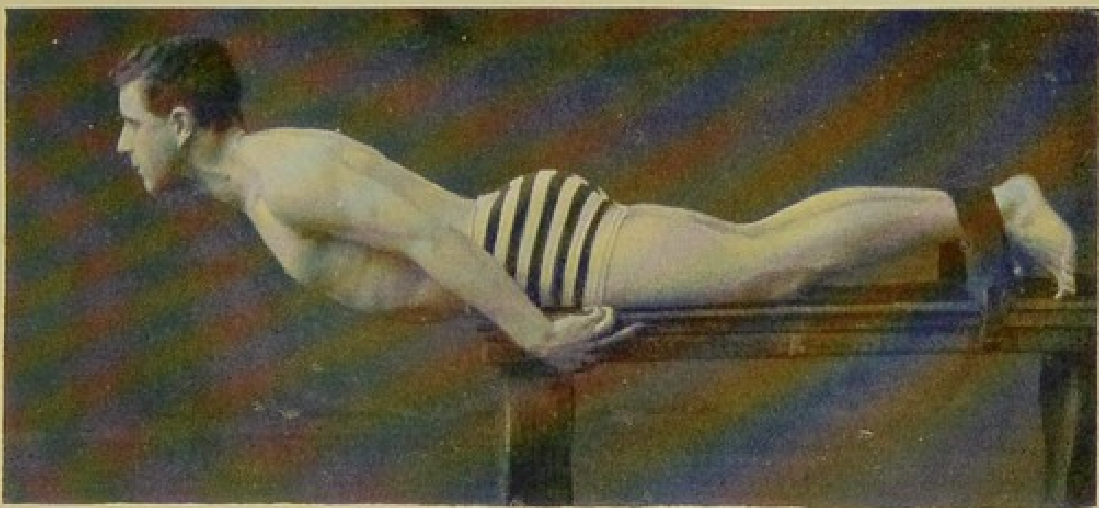


Fig. 54.—The starting position of Exercise No. 1 on the bench.

Fig. 55.—The starting position of Exercise No. 3 on the bench.

In Exercises 2, 4, and 6, the trunk is maintained in position similar to that shown in *Figs.* 54 and 55, whilst the arm movements are carried out.

After each period of exercise the back should be massaged for five minutes in order to assist the removal of the waste products of muscle activity. Patient lies prone, elbows out, forehead resting on the crossed hands. The movements are carried out gently but firmly, care being taken not to bruise the muscles by making the manipulations too heavy or too long.

Loins and back :—

1. Stroking (effleurage). One palm on each mass of the erector spinæ at the loins. Stroke upwards and then outwards in a continuous movement along the lines of the latissimus dorsi and lower part of the trapezius. Repeat six times.

2. Deep friction of each mass of the erector spinæ. Place fingers of left hand flat on the muscle. Press down on them with the fingers of the right hand, and apply circular motion. Travel gradually along the length of the muscle. One minute or so on each side.

Repeat both 1 and 2, ending up with a final stroking.

Neck :—

1. Firm stroking from the occiput downwards and outwards along the line of the upper part of the trapezius.

2. Squeezing or pinching (pétrissage) of the muscles between the thumb and fingers for one minute or so on each side. Repeat both 1 and 2, ending, as before, with a final stroking.

In the absence of the surgeon the deeper movements may be omitted should there be any difficulty in their performance, and the simple stroking movement, repeated a dozen times or so, carried out.

CHAPTER VIII.

WEAK ANKLES—FLAT-FOOT.

I.—WEAK ANKLES.

THIS term is applied to a very distinct condition in which the ankle joint is loosely held together as the

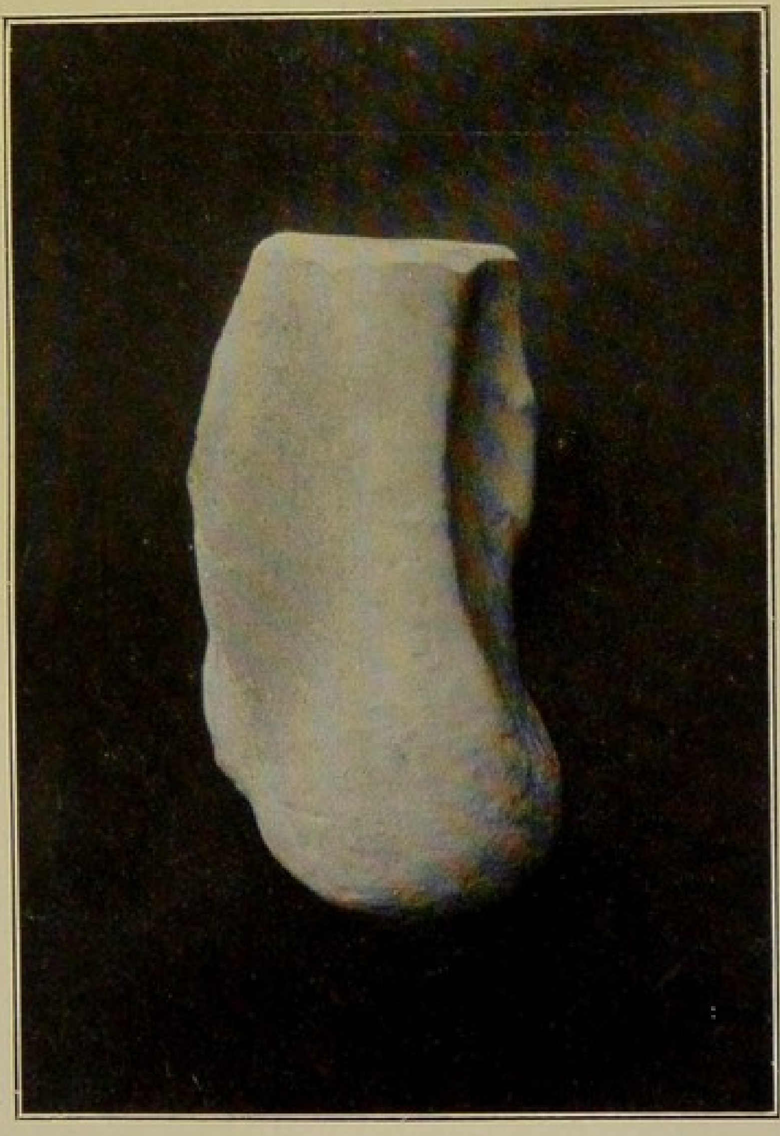


Fig. 56.—Model showing eversion of the heel in a case of weak ankles.

result of a lax state of the structures supporting it, and so lends itself to exaggeration of its normal movements. Some cases of weak ankles are associated with flat-foot; others occur in patients in whom the foot-arches are perfectly sound. In these latter the physical pose of flat-foot may be simulated by an undue prominence of the internal malleolus and a slight eversion of the whole foot when the

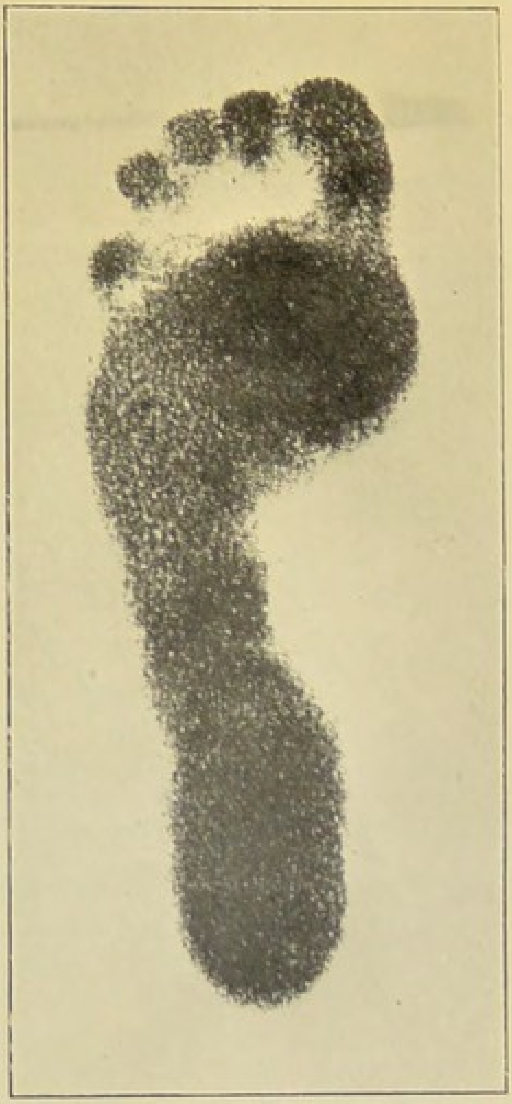


Fig. 57.—Showing the presence of a good plantar arch in the case from which the model in *Fig.* 56 was taken.

patient's weight is put upon it. This is shown in *Fig.* 56, which is taken from a plaster model of the heel of a patient with weak ankles. This patient had quite good foot-arches, as is evidenced in the impression of her foot in *Fig.* 57.

I have noticed that this condition is often associated with a peculiar anatomical defect. At one period of fœtal development the external and internal malleoli are at the same level. At birth the external malleolus is slightly lower than the internal, and thence onwards it descends until it forms a firm splint to the ankle joint. In subjects with weak ankles, as also in those who develop flat-foot at an early age, it is often found that its downward growth has not progressed to its full extent, and the normal support is thus deficient.

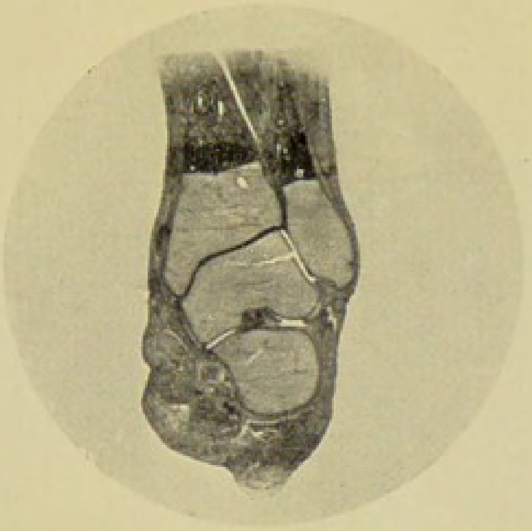


Fig. 58.—Section through ankle-joint of fœtus, showing the malleoli at approximately the same level. (Double size.)

The treatment of weak ankles resolves itself into the use of the same exercises as are recommended for flat-foot.

II.—FLAT-FOOT.

The human foot has three main functions : (1) To afford a basis of support to the erect body ; (2) To act as a lever of complicated order in walking, etc. ; (3) To do (1) and (2) in such a manner as to act at the same time as a shock-absorber.

For the latter purpose it is, in part of its extent, built up in the form of non-rigid and "springy" arches.

As a rule two arches are described :—

1. An antero-posterior, composed of the os calcis, head of the astragalus, scaphoid, the three cuneiforms, and the

three inner metatarsals. This arch has its extreme bearings, or "springing points," at the heel and the heads of the metatarsals, and its "key," or uppermost component, is formed by the head of the astragalus.

2. A transverse, which is incomplete, taking its outer

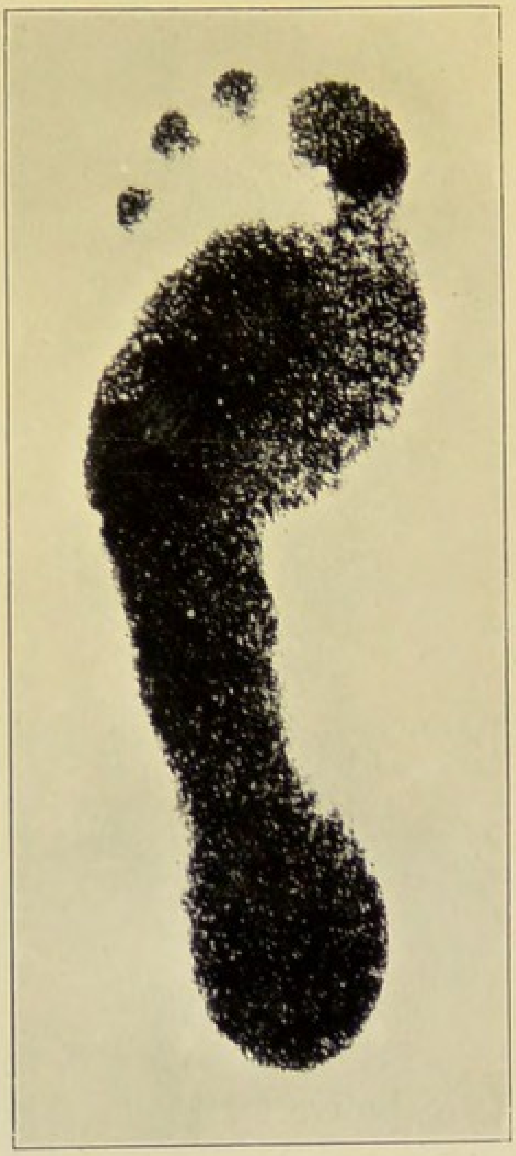


Fig. 59.—Impression of a normal foot: the deep concavity on the inner side is due to the existence of the plantar cave.

bearing about a point near the base of the fifth metatarsal, where the outer part of the foot comes into contact with the ground, and rising upwards and inwards to merge into the inner border of the antero-posterior arch.

