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LATERAL CURVATURE OF THE SPINE

AND

ROUND SHOULDERS

LOVETT

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ROUND SHOULDERS

BY

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TO

ROBERT JONES

LIVERPOOL

A GREAT SURGEON AND AN OLD FRIEND

PREFACE TO SECOND EDITION.

In preparing a second edition of this book I have found it necessary to rewrite several parts of it in order to keep pace with the progress made in certain aspects of the subject in the last few years. The advance made in our knowledge of the etiology has been notable and the views on treatment have changed markedly since 1907 when the use of forcible correction was comparatively new. The German studies on the relation of scoliosis to school life have thrown a new light on the matter and a chapter has been added on that subject.

I am again indebted to my colleagues for permission to use their material and I have not knowingly used the material of other men without proper acknowledgment.

If I have made this edition of the book a little less the reflection of the writings of others and a little more the expression of my own views, it is because I have felt that the added experience of these last years had perhaps given me the right to approach the subject from a more personal point of view.

ROBERT W. LOVETT.

PREFACE TO FIRST EDITION.

The successful treatment of lateral curvature of the spine cannot in the past be counted as one of the achievements of orthopedic surgery. The affection is not only intrinsically resistant to treatment, but the therapeutic measures employed have been on the whole largely empirical and have not been sufficiently correlated to its pathology and to the mechanism by which it is caused. In the last ten years, however, a good deal of progress has been made along new and promising lines, by means of experimental and clinical work, the records of which lie scattered through later medical literature. In the following pages I have attempted to bring together this literature and to add my own personal views and experience, in the hope of presenting the subject in English in a modern light and to call attention to the prospect offered of obtaining better results. That such a book is needed I have been led to infer from many inquiries in connection with this subject by physicians, medical students, and teachers of physical training. If I have devoted too large a part of the book to the question of treatment it is because of the scant attention paid to that part of the subject in most books dealing with deformities.

The anatomical part of the work is from the Anatomical Department of Harvard University, and much of the clinical work is from the Scoliosis Clinic of the Children's Hospital, Boston.

It is impossible to acknowledge my indebtedness individually to those of my colleagues and others who have helped me by contributing material and other assistance. I should, however, express my obligation to Professor Thomas Dwight for his advice given in connection with the anatomical part of my work, for the liberal supply of anatomical material with which he has provided me, and for criticising my chapter on Anatomy. To Miss Amy Morris Homans, Director of the Boston Normal School of Gymnastics, I wish to express my indebtedness for assistance given in many ways; and to my assistants, Fraülein Helene Seltmann and Miss W. G. Wright, for great help in preparing the list of exercises.

I have used freely the chapters on Pathology and Occurrence in the admirable article on Scoliosis by Schulthess of Zürich, recently published in Joachimsthal's "Handbuch der Orthopädischen Chirurgie."

BOSTON. ROBERT W. LOVETT.

LATERAL CURVATURE OF THE SPINE AND ROUND SHOULDERS.

CHAPTER I.

ANATOMY OF THE VERTEBRAL COLUMN AND THE THORAX.

The spine is a flexible weight-bearing column made up of a series of vertebræ separated from each other by twenty-three intervertebral discs and connected with each other by ligaments and muscles. In early life the vertebræ are thirty-three in number. The upper twenty-four, remaining separate throughout life, are distinguished as true, movable, or presacral vertebræ. In the adult the lower nine are fused into two masses to form the sacrum and the coccyx, and are called the false, fixed, or immovable vertebræ. The spine forms the central axis of the skeleton, situated in the median plane of the body and posterior part of the trunk. By the term "the spine" is generally understood the part of the column above the sacrum.

In shape the spinal column is roughly pyramidal, the column of vertebral bodies tapering from below upward, and after early infancy it shows four curves, two anterior and two posterior, in the sagittal or median anteroposterior plane. These are called the physiological curves, which will be discussed later in the chapter.

The spine encloses and protects the spinal cord, and provides, with the sacrum, thirty-one pairs of intervertebral foramina through which the spinal nerves emerge. It serves by its intervertebral discs to diminish the jar of walking.

The total length of the spine is given as follows by different authors: Cunningham, 70 to 73 cm.; Morris, 70 cm.; and Krause, 72 to 75 cm. (along the curves), which is 45 per cent. of the body-length. The relative length of the separate regions is shown in the following table:

	Cunningham.[1]	Morris.[2]	Beaunois.	Dwight.[3] Males.	Dwight.[3] Females.
Cervical region	13–14 cm.	12.5 cm.	10.8 cm.	13.3 cm.	12.1 cm.
Dorsal region	27–29 cm.	27.5 cm.	27 cm.	28.7 cm.	26.5 cm.
Lumbar region	12–15 cm.	17.5 cm.	16.8 cm.	19.9 cm.	18.7 cm.

[1] Cunningham: "Text-book of Anatomy," Macmillan, 1902.
[2] Morris: "Human Anatomy," Blakiston, 1903.
[3] Dwight: "Medical Record," Sept. 8, 1894.

It is frequently stated that the length of the spine in different individuals is pretty constant, but Dwight's figures show rather a wide variation. In fifty-six male spines the longest was 69.8 cm. and the shortest 56.4 cm.

In a straight line, the column measures in men from 66 to 70 cm.,

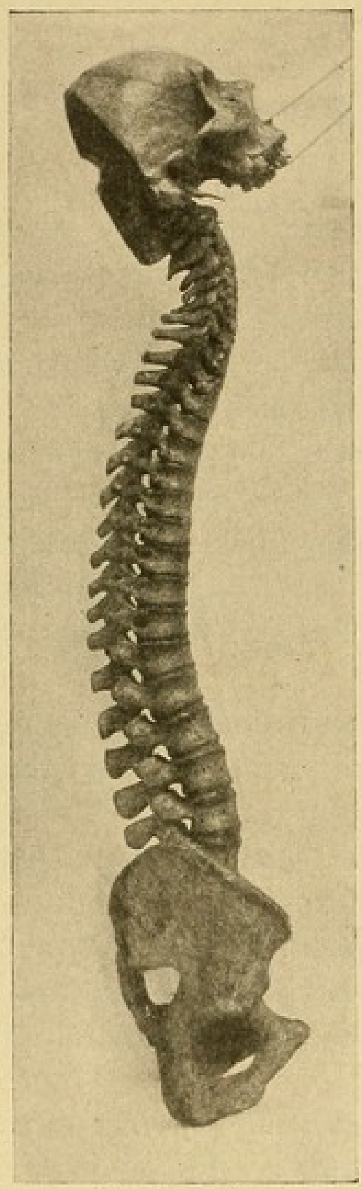


FIG. 1.—THE SPINE SEEN FROM THE SIDE, SHOWING THE PHYSIOLOGCIAL CURVES.—(*Warren Museum.*)

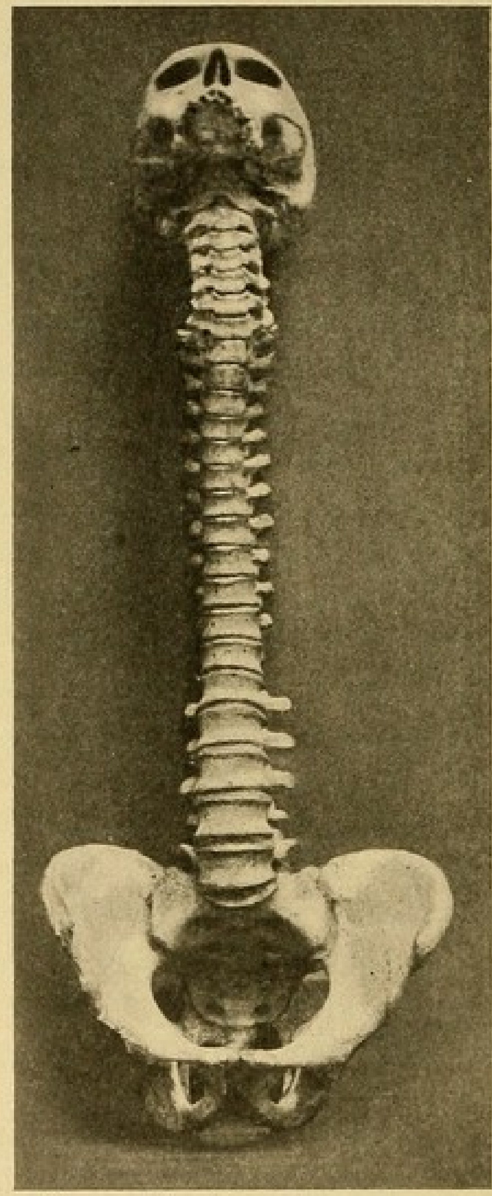


FIG. 2.—THE SPINE SEEN FROM THE FRONT.—(*Warren Museum.*)

and in women from 66 to 69 cm., with an average of 67 cm. (Krause). This height is approximately 40 per cent. of the total height of the individual. In the fetus and young child the column forms a greater proportion of the body-length. At puberty the more rapid growth of the rest of the body overtakes that of the spine, which completes its growth between the ages of twenty-three and thirty-one years.

The percentage of total length of the individual occupied by the spine without the sacrum is given for different ages by Moser as follows:

Age.	Body-length.	Vertebral Column Length.	Per Cent. of Vertebral Column to Body-length.
0	50	19.2	38.4
3	86	31.7	36.8
5	112	35	30
11	138	41	29.7
14	152	44	28.9
15 1/2	162	45	28.1
Adult	167	57	34.1

The spine is divided into three regions corresponding to the parts of the trunk with which it is connected: (1) The cervical region; (2) the thoracic or dorsal region; (3) the lumbar region.

The cervical region comprises the upper seven vertebræ, including the atlas and axis; the thoracic, twelve vertebræ; and the lumbar, five vertebræ. The lower part of the spine may be spoken of as the posterior end, while the upper part may be called the anterior end of the column. The middle of the spine is placed at the eleventh dorsal vertebra.

INTERVERTEBRAL DISCS.

The bodies of the vertebræ, from the second cervical to the sacrum, are firmly held together by the intervertebral discs lying between them, twenty-three in number. The discs correspond in size and shape to the horizontal surfaces of the bodies of the vertebræ between which they are found, but they project slightly beyond the edges of the vertebræ. The sum of the heights of all the discs is greatest through the middle portion, next largest through the anterior borders, and least through the posterior borders. Singly the discs vary in height in the different regions of the spine. They are higher anteriorly in the cervical and lumbar regions and posteriorly in the dorsal region. The ratio of the height of the discs to the height of the bodies varies according to different authors. Weber gives the ratio of the average height of all the discs to the average height of all the vertebræ, not including the sacrum, as 1 : 5. According to the same author the ratio of the height of all the discs through the centers to the height of the vertebral column, represented by a perpendicular from the highest point of the atlas to the sacrum, is as 1 : 4.

The influence of the discs in the formation of the physiological curves of the spine is shown by the two curves in Fig. 5. Curve (*a*) is formed by the bodies and the discs together, and curve (*b*) is the result obtained by placing the bodies one upon the other, forming a long curve with convexity backward, greatest in the lower dorsal region. The convexity of the thoracic spine is flattened in the upper part, and the lumbar and cervical physiological curves almost completely disappear when the discs are removed.

The discs become smaller and harder with age, shrinking to a greater extent where they are thickest than in the region where they

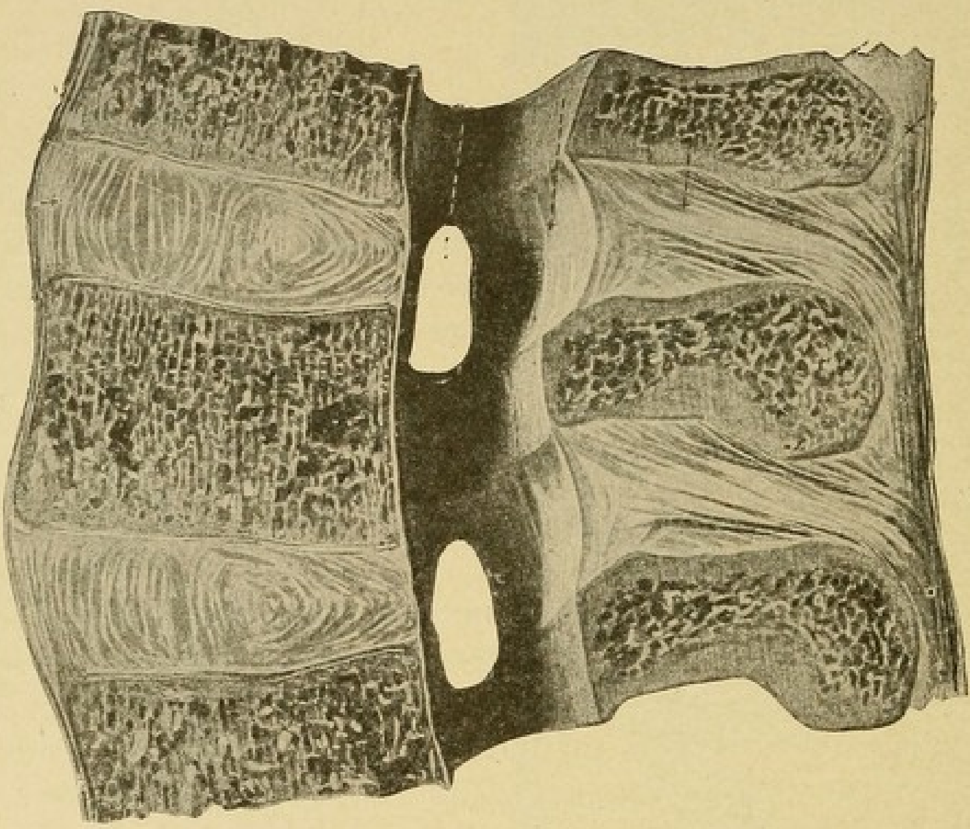


FIG. 3.—MEDIAN SECTION OF A PORTION OF THE ADULT LUMBAR VERTEBRAL COLUMN THE RIGHT HALF SEEN FROM THE LEFT.—(*Fick.*)

are thin. For this reason the curve of the spine in old age approaches the long convexity backward represented by curve (*b*), and the bowed back of old age is substituted for the upright attitude with a lumbar forward curve which is largely due to the influence of intervertebral discs.

The discs are very firmly attached to the bodies of the vertebræ and are also attached to the anterior and posterior common ligaments of the spine. The intervertebral discs thus furnish a connecting structure of great strength between each two vertebræ, and at the same time they furnish what amounts to a ball-and-socket joint on account of the incompressible fluid pulp in the center of each disc between each two vertebral bodies, except of course the first two cervical.

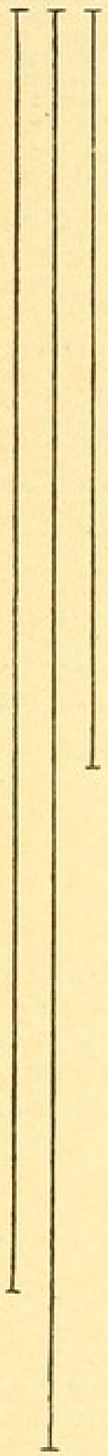


FIG. 4.—LINES REPRESENTING THE SUM OF THE THICKNESS OF THE INTERVERTEBRAL DISCS.—(*Fick.*)
v, At the front border; m, in the middle of the disc; h, at the posterior border.

LIGAMENTS OF THE SPINE.

In addition to the connection of the bodies by means of the intervertebral discs the vertebræ are bound together by ligaments which serve to limit movement between them and contribute stability and strength to the column. Ligaments are composed of white fibrous tissue, the strongest tissue in the body, highly elastic, but non-extensible. Two of the spinal ligaments, the ligamentum nuchæ and the subflava, form exceptions to this statement, being made up almost entirely of yellow fibrous tissue.

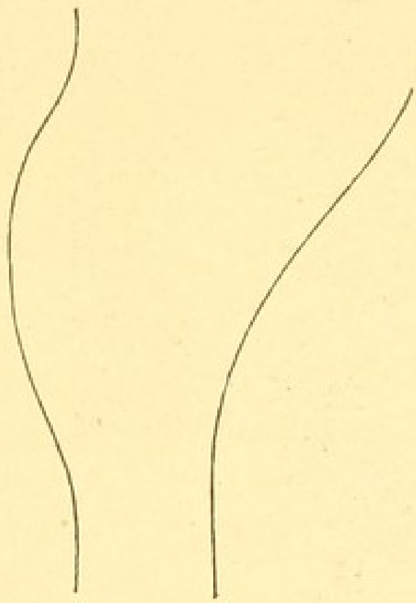


FIG. 5.—CURVES OF THE VERTEBRAL COLUMN.—(*Fick.*)
A, With intervertebral discs; *B*, without intervertebral discs.

SACRO-ILIAC ARTICULATION.

The strong joint between the sacrum and the ilium through which the whole body-weight is transmitted is a synchondrosis which permits but little motion. What motion occurs between the sacrum and the ilia consists of a forward and backward tilting of the sacrum on the ilia on a transverse axis passing through the second sacral vertebra. If the top of the sacrum is tilted backward, because of the obliquity of the articular surfaces, the ilia are separated.[1]

The sacro-iliac joint is made safe and strong in part by the wedge shape of the sacrum, but chiefly by the iliosacral ligaments. The corresponding articular surfaces of the two bones are covered more or less completely with hyaline articular cartilage and the very slight joint cavity between them is crossed by fibrous bands. The capsule is formed by the ligaments surrounding the joint. The anterior sacroiliac ligament is thin, and consists of short, strong fibers passing between the adjacent surfaces of the sacrum and the iliac fossæ. The posterior sacro-iliac ligament is very strong, and is responsible, in connection with the muscles of the back, for holding the weight of the trunk, head, and arms in their proper relation to the pelvis.

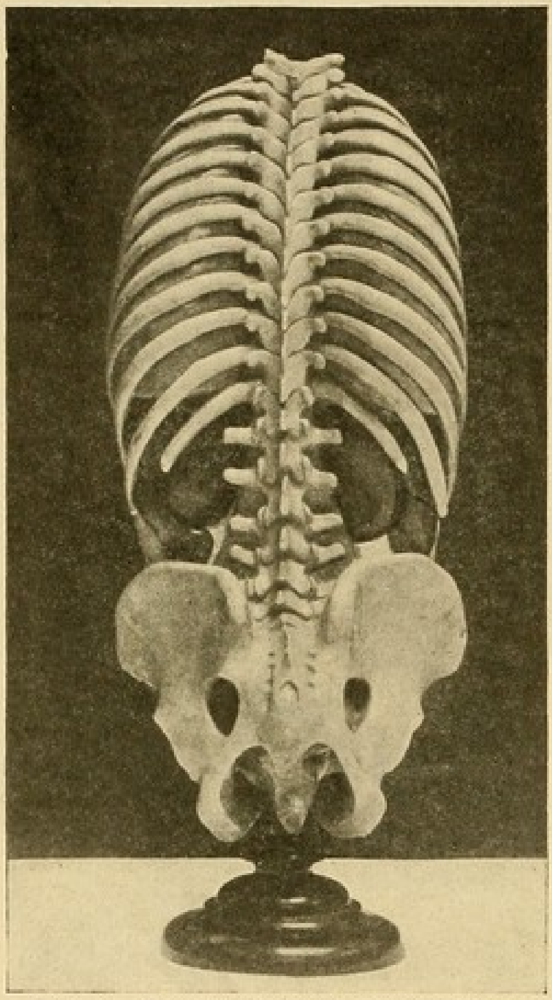


Fig. 6.—Model of the Spine Showing the Anatomical Relations, Especially the Disposition of the Soft Parts in the Lumbar Region.—(*Warren Museum.*)

THORAX.

The thorax is a bony cage containing the principal organs of circulation and respiration. It is formed by the thoracic vertebræ, the ribs, the costal cartilages, and the sternum. The ribs, twelve on each side, form a double series of narrow, curved, flattened bones attached posteriorly to the thoracic vertebræ. They extend at first outward, and then forward, inward, and downward toward the median line anteriorly. The seven upper ribs, called the true, sternal, or vertebrosternal ribs, are attached directly to the sternum by the costal cartilages anteriorly. The five lower ribs are called false or asternal ribs; the eighth, ninth, and tenth are distinguished as vertebrochondral, as they

[1] Goldthwait and Osgood: "Bos. Med. and Sur. Jour.," May 25 and June 1, 1905, with literature.

are anteriorly indirectly united to the sternum by the cartilage of the rib or ribs above; the eleventh and twelfth are called floating ribs, as their anterior extremities are loose in the abdominal wall. The ribs increase in length from the first to the seventh or eighth, decreasing from the eighth to the twelfth. They are approximately parallel with the exception of the eleventh and twelfth, which slant somewhat more downward.

It must be remembered that ribs are lower at their front ends than at their vertebral connection, so that if it is desired to rotate a vertebra by pressure on a rib, the rib horizontally opposite the vertebra is not to be chosen. It has been shown[1] in the cadaver

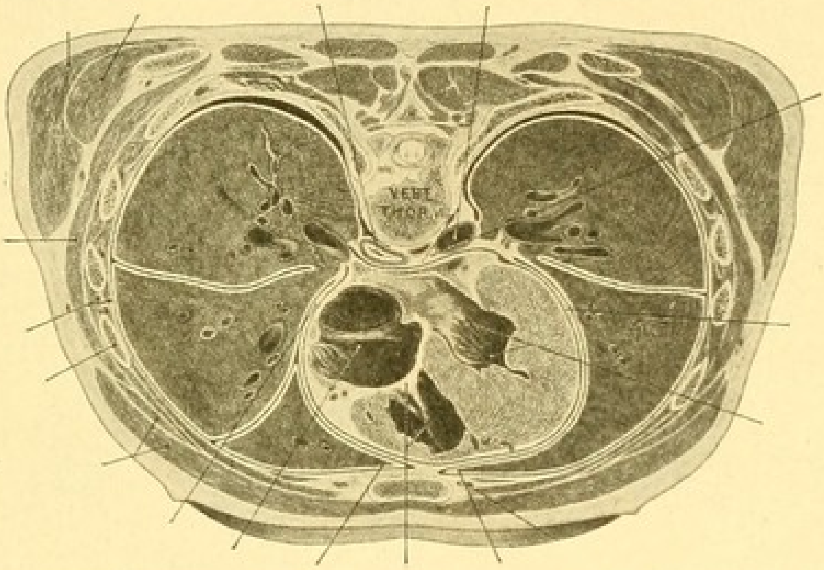


FIG. 7.—HORIZONTAL SECTION OF THORAX AT SEVENTH DORSAL VERTEBRA SHOWING THE POSITION OF THE VERTEBRAL BODIES.—(From *Braun's Atlas-Corning.*)

(1) that rotation of vertebræ may be produced, when the extremities of the spine are fixed, by pressure upon any of the intermediate ribs; (2) that the vertebræ attached to the ribs on which pressure is made are the most affected; (3) that the rotation never equals the rib excursion; (4) that the most effective points for pressure or counterpressure are as far as possible from the midline anteriorly and posteriorly except on the lowest four ribs.