All this is another way of saying that the under part of each foot is hollowed out at the inner side, to form with the ground a shallow cave, the roof of which is composed of a non-rigid and "springy" compound of bones, joints, and ligaments. From a mechanical point of view this roof may be regarded as a series of arches disposed antero-posteriorly and diverging from the heel to the line of the heads of the metatarsals, and the relation between the height and the span of the arches is such that those on the inner side are the weakest, and those on the outer side the strongest.

Although this plantar cave is filled up to a great extent

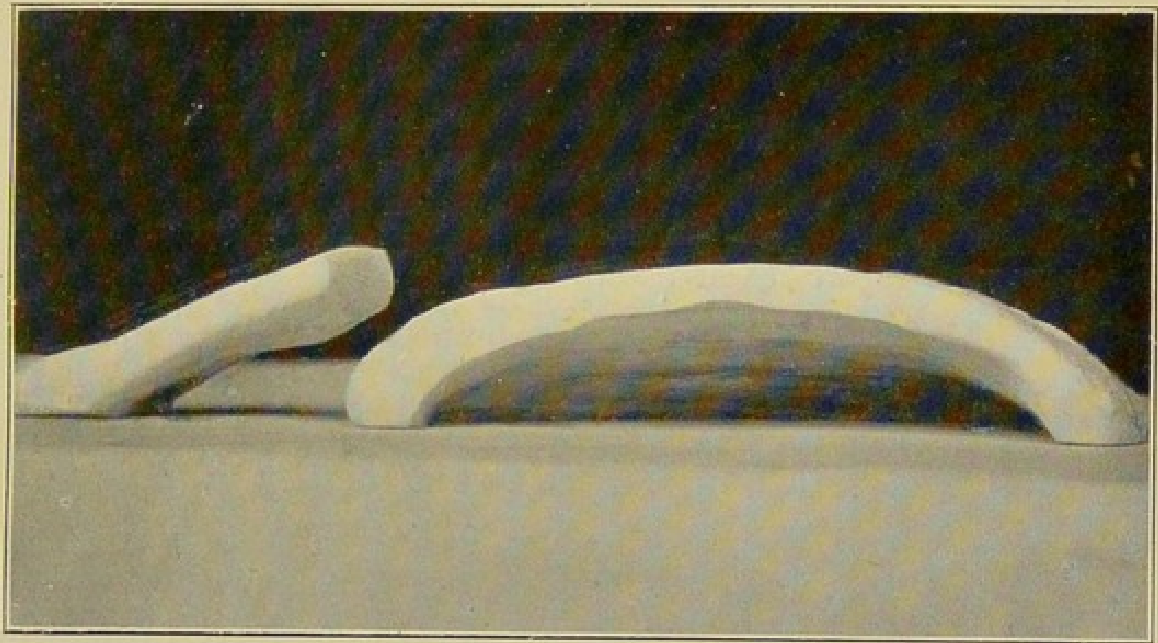


Fig. 60.—Model of a "plantar cave" obtained as described in the text. The smaller object on the left is a transverse section thereof.

by soft tissues, it is still very evident in an impress of the foot, and may be shown also in a cast.

Fig. 60 was obtained by pressing a foot with a high instep on some plastic material: a roof of plaster was then built over the cast so made, and the photograph thereof represents a plantar cave of the right side.

The roof is supported to some extent by the tough plantar fascia and by certain of the intrinsic muscles of the sole, but chiefly by the long and short plantar ligaments and by the tendons of the tibialis anticus, tibialis posticus, flexor longus digitorum, flexor longus hallucis, and, especially as regards the tendency to transverse spread, by the peroneus longus. Most strain comes upon it during locomotion, and it is just at this time that these muscles, being in a state of contraction, afford their most strenuous support. The tibialis anticus is especially important, and the great part taken by this muscle in sustaining the arch, etc., in the mechanism of walking may be judged from the fact that most people, when walking is overdone, feel tired first in this muscle, and have greater after-soreness in it than elsewhere.

Flat-foot occurs when the muscles are inefficient and an undue strain is thrown upon the ligaments. These yield sooner or later, and when the short plantar ligament no longer affords its support, the head of the astragalus—the keystone and crown of the great plantar arch—slips downwards, forwards, and inwards, carrying the scaphoid and the other components of the arch with it.

Paralysis of the muscles—peronei, posterior tibials, or the tibialis anticus—may result in severe flat-foot. The tibialis anticus may become wasted and so powerless as to simulate paralysis through mere stretching, by dropping of the point of its insertion, in cases where the arch has collapsed. Stretched muscle is very powerless : the feebleness of the anterior tibials when the toes have been pressed down by the weight of the clothes in patients who have been confined to bed for any long period, is well known to all.

Muscular inefficiency is the state which obtains in the subjects of spinal curvature, and it is therefore not surprising that these show a large percentage of flat-foot. In fact, each subject of spinal curvature ought to have the feet examined for this condition.

Muscular weakness being the predisposing cause, the actuating cause is the placing upon the roof of the plantar cave of a weight beyond its carrying strength. Some parts of the roof, however, are stronger than others. Regarded as built up of a series of arches disposed longitudinally, the outer arches, as already explained, are stronger than the inner arches, and will often carry in safety a weight which would speedily break down the latter.

Transmission of the body-weight in walking is an ideal illustration of this, and one that has a very practical bearing. As the body inclines forward in taking a step, the body-weight swings from the heel right along the foot to the toes. Its line of swing must, for the sake of stability, lie somewhere along the breadth of the foot, and not along either of its borders. Moreover, this line of swing diverges slightly from the direct forward path of the person travelling, owing to the transference of weight first to one side and then to the other, and to the mechanics of the lower limbs in walking: in other words, forward motion is the resultant of a series of swayings to either side of the line travelled. Now, which is the strongest part of the foot for this line of swing to pass over?

"In the ordinary position of supporting the body it appears that the essential arch is through the calcaneum, cuboid, external cuneiform, joined to the latter by a firm interosseous ligament, and the third metatarsal. This can be proved by removing the first and fifth metatarsals with their phalanges and the first cuneiform bone, without impairing the stability of the foot. The fourth metatarsal may next be taken away without trouble. If the second with its cuneiform be detached with care, the arch is still reasonably firm. It is possible to preserve the arch after taking out the astragalus and then removing the scaphoid. Although the arch still stands, it will bear little weight, the third cuneiform being inadequately supported behind; but with the scaphoid and astragalus retained, the arch is a good one." *

The best line, therefore, and the one which demands least support from the other components of the foot, is from the heel along the third metatarsal. The practical deduction

* Piersol's "Human Anatomy."

is that *in walking, the feet should be held only very slightly divergent from the line of progression.* If the toes are turned outwards, as is usual, then the line of swing crosses

Fig. 61.—Diagram illustrating the above statement: the vertical line is the line of progression, and the side lines mark the direction of swing of the body-weight.

Fig. 62.—Showing the pressure-points with the feet parallel.

over the inner arches, which are the least able to bear the strain. With the foot held only slightly divergent, as shown in the upper part of the diagram (*Fig.* 61), this passes

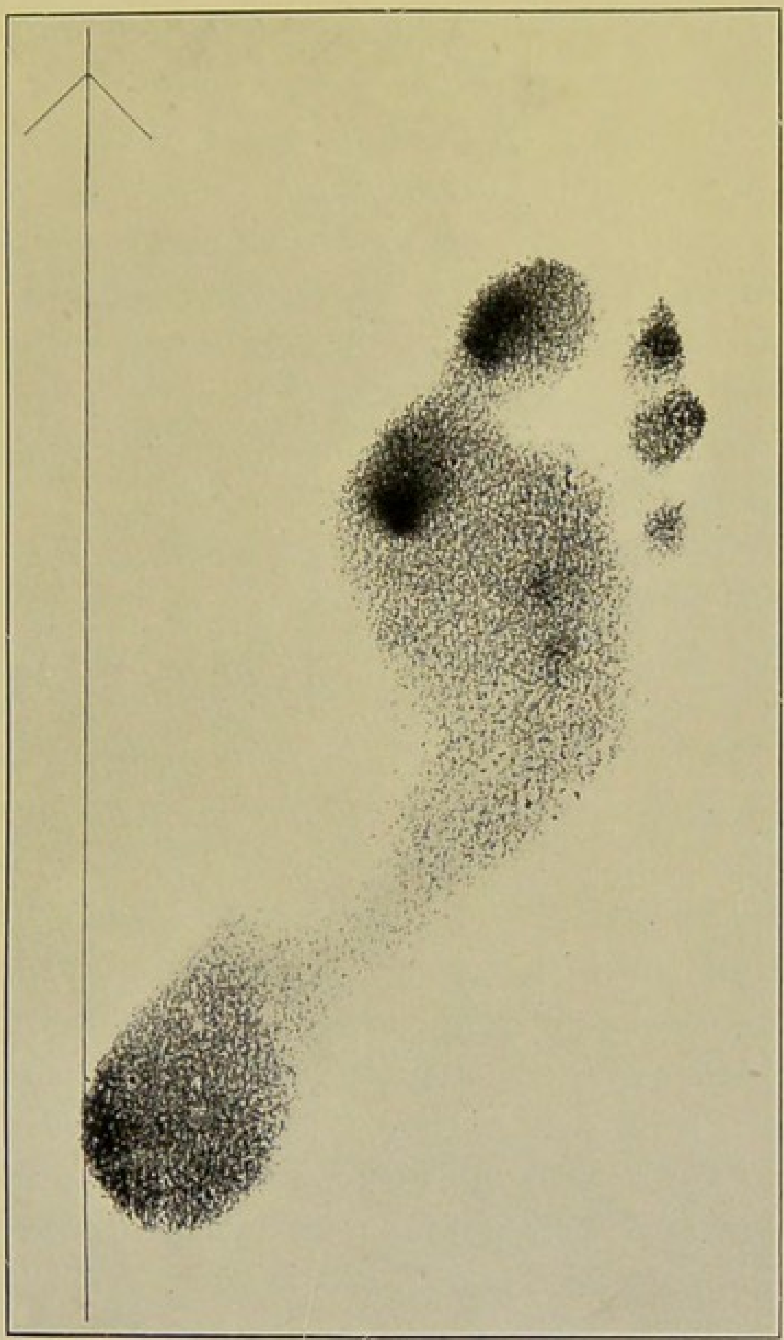


Fig. 63.—Showing the pressure-points with toes turned outwards.

along the most stable arch, but with the foot held turned outwards (lower part of diagram) it crosses the inner arches.

Trial can be made of this in a very easy manner by walking fifty paces with the boots off and the heels held an inch off the ground, first with the feet straight, and then with the toes turned outwards. The great strain in the latter position is very evident.

It may be demonstrated also very effectively by taking foot-prints by the method devised by me, and explained later in this section, in which the pressure-points are shown up in darker shade than the remainder of the print. *Figs.* 62 and 63 were obtained by causing the subject to place one step on the printing frame during the act of walking. In *Fig.* 62 the walk was made with the feet parallel ; in *Fig.* 63 the toes were turned outwards. In the former case the pressure comes on the heel, and is then distributed mainly along the second, third, and fourth metatarsals. In the latter case the heel and the head of the first metatarsal are especially indicated, and it is clear that the inner arch takes more than its due share of the burden. The pressure-point at the terminal phalanx of the great toe seen in both prints represents the final "shove off" as the foot leaves the ground.