STERNUM.

The sternum or breast-bone is situated in the median line of the trunk, completing the thoracic cage anteriorly. The sternum is a flat bone, and as a whole, it lies directed obliquely forward and

[1] Keene: "Amer. Jour. of Orth. Sur.," July, 1906, page 69.

downward. It consists of three parts—the manubrium sterni, the gladiolus, and the ensiform cartilage or xiphoid process.

SHAPE AND BOUNDARIES OF THE THORAX.

In shape the thorax is somewhat conical, larger behind than in front and compressed anteroposteriorly. The posterior wall is formed by the thoracic vertebræ, and by the ribs, from their heads to their angles, and is convex vertically and horizontally. Laterally the cage is formed by the shafts of the ribs; it is somewhat convex vertically

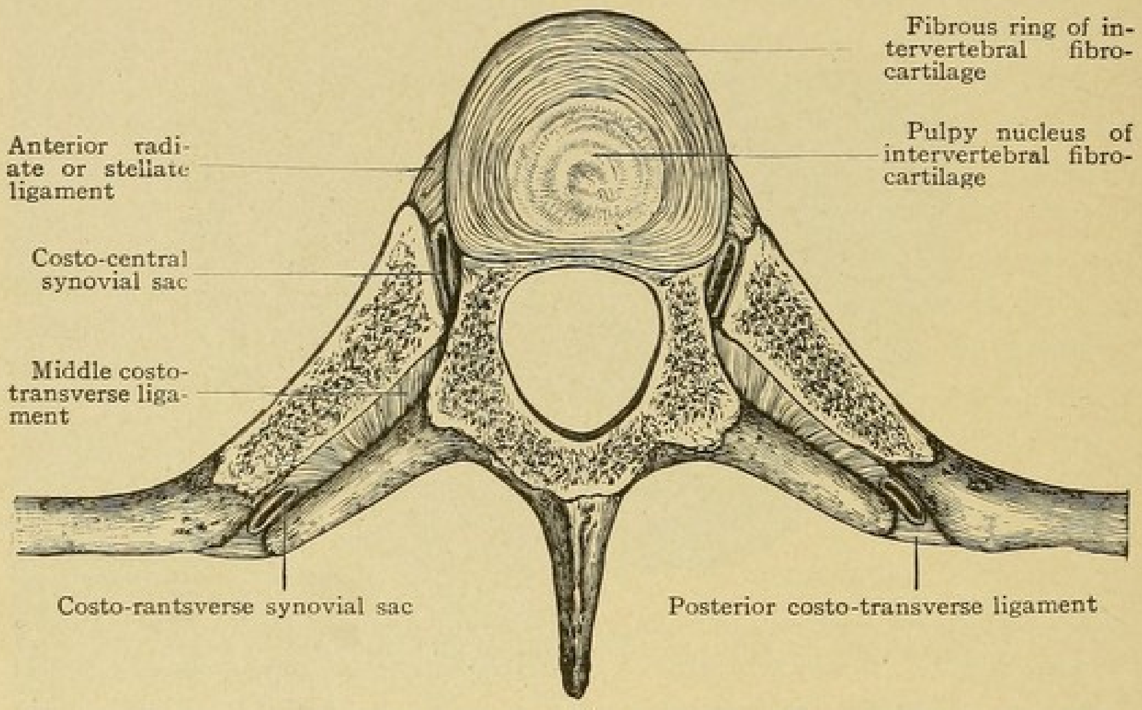


Fig. 8.—Horizontal Section through an Intervertebral Fibro-cartilage and the Corresponding Ribs.—(*Morris's "Anatomy."*)

and sharply convex from before backward. The anterior surface, slightly convex and directed forward and downward, is formed by the sternum and the costal cartilages. The plane of the superior opening or inlet of the thorax is inclined forward and downward, showing a greater obliquity in women than in men. The inferior border of the thoracic cage is formed by the twelfth thoracic vertebra, the lower borders of the twelfth rib, and by two curved lines, extending from the anterior extremities of the last rib to the inferior angles of the gladiolus, touching the anterior extremities of the eleventh rib and the costal cartilages of the tenth, ninth, and eighth ribs. The angle formed by these lines is known as the subcostal angle. The inferior surface of the thorax is directed forward and downward.

MUSCLES OF THE SPINE AND THORAX.

The general grouping and arrangement of the muscles in their relation to the spine has an important practical bearing on scoliosis. The spine lies toward the back of a more or less cylindrical muscular tube of

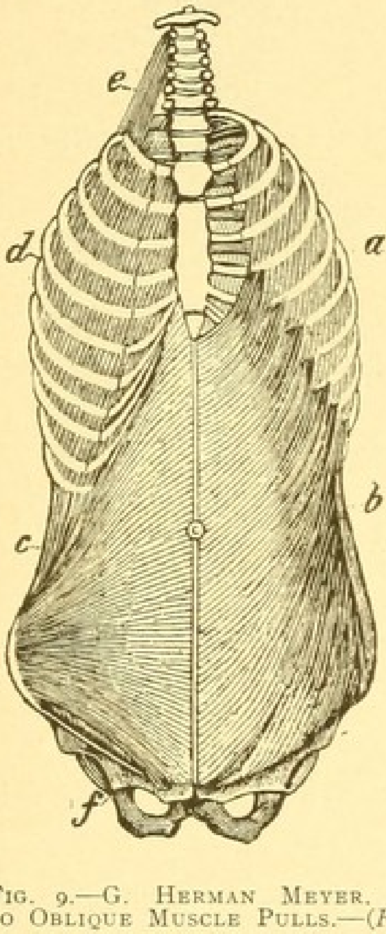


FIG. 9.—G. HERMAN MEYER. THE TWO OBLIQUE MUSCLE PULLS.—(*Feiss.*)

On the left the descending oblique. *a*, External intercostals; *b*, descending oblique or externus abdominis. On the right the ascending oblique muscle pull. *c*, Descending oblique or internus abdominis; *d*, internal intercostals; *e*, scalenus colli; *f*, cremaster.

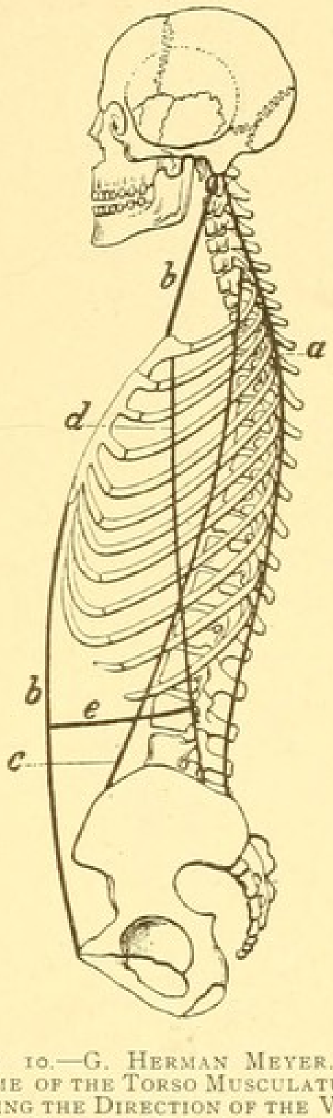


FIG. 10.—G. HERMAN MEYER. THE SCHEME OF THE TORSO MUSCULATURE INDICATING THE DIRECTION OF THE VARIOUS MUSCLE PULLS.—(*Feiss.*)

a, Posterior longitudinal muscle pull (sacrospinalis); *b*, anterior longitudinal muscle pull; *c*, oblique descending muscle pull; *d*, oblique ascending muscle pull; *e*, transverse muscle pull.

which the abdominal muscles form the front. Of muscles directly attached to the spine there are two varieties: (1) muscles running from one part of the spine to another part and to the head; (2) muscles running from the spine to the pelvis or shoulder-girdle. The abdominal muscles by their attachment to the thorax, which is comparatively rigid, have an action on the spine. By the combined action of these three the erect position is maintained, or any variation from it is accomplished.

In making a side flexion of the spine from the erect position, for example, no one muscle or group of muscles is alone active, but it

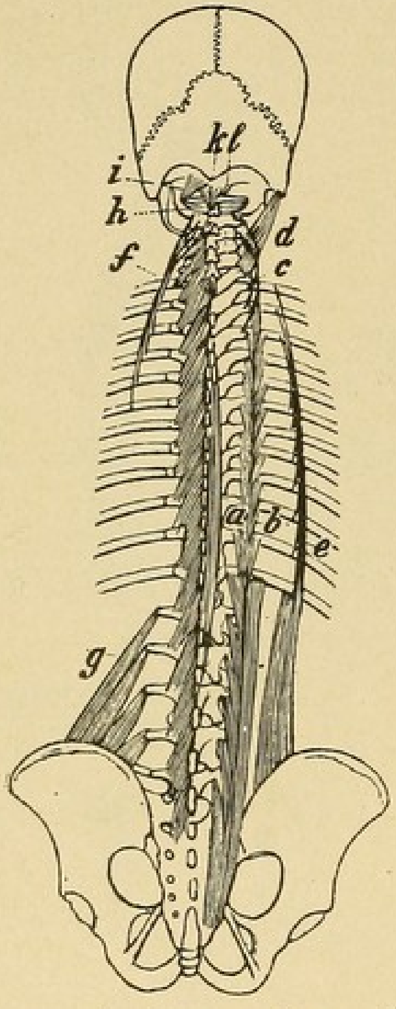


FIG. 11.—G. HERMAN MEYER. THE SYSTEM OF THE SACROSPINALIS.—(*Feiss.*)

a, Spinalis; *b*, longissimus dorsi; *c*, transversalis cervicis; *d*, trachelomastoideus; *e*, ileocostalis; *f*, ascendens cervices; *g*, ileolumbalis (hinder portion of m. quadratus lumborum Auct.); *h*, obliquus capitis inferior; *i*, obliqutus capitis superior; *k*, rectus capitis posterior major; *l*, recus capitis posterior minor.

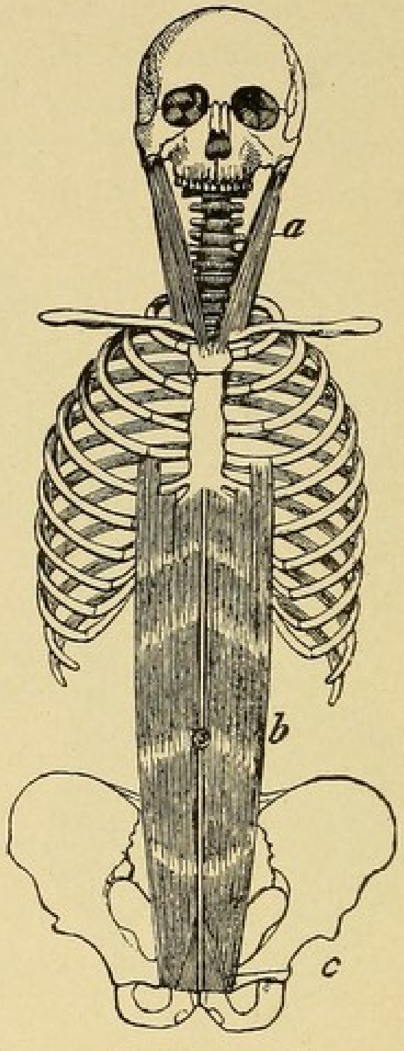


FIG. 12.—G. HERMAN MEYER. ANTERIOR LONGITUDINAL MUSCLES OF THE TRUNK.—(*Feiss.*)

a, Sternocleido-mastoideus; *b*, rectus abdominis; *c*, pyramidalis.

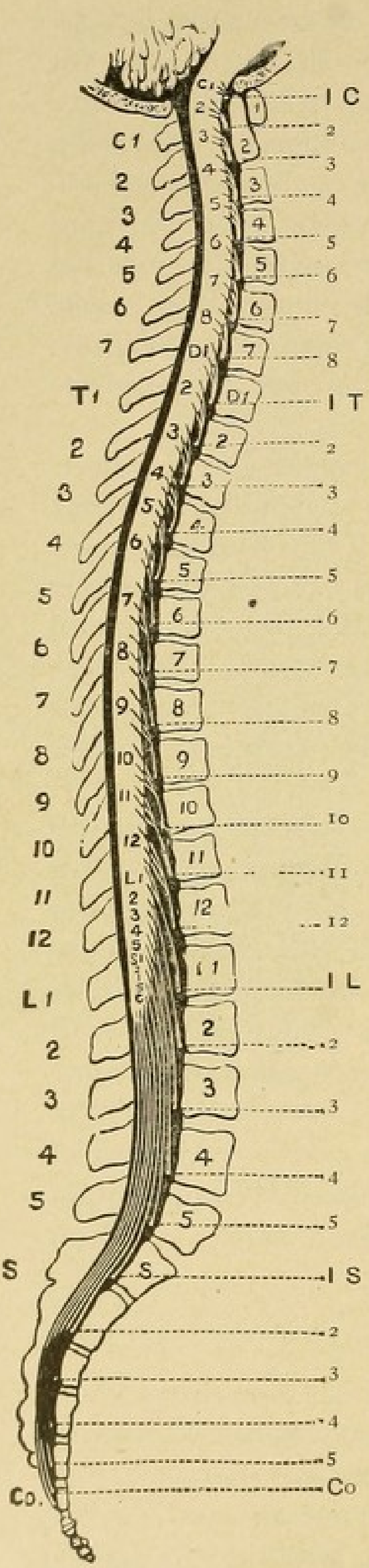
implies a concerted and coördinated action of all the groups mentioned, as well as of the muscles of the lower extremities, to keep the balance and perform the bending. The maintenance of the spine in the upright position by the muscles has been compared to the way in which a flagstaff is held upright by stays reaching from the top of the staff to the ground. Although there is no one muscle running from the head to the pelvis there is a continuous set of muscles supplementing each other's action. For example, in the anterior line the sternomastoid runs from the skull to the front of the top of the thorax, the sternum connects the upper and lower ribs and forms a rigid piece, and the lower thorax is connected with the pelvis by the rectus abdominis muscle. In the back the continuity of muscular action is shown by the fact that before the top insertion of the longissimus dorsi has been reached, the complexus and transversalis cervicis have begun. The whole conception of muscular action in its relation to gymnastics is simplified by remembering the continuity of the muscular tube from the head to the pelvis.

The thorax represents a comparatively fixed cage inserted in a structure quite movable above and below it; muscles attached to the thorax are therefore indirectly attached to the spine. The comparative rigidity of the thoracic part of the spine is due to the fact that the majority of the ribs are attached between two vertebræ, that they pass forward to be also attached to the sternum, and that the whole structure is one well calculated to prevent physiological side bending or extensive forward or backward motion in that region; the cage must therefore largely move as a whole.

It has been pointed out that the dorsolumbar junction is a dividing point for important muscular origins and insertions above and below it, *e.g.*, the psoas muscles originate largely below it and the trapezius above it, and that it forms a weak and movable part of the spine for this reason. More important than this is the fact that muscles connecting the thorax and pelvis will move the spine where the rigid dorsal region changes to the movable lumbar region and that a large number of muscles will therefore express their contraction by motion at the dorsolumbar junction. A similar weak and movable part of the spine is said to exist at the cervicodorsal junction, where important muscles (splenius and rhomboids) have a dividing point.

NERVE-SUPPLY.

The spinal nerves emerge from the spinal canal through the intervertebral foramina and are distributed to the integument and muscles all over the body. Eight are cervical nerves (the first passing over the atlas), twelve dorsal, five lumbar, five sacral, and one coccygeal. Each nerve is formed by the union of two nerve roots, which occurs outside of the spinal cord and just inside of or at the intervertebral foramen. The anterior, motor, or efferent fibers come from the cells of the



MOTOR	SENSORY	REFLEX
Sterno-mastoid	Neck and scalp	
Trapezius	Neck and shoulder	
Diaphragm		
Serratus / Shoulder (musc.)	Shoulder	Scapular
Arm (musc.)	Arm	
Hand (ulnar lowest) (musc.)	Hand	
	Front of thorax	Epigastric
Intercostal muscles	Xiphoid area	
Abdominal muscles	Abdomen (Umbilicus 10th)	Abdominal
	Buttock, upper part	
Flexors, hip	Groin and scrotum (front)	Cremasteric
Extensors, knee	Thigh: outer side	
Adductors (hip)	Thigh: front	*Knee-joint*
	Thigh: inner side	
Abductors (hip)	Leg, inner side	Gluteal
Extensors (?) (hip)	Buttock, lower part	
Flexors, knee (?)	Back of thigh	*Foot-clonus*
Muscles of leg moving foot	Leg and foot except inner part	Plantar
Perinæal and anal muscles	Perinæum and anus	
	Skin from coccyx to anus	

FIG. 13.—DIAGRAM AND TABLE SHOWING THE APPROXIMATE RELATION TO THE SPINAL NERVES OF THE VARIOUS MOTOR, SENSORY, AND REFLEX FUNCTIONS OF THE SPINAL CORD. (Arranged by Dr. Gowers from anatomical and pathological data.)—(*Morris's* "*Anatomy.*")

anterior horn of the cord; the posterior, sensory, or afferent fibers emerge from the cells of the posterior horn on the same side of the cord. The nerve formed by these two roots on leaving the intervertebral foramen divides into an anterior and posterior branch, each with motor and sensory fibers. The posterior divisions are small and supply the skin and muscles of the back. The anterior divisions are distributed to the neck, the front and sides of the trunk, and to the extremities. Each anterior division is connected with a plexus, ganglion, or nerve of the sympathetic system.

EVOLUTION OF THE SPINE.

The history of the spine in its evolution is of interest. In the Cyclostomata the vertebral column consists of a non-segmented, homogeneous, cartilaginous rod. Articular processes first appear in the Rays and Teleostei. The backbone of the lower fishes consists of a series of bony discs bound together by elastic intervertebral discs. It would seem from the history of the spine as if articular processes developed concomitantly with the elaboration of structure, and as if they were incidental to its use rather than factors determining of themselves its types of motion.

As will be mentioned in a later section, the human spine, from an evolutionary point of view, is practically the quadruped spine set on end, a matter which has a distinct bearing on its weaknesses as an upright supporting column.

OSSIFICATION.

The ossification of a vertebra occurs from three primary centers, one for the body and one for each lateral mass. These appear in the sixth week, and in the cervical region the lateral centers are the first to appear, while in the dorsal region the one for the body is the first seen. The center for the body is often double in appearance if not in reality. The centers for the lateral masses are found near the bases of the articular processes and from them form the pedicles, laminæ, articular processes, and a large part of the transverse and spinous processes, the bodies of the vertebræ forming from the other center. The vertebral epiphyses serve to assist in the formation of joints, to provide for the attachment of ligaments and tendons, and to increase the development in length of the bone of which they form a part. At about puberty appear five other secondary or complementary centers, one at the tip of the spinous process, one at the tip of each transverse process, and one at the upper and one at the lower surface of each body, occurring as a flat meniscus at about the seventeenth year and uniting to the vertebral body a few years later (twentieth year). Inasmuch as vertebral growth occurs at each of these epiphyses this complicated method of ossification is important because the injury or disease of one of these epiphyseal lines might lead to serious bony deformity of the vertebra (Figs. 14 and 15).

ELASTICITY OF SPINE.

The spinal column is capable of some movement in all directions. The elasticity of the intervertebral discs is such that the ball-and-socket joint between each two vertebræ allows motion between them in any plane or direction until limited by bony contact and ligamentous or muscular tension. It also allows rotation to occur between two separate vertebræ in an approximately horizontal plane. Bone is slightly compressible, but this is not a factor of importance in contributing to vertebral flexibility.

In childhood the vertebræ are largely cartilaginous, and the increasing proportion of bone, along with the diminishing proportion of cartilage, causes a decrease of flexibility from youth to adult age, aside from the fact that the flexibility of all joints is greater in youth. With old age the capability of movement of the spine is greatly lessened on account of the atrophy of the intervertebral discs.

PLANES OF THE BODY.

The planes of the body will be frequently spoken of and should be defined. The *frontal* plane is a vertical and transverse one. The *sagittal* or antero-posterior plane runs in the antero-posterior axis. The term *horizontal* plane is self-explanatory.

PHYSIOLOGICAL CURVES (ANTERO-POSTERIOR).

The physiological curves, so-called, are antero-posterior curves and are important. They are three in number.

The *dorsal* (backward) *curve* is the first to become evident, and was found present in 86 per cent. of normal children under one year old when lying on the face and in 99 per cent. of children over one year old. In children under six months this backward convexity included the lumbar region, but after this age it did not as a rule,[1] the lumbar curve then occurring at the expense of the dorsal curve.

The *lumbar* (forward) *curve* in lying showed frequently after the age of one year and in a very large majority of cases after the age of three years. The lumbar curve when it formed took the place

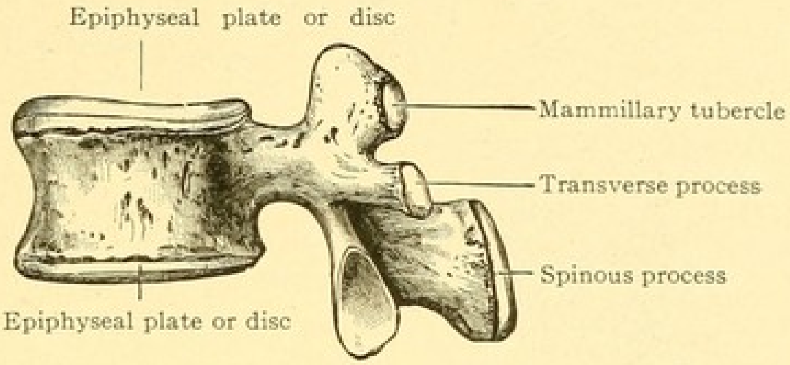


FIG. 14.—LUMBAR VERTEBRA AT THE EIGHTEENTH YEAR WITH SECONDARY CENTERS.—(*Morris's "Anatomy."*)

of part of the original backward dorsal curve and was more marked in standing than in lying. In standing it was present after the age of two years in a very large majority of cases, the exceptions being usually in children under three who had not walked. The lumbar curve in childhood is obliterated in the sitting position, only four chil-

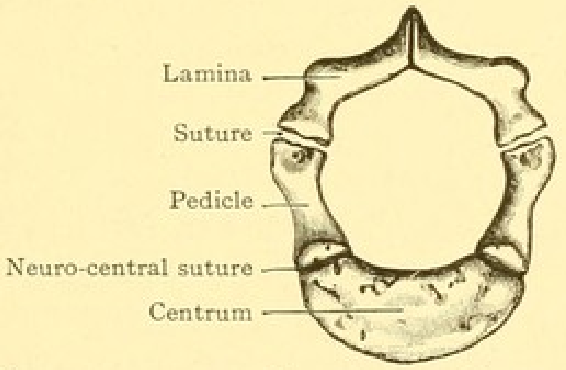


FIG. 15.—OSSIFICATION OF THE FIFTH LUMBAR VERTEBRA.—(*Morris's "Anatomy."*)

dren of those examined between the ages of nine and thirteen showing such a curve in the sitting position.

The *cervical* (forward) *curve* could not be accurately determined in either standing or lying in the youngest children, but after the age of fourteen months this curve was observed in standing.

[1] Lovett, Davis, and Montgomery: "Arch. di Ortopedia," 1906, v and vi, page 372.

In the adult, the part played by the bodies of the vertebræ and the discs in producing the physiological curves is shown by the following table:

DIFFERENCE BETWEEN THE SUMS OF THE ANTERIOR AND POSTERIOR BORDERS.

	VERTEBRÆ.	DISCS.
Cervical region	1.3 mm.	7.8 mm.
Dorsal region	13.3 mm.	9.2 mm.
Lumbar region	6.7 mm.	21.1 mm.

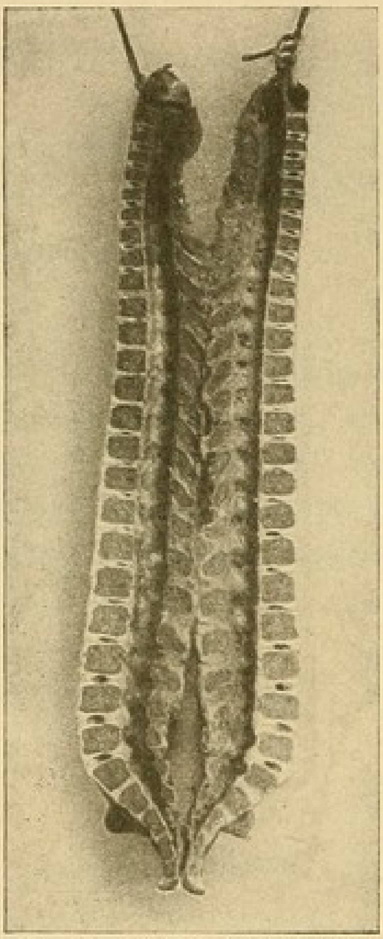


FIG. 16.—SECTION OF THE SPINE OF A NEW-BORN INFANT.

The cervical curve is formed principally by the intervertebral discs. It is a fairly mobile curve, and may be straightened by suspension. The dorsal curve is formed chiefly by the bodies of the vertebræ; it is a rigid curve and cannot be obliterated. The lumbar physiological curve is produced mainly by the greater anterior height of the intervertebral discs and is therefore mobile.

A slight physiological lateral curve convex to the right has long been recognized in the spine. It has been attributed to the pressure of the aorta on the vertebral bodies, to excessive use of the right side of the body in certain occupations, and to extreme right-handedness. The almost constant occurrence of the curve indicates a common cause, which is most probably aortic pressure. The asymmetry extends from the fifth dorsal to the second or third lumbar vertebra. The body of the fifth dorsal vertebra is flattened on the left side, and the discs above and below are similarly affected. There is a groove from one and a half to two centimeters broad passing downward in a spiral direction, following the course of the aorta, to the anterior surface of the second or third lumbar vertebra. The discs between these vertebræ are usually less projecting than the others, and if the cutting away of the vertebra cannot be seen the flattening of the disc is always apparent.[1]

[1] Pere: "Les courb. lat. norm du Rachis humaine," These de Toulouse, 1900.

PELVIC INCLINATION.

The position of the pelvis in relation to the horizontal plane would be of importance in relation to scoliosis and faulty attitude if it could be accurately measured in the living subject.

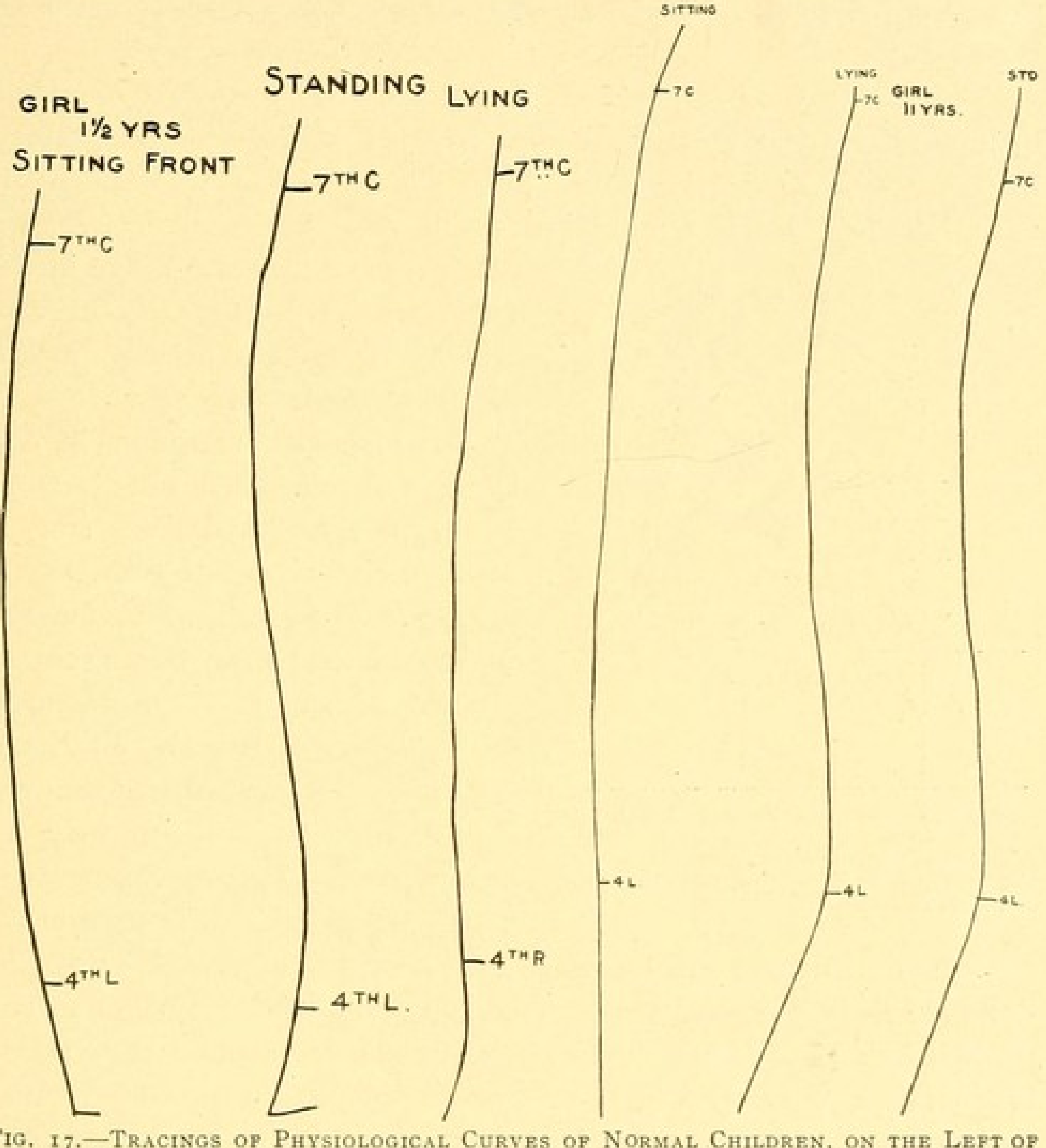


FIG. 17.—TRACINGS OF PHYSIOLOGICAL CURVES OF NORMAL CHILDREN, ON THE LEFT OF A GIRL OF ONE AND A HALF YEARS, ON THE RIGHT OF A GIRL OF ELEVEN.

If the front part of the pelvis is lowered and the back part correspondingly tilted up it is spoken of as "increased inclination." If the front part is raised and the back part lowered is it spoken of as "diminished inclination." With the former is associated an increase of the lumbar physiological curve and with the latter a flattening of it. Changes in inclination of the pelvis must form an important elment in the faulty attitude to be spoken of as round shoulders.

The internal or true conjugate diameter (conjugata vera) of the pelvis is a line from the sacrolumbar junction to the top of the symphysis pubis and is generally accepted as the line by which pelvic inclination is to be determined. The angle which this line makes with the horizon when the patient stands erect is spoken of as the "angle of pelvic inclination," and the observers do not wholly agree in their results.

But desirable as information would be as to the angle of pelvic inclination in spinal abnormalities, a study of the results obtained by those who have formulated them shows such a wide range of variation that one is tempted to doubt their value even if for no other reason than the range in the angle given by different observers and by the great variation in the results of single observers.

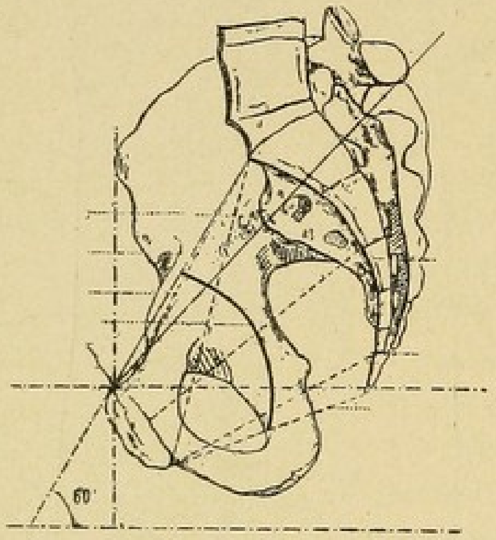


Fig. 18.—Female Pelvis, Median Section.—(*Spalteholz.*)
The solid line running up and back from the symphysis indicates the "external conjugate diameter."

In men the variation in the average of collected results is from 44 degrees to 60 degrees and in women, from 41 degrees to 65 degrees. The results of Prochovnik were obtained by the most accurate method of any and the research was conducted entirely on living subjects. The variation in men according to his figures was from 26 degrees to 76 degrees and in women from 40.5 degrees to 71 degrees.

Again, a research by Reynolds and Lovett (Chapter III) was undertaken as to the mechanics of the antero-posterior positon in the upright living individual in which research a determination of pelvic inclination and its variations under varying static conditions would have been of presumable value, but after months of experimentation with various methods the investigators came to the conclusion that it was impossible to measure the variations in the inclination of the pelvis in a living individual with sufficient accuracy to be of any practical value.

The following figures are therefore quoted in the belief that they can only be approximate and that they must be taken only in the most general way. They are partly obtained from the living, but in many instances are from the cadaver.

	Average in Men.	Average in Women.
Year 1745, Müller	45 degrees	.....
Year 1825, Nägele[1]	60 "	.....
Year 1836, Weber Brothers[2]		65 degrees
Year 1841, Krause[3]	60 "	60 "
Year 1873, Meyer[4]	55 "	50 "
Year 1882, Prochovnik[5]	54.17"	51.72"
Year 1898, Henggeler[6]	44 "	41.1 "

In 1910 Engelhard[7] published some observations on pelvic inclination in living children from six to fourteen. The extremes of inclination were from 21 degrees to 46 degrees to the horizontal with an average inclination of 32 degrees.

Seventy-six males and eighty females, all apparently normal, over the age of fifteen were investigated and tabulated by Prochovnik as follows:

	Least Inclination.	Greatest.	Average.
Males	26 degrees	76 degrees	51.72 degrees
Females	40.5 "	71 "	54.17 "

The grouping of the results suggests that a normal pelvis shows an inclination of from 50 to 60 degrees, that there is a subnormal zone from 45 to 50 degrees, a supranormal of 60 to 65 degrees, but that an inclination above 65 degrees or below 45 degrees is to be regarded as pathological. The figures given refer to the external conjugate and are a little higher when the internal conjugate is taken as determining the angle of inclination.

The whole subject of pelvic inclination and its variations, the influences of such changes of inclination on static conditions, and the difference of inclination between children and adults must therefore be left in an unsatisfactory and unsettled condition.

SURFACE ANATOMY OF THE BACK.

The position of the spine in the median line of the body is indicated on the normal back by a longitudinal furrow (median furrow) extending from the occipital bone to the sacrum. The lower end of the furrow corresponds to the interval between the fifth lumbar vertebra and the sacrum. In the cervical region this furrow lies between the trapezii and

[1] "Das Weibl Becken," etc., Carlsruhe, 1825.
[2] "Mech. d. Menschl. Gehwerkzeuge.," Göttingen, 1836.
[3] "Hdbch. d. Mensch. Anat. Hauft.," 1, 1, 324, Hanover, 1841.
[4] "Müller's Archiv," 1873, 9.
[5] "Archiv. f. Gyn.," 1882, xix, 1.
[6] "Zeitsch. f. orth. Chir.," xii, 4, 613.
[7] Zeitsch. f. orth. Chir.," xxvii, page 1, 1910.

complexi, and in the dorsal and lumbar regions it lies between the erector spinæ muscles. It is usually most marked in the upper lumbar and lower dorsal regions.

Identification of Vertebra.—In this median furrow the spinous processes of the lower cervical vertebræ can be felt easily, but the spine of the second cervical vertebra can be reached by deep pressure in a relaxed neck; in a poorly developed individual they can be seen in the erect position, and in one well developed in forward bending. The spinous process of the *seventh cervical* vertebra is usually quite prominent, though that of the first thoracic may be still more so. In proceeding downward the root of the spine of the scapula should be found opposite the spinous process of the *third dorsal* vertebra, and the inferior angle of the scapula opposite that of the *seventh dorsal* vertebra. The spine of the *fourth lumbar* vertebra is on a level with the highest points of the iliac crests. The spinous process of the fifth lumbar vertebra is very short, and usually forms a slight depression instead of a prominence. The *third sacral vertebra* is on the line drawn between the posterior superior spines of the ilium and this line lies over the sacro-iliac joints. The *twelfth dorsal vertebra* is found by counting down from the seventh dorsal and up from the fourth lumbar vertebra, and any vertebra may be found in this way. Of the methods of identification this is the most reliable. In the dorsal region the obliquity of the spinous processes causes the tip of each to be opposite the body of the vertebra next below it. So the spine of the second dorsal vertebra corresponds to the head of the third rib, but the eleventh and twelfth dorsal spines are opposite the heads of the eleventh and twelfth ribs. The spinous processes of the lumbar vertebræ are opposite the lower parts of the corresponding bodies and the discs below them.

In the adult the spinal cord ends at the lower border of the first lumbar vertebra; in children the cord terminates at the lower border of the third lumbar vertebra.

Muscles.—The outline of the neck posteriorly is formed by the trapezii and underlying muscles. The surface of the shoulder is shaped by the deltoid and the muscles underlying the trapezius. The posterior border of the axilla is formed by the latissimus dorsi, which also takes part in forming the contour of the lower part of the back. In action the anterior edge of the latissimus dorsi may be seen as a fold extending from the crest of the ilium to the axilla. The erector spinæ muscles form a rounded prominence longitudinally on either side of the spine in the lumbar region.

The following table from Gray's "Anatomy" gives the relation of the spines of the vertebræ to important organs:

TABULAR PLAN OF PARTS OPPOSITE THE SPINES OF THE VERTEBRÆ (GRAY).

CERVICAL....	5th.	Cricoid cartilage. Esophagus begins.
	7th.	Apex of lung: higher in the female than in the male.
DORSAL.....	3d.	Aorta reaches spine. Apex of lower lobe of lung. Angle of bifurcation of trachea.
	4th.	Aortic arch ends. Upper level of heart.
	8th.	Lower level of heart. Central tendon of diaphragm.
	9th.	Esophagus and vena cava through diaphragm. Upper edge of spleen.
	10th.	Lower edge of lung. Liver comes to surface posteriorly. Cardiac orifice of stomach.
	11th.	Lower border of spleen. Renal capsule.
	12th.	Lowest part of pleura. Aorta through diaphragm. Pylorus.
LUMBAR.....	1st.	Renal arteries. Pelvis of kidney.
	2d.	Termination of spinal cord. Pancreas. Duodenum just below. Receptaculum chyli.
	3d.	Umbilicus. Lower border of kidney.
	4th.	Division of arota. Highest part of ilium.

Points for Lateral Corrective Pressure.—The points at which corrective side pressure may be applied to the spine are determined by anatomical conditions. The important structures lying on both sides of the spine in the cervical and lumbar regions make it impossible to use effective side pressure upon a curved spine in these regions. In the dorsal region side pressure on the ribs is effective on the vertebræ, but it cannot be exerted on the upper vertebræ higher, of course, than the axilla. The anterior border of the axilla is formed by the pectoralis major muscle and is in the line of the fifth rib. This rib articulates with both the fourth and fifth dorsal vertebræ. Although with the arm nearly at the side the third rib may be reached by the exploring hand, side pressure on the thorax cannot be exerted efficiently above the fourth or fifth rib.

Chapter II.

THE MOVEMENTS OF THE SPINE.[1]

The movements of the human spine are three in number:

(1) Flexion; (2) extension, and (3) a compound movement—side bending-rotation.

The statement that there are four movements (flexion, extension, rotation and side bending) is wholly incorrect, as neither side bending nor rotation exist in a pure form as may be demonstrated on any normal child. The statement that such movements exist as pure movements necessarily leads to a false basis for gymnastic exercises and obscures the whole mechanism of scoliosis.

As long ago as 1844 Henry J. Bigelow wrote: "The principle of torsion is illustrated by bending a flat blade of grass or a flat, flexible stick in the direction of its width. The center immediately rotates upon its longitudinal axis to bend flatwise in the direction of its thickness. In the same way the spine, laterally flexed, turns upon its vertical axis to yield in its shortest or antero-posterior diameter." Occasional references are found to the association of torsion with lateral flexion, but no general recognition of the relation between the two has existed.

The human spine is not an extremely flexible structure taken by itself; much of its apparent flexibility is due to accessory movements between the spine and the pelvis and the head. An extreme forward flexion, *e.g.*, in the living model or the intact cadaver, with the flexed head, the drooping shoulders, and the rotated pelvis, implies a greater curve than the spine itself possesses. It is surprising to see in the cadaver how little actual mobility is possessed by the three regions of the spine considered separately, or by the whole spine.

The application of this is obvious without extended comment. If active or passive exercises are given which are intended to take effect upon the spine alone and to be effective there, the pelvis must be fixed. If this is not done, part of the muscular force is used in displacing the pelvis to the opposite side to balance the body, and the movement becomes a general and not a spinal one.

[1] R. W. Lovett: "Bos. Med. and Surg. Jour.," June 4, 1900, Oct. 31, 1901, March 17, 1904, Sept. 28, 1905; "Amer. Jour. of Anat.," ii, 4, 457.

I. FLEXION (FORWARD BENDING)

Is a pure antero-posterior movement without perceptible rotation. It is the most evenly distributed of the spinal movements, and in extreme flexion the outline of the tips of the spinous processes forms a curve approaching the arc of a circle. Most of the movement is accomplished in the lumbar region, which in extreme flexion loses most of its forward convexity, but in adult observations was not observed to become convex backward.