In this connection a personal reminiscence may not be irrelevant. Some years ago I had the medical supervision of an expedition into Central Africa. We had with us a varying number, but always about five hundred, of carriers, whose loads, borne on the head, averaged 56 lb. each. They all walked with the feet straight, which is the only possible way along the narrow native paths, and made an average progress on the march of two and a half miles an hour. I cannot recall a single case of trouble due to flat-foot during the many months of this arduous labour.

SIGNS AND SYMPTOMS.

Flat-foot produces pain and deformity.

The amount and character of the pain are not constant. Slight stretching of the ligaments may cause such intense suffering that nature adopts her first method of cure by paralyzing the part functionally, and the patient is unable to use the feet at all. On the other hand, there may be advanced mischief with only a moderate degree of discomfort. Patients who are the subjects of commencing flat-foot complain of pain during and after walking, or at the end of the day, especially if their occupation involves much standing. They may be able to locate the pain around the head of the astragalus, but often they describe it in one of three different ways: (1) As a lancinating pain apparently located in the centre portion of the plantar fascia, and darting from heel to toes when weight is placed upon the foot; (2) As an aching or burning pain in the bones, which they attribute to rheumatism; (3) As shooting pains passing deeply up the calf of the leg. Complaint of pains such as these should always lead to an examination of the feet. There may be no deformity present as yet; even the tuberosity of the scaphoid may not appear too prominent; but when pressure exerted in various directions is put upon it by the thumb, pain due to inflammation of the bony attachments of the short plantar ligament will be evoked. This most important condition of *commencing flat-foot* is overlooked very often, especially in those cases in which the patients suffer from the third class of pain and profess nothing to draw attention to their feet.

The deformity in advanced flat-foot is characteristic, and is so palpably due to derangement of the normal "set" of the bones that it can be mistaken for nothing else. There is one detail of deformity which has been held to be typical of the earliest stages, and which is dependent upon the fact that as soon as the great arch commences to "let down" the foot tends to evert when weight is put upon it. Viewed in this position from behind, the tendo Achillis no longer makes a clean run down to the heel, but is deflected outwards at its lower end. This deformity, however, occurs also in cases of weak ankle in which there may be no suspicion of flat-foot (see *Figs.* 56 and 57), and therefore, when the sign is present, a simple differential diagnosis is called for.

In a marked case the plantar cave, of course, disappears through the flattening down of its roof, and an impress of the foot shows clearly the departure from the normal (*Fig.* 64). The inner border is convex instead of deeply concave, whilst the outer border has a slight concavity instead of being nearly straight: in short, the whole fore-part of the foot is pushed outwards by the forcible lengthening of its inner border caused by the collapse of the arch.

The Making of Foot-prints.—An impress of the foot is not only useful for diagnosis, but an excellent way of keeping a record of the case. One of the best-known

Fig. 64.—Prints of normal and of flat-foot. (Diagrammatic).

methods of making foot-prints is to paint the sole of the foot with a solution of perchloride of iron in glycerin, and then to allow the patient to press the foot on to a sheet of paper. This print is afterwards brushed over with a solution of tannic acid, which turns it black.

This method gives good prints, but is not very agreeable to the patient, and in place thereof I have devised a process, very simple and cleanly in its application, and the results of which are all that can be desired. The apparatus consists of a slab of wood, 15 in. square, which is faced up on one side with $\frac{1}{16}$ in. sheet zinc. This zinc face is surrounded by a $\frac{1}{2}$-in. frame, $\frac{1}{8}$ in. deep, the object of which is to keep the impression paper which rests upon it from immediate contact with the zinc surface. A movable wooden batten, 2 in. wide and $\frac{1}{8}$ in. deep, rests along the middle of the face, dividing it into two parts; it supports the inner edge of the single sheet of paper when only one side of the press is in use, and supports the inner edges of both sheets when simultaneous prints of the two feet are desired.

To use the apparatus, printers' black ink is spread on the zinc surface with a photographic rubber roller. A very thin layer only is required, and should the ink at any time be too thick to work easily, two or three drops of turpentine will facilitate. A sheet of paper, 16 in. by 10 in., is then laid above the inked surface, resting upon the wooden frame on three sides, and on the central batten on the fourth. The central batten being movable, the size of the part of the surface in use can be varied to take impressions of a foot at the different angles of divergence habitual to different patients, and for this reason the sheets of paper are cut to a size which at first seems unnecessarily large. The surface being inked and the paper laid down, it simply remains for the patient to step on to the centre of the paper for a moment, and the process is complete. The only experience necessary is in judging the amount of ink to be used. The error is always on the plus side, but the excess comes off with the first spoilt print, and after re-rolling, satisfactory results are obtained. When finished with, the zinc face is cleaned up with turpentine.

The kind of paper used is of great importance. It must be stiff enough to rest on the raised frame without sagging down and adhering to the inked surface; also it must be stiff enough not to crease when the weight of the foot is put upon it; and yet it must be pliable enough to respond to varying grades of pressure. The trade descriptions of the two kinds found most suitable are, (1) Royal art boards—25 lb. per gross, (2) Antique double crown—60 lb. per ream. The first has a glazed surface and gives very distinct black prints without much detail (see *Fig.* 59). Some care is required in using it: if the pressure of the foot is applied unevenly it is apt to slip somewhat and give a smeared reading. The second is the best for general use.

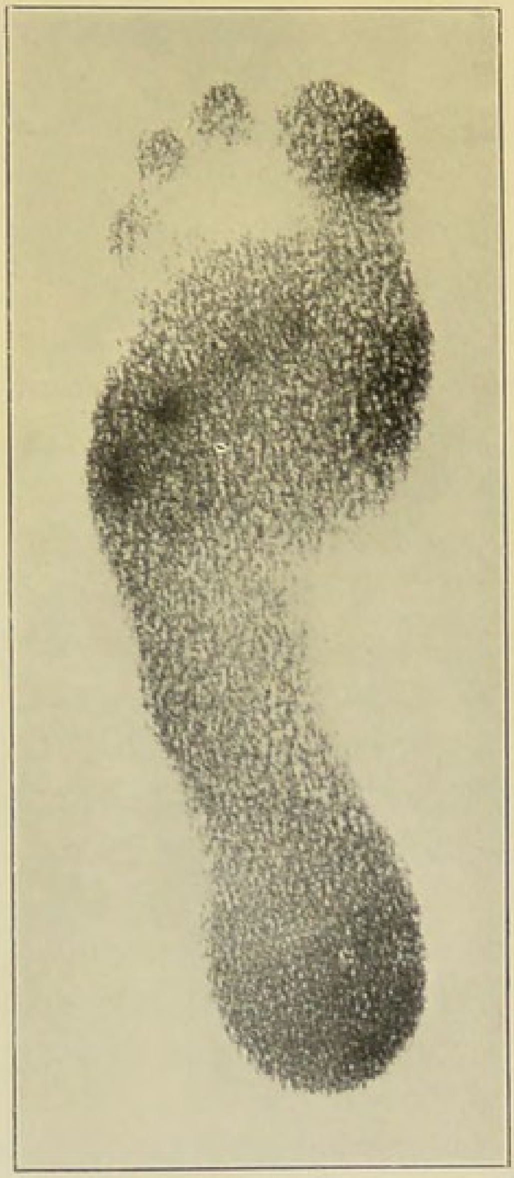


Fig. 65.—A typical print of foot with normal arch taken on the second kind of paper. Patient standing still. The distribution of weight is indicated by varying intensity of colour.

It has a rather rough, dull, absorbent surface, and gives excellent detail regarding pressure-points (see *Figs.* 62 and 63). With a little care not to ink the zinc too heavily, it gives uniformly good results.

TREATMENT.

Advanced cases, in which all semblance to an arch has disappeared, may require forcible correction under an anæsthetic, and prolonged rest, before any treatment by exercises can be undertaken.

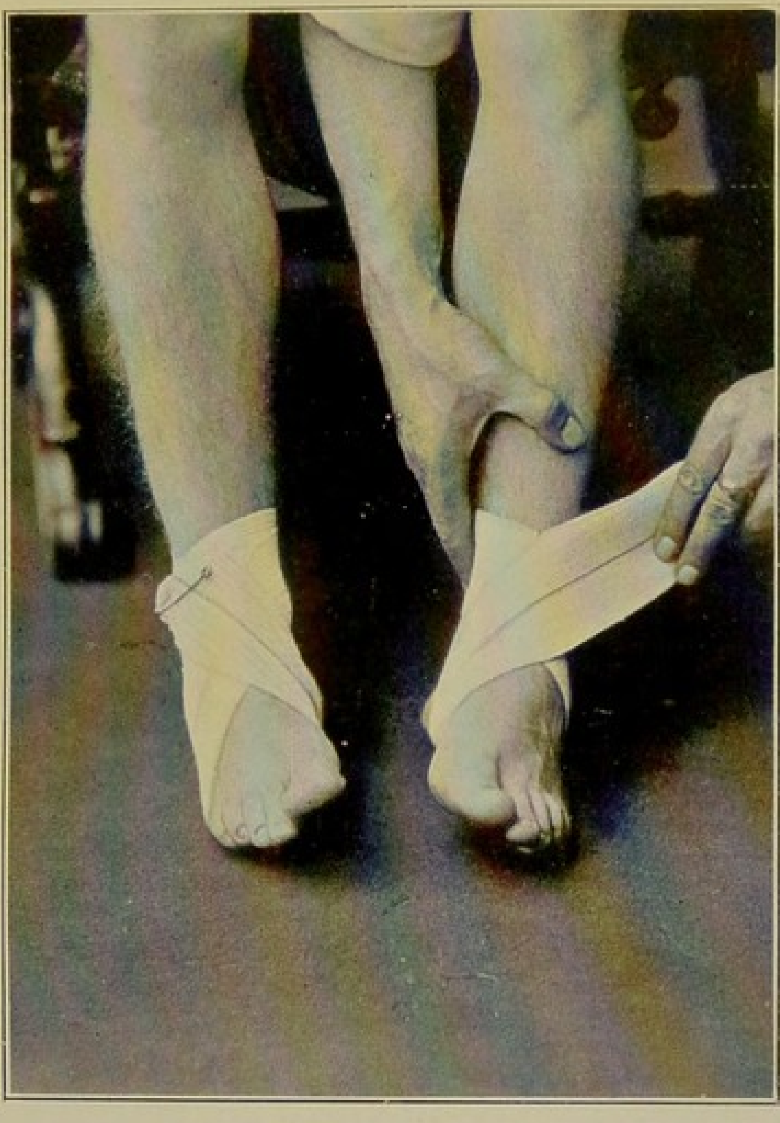


Fig. 66.—Showing application of elastic bandage to the inverted foot. The final turn is taken abruptly upwards and fastened in front of the ankle.

In the less advanced cases treatment may be commenced forthwith as a rule, although, when the foot is very tender, the advantage of a few days' rest in bed, combined with massage, must be borne in mind.

Patients who suffer from the lancinating pain in the sole of the foot often get much relief from wearing a double turn of elastic-webbing bandage ($2\frac{1}{2}$ in. wide and a yard long), taken in a figure-of-8 round the ankle. The second turn of the bandage should be taken under the sole well forward to the heads of the metatarsals (*Fig.* 66), and should then be brought sharply upwards and fastened in front of the ankle. It is applied with the foot in position of inversion.

The bandage exerts a comfortable supporting pressure, which may be increased if necessary by applying it over a pad of cotton-wool (well "fluffed out" before the fire) placed along and beneath the instep. It acts also by holding the foot in the inverted position, thus allowing the stretched tissues to contract. The inverted position is the "position of rest" for flat-foot, and should be adopted by all patients when sitting.

This bandage, which is useful in all ordinary cases at the beginning of treatment, should be worn at night-time and also during sedentary occupations. If the patient has to get about much and suffers pain, even when wearing the special boots described later, it may be necessary to support the foot by applying firm strapping on the same principle.

Further treatment resolves itself into: (1) The use of appliances or special boots; (2) Exercises.

1. There are numerous valgus pads, valgus sole-plates, arch socks, etc., on the market, and people who have a suspicion that they are suffering from flat-foot very generally prescribe one or other for themselves. My experience is that those who obtain comfort from them are very few and far between; the majority find them intolerable and quickly leave them off. *The sensible principle of treatment is not to depend upon propping up the arch from below, leaving it at the same time to bear all its original burden, but to remove or diminish the weight which is breaking it down, and to strengthen up the muscles upon whose integrity the stability of the arch depends.*

First of all, the patient must be taught to walk properly, with the feet straight, or only very slightly turned outwards. The reasons for this have already been given.