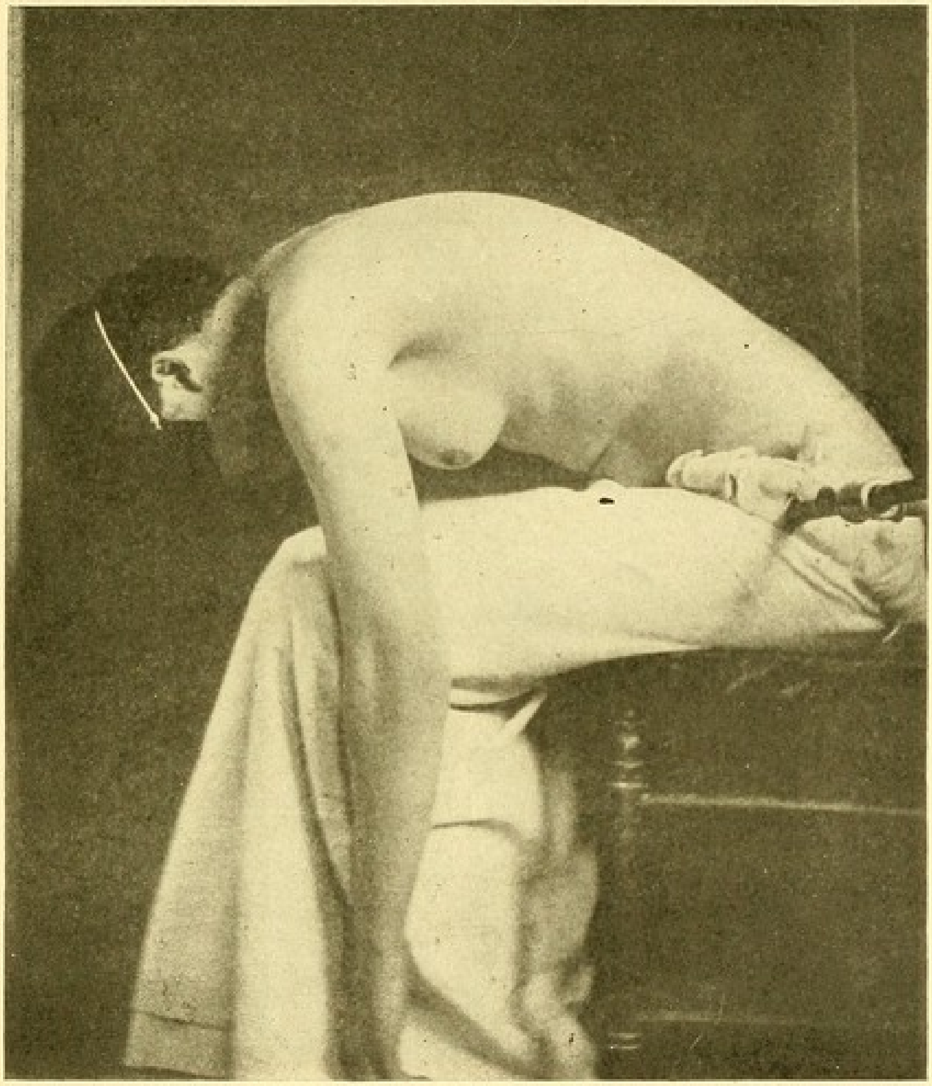


FIG. 19.—FLEXION OF THE SPINE IN THE MODEL.

The dorsal region in extreme flexion becomes decidedly more convex than in the upright position. The twelfth dorsal vertebra takes part in flexion more as a lumbar than as a dorsal vertebra, and free movement occurs below it and fairly free movement between the eleventh and twelfth vertebræ.

The cervical region cannot be accurately observed or measured in the model. In the cadaver it dries so rapidly that no conclusions can be drawn beyond the statement that its forward convexity may be obliterated by forcible flexion with the hands.

The most marked flexion of the spine may be obtained by having the model sit cross-legged and bend forward with the chest between the knees. Extreme passive flexion with the model lying on the side is not so great as that obtained by flexion in the cross-legged position.

In flexion the distance of the seventh cervical vertebra from the sacrum when measured along the spinous processes is increased over the same measurement taken in standing or lying.

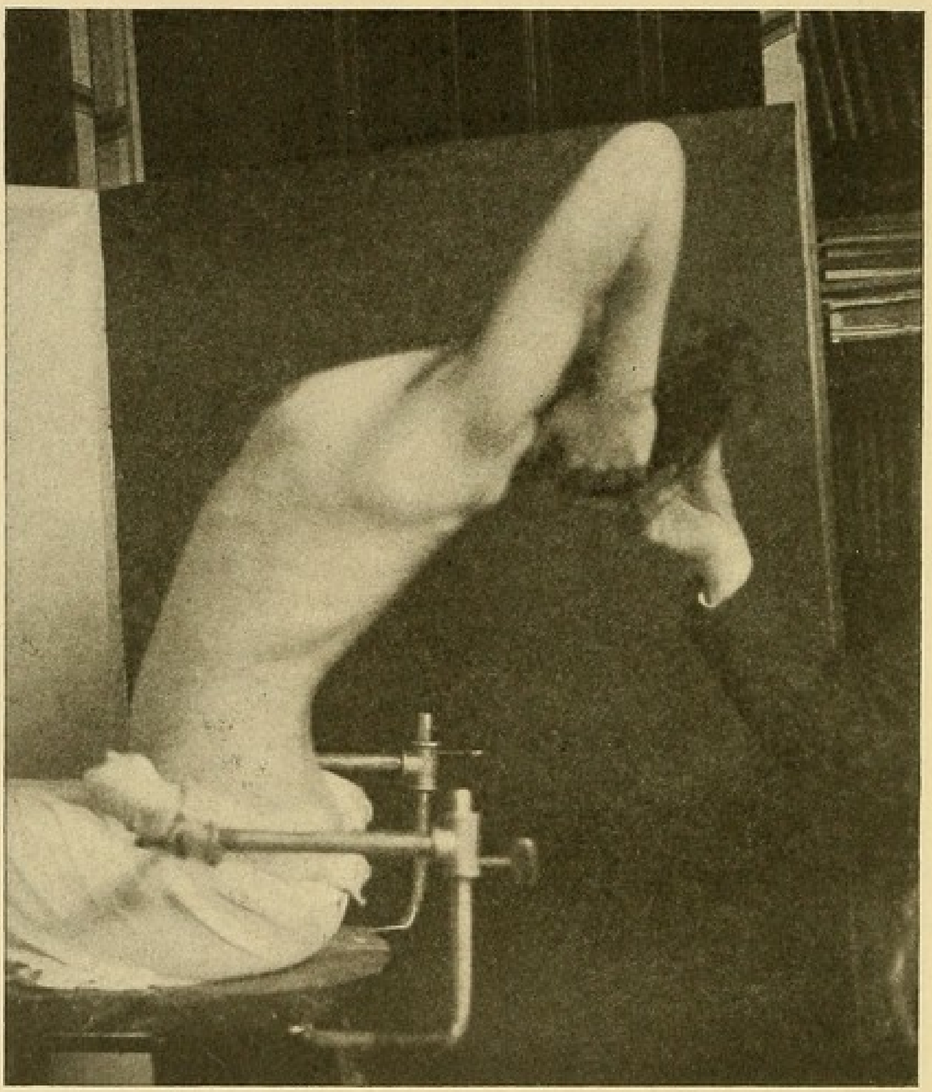


FIG. 20.—HYPEREXTENSION IN THE MODEL.
The head is supported to secure steadiness.

There seems to be no constant difference in the amount of flexion obtained in the standing and sitting positions, the resultant curve being practically the same. The chief difference between flexion in model and cadaver seems to consist in a greater relative participation of the dorsal region in flexion in the model.

Measurements and tracings of the spine in the model and in children show the relaxed sitting position to be one of slight flexion.

Forward flexion of the spine in scoliosis tends to straighten the curved line formed by the spinous processes.

II. HYPEREXTENSION (BACKWARD BENDING).

Hyperextension is a pure antero-posterior movement of the spine without perceptible rotation. It is not an evenly distributed movement, but occurs almost wholly in the lumbar and lower two dorsal vertebræ. A tracing taken over the spinous processes in extreme hyperextension in outline resembles a hockey stick. The dorsal region is but little affected, being slightly straightened by hyperextension. The bending reaches to about the tenth dorsal, the upper dorsal region showing but little diminution in the physiological curve, the twelfth dorsal vertebra, and, to a certain extent, the eleventh, behaving as do the lumbar vertebræ in hyperextension. The character of the curve obtained in marked hyperextension is practically the same, whether it is obtained by active or passive means, and whether the model lies on the face or on the side, or stands, or sits. The column of vertebral bodies alone shows the same character and distribution of the movement as does the intact spine of the cadaver. The illustration (Fig. 21) shows the characteristic rigidity of the dorsal region to hyperextension.

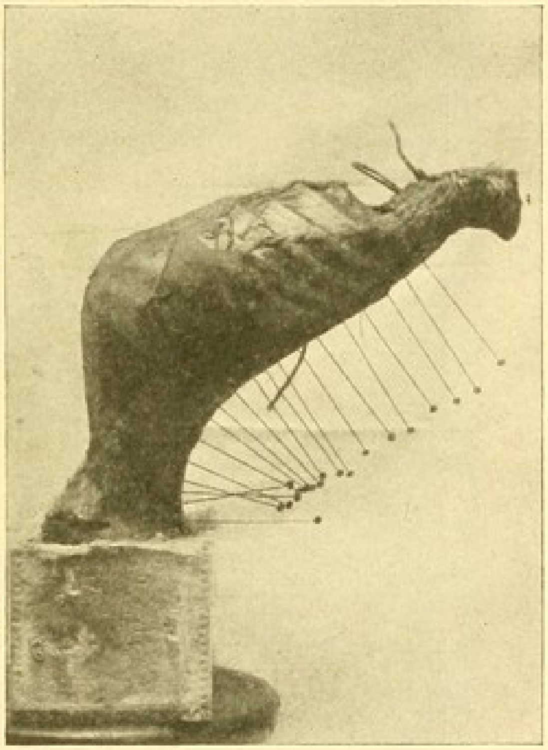


FIG. 21.—HYPEREXTENSION IN THE CADAVER.

In hyperextension, the distance from the seventh cervical vertebra to the sacrum, measured over the spinous processes, is decreased from the same measurement taken in the erect position.

IIIa. LATERAL FLEXION (SIDE BENDING).

Lateral flexion of the spine does not exist as a pure movement, but is to be considered as one part of a compound movement, of which twisting or rotation forms the other part.

In describing this side bending it must be stated that the character and distribution of the movement vary widely according to the degree of flexion or extension of the spine when the side bending is made. In other words, there is no one type of spinal side bending, as there are types of flexion and extension, but the character and distribution of the movements are wholly dependent upon whether the spine is flexed, erect, or hyperextended when the side bending is performed.

Side bending will first be considered alone without regard to the rotation caused by it, and then the rotation accompanying each kind of side bending will be described.

The extent and distribution of forward and backward bending have been investigated in children from six to fourteen years old by Engelhard[1], and the figure, fig. 31 shows the amount and distribution of these movements as formulated by him in an average individual.

Side bending in lying on the face shows a more evenly distributed lateral

[1] "Zeitsch. für orth. chir.," 1910, xxvii, p. 1.

curve than does that in the erect position. The character of the curve does not change essentially when the shoulders and pelvis are held and the middle of the trunk pushed to one side. The curve in this position of the spine is greater in the upper lumbar vertebræ and in the two lower dorsal than in the upper part of the spine.

Rotation Accompanying Side Bending Lying on the Face.—With the cadaver

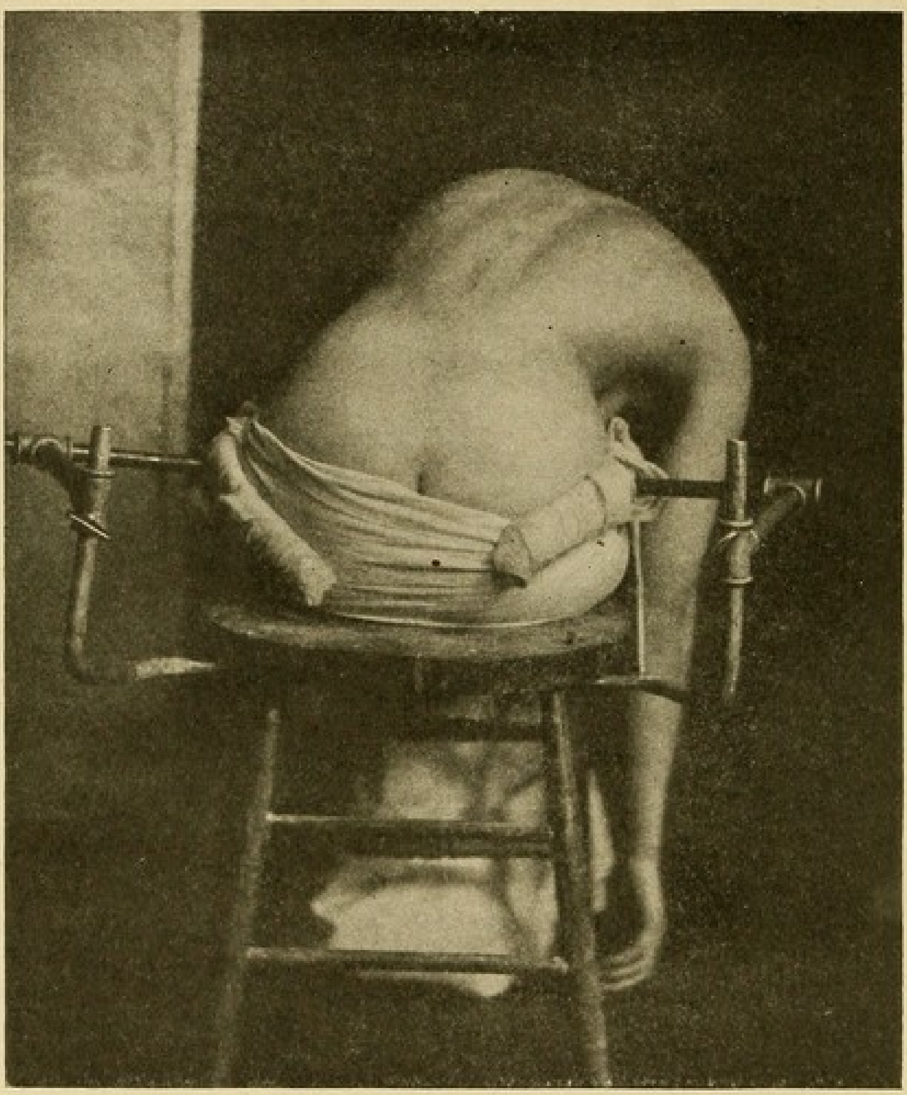


FIG. 22.—SIDE BENDING TO THE RIGHT IN THE FLEXED POSITION OF THE SPINE IN THE MODEL.

A lateral curve convex to the left is formed and the vertebral bodies have turned to the left, as shown by the elevation of the left side of the back.

lying flat on the face on the table no rotation in side bending was found by v. Meyer and in some experiments by Schluthess; it was, however, found by Benno Schmidt. With the cadaver lying prone on a table the conditions, of course, are against rotation, the thorax and shoulders being to a certain extent held against it by the surface of the table. No perceptible rotation is noted in slight side bending under these conditions, but the vertebral bodies turn to the concave side in marked side bending. In the model lying flat on a table one side of the chest is felt to press on the table harder than the other in moderate side bending. The point is not of great importance, as the practical problem is that of the behavior of the weight-bearing spine.

Side bending in the flexed position of the spine is a more evenly distributed movement in which the dorsal region participates more and the lumbar region less than in the erect position. The greatest deviation from a line connecting the two ends of the spine occurs at about the eighth dorsal vertebra in both cadaver and model. In short, side bending occurs higher in the spine in flexion than in any

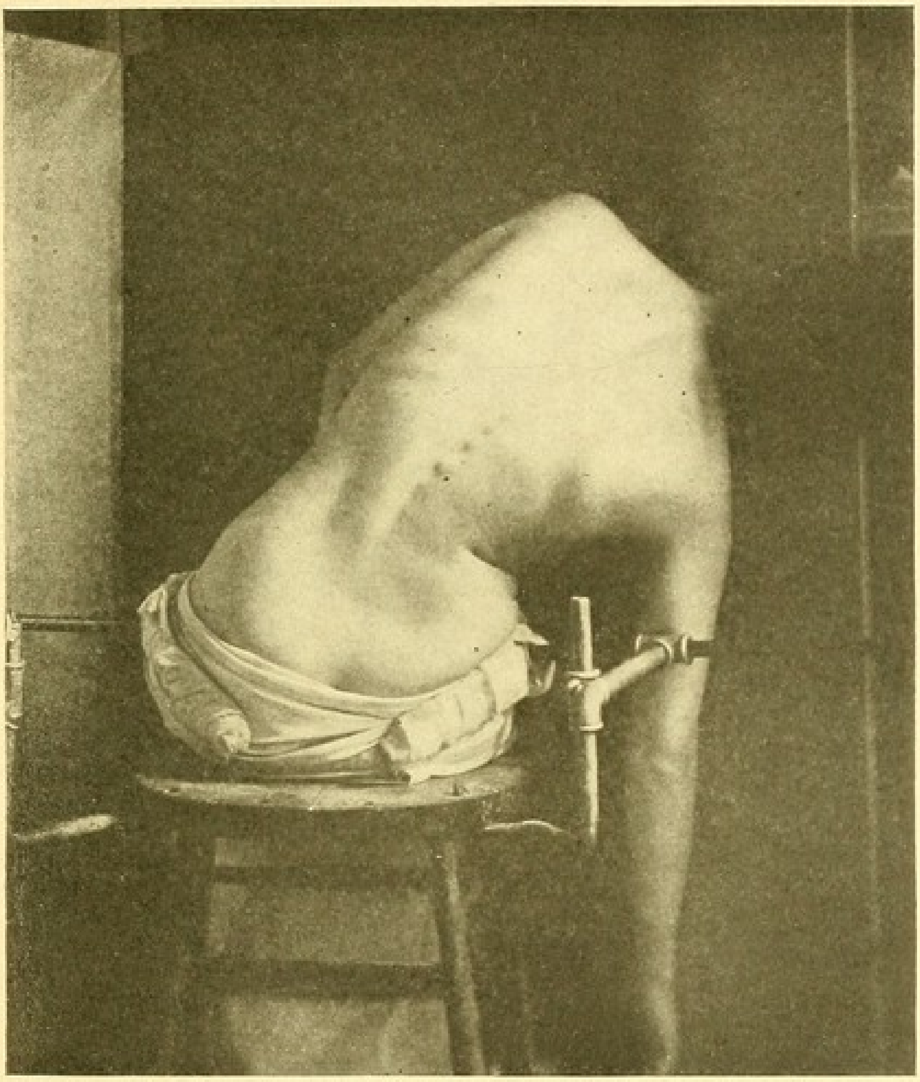


FIG. 23.—SIDE BENDING IN THE UPRIGHT POSITION OF THE MODEL.
The movement is chiefly located at the dorsolumbar junction.

other position, the lumbar region being comparatively locked against side bending by the flexed position. The more marked the flexed position, the higher in the spine is the side bending localized.

Rotation Accompanying Side Bending in Flexion.—In the flexed position of the spine, side bending is accompanied by rotation of the vertebral bodies toward the convexity of the lateral curve. This rotation occurs chiefly in the dorsal region.

Side Bending in the Erect Position.—In the cadaver side bending is most marked below the tenth dorsal vertebra, and the dorsal region shares but slightly. The lumbar region is most affected in its upper part, but shares to some extent throughout. Side bending in the erect position is, therefore, largely a movement occurring in the neighborhood of and below the lumbar dorsal junction. It shows the same characteristics in the cadaver, the model, and the child, except that in the two last named the dorsal region takes a greater relative part than in the cadaver.

Rotation Accompanying Side Bending in the Erect Position.—In this position side bending causes the rotation of the bodies of the vertebræ to the concave side of the lateral curve. This, however, occurs lower down in the spine than in the

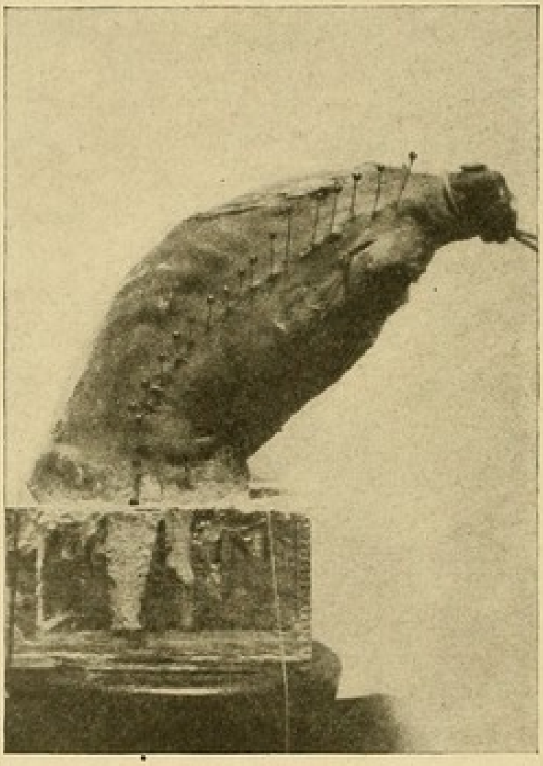


FIG. 24.—SIDE BENDING IN THE UPRIGHT POSITION OF THE CADAVER, SHOWING THE SAME CHARACTERISTICS AS IN THE MODEL.

flexed position. The dorsal region participates less and the lumbar region more in the movement.

Side Bending in the Hyperextended Position of the Spine.—With the spine of the cadaver, model, or child hyperextended, the side bending becomes a sharply limited movement, localized low down in the spine and occurring almost wholly below the eleventh dorsal vertebra, becoming therefore, essentially a lumbar movement. The dorsal region bends as a whole upon the lumbar and rocks over to the side practically unchanged, being locked against side bending by the hyperextended position.

Side bending, therefore, is situated highest in the flexed position lower down in the erect position, and lowest in hyperextension in the model cadaver, and child.

Rotation Accompanying Side Bending in the Hyperextended Position.—This is a sharply limited movement occurring in the lumbar region, including the twelfth dorsal as functionally a lumbar vertebra. The thorax rocks over to the side unchanged, and the rotation of the bodies is to the concave side of the lateral curve.

Rotation accompanying side bending is, therefore, of a different type in the flexed position of the spine from what it is in the erect or hyperextended position.

IIIb. ROTATION.

Rotation or twisting of the spine is to be considered as part of a compound movement of which side bending forms the other part. For purposes of simplicity

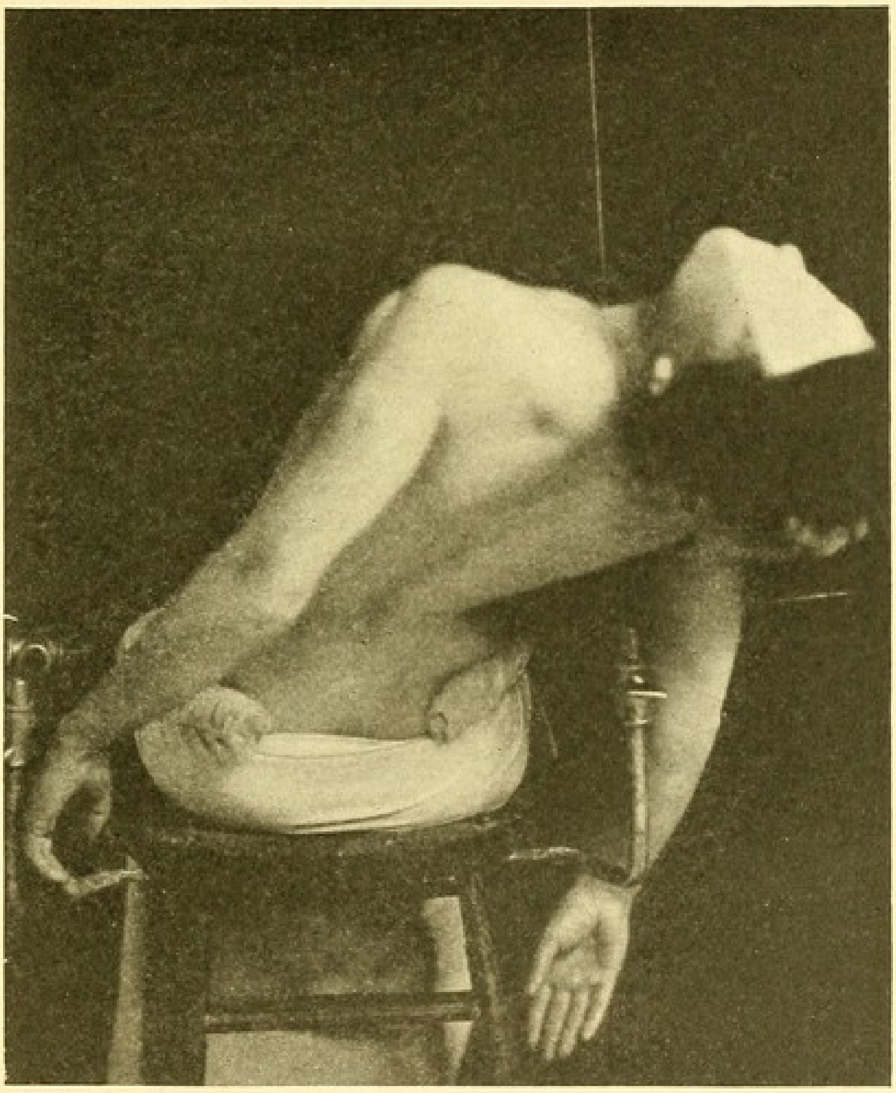


FIG. 25.—SIDE BENDING TO THE RIGHT IN THE HYPEREXTENDED POSITOIN OF THE SPINE IN THE MODEL.
The head is supported to secure steadiness.

the rotation element of the movement will be considered by itself. Under ordinary conditions it is essentially a movement of the dorsal and cervical regions in which the lumbar vertebræ take but little part except in hyperextension and with the use of traction. The lumbar vertebral region possesses some power of rotation, as has been generally observed.

Rotation in the Erect Position.—Rotation is freest in the erect position and is situated in the cervical and dorsal regions, reaching its maximum at the top of the cervical column and extending down the spine to the lower dorsal region, where it disappears. With very forcible rotation applied to the top of the column in the cadaver, the first and even the second lumbar vertebræ may be rotated. The rotation in this position is accompanied by a side bend of the rotated region away from the side to which the bodies of the vertebræ turn. If the rotation is to the right, it is accompanied by a lateral bend convex to the left and *vice versa*. In the model an active rotation to the right is accompanied by a displacement of the trunk to the left side and *vice versa*. If traction is applied to the head of the

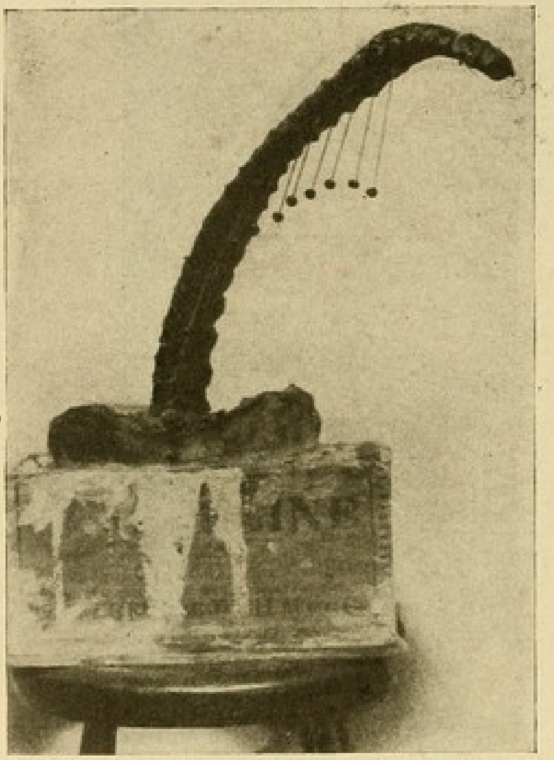


FIG. 26.—SIDE BENDING TO THE RIGHT IN HYPEREXTENSION IN THE COLUMN OF VERTEBRAL BODIES.

The same characteristics are shown as in the previous figure.

FIG. 27.—SIDE BENDING TO THE RIGHT IN THE HYPEREXTENDED POSITION OF THE SPINE IN THE CADAVER.

The movement occurs chiefly at and below the dorsolumbar junction, and the bodies of the vertebræ turn to the right, as shown by the pins. The lateral curve is convex to the left.

erect cadaver, forcible twisting of the head results in rotation of the lumbar vertebræ, including the fourth.

Rotation in the Flexed Position.—Rotation in the flexed position of the spine occurs chiefly in the cervical and upper dorsal spine, the lower dorsal and lumbar region seeming locked against rotating forces by the flexed position. The more extreme the flexion the more markedly in cadaver, model, and child is the rotation restricted to the cervical and upper dorsal spine.

Rotation in the Hyperextended Position.—In hyperextended positions rotation with moderate manual force occurs as a twisting of the whole thorax on an axis in the dorsolumbar region, the upper and middorsal regions apparently being locked against rotation by hyperextension. The site of rotating movement in this position is, therefore, in the one or two vertebræ above and the one or two vertebræ below the dorsolumbar junction.

Rotation, therefore, is located high in flexed positions, lower in erect positions, and is situated lowest and is more sharply localized, in hyperextended positions.

Side Bends Accompanying Rotation.—A lateral deviation of the spine accompanies all rotations. It is situated at the site of the rotation and is convex to the

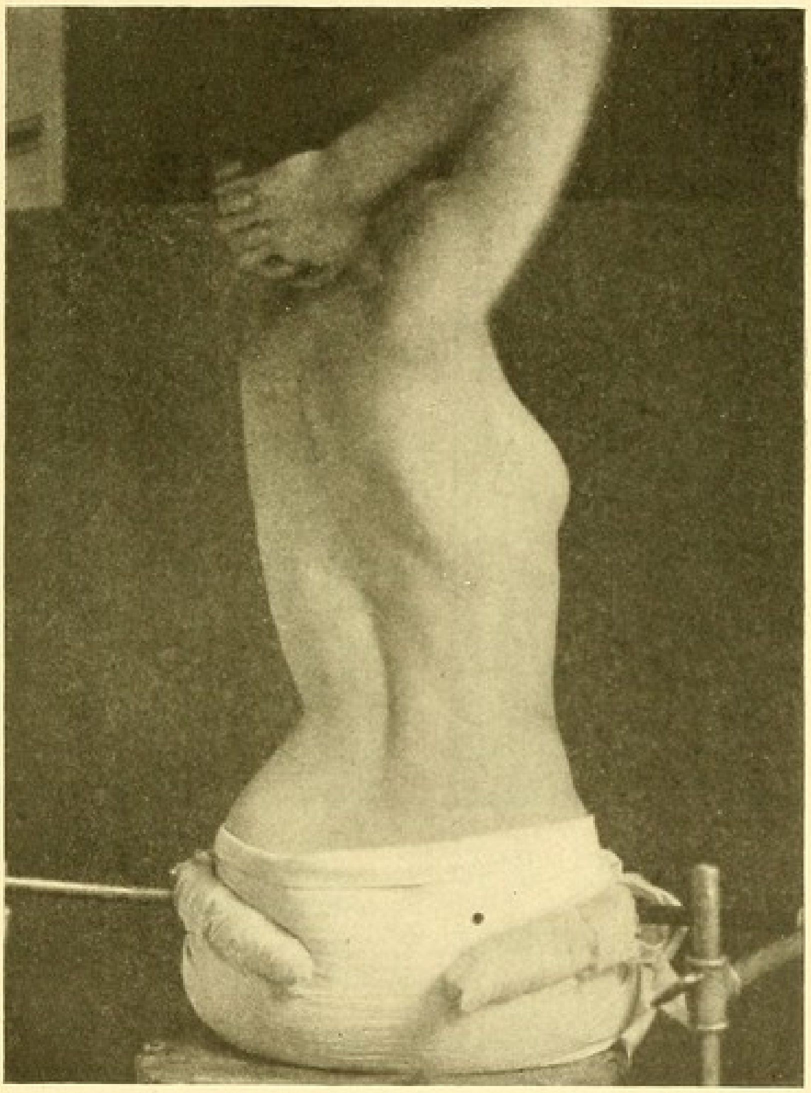


Fig. 28.—Rotation of the Model, Face to the Right, Causing a Dorsal Lateral Curve Convex to the Left and a Displacement of the Trunk to the Left.

right when the rotation is to the left and *vice versa*. In the erect position rotation causes a marked side curve in the dorsal region.

Reasons for Torsion.—It is obvious from these experiments that there must be some fundamental reason for the constant occurrence of one type of torsion for side bendings in flexion and the occurrence of another type in extension, as well as for the constant association of torsion with side bending. The vertebral column is a flexible rod capable of bearing great weight. It is not equally flexible in all directions, but it is, of course, capable of some movement in all planes, and, as such, should come under the control of the laws governing flexible rods in general. The extent of any of the movements of the spine is, of course, greatly influenced by the shape of the vertebral bodies, the curves of the spine, the character of the articular processes, the resistance of the ligaments, and the relative strength of the muscles.

From the mechanical point of view, torsion results from any motion of a straight flexible rod in which all the particles do not move in parallel planes. Consequently, if such a rod is bent in two planes at the same time, torsion must inevitably occur. The vertebral column is not a straight flexible rod, but one bent in physiological

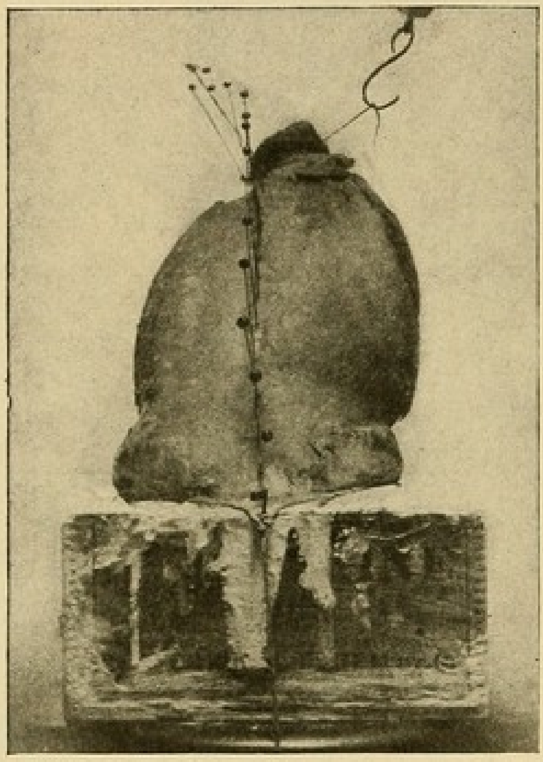


FIG. 29.—ROTATION OF THE SPINE OF THE CADAVER FACE TO THE RIGHT IN THE FLEXED POSITION OF THE SPINE.

The movement is seen to be located in the upper part of the column by the deviation of the pins.

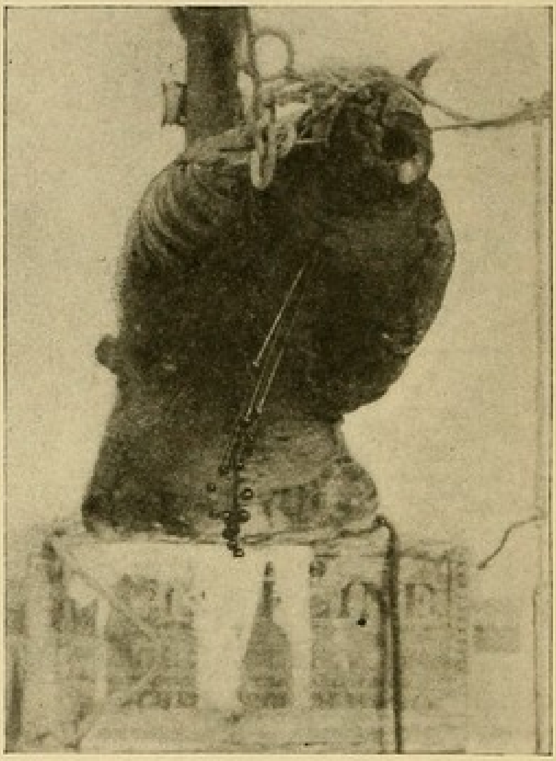


FIG. 30.—ROTATION OF THE SPINE OF THE CADAVER, FACE TO THE RIGHT, IN THE HYPEREXTENDED POSITION.

The movement is seen to occur in the lower part of the spine by the rotation of the pins.

curves in the antero-posterior plane; side bending must therefore inevitably lead to torsion, because it means bending in two planes. Nor does the fact that the intervertebral discs permit motion in all directions affect the question, because from a mechanical point of view the vertebral column behaves in general as it would if it were a homogeneous flexible rod.

A strip of sponge rubber, half an inch in diameter and 14 inches long, rotates in the same way that the vertebral column does in the same position. A lateral curvature, in what corresponds to the flexed position of the spine, may be produced in the rubber strip following the same rule of rotation seen in life; that is, the front of the rod turns toward the convexity of the lateral curve. An artificial lateral curvature in the rubber strip, made in what corresponds to the extended position of the spine, results in a reverse rotation to that from the rotation of the flexed position. A piece of rattan, a piece of rubber tubing, a strip of sponge rubber, round or square, the backbone of a fish, or the backbone of a cat, behave all in the same way, and rotate in the same direction as does the human spine.

Articular Processes.—Although it is easy to understand that the column of vertebral bodies by itself might easily behave as a flexible rod, yet the articular processes cannot be left out of account. They must be an important factor in determining torsion, and they must do one of two things. Either they must fall in with the behavior of the flexible column of bodies and severe to carry out the rotation which would occur without them, or they must obstruct or reverse the rotation which would occur in the column of vertebral bodies alone. Experiments seem to show that the articular processes merely serve to accentuate the same rotation that would be present if the column of vertebral bodies were by itself.

THE CERVICAL REGION.

Flexion.—It is possible to straighten the anterior physiological curve. Much of the apparent forward flexion in the cervical region in life is evidently due to the motion between the occiput and the atlas.

Hyperextension.—The physiological curve can be increased to a certain extent.

Side Bending.—Side bending is uniformly distributed throughout the cervical region and is accompanied by rotation of the bodies of the vertebra to the concavity of the lateral curve, as in the lumbar region.

Rotation.—Rotation is extremely free between the first and second cervical vertebræ, but for the rest of the region it is limited. Rotation is accompanied by a side bend convex to the side opposite to which the bodies of the vertebræ turn: that is, in a right rotation the curve is convex to the left.

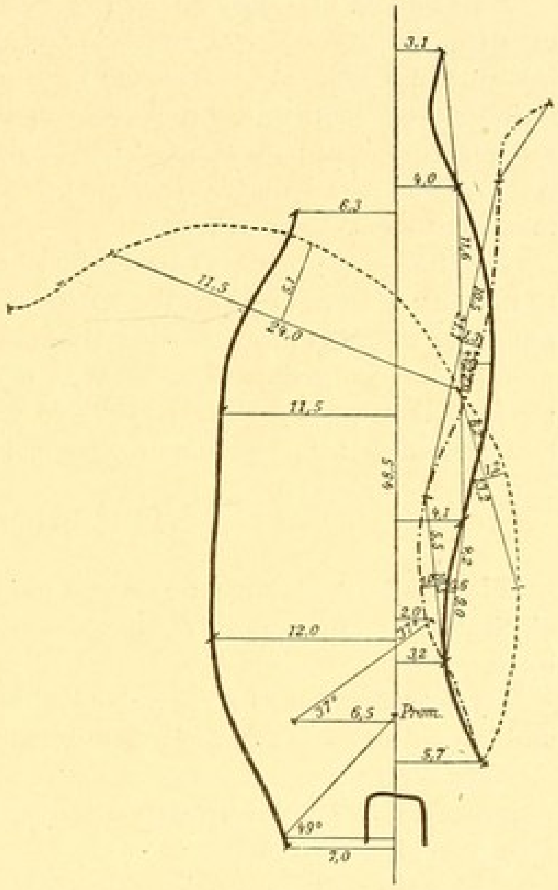


FIG. 31.—DIAGRAM OF THE SPINAL MOVEMENTS IN A LIVING CHILD.—(*Engelhard.*) The solid line shows the normal position, the dotted line the forward bent and the line of dots and dashes the hyeprextended position.

DORSAL REGION.

The dorsal region is the least mobile part of the spine as a whole. The twelfth dorsal vertebra from the point of view of function must be regarded as a lumbar vertebra and not as part of the dorsal region.

Flexion.—The dorsal spine already convex backward can be made somewhat more convex by forward bending, but the extent of the movement is not great and by no means comparable to the same movement in the lumbar region.

Hyperextension.—Hyperextension is a motion of very slight extent in the dorsal region. It consists of a diminution of the backward convexity and is most noticeable in the lower half of the region.

Side Bending.—Side bending of the dorsal region is a fairly evenly distributed movement of slight extent, presenting an even curve which is greatest in the mid-dorsal region. It is freest in the erect position or lying on the face. It occurs less markedly in flexed positions and least in hyperextension. Side bending here is always accompanied by rotation of the bodies of the vertebræ to the convex side of the lateral curve.

Rotation is the most marked of dorsal movements. It reaches its greatest extent in the upper dorsal vertebræ and diminishes toward the lower end of the region. In a rotation of moderate force in the upright position it extends to and includes the seventh or eighth dorsal vertebra. Rotation of the dorsal region is less easily accomplished in flexion than in the erect position and in hyperextension it is much limited, while in extreme hyperextension in the cadaver the dorsal rotation movement seems to be obliterated.

Rotation is accompanied always by side bending, the lateral curve being convex to the side away from which the bodies of the vertebræ turn. In a rotation of the top of the column to the left the lateral curve is to the right and *vice versa*.

The practical points to be borne in mind in the study of the dorsal region are the facts that rotation is freer than side bending, that hyperextension is extremely limited, and that the region on the whole is comparatively immobile.

LUMBAR REGION.

Flexion in the lumbar region is a movement of much freedom, but the physiological curve in the adult cadaver has not been obliterated in any case observed by the writer.

Hyperextension as a general spinal movement is essentially a lumbar motion and in that region is an evenly distributed bend.

Side bending is a free movement in the lumbar region and forms in the erect position a very evenly distributed curve; it is greatest in the erect position and least in extreme flexion.

The rotation accompanying side bending in the lumbar spine is always with the bodies turning to the concavity of the lateral curve; which is to be contrasted with the opposite rotation occurring in side bending in the dorsal region.

Rotation in the lumbar region is extremely limited and is diminished by extreme hyperextension and is least or absent in extreme flexion. The lumbar region possesses marked mobility in flexion, hyperextension, and side bending, and but little in rotation. Side bending is more free than rotation in contradistinction to the relation of these two movements in the dorsal region.

CERTAIN CONCLUSIONS AS TO THE MOVEMENTS OF THE THREE REGIONS OF THE SPINE.

1. In the lumbar region flexion diminishes mobility in the direction of side bending and rotation, and extreme flexion seems to lock the lumbar spine against these movements.

2. In the dorsal region hyperextension diminishes mobility in the direction of

side bending and rotation. Extreme hyperextension seems to lock the dorsal spine against these movements.

3. In flexion of the whole spine side bending is accompanied by rotation of the vertebral bodies to the convexity of the lateral curve, the characteristic of the dorsal region.

4. In the erect position and in hyperextension of the whole spine side bending is accompanied by rotation of the vertical bodies to the concavity of the lateral curve, the characteristic of the lumbar region.

5. The dorsal region rotates more easily than it bends to the side, whereas the lumbar region bends to the side more easily than it rotates.

6. Rotation in the dorsal region is accompanied by a lateral curve, the convexity of which is opposite to the side to which the bodies of the vertebræ rotate.

These conclusions are true of the normal spine, but they do not necessarily apply to a deformed scoliotic spine. The nearer a scoliotic spine approaches the normal, the more likely are they to apply without modification.

CHAPTER III.

MECHANISM OF SCOLIOSIS.

The Mechanics of the Upright Position (Balance).—The spine is a curved, segmented, weight-bearing rod resting in unstable equilibrium on the sacrum, which forms part of a bony ring balanced on the hip-joints. Its upright position is due to a sense of balance possessed by the living individual, for if the cadaver is placed in the upright position it falls on account of the absence of muscular action. This sense of balance expresses itself in a muscular contraction by which the living individual keeps his center of gravity over the center of support. It is reflex and instinctive, and the individual has no knowledge of it as such any more than he has of the mechanism of breathing or swallowing.

The living individual, therefore, keeps his spine erect, first, because he has a sense of balance, and, second, because he has a muscular system which responds to his instinctive nervous impulses and carries out of itself the necessary muscular adjustment which is too complicated to describe or formulate. This instinctive sense of balance and equilibrium must be regarded as an attribute of the erect living individual, and must be given a place in the study of scoliosis. It is effective in two directions:

1. The erect person instinctively strives to keep the head approximately over the middle of the pelvis, that is, in the sagittal or antero-posterior median plane of the body.