Secondly, weight must be transferred from the inner arch to the stronger outer arches, and this is done by increasing the thickness of the inner side of the heel and part of the sole of the boot. *Figs.* 67 and 68 explain how this acts.

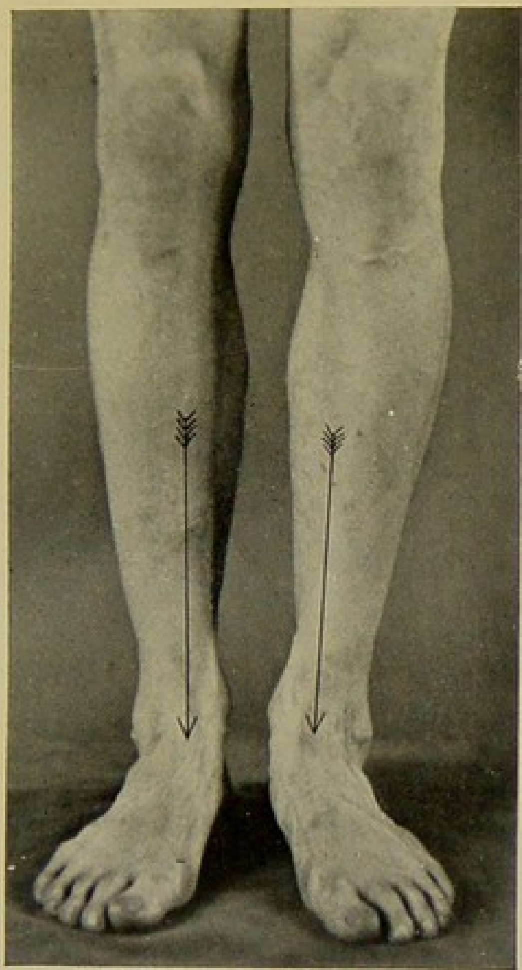


Fig. 67.*—Body weight transmitted through the weak portion of the foot.

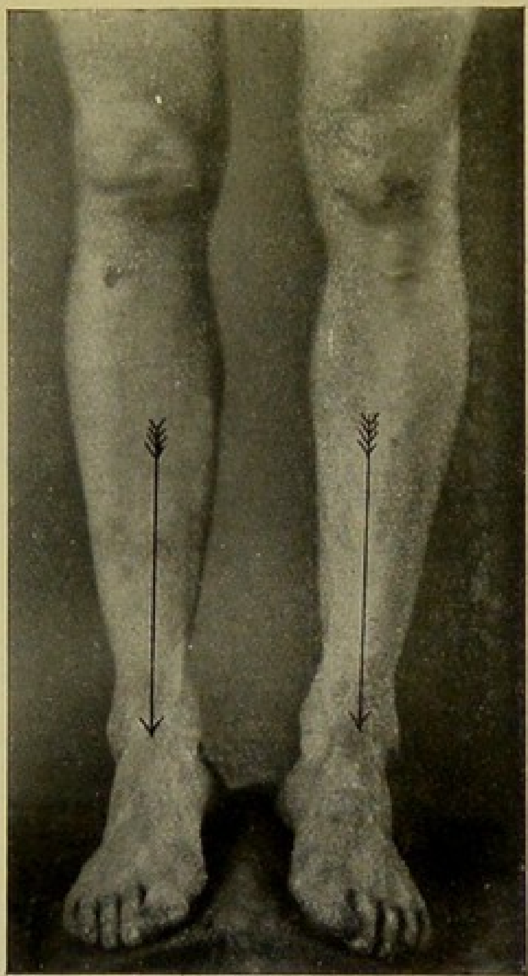


Fig. 68.*—Body weight transferred to the outer and stronger portion of the foot by raising its inner border.

In the natural position, and especially if there be any suspicion of yielding of the ankles or arches, the body weight is transmitted through the inner part of the foot. By raising the inner side of the heel and sole the weight is transferred towards the direction of the outer border.

* From McKenzie. The blocks were supplied to me by courtesy of the W. B. Saunders Co.

To obtain the result with the greatest comfort it is necessary for the alterations in the boots or shoes to be carried out skilfully. They may be best explained with the help of illustrations. *Fig.* 69 shows the heel built up on the inner side. The increased thickness will vary somewhat in proportion to the breadth of the heel, but it is

Fig. 69 —Shows the wedge-shaped or "crook'd" heel.

always a safe plan to order $\frac{1}{3}$ in. increase to begin with, and in the vast majority of cases this will be found quite efficient.

Figs. 70, 71, and 72 give the details in the three types employed, together with their trade descriptions. *Fig.* 69 is the original pattern, made to the design of the late

Mr. Thomas. Here the heel is built up or "crook'd" as described; the waist is filled in on the inner side, and continues the line and level of the heel on that side straight on to the hinder part of the sole. All added leather ceases behind the line of the heads of the metatarsals, so that the

Fig. 70.—Crook'd heel and waist filled in on inner side, or "inside block."
This model may be made lighter by not filling in the waist to such a breadth.

Fig. 71.—Inner elongated crook'd skewed heel with sole-piece.
In this pattern and in *Fig.* 72 the waist must be made of good honest leather, in order not to "sag" under the extra strain caused by raising the inner side.

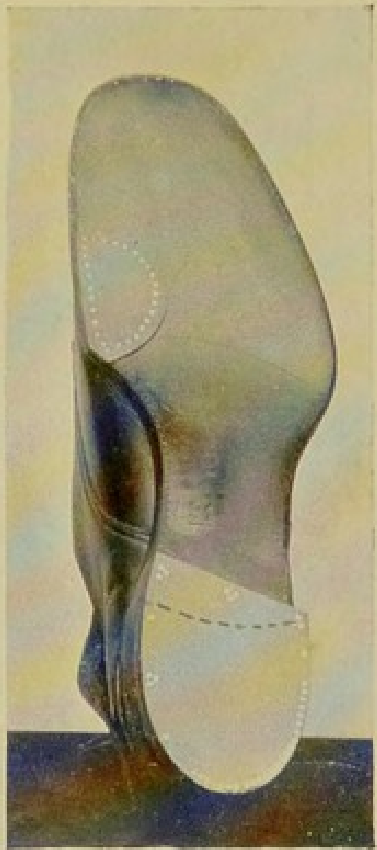


Fig. 72.*—Inner elongated crook'd heel with sole-piece.

tread of the boot is left flexible. The firm support afforded by the continuous run of leather gives a sense of great comfort and security, and patients who have recovered to the point of wearing ordinary foot-gear often voluntarily

* Models by J. Critchley & Sons, Liverpool.

revert to their old filled-in boots or shoes when undertaking long walks.

The objections to this pattern are the slight added weight and the appearance: the filled-in waist makes it look a "surgical boot," to which many people object. This appearance is avoided in the pattern of *Fig.* 72, which is the suggestion of Mr. Robert Jones. Here the heel is elongated, especially on the inner side, and a sole-piece is fixed immediately behind and over the situation of the head of the first metatarsal. The pattern in *Fig.* 71 is used for cases in which there is marked eversion of the foot; not only is the heel elongated, but it is also projected inwards to afford greater support. In the figures the situation of the original heels is indicated by an interrupted line.

CHAPTER IX.

EXERCISES FOR FLAT-FOOT.

THE number of exercises for flat-foot is limited, owing to the fact that only a few movements are called for. The following list is varied enough to avoid monotony.

The surgeon should practise all the movements, and satisfy himself as to which muscles are involved. He should then teach the patient how to bring out the full value of each.

The number of times against each exercise is simply suggested as making up an adequate minimum programme when the whole series is performed. This programme should be repeated twice daily.

If the patient is under treatment for skoliosis at the same time, the first practice takes place immediately upon rising in the morning, and the second occupies part of the afternoon period of exercise.

Each exercise is followed by a short interval of rest.

Notice that all exercises, except No. II., are performed with the feet either parallel or turned slightly inwards.

EXERCISE I.

Patient sitting. Feet rest on heels and are held parallel, or with the toes turned slightly inwards. Flex and extend toes. Dwell on full flexion and extension for three seconds, holding the tibialis anticus strongly contracted. Rest in mid-position for one second with muscles relaxed. (12 times.)

SECONDS TIME.

1, 2, 3 — Full flexion (*Fig.* 73).
4 — Rest. Toes in mid-position with muscles relaxed.
5, 6, 7 — Full extension (*Fig.* 74).
8 — Rest in mid-position.

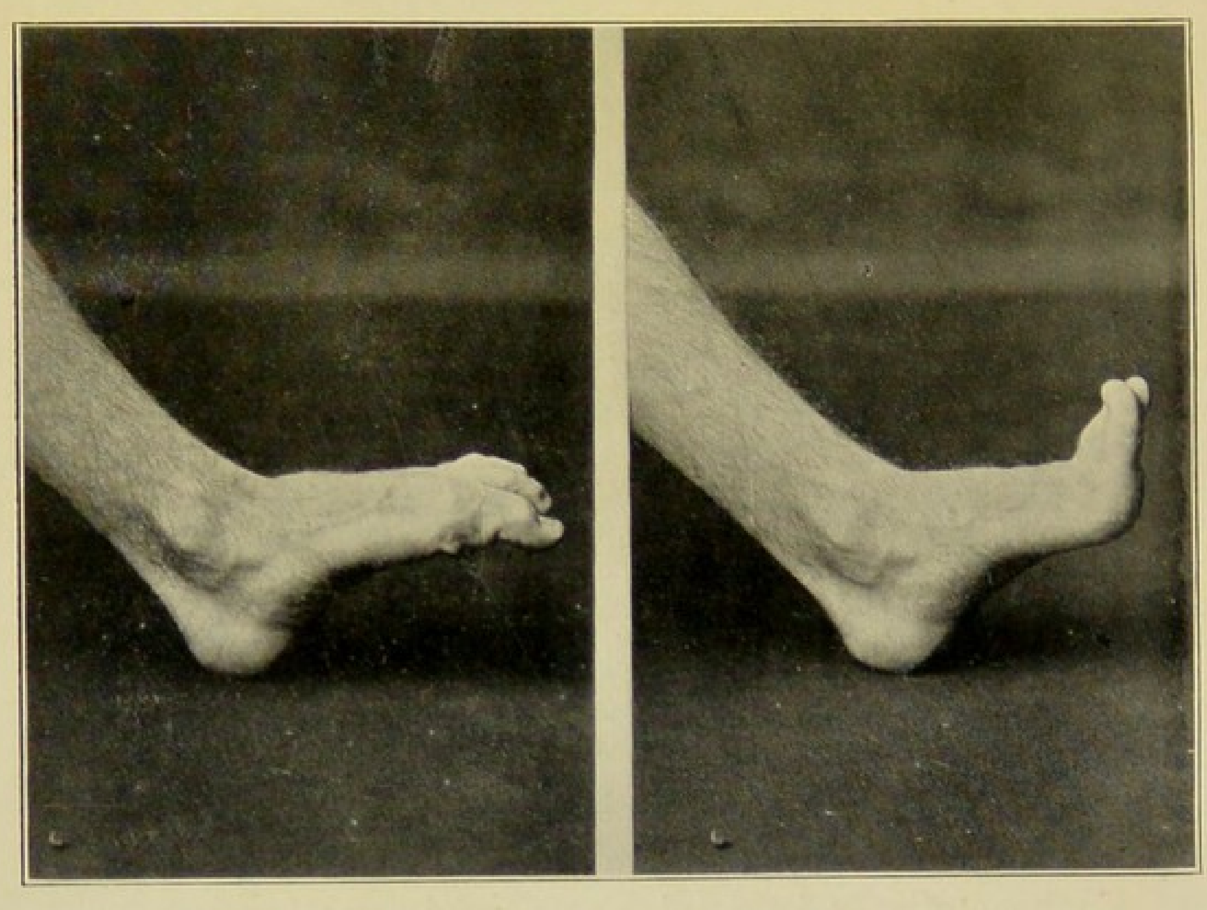


Fig. 73.—Flexion of the toes. *Fig.* 74.—Extension of the toes.

EXERCISE II.