2. The erect person instinctively strives to keep the face to the front and the shoulder-girdle approximately in the same plane as the pelvis, *i.e.*, in the frontal or lateral plane of the body.

This adjustment, especially the element which seeks to keep the shoulder-girdle in the same plane as the pelvis while disturbances twisting the column below are taking place, is an important factor in explaining the phenomena of scoliosis, as will be seen later.

The body is, however, not a firm mass, but consists of segments joined together, one segment resting upon the other, and firmly connected by a tube made up of muscles, fasciæ, and integument.[1] Since

[1] Feiss: "Amer. Jour. Orth. Surg.," iv., 1, 37.

to maintain the erect attitude the line of gravity must pass through the base of support, so in all positions in which balance is maintained there is a constant equilibration by means of shifting segments.

It is necessary at this place to introduce certain elementary points in mechanics which are familiar to every one.

These points are the following:

1. The base of support of the upright human figure consists of a trapezoid formed by the outer borders of the feet and lines connecting the back of the heels and the front of the toes.

2. The center of support lies perpendicularly under the center of gravity and in the erect position must always lie within this trapezoid.

3. For the purpose of studying the mechanism by which any weight is borne by a solid body in unstable equilibrium, the entire weight may be regarded as concentrated in the center of gravity, and the determination of the relation between the center of gravity and the bearing points determines the lines of stress.

The Defects of the Upright Position.—An important matter in the mechanics of the spine and its appendages is that it is evolved with comparatively slight modifications from the quadruped spine and in fact is hardly more than the quadruped spine set upright. In the quadruped the spine is a horizontal sustaining structure arched upward, supported at one end by two anterior limbs and at the other by two posterior limbs; the viscera hang directly down from this, being supported by ligaments and attachments at right angles to the supporting structure. On account of the angle of the ribs the thoracic cavity is helped in inspiration by gravity as the ribs fall into the position of thoracic expansion, but they must be pulled up to contract the thorax; and, finally, equilibrium is much more easily maintained than in the biped, because the supporting base is broad and the weight of the mass to be supported is comparatively small.

When this structure with only comparatively slight modifications is set on end and made to fulfil the functions of a weight bearing column in a plane at right angles to that for which it is best adapted, certain unfavorable factors are introduced which serve as distinct limitations. The column constructed to bear weight and sustain strain at right angles to its long axis must now bear weight and sustain strain in its long axis. The two anterior limbs which formerly served as props, now hang as dead weights to be supported by the column. To maintain equilibrium much greater muscular effort is necessary to maintain functional balance in the man than in the quadruped. The viscera hang no longer at right angles to the supporting structure, but in the line of its long axis. The thorax to expand has to raise all the ribs and work against gravity.

But what is most important in the present connection is the fact that the upright position is decidedly hard to maintain, because the base of support is so small and the height of structure to be supported is relatively so great.

This structure from a mechanical point of view consists of two vertical legs attached to a horizontal pelvis in the middle of which is set an upright column expanding into a bony cage carrying the weight of arms, head, and thoracic contents. All the weight comes down through a single column, the lumbar region of the spine, which column rests upon the middle of the pelvis. Such a structure is one necessarily susceptible to disturbances of balance, and it will yield to such disturbances by assuming abnormal curves either lateral or antero-posterior.

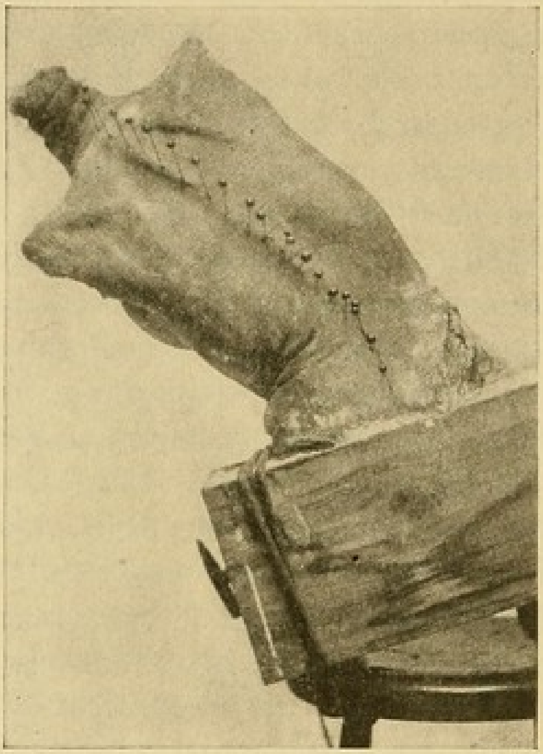


Fig. 32.—The Right Side of the Pelvis of the Cadaver is Raised and the Upper Part of the Spine Falls to the left, Making a Lateral Curve Convex to the Right.

Relation of Balance to Curves.—If the pelvis of a cadaver is raised on the right side and the upright spine is left free to move, the top of the column falls to the left and the spine is curved convex to the right. This is the position induced by gravity. If, on the other hand, the right side of the pelvis of a living model is raised and the upright spine is left free to move, the top of the column remains upright and the spine is curved in the opposite direction, convex to the left. This is the position of balance overcoming the position induced by gravity. The sense of equilibrium has worked against the force of gravity and has reversed the position natural to the cadaver. Anything which causes any part of the body to be held in an asymmetrical position will cause a lateral deviation of some part of the spine, because a straight erect spine in the sagittal plane is possible only when the person stands, on both feet or sits erect with the arms in similar positions and the head pointing straight ahead. Every step, every raising of the arm, every tilting of the head is accompanied by a deviation of the spine from the median plane of the body: in other words, by a temporary lateral curve which disappears as the symmetrical attitude is resumed.

If there is a visual error that causes the head to be held obliquely; if there is a short leg causing the pelvis to be no longer horizontal but

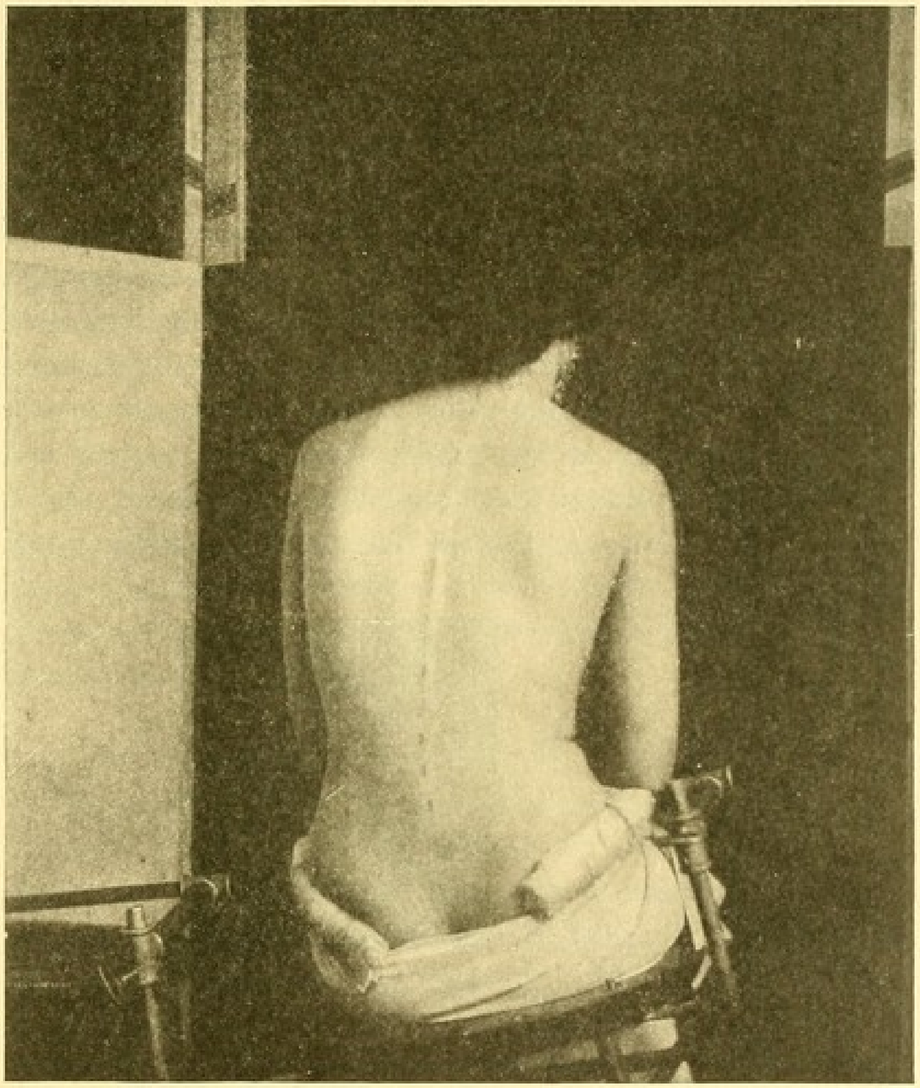


FIG. 33.—THE RIGHT SIDE OF THE PELVIS OF THE MODEL IS RAISED AND THE UPPER PART OF THE SPINE IS CARRIED TO THE RIGHT, MAKING A LATERAL CURVE CONVEX TO THE LEFT. (Cf. Fig. 44.)

slanted; if the muscles of one side of the back are paralyzed, there must be a constant compensation or curve which will still enable the center of gravity to be held over the center of support. When such a curved position becomes habitual for any of the reasons given or for other reasons, there exists in the adaptive character of bone a reason why this constantly assumed malposition should make a change in the shape of the bones in a growing child and that these changes should become fixed.

Plasticity of Bone.—The adaptability of bone to pressure has been recognized in general and has been formulated and forms one aspect of what is often spoken of as Wolff's[1] law, which may be expressed briefly as follows: "Every change in the formation and function of the bones or of their function alone, is followed by certain definite changes in their internal architecture and equally definite secondary alterations of their, external conformation in accordance with mathematical laws."

The phenomena of lateral curvature have become somewhat more comprehensible since we have understood that bone is a plastic and adaptable structure adapting itself to the demands on it, following in its growth the lines of least resistance, and in children susceptible to great changes in shape from abnormal conditions. As an instance of this may be mentioned the great distortion of the shape of the bones in the Chinese lady's foot produced by bandaging. It is not necessary to multiply them, for we have direct experimental proof of the case in question in the experiments of Wullstein and Arnd.

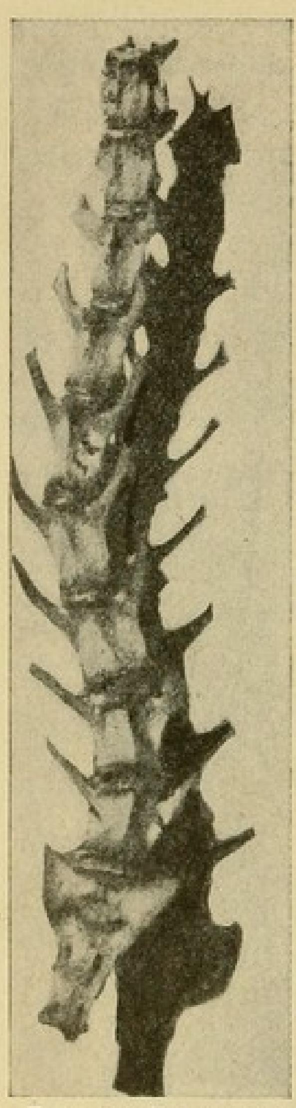


FIG. 34.—EXPERIMENTAL SCOLIOSIS IN A RABBIT PRODUCED BY CUTTING THE ERECTOR SPINÆ MUSCLES.—(*Arnd.*)

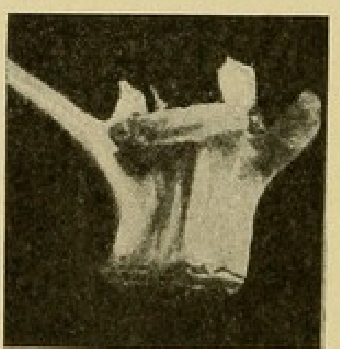


FIG. 35.—FIFTH LUMBAR VERTEBRA FROM EXPERIMENTAL SCOLIOSIS IN RABBIT.—(*Arnd.*)

Wullstein[2] showed, by bandaging young dogs for months in posi-

[1] Wolff: "Das Gesetz der Transformation der Knochen," Berlin, 1892; Freiberg: "Am. Jour. Med. Sci.," Dec., 1902; "Animal Mechanics," by Sir Charles Bell and J. Wyman, Cambridge, 1902.

[2] "Zeitsch. f. orth. Chir.," x, 2.

tions with the spine bent laterally in some and in others bent backward, that a permanent bony deformity occurred which could not be removed by traction in the length of the spine after death. A section of these columns showed wedge-shaped deformity of the vertebræ with a "lipping" or overgrowth of the borders of the vertebræ on the concave side of the curve, the trabeculæ being thickened on the side of the bodies toward the concavity. The changes were more marked at the articular ends of the bones than in the middle of them.

Arndt[1] produced similar permanent curves characterized by bony deformity and marked rotation in rabbits by extirpation of the erector trunci muscles on one side. They showed, as in Wullstein's experiments, that the changes are greatest at the articular ends of the bodies, and the epiphyseal plates in the most deformed vertebræ clearly overlap the sides of the body.

The point to be remembered is that, the erect position is a singularly unstable one and temporary lateral deviation of the spine occurs in almost every body movement. If such deviation becomes permanent for any reason it must further be remembered that growing bone is a plastic structure and that the spine will tend to conform its bony shape to the abnormal position. Here then exists the mechanism for the requirement of bony lateral curvature if sufficiently long continued. There are of course many other causes of lateral curvature which will be mentioned.

TYPES OF LATERAL CURVATURE.

There are two types of malposition commonly described as lateral curvature or scoliosis. This is unfortunate and leads to misunderstanding and confusion. In one, the position is that which any normal spine may assume; in the second, the position is one that the normal spine cannot assume, a position which implies a change in the shape of the bones.

It would add much to a better understanding of the subject if the former were called faulty attitude or some similar name, and the term scoliosis were reserved for the latter form.

The first is due to the adjustment necessary to keep the balance of the spine in the presence of one of the disturbing causes mentioned. If this becomes habitual, it results in a typical attitude to be described as *total* or *postural lateral curvature* in the chapter on Description and Symptoms. This attitude may persist as such or change to the second form to be described next.

[1] "Archiv. f. orth. Chir.," i, 1, 2.

The second type of lateral curvature is accompanied by a change in the shape of the bones and soft parts. It cannot be reproduced experimentally in the model, cadaver, or child, and is not within the physiological limits of the spine. It must, therefore, be classed as *structural* or *organic lateral curvature.* The characteristic feature is a local backward prominence of the ribs or lumbar transverse processes in the curved region, which is called "bony rotation."

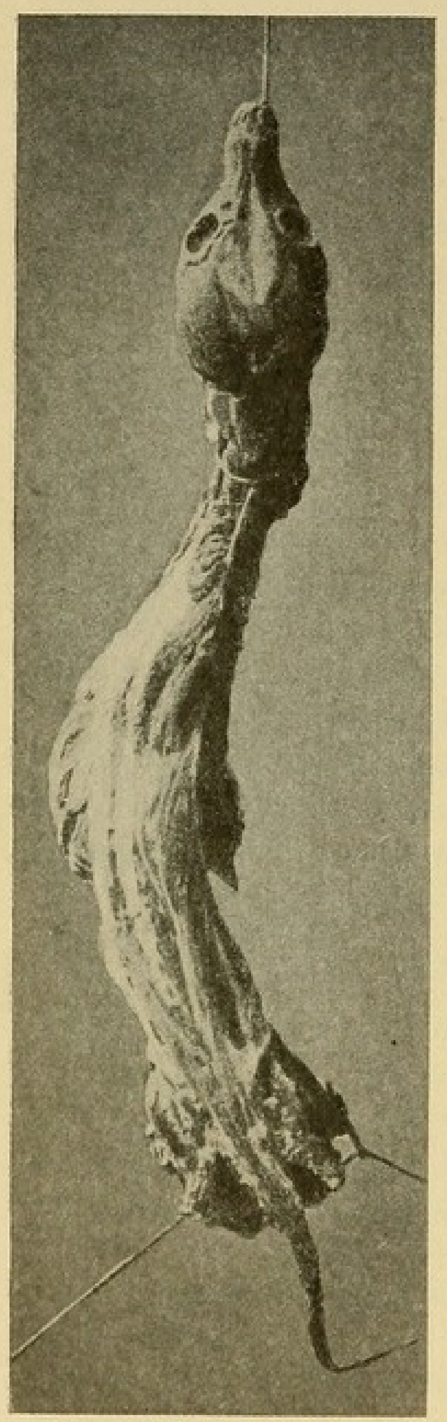


Fig. 36.—Experimental Scoliosis in a Young Dog Produced by Bandaging in a One-sided Position.—(*Wullstein.*)

Bony Rotation.—The reason that bony rotation or twisting of the vertebral bodies always accompanies organic lateral curvature has been widely discussed from every point of view, and the question has been much complicated by the abstruse reasoning applied to its solution. The facts seem to be these: the vertebral column is a flexible weight-bearing rod curved in the antero-posterior plane by the physiological curves. In a column affected by lateral curvature it is now beginning to be curved to one side in some part of its length for reasons which will be discussed later. Growing bone it has been stated is a plastic structure and will yield to unequal conditions of weight or strain. This curved part of the column being subject to unequal conditions of weight on the two sides tends to yield to the side and to change its structure in accordance with the unequal conditions of weight.

But a plastic weight-bearing column already curved in one plane cannot yield in another plane (*i.e.*, to the side) without twisting, and in this twist the vertebræ can turn in only one way, namely, away from the greatest weight and pressure which is of course on the concave side of the lateral curve. If they were to turn toward the middle line instead of away from it they would encounter the greater resistance and have to raise the whole weight of the parts above them. In so far as they are plastic they will be compressed where the weight is greatest or on the concave side. The deformity of the vertebræ is therefore due to their plasticity yielding to conditions of unequal strain, and turning where they must to escape.

Double Curves.—The explanation of a double curve is more difficult. It has been observed that frequently a double organic curve grows out of a single functional one, the reason for which will be explained in the chapter on Description and Symptoms. It cannot be said that every case of organic double curve has first been a single postural one, for congenital, early rachitic, and other cases make that unlikely, but the mechanism is present for forming double curves from single ones under the influence of existing conditions. The occurrence of bony change in some cases and the persistence of functional curves in others can only be explained by assuming a plasticity of the bones in certain individuals which does not exist in the bones of others.

The chain of events in the cases where a single curve changes to a double one is then, first, a disturbance of the symmetry of the body and the appearance of a functional curve; second, the persistence of this curve from the same causes that started it, the phenomena being still within the normal mechanism of the spine; third, the yielding of plastic vertebræ in the line of least resistance and the appearance of rotation on the convex side of the lateral curve; fourth, the formation of double curves from single ones by the normal mechanism of the spine originating in the sense of balance and adjustment. It seems that in many cases, perhaps the majority, these steps cannot be traced, but coincide in time.

CHAPTER IV.

DESCRIPTION AND SYMPTOMS.

SYNONYMS.

English: Scoliosis, lateral curvature of the spine, rotary lateral curvature of the spine.

German: Skoliose, seitliche Rückgratsverkrümmung, Kypho-skoliose.

French: Scoliose, deviation latérale de la taille.

Italian: Scoliose.

Scoliosis, or lateral curvature of the spine, is the name applied to a condition in which any series of vertebral spinous processes shows a constant deviation from the median line of the body, a deviation always accompanied by an element of twisting. In certain rare cases the twisting may be the predominant appearance. Deviation of a single vertebra from the median line does not constitute scoliosis.

Although scoliosis is generally studied and classified as a deformity of the spine, the laws of equilibrium of the body are such that any deviation of the vertebral column must disturb the whole balance of the body, and scoliosis is therefore accompanied by compensating lateral displacement of the pelvis and legs. In this wider sense scoliosis is to be regarded as a deformity of the whole body, especially manifest in the spine.

Lateral curvature of the spine has for its chief clinical characteristic a distortion of the symmetry of the body for which the patient or her parents seek advice. It is not generally recognized by the laity as a spinal distortion, but the patient is brought for surgical advice because of "a high shoulder," "a prominent hip," or "a projecting shoulder-blade." Very often the dressmaker is the first to recognize it because she finds that she must make the skirt longer on one side than on the other, or because the distance from the armhole of the waist to the waistband is longer on one side than on the other.

The condition is essentially a distortion, and symptoms other than the deformity are rather unusual in average cases. Occasionally the patient complains of feeling "one-sided," but this is rare. *Pain* is generally not complained of, but in neurasthenic young women, especially with functional curves, backache may be felt more or less on standing. Pain in the severer cases is caused by the descent of the ribs to the level of the crest of the ilium against which the lower ribs may rub, and severe local pain may be felt. In other severe cases, nerve-root pressure may result from the distortion and be referred to the peripheral ends of the spinal nerves.

The shortening of the trunk and the diminished capacity and immobility of the thorax may lead to impairment of the function of thoracic and abdominal organs, and in severe cases this must result to some extent. Shortness of breath is common in such cases on account of diminished respiratory capacity and displacement of the heart and phthisis frequently occur in severe cases during adult life. Disturbances of digestion are also frequent from displacement of the stomach and liver. Impairment of vigor and of the general health generally result in severe cases in adult life, although children with severe curves as a rule suffer less deterioration of the general condition.

It is not uncommon for patients to go through life with curves of moderate degree which have given rise to little or no trouble; but after the age of fifty or sixty, when atrophy of the intervertebral discs has become marked, such curves may increase and give rise to a sense of asymmetry or to pain in the back or at nerve terminations. It can generally be predicted that a curve of moderate severity may be more troublesome in later adult life.

TERMINOLOGY.

The terms used in describing lateral curvature must be defined. Curves are named right or left according to their convexities, curves convex to the right being called right curves and *vice versa*. In addition to the terms right or left, the curves are named also according to the anatomical region involved in the curves. If a deviation involves the whole spine, it is called a total curve; all other curves are called cervical, dorsal, or lumbar, according to the region involved, with the qualifying adjective right or left preceding the anatomical name. If a curve involves more than one region, it is classed as cervicodorsal or dorsolumbar. If two curves exist, the upper curve is spoken of first and the lower follows, *e.g.*, right cervicodorsal, left dorsolumbar; or right dorsal, left lumbar.

It is important that the anatomical region affected by the curve be designated accurately and not loosely. For this purpose the seventh cervical and last lumbar vertebral spines are marked on the skin and connected by a string representing the long axis of the spine. Parts of the spine lying to the right of this line are to be classified as right curves, parts to the left as left curves. Such curves must be assumed to begin and end where they pass under this string. For example, if the spine from the seventh cervical to the twelfth dorsal is to the right of the line and below it is to the left, it is a right-dorsal, left-lumbar curve. If the spine from the fourth dorsal to the third lumbar is to the right of the line, it is a right dorsolumbar curve.

This, therefore, provides for a simple rule for the naming of every curve, insisting on the fact that the location of the upper end of the column has nothing to do with the naming of the curve. The upper end of the spine may be in the median plane or at either side of it, without affecting in any way the recognition and description of the spinal curves.

The classification of curves into primary and secondary or compensatory, is not of great importance, nor is it sound, as one cannot always say which curve was really primary. Often it is obvious that one curve is predominant and evidently the one to be attacked in treatment. In other cases this cannot be done, as the curves are of equal degree and importance so far as can be seen. It is, however, of importance to recognize the predominant curve where possible. For example, in a marked and predominant right dorsal curve it matters but little, practically, whether a slight lumbar curve exists or not; for purposes of treatment the case is a dorsal curve. In general, rational treatment must eliminate unimportant factors and deal with the salient ones.

The former division of lateral curvature into stages has no rational basis. It is a progressive affection passing over only one sharp line, the transition from postural or functional curves to structural or organic ones. This classification of functional and structural will, therefore, be adopted here with slight emphasis on a certain puzzling type of cases evidently in the transitional stage from the functional to the structural type.

FUNCTIONAL SCOLIOSIS (TOTAL SCOLIOSIS; POSTURAL SCOLIOSIS).

The term "total scoliosis" is applied to cases where the spine forms one gradual curve to one side without marked rotation or compensatory curves. In 90 per cent. of such cases the curve is to the left. According to the figures of Scholder and at the Children's Hospital clinic, right total scoliosis is very rarely seen, while the left curve is very common. The greatest point of deviation, *i.e.*, the apex of the curve, is generally found at the ninth or tenth dorsal vertebra, but it may be found in any part of the lower half of the dorsal or upper half of the lumbar region.

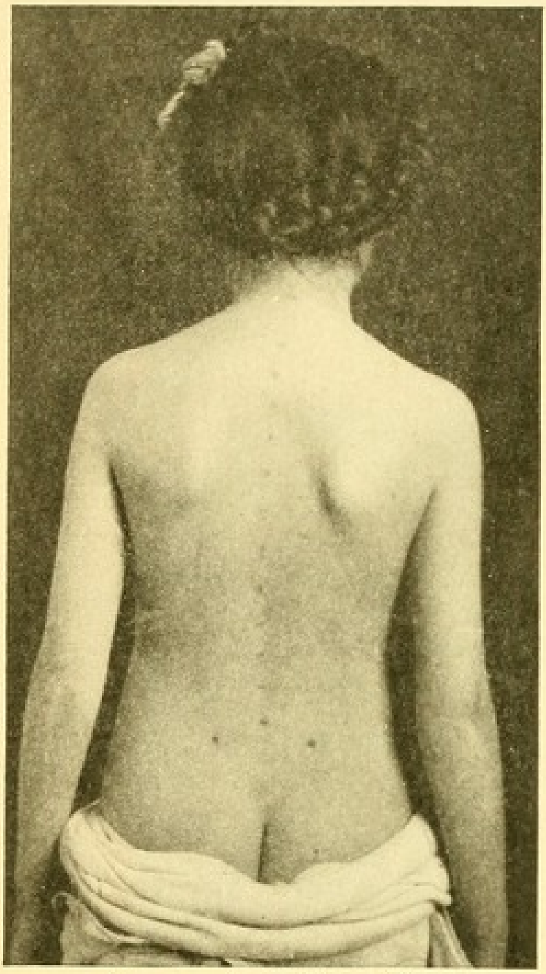


FIG. 37.—LEFT TOTAL CURVE.

In frequency of occurrence total scoliosis stands in the fourth place in the records of the institute of Lüning and Schulthess, where patients came for treatment, forming but 15.39 per cent. of the entire number of lateral curvatures. As to sex, the percentage shown in these cases is 24 for males and 17 for females. In boys the number of total scolioses increases steadily with age, but in girls a decrease is noted after the twelfth year, coinciding with an increase in the number of left lumbar curves. Total scoliosis is found between the ages of five and eighteen years, as a rule.

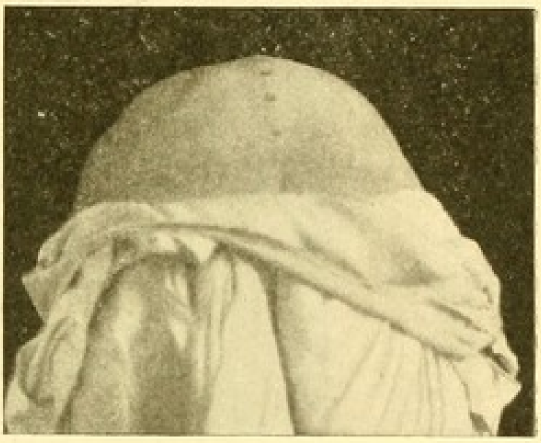


FIG. 38.—LEFT TOTAL CURVE BENT FORWARD, SHOWING PROMINENCE OF BACK ON THE RIGHT (SAME PATIENT AS FIG. 37.)

The deviation at the greatest curve is not often over an inch and a half from the median line of the body. There is no obvious compensatory curve, and the untrained eye is likely to find slight cases normal. There is, however, a perceptible displacement of the trunk to the left, especially as seen from the front, and a plumb-line suspended in the median line of the body will detect a decided deviation of the marked spines from the median plane. The typical characteristics of a left total scoliosis are as follows: (1) *A general curve convex to the left;* (2) *the* *left shoulder is elevated;* (3) *the right side of the shoulder-girdle is carried back and the left side forward;* (4) *when the patient bends forward the right side of the back may be slightly higher than the left.* Any case which simulates a left total curve and in which these signs are not all present should be subjected to the closest examination and will probably be found to be transitional in character. Functional curves disappear on suspension or recumbency, and side flexibility is but little limited, bending to the left being perhaps somewhat restricted. In cases of right curves the description is reversed.

The changed relation of the shoulders to the pelvis is more evident in children with marked lumbar physiological curves than in cases with round backs.[1]

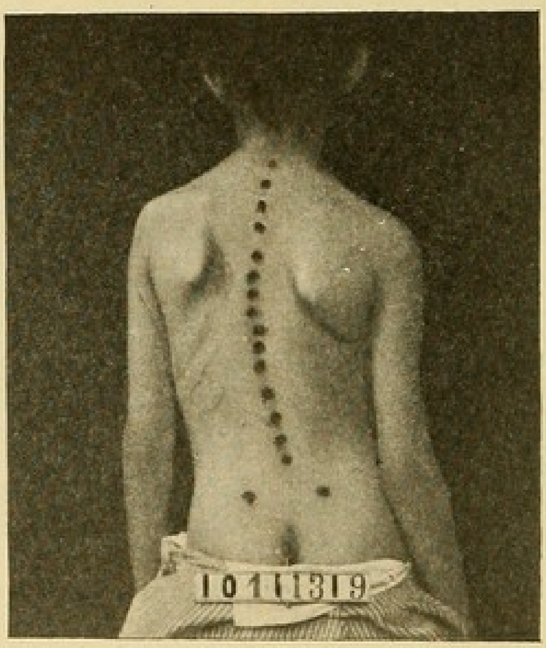


FIG. 39.—LEFT TOTAL CURVE. THE PATIENT FROM WHICH RADIOGRAM WAS TAKEN.

The position in a typical functional total curve is merely the physiological one necessitated in every normal spine for any reason made convex to the left, and can be produced experimentally by putting a book under the right foot, which raises the right side of the pelvis and necessitates for balance a left convex curve of the spine. A spine making any bend convex to the left in the erect position will turn at its upper end to the right, as explained in the movements of the spine. The thorax and shoulders will be twisted backward on the right, and when the patient bends forward, this twisted position of the shoulders

[1] Schulthess: "Zeitsch. f. orth. Chir.," vi, 399–566, 1902.

may be carried over into the position of forward bending, if the case has been of long standing, and the right side of the back will be higher

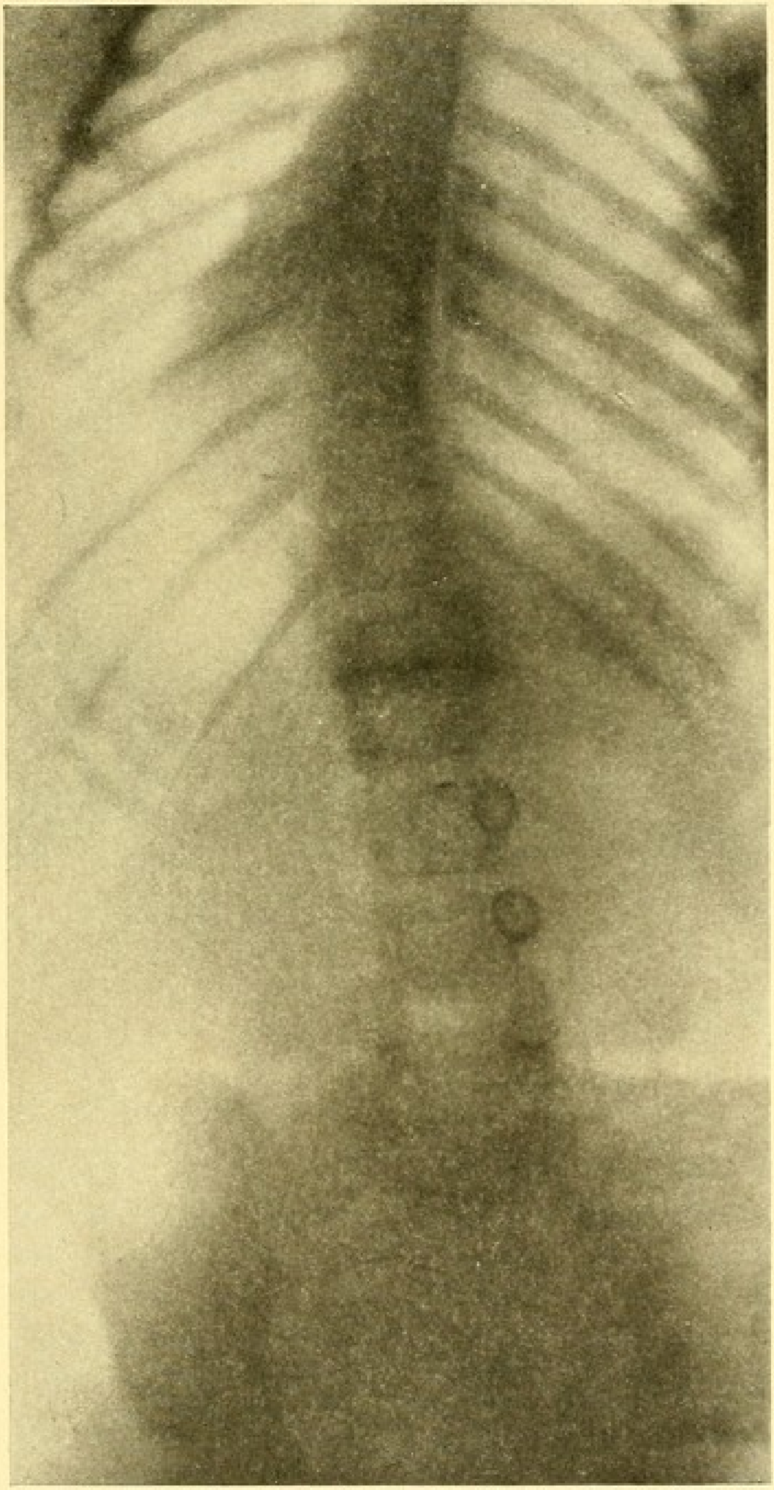


FIG. 40.—RADIOGRAM OF TOTAL CURVE IN PATIENT SHOWN IN FIG. 39.

in this position. This "reverse rotation," "concave torsion," "retro-torsion," as it has been called, has been much discussed[1] and is an

[1] Schulthess: "Zeitsch. f. orth. Chir.," x, page 489.

accompaniment of total scoliosis, but it is a physiological matter easily understood by studying the mechanics of the normal spine. It has been claimed that total scoliosis is really a triple-compound curve,[1] and that the torsion to the concave side is really due to a slight right dorsal curve; x-rays of such cases taken in the standing position show, however, in many cases, a gradual curve to the left without compensating curves (Fig. 40); in other cases apparently total curves in x-rays taken in this way seem to be transitional cases.

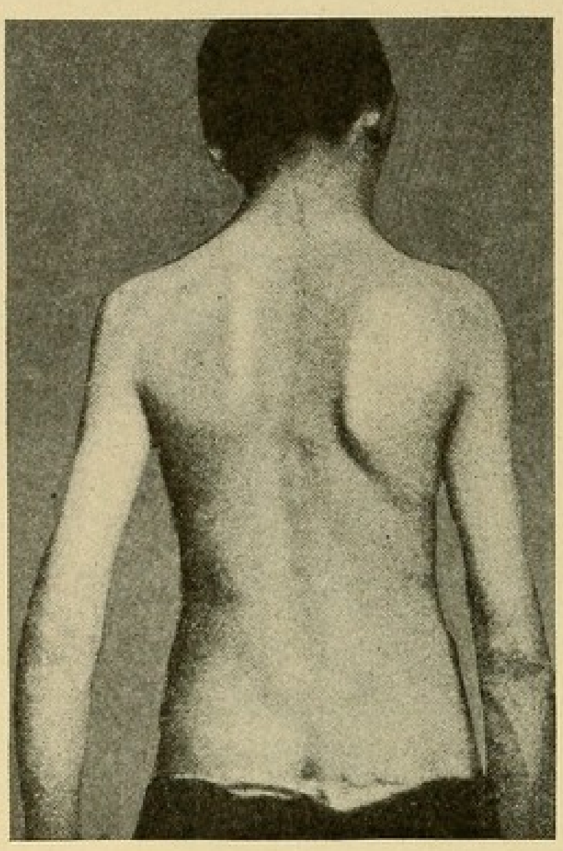


FIG. 41.—CASE OF "PARADOXICAL DORSOLUMBAR SCOLIOSIS" FIGURED BY WILBOUCHEWITCH. (Compare Figs 37–39.)

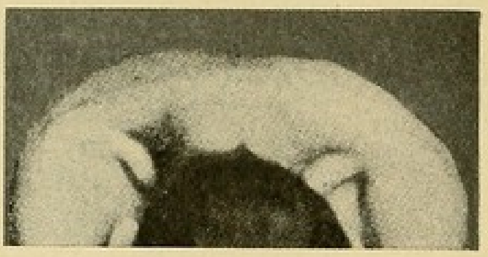


FIG. 42.—SAME CASE AS IN FIG. 47 BENT FORWARD SHOWING PROMINENCE OF RIBS ON RIGHT SIDE WITH LEFT CURVE.—(*Wilbouchewitch.*)

TRANSITIONAL CURVES.

In many cases which on first inspection appear to be postural, more careful examination will show that the curve is obviously changing from the postural to the structural type, *i.e.*, is beginning to show changes of structure.

In such transitional cases the upper part of the spine is less curved than the lower, and one or more of the characteristic signs of postural curves are most often wanting. For example, the right shoulder may be elevated in a left curve, or the left side of the back may be prominent upward in forward bending, or the left shoulder may be carried forward. Such cases must, of course, be recognized as early structural cases, but are so nearly postural that they may be wrongly classed

[1] Reiner and Werndorff: "Verhandl. Deut. Gesel. f. orth. Chir.," 1906, page 232.

unless identified. It is not exceptional to notice that in a curve that has been clearly a typical left postural one, a few months later the dorsal spine is straightening and even becoming slightly curved to the right, while the twist of the shoulder-girdle has disappeared or become reversed.

The mechanism of this is as follows:

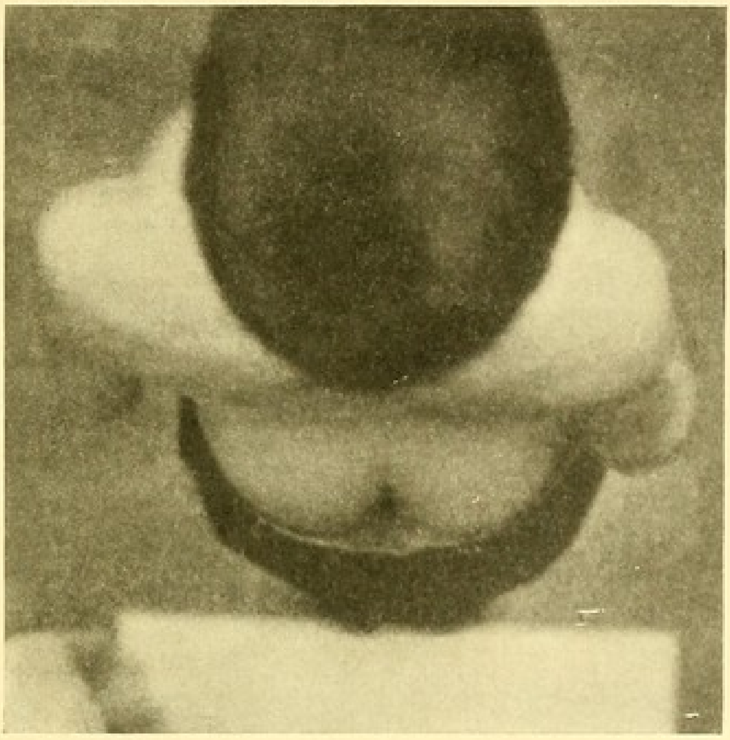


FIG. 43.—BOY WITH LEFT TOTAL SCOLIOSIS PHOTOGRAPHED FROM OVERHEAD, SHOWING THE CARRYING BACK OF THE SHOULDER GIRDLE ON THE RIGHT.
The front edge of the board on the floor marks the lateral plane of the pelvis.

Mechanism of Transitional Curves.—If total scoliosis tends to increase, it must do so by an increase of the existing side bend and of the existing twist, since both are correlated, not necessarily of both in exact proportion, but to some extent both factors must share in it. The shoulder-girdle will, therefore, be more twisted as the lateral curve increases. One, however, does not see the condition clinically of extreme left total curve and extreme right backward rotation of the shoulder-girdle except, possibly, in cicatricial, hysterical, or paralytic cases. An adjustment apparently takes place when the tendency of the total curve to increase passes beyond a certain point. For the explanation of this, one naturally looks to the instinctive tendency to equilibrium and balance spoken of as an intrinsic property of the upright living spine. There must be going on at all times this effort to sqare the shoulder-girdle with the pelvis and to keep the head and upper spine as nearly as possible in the median line of the body. This adjustment will naturally occur where the spine offers the least resistance to it, and as individual vertebral columns vary, the compensatory adjustment will take various forms.

Assume that a child stands and sits with a left total curve. He will, after a certain point in the deformity is reached, be continually striving instinctively and unconsciously to twist the upper part of his spine and his shoulder-girdle forward on the right and to bend the upper part of his spine convex to the right to restore his balance. We have seen that the dorsal spine twists more easily than it bends to the side. He is, therefore, more likely to twist his dorsal spine than to bend it to the side. He will, for this reason, twist the upper dorsal spine to the left, which twist, as we have seen, necessarily carries with it a dorsal lateral curve convex to the right.

The tendency to correct the twist of the shoulder and upper end of the spine is sufficient to explain the transition of a left total curve to a right dorsal, left lumbar curve. Such a double curve can be reproduced experimentally in the cadaver, the model, and the child by inducing a left total curve and adding a twist, active

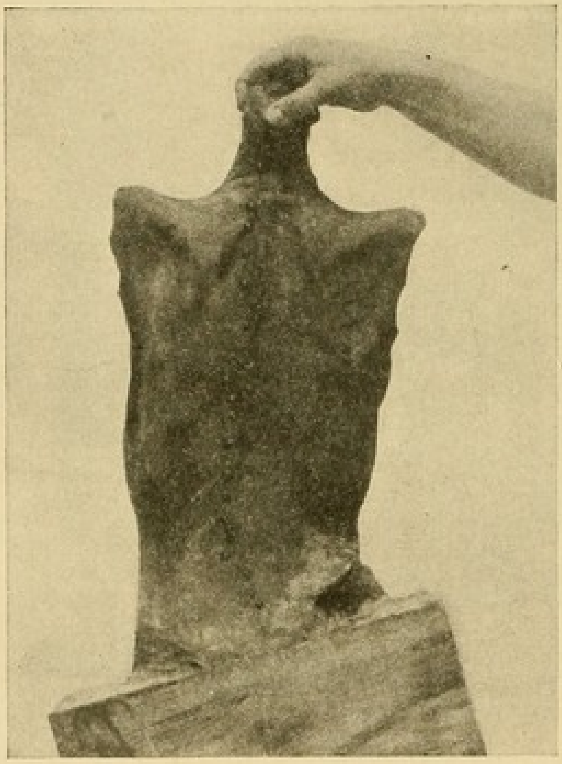


FIG. 44.—THE UPPER END OF THE SPINE OF THE CADAVER IS HELD BY THE HAND OVER THE MIDDLE OF THE PELVIS, WHILE THE RIGHT SIDE OF THE PELVIS IS RAISED, AND A POSITION LIKE THAT OF THE LIVING MODEL IS PRODUCED WITH A LATERAL CURVE CONVEX TO THE LEFT. (Cf. Fig. 33.)