Circumduction of ankle joint divided up into its component movements. Movements resisted by the surgeon.

Patient sits and rests leg on surgeon's knee. For right foot, surgeon sits on patient's right, left hand grasps the leg above the ankle, right hand has palm on sole with the fingers wrapping round inner border of foot and the head of the first metatarsal embraced between thumb and index finger. Surgeon's right elbow rests against his own right knee (*Fig.* 75). In this position all the movements are under control, eversion least so, but it is also the least important.

For left foot the position is reversed. Surgeon sits on patient's left, right hand above ankle, left hand controlling foot.

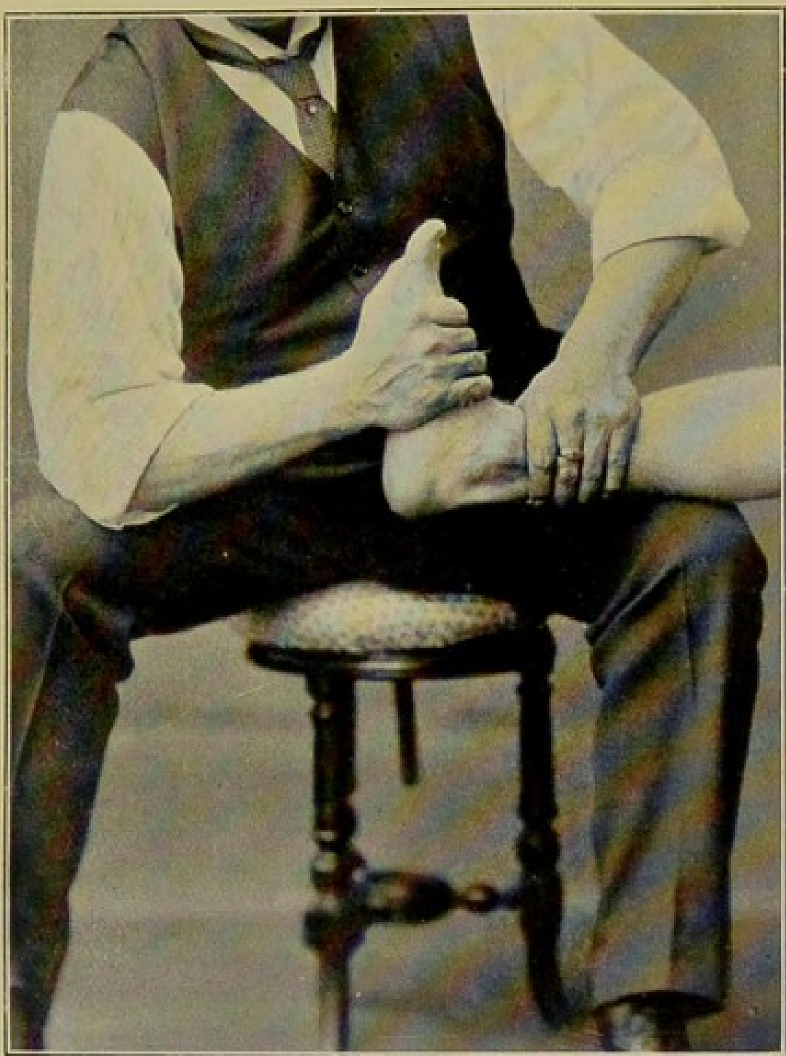
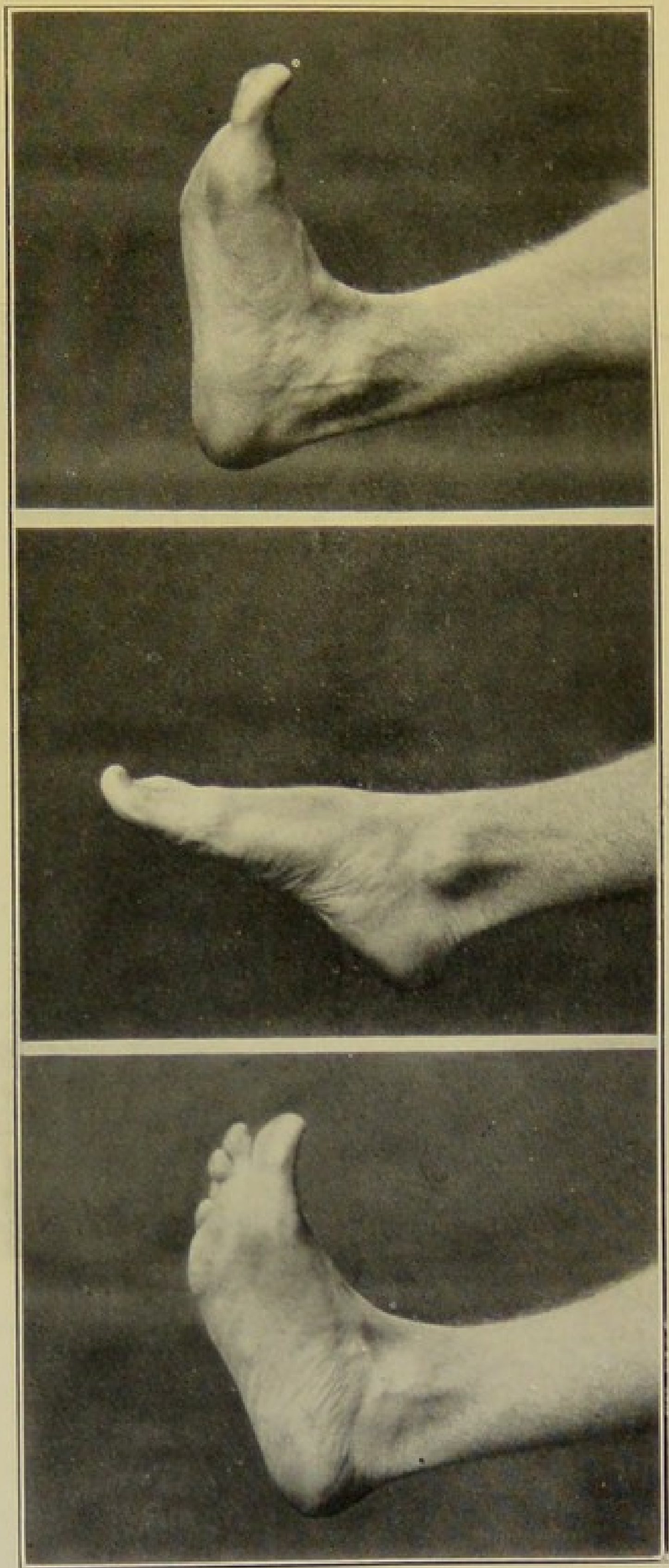


Fig. 75.—Control of the foot in the circumduction exercise.

The movements must be ankle movements only, knee and hip kept still.

Commence with foot in flexion (*Fig.* 76A). Sweep the toes outwards and downwards to full extension (*Fig.* 76B). Complete the circle by bringing the toes upwards and inwards, making the inversion of the foot as marked as possible



A

B

C

Fig. 76.—(*A*) Flexion of the foot: (*B*) Extension of the foot (*C*) Inversion of the foot.

(*Fig.* 76c). Make a slight pause at full flexion and extension.

This exercise can be made very severe if the surgeon offers full resistance.

In the absence of the surgeon or assistant, the patient, having learnt from practice how to contract the muscles fully, rests his leg on a chair and carries out the movements against imaginary resistance. (12 times.)

EXERCISE III.

Feet parallel. Heels kept *slightly* off the ground all the

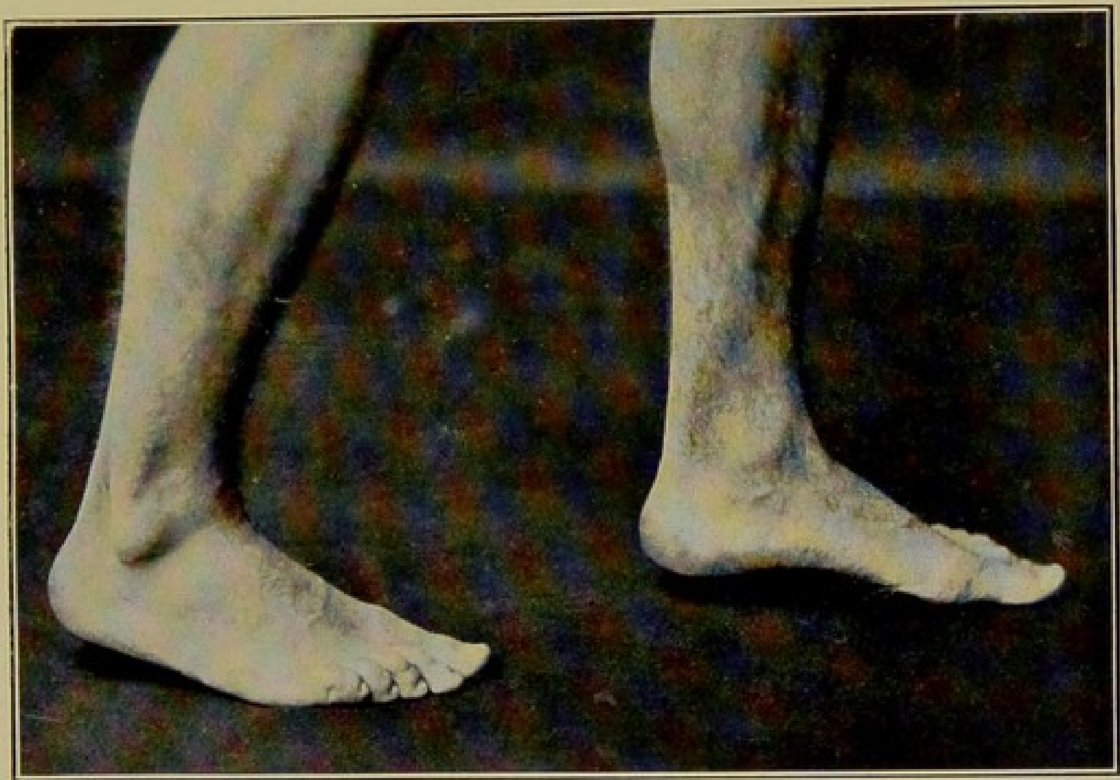


Fig. 77.—Walking exercise on the toes, the heels being slightly raised from the ground.

time. Patient walks slowly round the room. (3 to 5 minutes.)

EXERCISE IV.

Feet turned slightly inwards (*Fig.* 78). Slowly rise on to toes and stand on the heads of the 2nd, 3rd, 4th, and 5th metatarsals (*Fig.* 79). Then return slowly to ground.

This exercise must be done slowly, otherwise the patient develops a rocking movement and jerks on to the toes instead of lifting. Patient is allowed to steady himself by

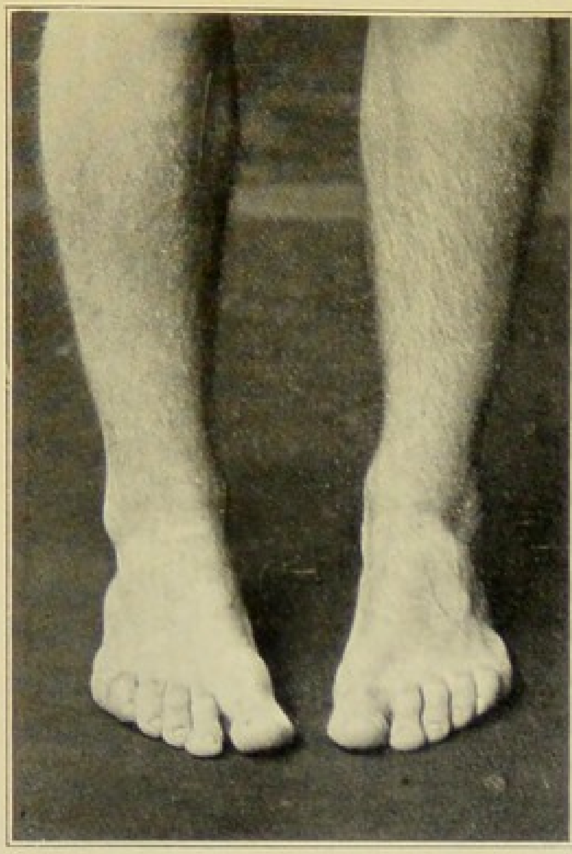


Fig. 78.—The starting position in Exercise IV.

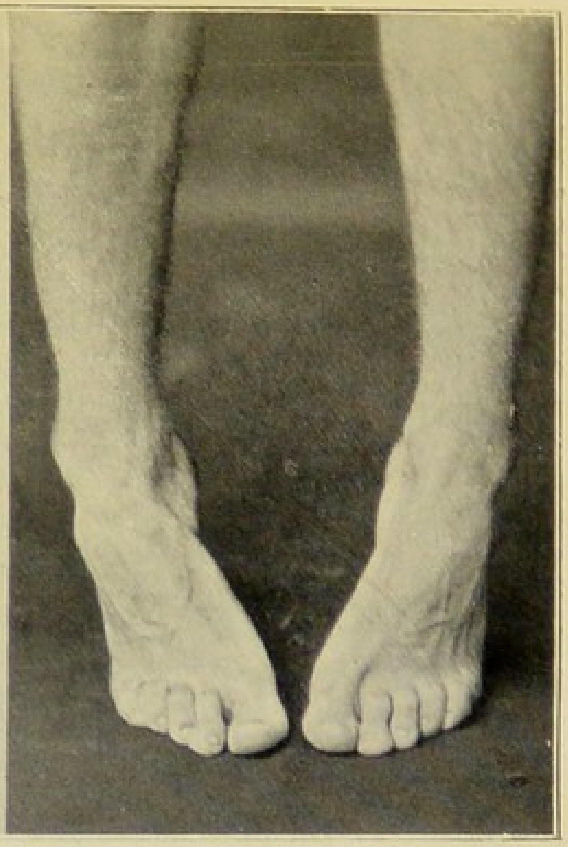


Fig. 79.—Standing on the heads of the outer metatarsals.

holding the back of a chair without bearing weight upon it. (12 times).

SECONDS TIME.

1, 2, 3	Lifting.
4	Standing on toes.
5, 6, 7	Lowering.
8	Resting on ground.

EXERCISE V.

Feet parallel. Lift on to outer borders and walk slowly round the room in this position (*Fig.* 80). (3 to 5 minutes.)

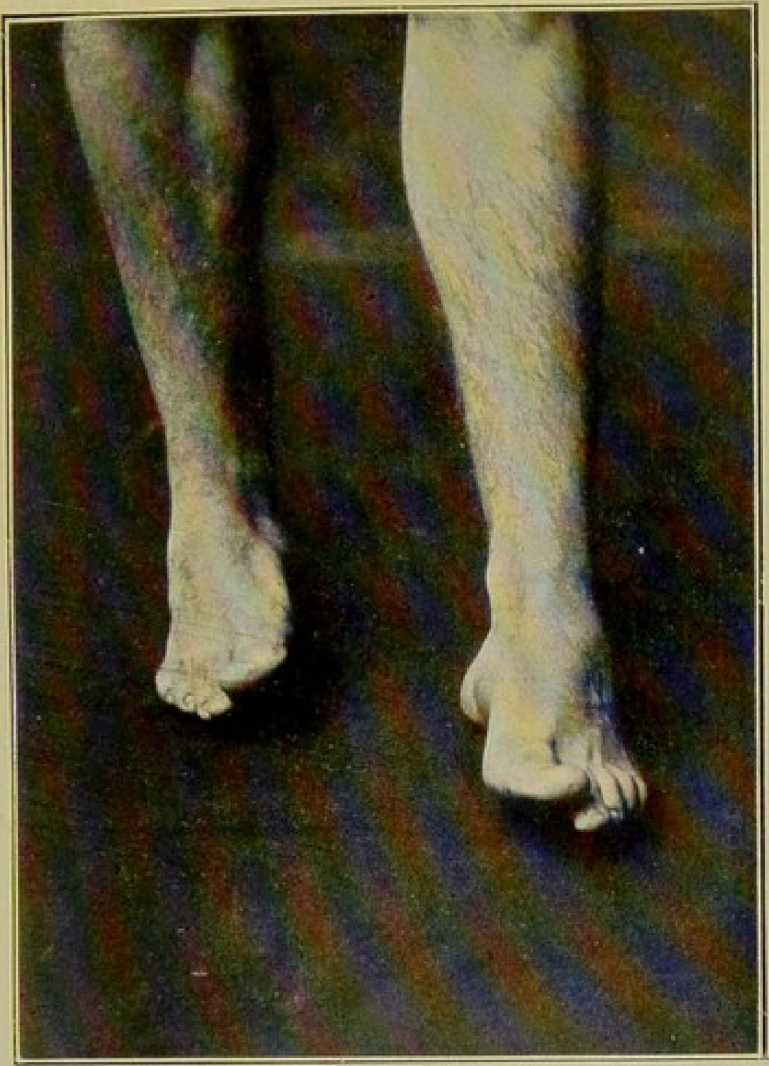


Fig. 80.—Walking on the outer borders of the feet.

EXERCISE VI.

Patient stands upright. Feet with toes turned slightly inwards. Heels one inch off ground. Heels are raised rapidly to two inches off ground, then lowered rapidly to

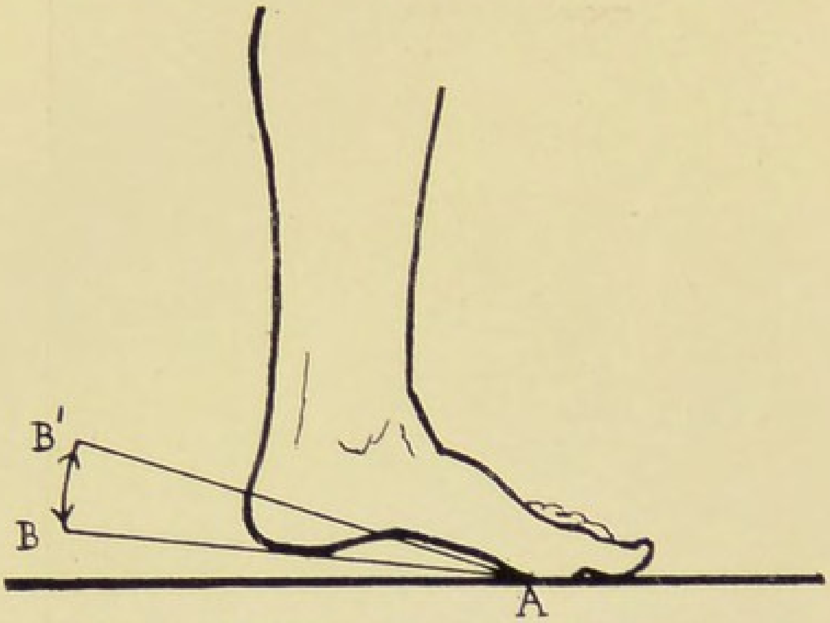


Fig. 81.—Illustrating the quick lifting exercise.

original position. Repeat. The movement must be rapid enough to "jog" the body up and down (*Fig.* 81). (Six periods of 15 seconds each, with 15 seconds' rest between).

The muscles of the leg should be massaged for five minutes after each period of exercise. Patient lies on back with knees drawn up in order to relax the parts.

1. Empty the saphenous veins and their tributaries by stroking half-a-dozen times or so from foot to knee.

2. Grasp the foot in the hands, thumbs on dorsum. Squeeze the muscles in the sole with the fingers, making pressure and relaxing frequently. Then squeeze the muscles in the calf in the same way with both hands round the leg, using the fingers for the posterior group and the thumbs for the anterior group, and travelling slowly from foot to knee. Interrupt the movement every now and then to repeat (1).

CYCLING.

Cycling along fairly level roads is recommended, but the patient *must* learn to use ankle action. This method was more appreciated in the days of the old high bicycle than it is now, when the proper use of the feet is neglected by most riders. An authority upon cycling says :—

"The object of ankling is to overcome the 'dead centre.' Fig. 82 shows the action. In *A* we have the foot at the commencement of the stroke pushing the pedal over the

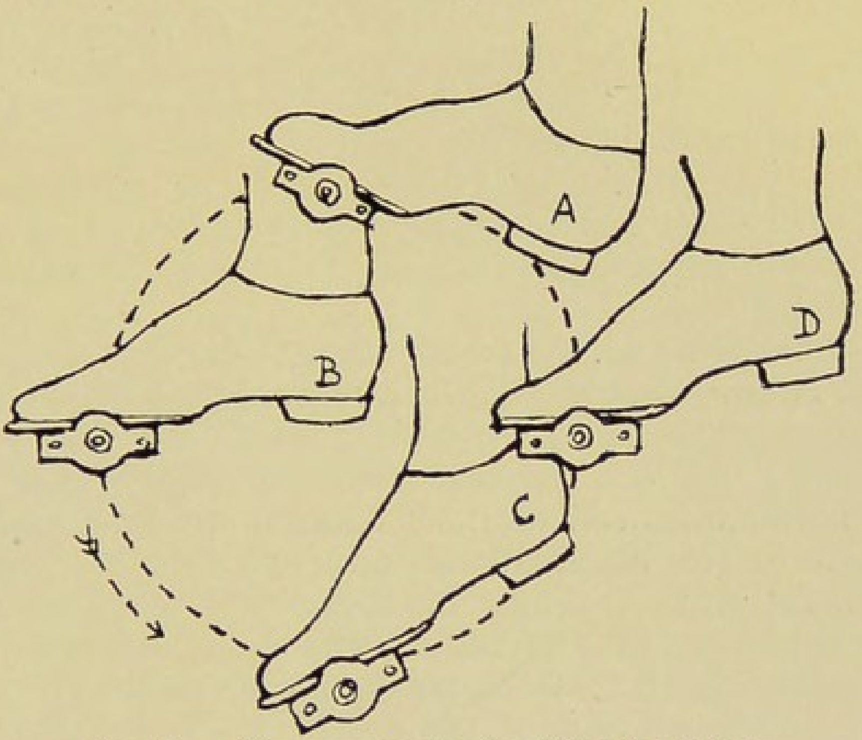


Fig. 82.—The movements of ankling in cycling.

top. This is done by dropping the heel, the most difficult action to acquire, and the most tiring to the novice. The ankle joints are stiff, and require practice before it can be done easily and without discomfort. Having pushed the pedal over the top, the pressure is fully maintained on the downward stroke (*B*) until near the bottom of the revolution of the crank, when the heel is kept up, the toe dropped, and the pedal slightly 'clawed' back when at the foot of the revolution (C). Then the pressure is taken off and the foot brought up again (D), to be ready with heel dropped for the push at the top. Early practice should be made by slow pedalling till the habit is naturally acquired."

CHAPTER X.

ANÆMIA AND IRON—COD-LIVER-OIL—OLIVE OIL —PETROLEUM.

I.—ANÆMIA AND IRON.

OSLER commences his article upon anæmia with a definition. He says: "Anæmia may be defined as a reduction in the amount of the blood as a whole, or of its corpuscles, or of certain of its more important constituents, such as albumin and hæmoglobin."

This definition opens up an enormous field, the greater part of which is unexplored. We really know very little concerning "blood-making and blood-breaking," and very little also of the marvellously complex plasma. The investigation of enzymes and of hormones, even of the longer-known food materials as they exist in the blood-stream, and of the waste products of tissue metabolism, is quite incomplete. Opsonins and lysins are the discovery of yesterday. The intestinal mucous membrane, especially that of the duodenum, presents problems still unsolved. Recognizing as we do, that all these factors, not only in their normal but also in their pathological aspects, are concerned in anæmia, we yet have to be content, until such time as the bio-chemists shall lighten the darkness, to accept the conclusions of empiricism, and to practise on lines which give fairly satisfactory results.

The anæmias which are likely to come under treatment in the subjects of lateral curvature are: (1) *A primary anæmia—chlorosis*; (2) *Secondary anæmias* dependent upon, or associated with, hæmorrhage and various discharges, disorders of the alimentary tract, and absorption of certain poisons.

1. **Chlorosis** is peculiar to girls, and is associated with the period of establishment of full puberty. It is rare before the age of twelve, and first attacks are not common after twenty, although recurrences after that age are frequent. As a rule the early cases, which generally occur in young girls who have "always been pale," are the most difficult to cure and the most

liable to recur. The chlorosis which comes on quickly in a previously healthy, rosy girl gives the best and most stable results.

In boys some hint of a parallel condition may be given, especially when the approach of puberty is marked by frequent nose-bleedings; but the condition never proceeds to the characteristic picture shown in the female.

Chlorosis is probably dependent upon some defect in the ovarian secretions. It responds well to treatment with iron, which has been called a "specific" in this disease. The fact that the condition may recur up to the time of maturity suggests an instability of the normal physiological relation between the ovarian hormone and the blood-controlling organs.

In older girls the thyroid function may become deranged, and all the nervous symptoms of a "minor thyroidism" ensue. Phthisis and gastric ulcer are frequent complications, and obstinate constipation is almost constant.

The blood shows but a small diminution in the red-cell count, with a great deficiency in hæmoglobin—average red cells 80 per cent, hæmoglobin 41 per cent. The constancy of this feature is characteristic of chlorosis, and distinguishes it and the secondary anæmias from pernicious anæmia, in which the corpuscles are very much diminished, but their individual richness in hæmoglobin is unaltered or actually increased.

2. **Secondary Anæmias.**—The patient should be carefully examined, with the following points in mind:—

Small repeated hæmorrhages are capable of setting up profound anæmia. The daily loss of a few drops of blood, as from a bleeding pile, will produce an effect out of all proportion to the chemical value of the loss; the same is true of mucous, purulent, and muco-purulent discharges. Mucus consists of mucin and a globulin, very like serum globulin, suspended in an alkaline exudation from the blood, and mixed with the débris of epithelial cells and a few white blood-cells. The amount poured out during a day from a mucous membrane growing adenoids is surprisingly large.

The urine should be tested for albumin in all cases, and several tests are advisable when there is a history of diphtheria or of any of the acute fevers. It is well to bear in mind the existence of orthostatic albuminuria ("lordotic albuminuria" of Jehle).

The alimentary canal requires careful overhauling. The teeth are often very bad, not only inefficient for mastication through absence or tenderness, but aggressively poisoning the patient through putrescent food particles collected in their cavities. In some cases the reaction of the mouth is found to be acid, and occasionally strongly so.

Adenoids prejudice the patient, not only by giving rise to a drain of mucus, but also by obstructing the air-way. Enlarged tonsils also obstruct the air-way. Tonsils which are not enlarged may contain crypts in which epithelial débris collects and by its putrefaction gives rise to septic tonsillitis and quinsy. Such collections may be often squeezed out in the form of soft cheese-like pellets of atrocious smell. When such crypts exist they must be opened up freely, and touched with pure carbolic or zinc chloride to prevent premature healing.

Stomach digestion is generally feeble. A great deal of the gastric catarrh is caused by eating sweets. Sugar is a distinct caustic to granulating surfaces, and in large quantities also acts as such to the mucous membrane of the stomach. In most anæmias the HCl is deficient or wanting, but in chlorosis it is nearly always increased.

Obstinate constipation is the rule: so much so that some authorities have attributed chlorosis and other anæmias to absorption of decomposition products from the intestine. But, on the other hand, it has been pointed out that constipation in the female is much more frequent than is anæmia, and when it occurs with anæmia is amply accounted for by the enfeeblement of the muscular power of the intestine resulting from that disease. Moreover, obstinate constipation is a frequent trouble of the time of puberty in the male, and yet males do not develop chlorosis. Whatever the truth may be, whether chlorosis is influenced by any such absorption, or whether it is a blood-state comparable to those in which we *know* that ductless glands are deranged, the facts remain that in all anæmias constipation has to be guarded against, and that treatment by iron demands for its success that the bowels shall be looked after.

Absorption of certain mineral poisons produces anæmia, and amongst them is lead. The typical case of lead-poisoning—the pallor, the blue gum-line when the teeth are bad, the stinking breath, the constipation and colic, the mental distress, the general muscular feebleness and tremulousness, the dropped wrist—is known to all, but such a case of lead poisoning is the result of big doses taken as a rule in the course of some employment, and is in a state in which very little more will result in death. There is a form very different from this, due to an infinitesimal dosage, and so insidious that it escaped notice until a few years ago, notwithstanding that it affected vast numbers of people. All water will take up lead if allowed to remain in contact with it for a sufficient length of time. Two types of water take it up rapidly, viz., water gathered from peaty ground, and that possessing a temporary hardness of less than three or four degrees, along with an absence of any appreciable amount of sodium carbonate. Peaty water develops an acid content said to be due to bacterial agency. Some waters from the Bagshot sands, " found in the Isle of Wight, capping many hills near London, and forming the Frimley and Chobham Ridges, the heaths of Bagshot, Hartford Bridge, and Sandhurst,"* are types of the second class. Peaty waters are common in Lancashire and Yorkshire, and it was in the latter district that their action on lead was first shown to be the cause of a general low standard of health. Anæmia and muscular feebleness were two of the common symptoms, and some of the supplies are now hardened up as a safeguard.

It seems rather a far cry from this subject to lateral curvature of the spine, but the connection is obvious when one remembers the influence of lead in producing anæmia, and its selective power for striped muscle tissue. It is a matter to be borne in mind in dealing with patients from districts in which such waters occur.

TREATMENT.

1. **Drugs.**—In obstinate cases of constipation the best thing for a preliminary good " clearing out " is either phenolphthalein or calomel and jalap. The medium dose of phenolphthalein is 3 gr. of the pure drug, but if the commercial article which contains resinous impurities is used, the dose must be increased to 5 or 7 gr. It may be mixed with a little powdered sugar, placed on the tongue, and washed down with water. Calomel and jalap are best given separately, the calomel, in powder or tablet, being laid on the tongue and washed down with pulv. jalapæ co. mixed to a draught with syrup and water.

For continued use, pil. aloes et ferri, gr. iv, once or twice a day as may be found necessary, is convenient, especially if the patient is taking the iron in the form of pills. Saline draughts in the morning are helpful. The artificial Carlsbad salt, still or effervescent, is good, and seems to help the absorption of iron.

℞ Exsiccated Sodium Sulphate, in powder	44·00
Potassium Sulphate, in powder	2·00
Sodium Chloride, in powder	18·00
Sodium Bicarbonate, in powder	36·00

Dose—30 to 60 grains.

An aqueous solution (0·5 per cent) of this preparation resembles Carlsbad water.

* Thresh.

℞	Exsiccated Sodium Sulphate	9·00
	Sodium Potassium Tartrate, in powder	38·00
	Sodium Chloride, in powder	3·00
	Sodium Bicarbonate, in powder	33·00
	Gluside	0·05
	Tartaric Acid, in powder to produce	100·00

Dose—60 to 120 grains.

There are hundreds of preparations of iron on the market. Blaud's pill, in its official or in one of the improved forms, and the mistura ferri co. for those who cannot swallow pills, are perhaps the favourite. Ferri et ammon. cit. is a useful preparation possessing little astringency.

In the stomach all salts of iron become converted into the chloride, and this has an important bearing in those cases in which the gastric juice is already deficient in HCl. Cases of chlorosis with hyperacidity will often bear iron better than anæmias in which the opposite is the case, and in which there is generally present some amount of gastritis. If this can be kept in check, the tinct. ferri perchloridi may be tried, and is often tolerated when the milder preparations disagree. The old mixture of tinct. ferri perchloridi and tinct. hyoscyami, with a little spirits of chloroform, is good, but is disagreeable to many people, and has the disadvantage of bringing an acid mixture in contact with the teeth. An excellent way of giving the perchloride is to make it into a jelly, in which form it can be swallowed without inconvenience.*

Melt 2 drachms of gelatin in 5 ounces of boiling water, add a teaspoonful or more of sugar and 30 drops of the tinct. ferri perchlor. Put it in a cold place to "set."

Dose—a dessertspoonful ($\frac{1}{8}$ part) three times a day after food.

Hæmoglobin as a drug is not an efficient substitute for the inorganic salts of iron.

Hypodermic medication is not a desirable method in the case of anæmic girls.

The great aim is to bring the iron through the stomach without deranging the digestion, either by robbery of more HCl than can be spared, or by astringent action upon the mucous membrane,

* I am a believer in the use of gelatin in cases of anæmia. It appears to help the assimilation of iron, though how is not known. Something has been attributed to the calcium salts it contains, but it is also possible that we have here another example of therapy by organic tissues. As a food its intrinsic value is not very great—it lacks both the tyrosine and the tryptophane radicals—but it acts as a "proteid saver," and in conjunction with only a small amount of proteid is capable of maintaining nitrogenous equilibrium. It may be given *ad lib.* in the form of table jellies, or stirred into hot milk, soups, etc.

and to present it in the duodenum ready for further reaction and absorption. How iron cures anæmia is still a puzzle. We know that it is taken up in the duodenum, passed on to the liver, and there worked up into some organic antecedent of hæmoglobin, but the whole process is apparently a slow and difficult one, as is shown by the fact that in cases of accidental hæmorrhage in healthy subjects the hæmoglobin is restored much more gradually than the corpuscles. Bunge's theory has much against its acceptance, and we must rest content with the practical facts that iron does cure, and that in some cases of chlorosis it has to be given in large doses to do so. The blood is the busiest tissue in the body, and, judging from the amount of pigment excreted in the bile, the death-rate of the red cells must be enormous; their birth-rate must keep pace, and young growing cells demand, not a bare sufficiency, but an excess of everything upon which they feed.

It is good practice to begin treatment with a small dose of iron and gradually work up to the maximum (45 gr., or more, of Blaud's pill daily), keeping careful watch over the patient's digestion. A course of iron should last at least three months.

Another important method of treatment is the removal of the patient to one of the watering-places possessing chalybeate springs. Those of the higher altitude are the most suitable, since it has been shown that a change from low to high ground acts as a powerful stimulant to the blood-forming process. A medical man familiar with the local practice should always be consulted: it may be advisable to prescribe some of the saline or sulphur waters in conjunction with the chalybeate, or to assist the latter with medicinal doses of other iron salts. Disastrous results may occur when patients prescribe for themselves.

Suitable spas are Tunbridge Wells, Harrogate, Buxton, Llandrindod Wells, and Trefriw.

2. **Diet, Etc.**—It will be found that most anæmics have been living on a diet rich in carbohydrates and poor in proteid and fat. They require generous feeding, with a relatively large amount of albumin, and the kinds of food need be dictated only by their digestive capacity and the ordinary rules applying thereto. Indigestible foods—pork, veal, re-cooked meats, curries, etc.—should not be given, although the indigestibility of some of them results solely from insufficient mastication. Cold meats very often agree better than hot, especially in the case of beef.

It is important to see that these patients take enough salt, and a sufficiency of fluid at proper times. All acids and cider should be forbidden.

Finally, the value of rest in these cases cannot be over-estimated. A week in bed with open windows will often give a good start towards recovery. The popular idea is to " get out for a good, long walk in the open air," which has the effect of distressing the patient and increasing the wear and tear of the blood. Exercise should be regulated strictly to the patient's capacity, and should never be pushed to the point of breathlessness or fatigue. Restlessness and muscle-soreness after exercise are indications that too much has been done.

II.—COD-LIVER OIL.

In cases of general malnutrition the administration of small doses of oil after each meal often produces marked results. Cod-liver oil has a great reputation in this respect, and its special value was attributed at one time to the free fatty acids, amounting to as much as 5 per cent., therein contained, combining with the alkali in the upper part of the small intestine to facilitate saponification and emulsion and consequent absorption of the mass of the oil. This assumption is now abandoned, and the nutritive value of the oil is explained by the fact that the final stages in the metabolism of fats occur in the liver, and consist in a desaturation of the fatty acids, so that liver fat differs from the fats of the body in containing these unsaturated fats, belonging to the oleic, linoleic, and lower series. These fats are much more susceptible to oxidation, and apparently, therefore, are turned into the blood to be burnt up in other parts of the body. Cod-liver oil—as might be expected from its source—contains a number of these unsaturated fatty acids, and is therefore a half-assimilated form of fat.

But cod-liver oil and some other oils very frequently produce effects which are out of all proportion to their value as food-stuffs alone. Light upon their action is to be found in recent researches upon the physiology of digestion.

Bayliss and Starling have shown that the cells of the mucous membrane of the upper part of the small gut contain a body—*pro-secretin*—which, when acted upon by dilute acids, forms a definite chemical substance which they have called *secretin*, and that this secretin, when absorbed into the blood, acts as a chemical messenger or *hormone*, rousing the secretions of the pancreas, the liver, and the intestinal glands themselves. Further, it has been shown that secretin may be produced, and the secretions stimulated in consequence, by a flow of oil over the mucous membrane, and the observations of Fleig suggest that " the action of oil may be due to the formation of a certain amount of soap as the oil comes in contact with the mucous membrane, and that this soap is responsible for the formation of secretin."

In the circumstances of normal digestion the acid chyme is responsible for the production of secretin, and for this reason the HCl of the gastric juice assumes an enhanced importance. Not only does it bear its part in stomach digestion, but—more necessary still—it is also the prime factor in calling forth the juices of intestinal digestion.

Now in the atonic dyspepsia of weakly children and of sufferers from some forms of anæmia—and in fact, according to Ewald, in all cases of chronic gastritis—the HCl is either deficient or wholly wanting, and this in itself is quite enough to explain the malnutrition in such cases. It also accounts for the benefit derived from the administration of HCl after food—a fact first strongly remarked by Trousseau.

The good effects of oil may be explained in the same way. Oil, besides its value as a food, *is only second to acid itself in calling forth a flow of pancreatic juice, and is thus a powerful stimulant of intestinal digestion and absorption.* Moreover, if Fleig's theory be true, the free acids in cod-liver oil being available for the quick production of soap would account for its pre-eminence over other oils.

Every medical man has his own pet way of giving cod-liver oil, but there are certain points in its administration which are fairly general. Always begin with a small dose—ten drops or so is not too small—and work up to the maximum as the patient becomes tolerant. For adults a dessertspoonful twice or three times a day, and for children less according to age, is ample. These small doses given within half an hour after food are of infinitely more value than the single large dose in the forenoon or at night which used to be the fashion, and the reason of this is plain from the consideration of its action already described. Children especially soon overcome any objection, and even acquire a liking for it. Adults who find a difficulty with fats in general often digest it with comfort. It agrees best in cold weather, and may he stopped in summer. Any diarrhœa is an indication to diminish the quantity or to leave it off entirely for an interval.

One of the best ways of giving cod-liver oil is to warm a spoon, pour the dose of oil into it, and then sprinkle it freely with salt and pepper. Another plan is to allow the patient to suck a liquorice lozenge before taking the dose, liquorice having such a strong and decided taste that it kills most other flavours.

It is said that the red corpuscles are always increased during the administration of cod-liver oil, probably as a result of the general improvement in nutrition, although much has been attributed to its most prominent inorganic constituents, which are iodine, bromine, and sulphuric and phosphoric acids.

If it is desired to give iron in combination with the oil, the following are useful :—

℞	Cod-liver Oil	4 fl. dr.
	Ferri et Ammon. Cit.	5 gr.
	Pot. Carb.	3 gr.
	Glusidum	$\frac{1}{4}$ gr.
	Oil of Caraway	$\frac{1}{4}$ min.
	Water	to 1 oz.

(*Hale White.*)

Or the ferri et ammon. cit. in the required dosage may be dissolved in a little water, and the solution shaken up with an emulsion of cod-liver oil.

Some patients cannot tolerate raw oil of any kind, but can manage it in emulsion, especially if the latter be pancreatized or mixed with malt extract. The following prescriptions are given in the British Pharmaceutical Codex, to the Editors of which I am indebted for permission to quote, and for advance copies of their revised formulæ :—

EMULSIO OLEI MORRHUÆ—EMULSION OF COD-LIVER OIL.

℞	Cod-liver Oil	50·00
	Gum Acacia, in fine powder	12·50
	Syrup	6·25
	Oil of Bitter Almond	0·10
	Distilled Water, sufficient to produce	100·00

Triturate the cod-liver oil with the gum, add 25 of water, stir briskly till emulsified ; then add the oil of bitter almond, syrup, and sufficient water to produce 100 by volume.

Dose—8 to 30 mils ($\frac{1}{4}$ to 1 fluid oz.).

EMULSIO OLEI MORRHUÆ COMPOSITA, B.P.C.—COMPOUND EMULSION OF COD-LIVER OIL.

℞	Cod-liver Oil	50·00	— 10 fl. oz.
	Yolk of Egg, by volume	6·57	— 1 fl. oz., 150 min.
	Tragacanth, in powder	0·23	— 20 gr.
	Elixir of Gluside	0·75	— 72 min.
	Simple Tincture of Benzoin	0·75	— 72 min.
	Spirit of Chloroform	3·125	— 300 min.
	Oil of Bitter Almond	0·105	— 10 min.
	Distilled Water	to 100·00	—to 20 fl. oz.

Mix the tragacanth with a little of the cod-liver oil in a dry mortar, add the previously beaten yolk of egg, stir briskly, and add just sufficient distilled water to thin the mixture to a suitable consistence; then add the remainder of the cod-liver oil and 30 (or 6 fluid oz.) of distilled water alternately, with constant stirring, but avoiding frothing, and transfer the whole to a bottle capable of holding one-fourth more than the required volume of product. Finally, add the previously mixed elixir, tincture, spirit, and oil of bitter almond, shake well, and add sufficient distilled water to produce the required volume.

Dose—8 to 30 mils (or 2 to 8 fluid drachms).

CREMOR OLEI MORRHUÆ PANCREATICUS, B.P.C.—PANCREATIC COD-LIVER OIL CREAM.

Synonyms.—Cremor Olei Morrhuæ Peptonatus; Peptonized Cod-liver Oil Cream.

℞	Glycerin of Pancreatin	4·00	—	384 min.
	Stronger Glycerin of Pepsin	4·00	—	384 min.
	Cod-liver Oil	50·00	—	10 fl. oz.
	Decoction of Irish Moss	27·50	—	5½ fl. oz.
	Syrup of Tolu	3·00	—	288 min.
	Alcohol	3·00	—	288 min.
	Oil of Bitter Almond	0·10	—	10 min.
	Distilled Water	to 100·00	—to	20 fl. oz.

Mix the cod-liver oil intimately with the decoction of Irish moss, and add separately the glycerin of pancreatin, stronger glycerin of pepsin, and syrup of tolu, stirring well after each addition; dissolve the oil of bitter almond in the alcohol, and add the solution to the mixture, then make up to the required volume with distilled water.

Dose—8 to 30 mils (or 2 to 8 fl. dr.).

EMULSIO OLEI MORRHUÆ PANCREATICA, B.P.C.—PANCREATIC EMULSION OF COD-LIVER OIL.

Synonyms.—Cod-liver Oil with Pancreatin; Peptonized Emulsion of Cod-liver Oil.

℞	Cod-liver Oil	50·00	—	10 fl. oz.
	Glycerin of Pancreatin	3·33	—	320 min.
	Stronger Glycerin of Pepsin	3·33	—	320 min.
	Gluside	0·03	—	3 gr.
	Solution of Potassium Hydroxide	1·25	—	120 min.
	Tragacanth, in powder	2·50	—	½ oz.
	Acacia, in powder	10·00	—	2 oz.
	Oil of Cassia	0·105	—	10 min.
	Oil of Bitter Almond	0·105	—	10 min.
	Distilled Water	to 100·00	— to	20 fl. oz.

Mix the gums and oils in a dry mortar, and add gradually a mixture prepared by dissolving the gluside in the solution of potassium hydroxide; then make up to 40 (or 8 fluid ounces) with distilled water, and mix the solution with the glycerins of pancreatin and pepsin; stir continuously until emulsification is complete, and gradually incorporate sufficient distilled water to produce the required volume.

Dose—8 to 30 mils (or 2 to 8 fluid dr.).

EMULSIO OLEI MORRHUÆ PANCREATICA COMPOSITA, B.P.C.—COMPOUND PANCREATIC EMULSION OF COD-LIVER OIL.

Synonyms.—Emulsio Olei Morrhuæ Pancreatica cum Extracto Malti; Pancreatic Emulsion of Cod-liver Oil with Malt Extract; Cod-liver Oil with Pancreatin and Malt.

℞ Cod-liver Oil	50·00	—	10 fl. oz.
Glycerin of Pancreatin	10·00	—	2 fl. oz.
Acacia, in powder	2·74	—	240 gr.
Tragacanth, in powder	0·343	—	30 gr.
Saccharated Solution of Lime	2·50	—	240 min.
Extract of Malt	to 100·00	—to	20 fl. oz.

Mix the saccharated solution of lime with the cod-liver oil; then mix the gums with the glycerin of pancreatin and 10 by weight (or 2 ounces) of the extract of malt in a warm mortar, gradually incorporate an equal quantity of the cod-liver oil mixture, and add the remainder of the extract of malt and of the cod-liver oil mixture in small portions, alternately, until the required volume is produced.

Dose—8 to 30 mils (or 2 to 8 fluid dr.).

Those who believe in them may add the glycerophosphates or the hypophosphites in appropriate doses to the emulsio olei morrhuæ co.

It will be seen that each of the above contains 50 per cent of cod-liver oil. This is an important point; some of the various emulsions on the market contain very little oil indeed, and that not always too closely related to the *Gadus morrhua*.

In view of the distinct individuality of cod-liver oil, it is well to know something about it as a commercial product. It is manufactured in Norway, Newfoundland, the east coasts of England and Scotland, to a small extent in Iceland, and in small quantities in various fishing centres where the cod is caught; but Norway is the place of the largest production and the finest quality. It is shipped to this country chiefly in tin-lined casks which hold about twenty-five imperial gallons each. The output of the Norwegian fisheries varies in different years, sometimes amounting to 35,000 to 40,000 casks, and at other times dropping to half this quantity, or less. With a harvest varying as widely as this, there is no doubt that much adulteration takes place. An oil prepared according to B.P. directions is a "non-freezing" oil, which does not readily become turbid when exposed to low temperatures. Adulteration with other fish oils or with vegetable oils is shown by the separation of solid fat on cooling to freezing-point for two hours, and a further test for other fish oils is given by their behaviour with fuming nitric acid. If about 10 drops of oil be placed in a watch-glass and a drop of fuming nitric acid be allowed to flow to them, then with cod-liver oil a red colour will be produced, which, on the mixture being stirred with a glass rod, will become bright rose-red, soon changing to lemon-yellow. Seal oil shows no change at first; other fish oils first turn blue and afterwards brown and yellow. If any doubt exists about the source of supply, it is often possible to obtain the genuine article from the wholesale fishmongers whose trawlers bring in cod to the various fishing-ports. It is apt to be rather strong in flavour, but is more medicinally active than the over-refined, tasteless, and more elegant preparations. It should have no suspicion of rancid odour, and should be only slightly acid to litmus paper previously moistened with alcohol.

III.—COD-LIVER OIL SUBSTITUTES.

Olive Oil is nutritious, and like cod-liver oil acts as a stimulant of intestinal digestion. It is frequently adulterated with various seed oils—chiefly that of cotton seed. Their absence in any appreciable quantity in a given specimen may be shown by the following test (B.P.C.):—When shaken vigorously with an equal volume of nitric acid (sp. gr. 1·370) olive oil should retain a light yellow colour, not becoming orange or reddish-brown, and after standing for six hours should separate into a yellowish-white solid mass and an almost colourless liquid. Good oil tends to congeal at 10° C., the palmitin separating out.

Large doses can be tolerated—as much as 8 oz. daily have been given for gall-stones—but a tablespoonful or less after food is quite sufficient when it is used, like cod-liver oil, to improve nutrition. If the slightly acrid after-taste is objected to, the oil may be made into an emulsion with acacia gum equal to one-third its weight.

Petroleum Emulsion.—Paraffin is not a food, and cannot in this respect be regarded as a substitute for cod-liver oil. Also it is incapable of saponification, and therefore, on Fleig's theory, ought not to be able to stimulate the production of secretin. Yet there is no doubt about its efficacy; it certainly favours nutrition, and since it has no intrinsic food value—it is questionable if it is absorbed at all—the only conclusion to be drawn is that some inherent quality ranks it with the other oils as a promoter of intestinal digestion and absorption.

It is very difficult to get a liquid paraffin free from the impurity of sulphur compounds, and since these decompose rapidly in emulsion, local productions are often unsatisfactory. Hypophosphites, which are frequently added, often contain sulphites as impurity, and these, too, may affect its keeping properties.

50 per cent Emulsion.

Rub powdered gum acacia (good) 4 oz. with liquid paraffin 8 oz., soft white paraffin 2 oz., cinnamon oil 24 min. Then add in two portions a solution of sodium and calcium hypophosphites, of each 192 grs., saccharin elixir 90 min., in water 10 oz.—(*Martindale and Westcott.*)

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