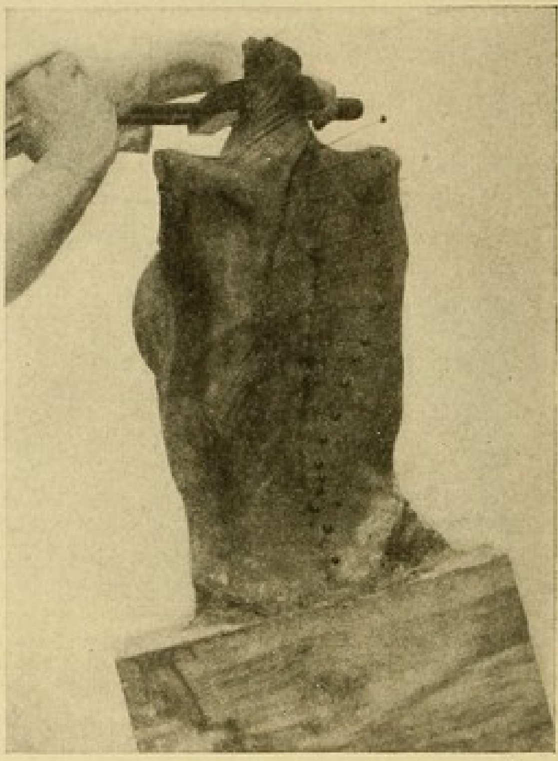


FIG. 45.—EXPERIMENTAL DOUBLE CURVE (RIGHT DORSAL, LEFT LUMBAR) PRODUCED IN THE CADAVER BY ELEVATING THE RIGHT SIDE OF THE PELVIS AND TWISTING THE UPPER END OF THE SPINE, FACE TO THE LEFT.

or passive, of the shoulder-girdle forward on the right. A right dorsal, left lumbar lateral curve then exists.

Support is given to this idea by the fact that in structural right dorsal, left lumbar curves with bony rotation, one is likely to find in looking down upon the standing patient that the left side of the shoulder-girdle is seen to be carried backward in its relation to the pelvis and the right side forward, which, of course, is the reversed position to that seen in the left total curve. The same relation of the shoulder-girdle is to be noticed in single curves to the left which are accompanied by bony rotation, the position again being the reverse of that seen in left total scoliosis.

The disappearance of concave-sided torsion which has once existed in any part of the spine may indicate that the compensatory change has already begun and that the so-called total scoliosis has begun on its transition to a compound curve.

We should, therefore, regard with suspicion any case of apparent total scoliosis that shows any departure from the clinical type described (see page 46), such cases probably having entered on the stage of transition.

That left total curves most frequently change to right dorsal, left

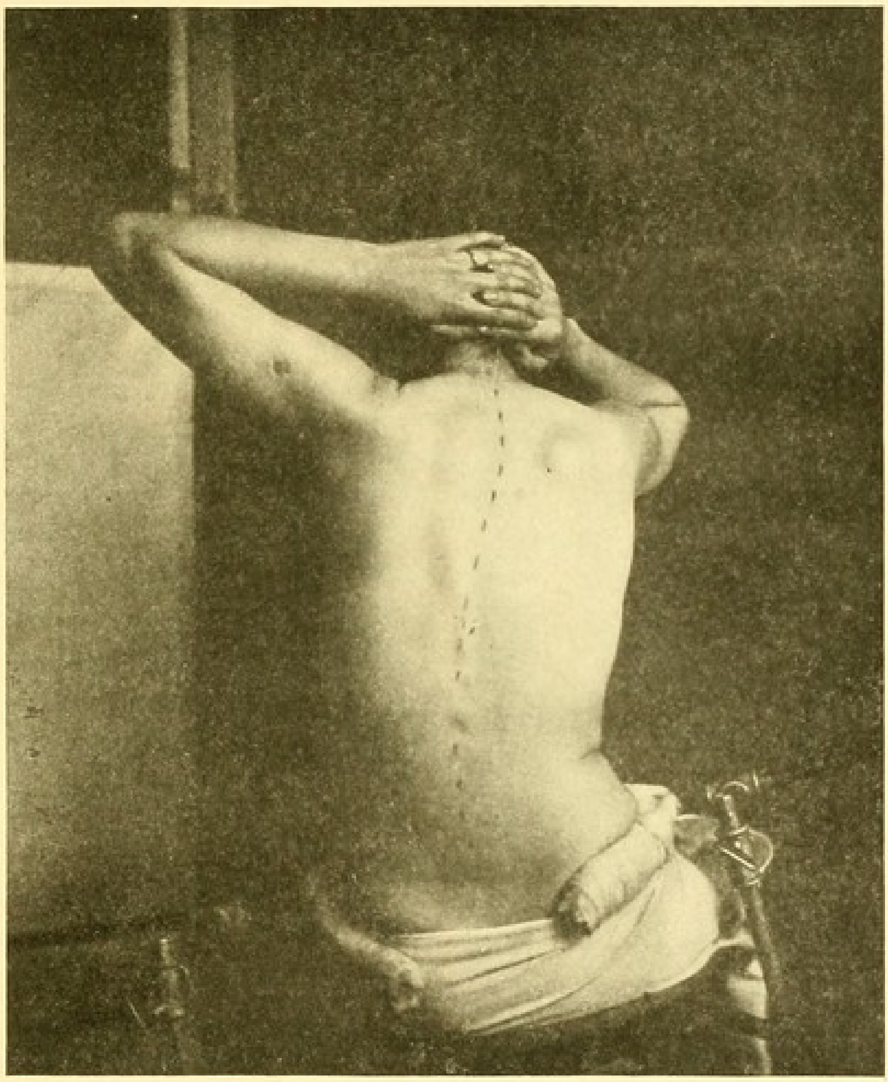


FIG. 46.—EXPERIMENTAL DOUBLE CURVE (RIGHT DORSAL, LEFT LUMBAR) PRODUCED IN THE MODELBY ELEVATING THE RIGHT SIDE OF THE PELVIS AND HAVING THE MODEL ACTIVELY TWIST THE UPPER SPINE, FACE TO THE LEFT.

lumbar compound curves than to any other form is shown by the figures of Hess and by a statement of Schulthess.[1] But we cannot expect the same final curve always to result from the same initial curve. Various forms of curves may occur from the same simple curve. For example, the dorsal region may not react as de-

[1] Lüning and Schulthess: "Orth. Chir.," 1901, page 248.

scribed, and the dorsal and lumbar region may yield, as a whole, to the left, later showing bony rotation on the left side. The spine has yielded backward and to the left as a whole, and other types of compound curves may obviously result from the same initial curve.

In his investigations concerning the persistence of total scoliosis Hess records the observations of 86 cases between the ages of five and twenty-one years during periods varying from two weeks to eight years and a half. Of these 86 cases, 60 persisted as total scolioses, and the remaining 26 underwent various changes, as shown by the list given below.

(*a*) Left total scoliosis in—

7 cases changed to right dorsal, left dorsolumbar scoliosis.
4 cases changed to left lumbar curves, with two right dorsal.
3 cases changed to left dorsal curves.
2 cases changed to left dorsal, right dorsolumbar curves.
2 cases changed to right dorsal curves.
1 case changed to right dorsolumbar, left dorsal.
1 case changed to slight left cervicodorsal curve.
1 case showed slight compensating curves.

21 cases.

(*b*) Right total scoliosis in—

1 case became right dorsal, left dorsolumbar.
1 case became left dorsal, right dorsolumbar.
1 case became left dorsal.
1 case became right dorsal.
1 case became left dorsal, right lumbar.

5 cases.

STRUCTURAL SCOLIOSIS (ORGANIC OR HABITUAL SCOLIOSIS).

This term is applied to those cases in which there is reason to believe that a structural change has occurred in the vertebræ. What this structural change is, is discussed in the chapter on Pathology, but the phenomena are no longer to be explained in physiological terms, for the spine has assumed a position which implies organic change.

Structural curves are simple or compound—simple, when the deviation is accompanied by no compensating curves, *e.g.*, left lumbar scoliosis. The scoliosis is compound when more than one curve is present, *e.g.*, right dorsal, left lumbar scoliosis. The simple curves are sometimes spoken of as C curves and the double as S curves. Triple curves at times exist. When compound curves are present, they alternate to the right and left, two left curves, *e.g.*, not separated by a right curve, never being seen.

No attempt has been made to discriminate between the words "torsion" and "rotation," and they have been used interchangeably in the text. The German writers distinguish between the two terms in a highly technical way, a distinction which it does not seem desirable to transfer to English.

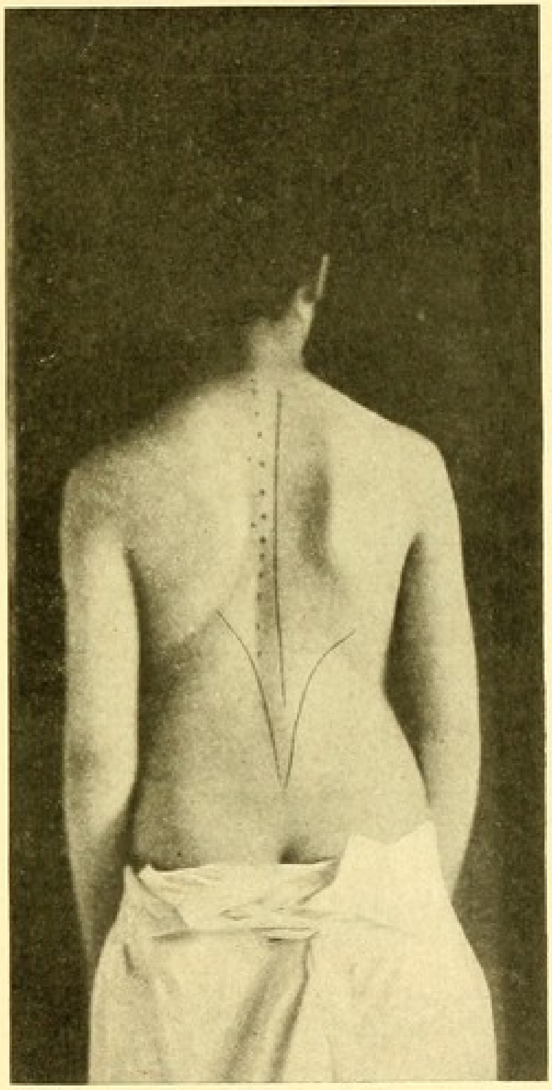


FIG. 47.—LEFT LUMBAR SCOLIOSIS NOT RETURNING TO THE MEDIAN LINE. The lines indicate the median plane and the flexibility to each side.

LUMBAR SCOLIOSIS.

Lumbar scoliosis exists as a simple curve, but more often is only one component of a compound curve, the dorsal curve being, of course, in the opposite direction. In the Schulthess figures the simple lumbar curve formed 11.7 per cent. of all cases treated, and right and left curves were of practically the same frequency. It occurs later than the total scoliosis, as shown by the ages of the patients observed. It occurs more frequently in females than in males (Scholder: 13.8 per cent. boys, 27.7 per cent. girls. Schulthess: 6.3 per cent. males, 12.7 per cent. females). The greatest deviation from the straight line is most often found at about the second lumbar vertebra, and as the lumbar region is short, the curve must be in general a sharp one.

The trunk is displaced to the side of the convexity of the curve and the line of the waist flattened on that side, while the waist on the concave side of the curve is sunken in, and folds may form in the skin of the flank on this side. This is expressed by an apparent prominence and greater size of the hip on the concave side, and it is popularly said that one hip has "grown out" or one hip is "higher" than the other. This inequality of the hips and waist-line is the most striking feature of lumbar curves, and unless corrected, forms an unsightly deformity in women with prominent hips, and makes it necessary to make the skirt longer on one side than on the other. The relative height of the shoulders is not noticeably affected by lumbar curves.

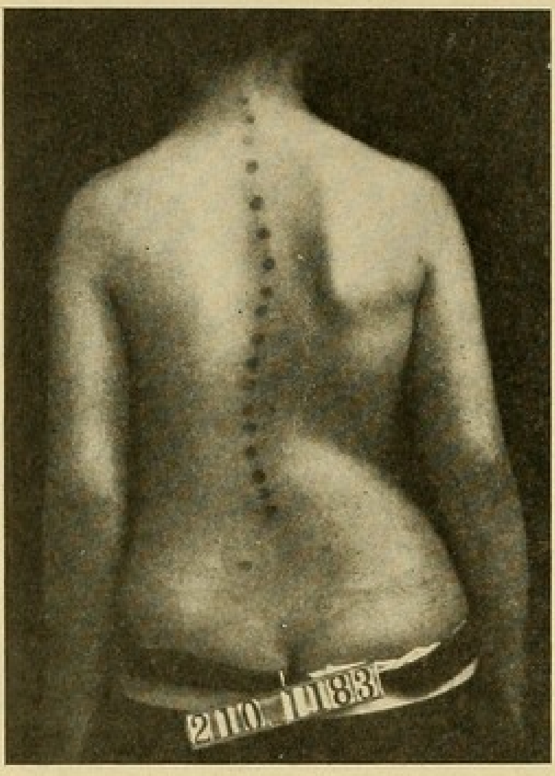


Fig. 48.—Left Lumbar Curve with Slight Right Dorsal Curve.

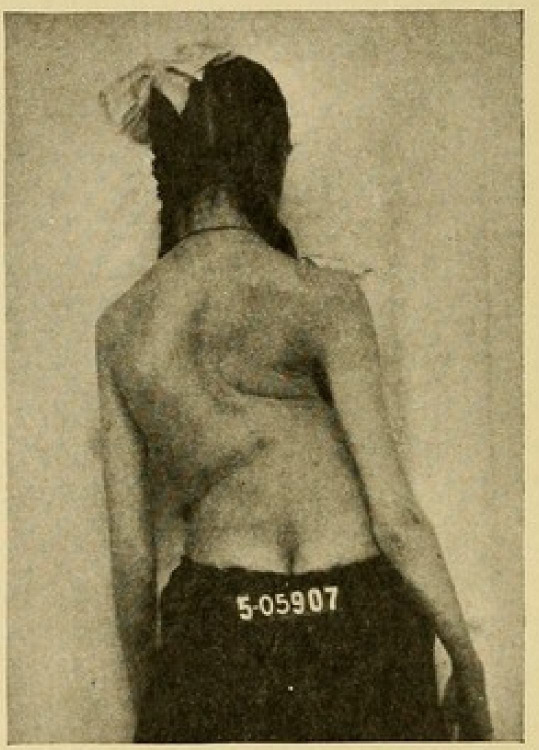


Fig. 49.—Left Dorsal Scoliosis.

As the patient stands, a fullness of the back is noticed in marked cases on the convex side of the curve caused by the rotation of the vertebræ, which carry the heavy transverse processes around and make prominent the overlying structures. In the position of extreme forward bending the side of the back which is on the convexity of the lateral curve is prominent upward, but lumbar rotation is always less prominent than dorsal, and to the untrained eye even in the severer cases seems slight (Fig. 56). In side bending mobility is greater toward the side which makes the curve worse than to the side which improves it (Fig. 61).

DORSAL SCOLIOSIS.

A single dorsal curve is more frequent than the single lumbar type, but is much less frequent than dorsal curves in combination with other forms; that is to say, dorsal curves are more often than not, accompanied by reverse or compensating curves above or below. In the Schulthess figures there were 19 per cent. of single dorsal curves and 30 per cent. where dorsal curves existed with others. The curves are as frequently to the right as to the left when they exist alone. The point of greatest curve is from the sixth to the eighth dorsal vertebra in the majority of cases.

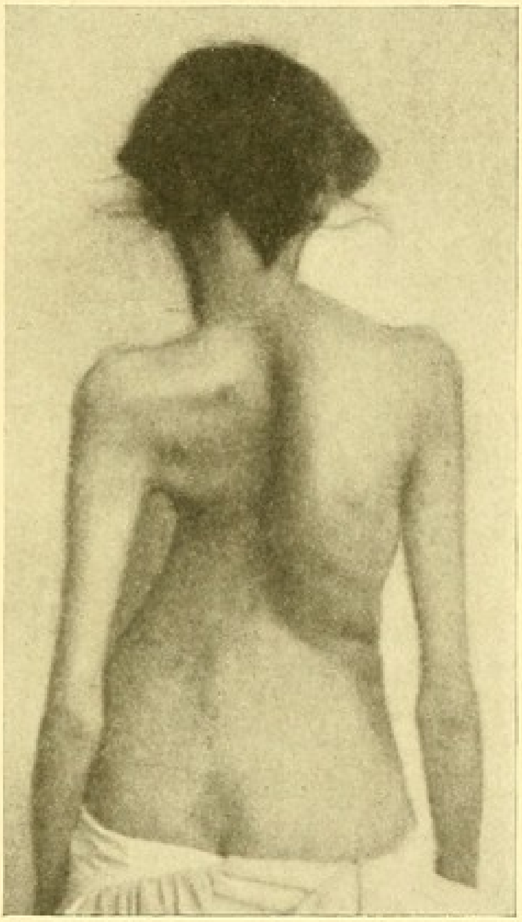


FIG. 50.—ADVANCED RIGHT DORSAL SCOLIOSIS IN AN ADULT.

In a marked right dorsal curve, as seen from behind, the thorax is displaced to the right, and the right arm hangs further from the side than the left; the right shoulder is raised and the waist-line on the right is less concave and much flattened in the severer cases, the ribs coming close to the crest of the ilium and obliterating the natural waist indentation. The rotation is made evident by a prominence, in the back, of the right side of the thorax, which may be seen as the patient stands erect (Fig. 50). Unlike the rotation in lumbar cases, the rotation element in dorsal cases is a very marked feature of the deformity, and a sharp prominence extends down the right side of the thorax, composed of the angles of the ribs, which pushes the scapula backward and to the right. The left side of the thorax as seen from behind is flat or concave, the left scapula sunken and rotated with the glenoid cavity downward and the inferior angle inward. A fold in the skin frequently runs inward and upward from the waist-line. When the patient bends forward until the trunk is horizontal, the rotated ribs are very prominent upward on the right, and a long arch of rib angles is seen which is much more marked than in the standing position.

On the left side the ribs are sunken and fall away, making a flat and even depressed surface to contrast with the striking prominence of the right side.

In a right dorsal curve the right shoulder will inevitably be higher than the other unless a left compensating cervico-dorsal curve exists above it. The absence of a high shoulder on the convex side therefore should always lead to an examination for a compensating curve above.

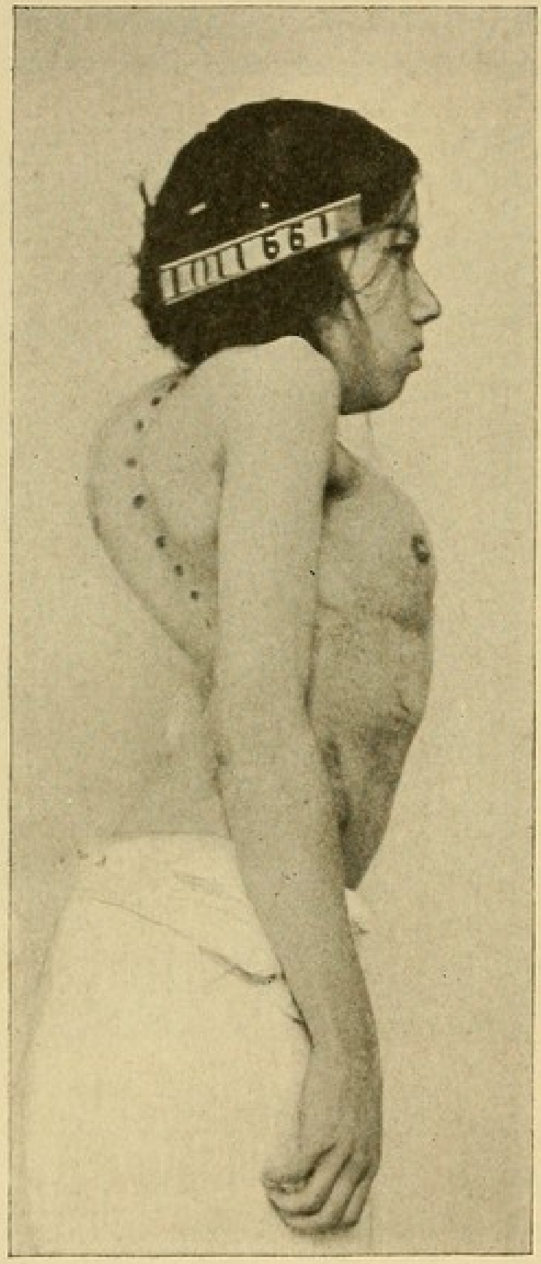


FIG. 51.—KYPHOSCOLIOSIS.

As seen from the front, the deformity is even more evident, the thorax is displaced to the right, the right shoulder is higher than the left, and the left side of the thorax more prominent in front than the right. In severe cases the lower end of the sternum in generally displaced toward the convexity of the curve—in this case to the right. The contour of the chest is changed, and the longest thoracic diameter is the oblique antero-posterior line from the point rotated backward on the right to the point rotated forward on the left—in this case from the right scapula to the left nipple. This description is, of course, to be reversed for leftdorsal curves.

The dorsal physiological curve is most often increased, making the rounded and distorted back spoken of as *kyphoscoliosis* (Fig. 51). It may, however, be flattened, and even slightly concave forward in the dorsal region. The loss of height and shortening of the trunk are evident in the severer cases.

The aspect is wholly different from that seen in lumbar cases, where, as has been said, the chief noticeable distortion is in the hips and waist-line; in dorsal cases the distortion is most noticeable in the thorax and shoulders.

DORSOLUMBAR SCOLIOSIS.

Dorsolumbar scoliosis is a form seen as a simple curve with considerable frequency (20 per cent.), being, therefore, much more common than simple lumbar, but about as frequent as simple dorsal scoliosis. It naturally partakes of the character of the two forms just described and affects nine females to one male. The seat of greatest curve is generally at the dorsolumbar junction. It is four times as frequently convex to the left as to the right. The trunk and lower thorax are displaced toward the side of the convexity of the curve and overhanging the pelvis, and the waist-line on that side is flattened or obliterated, while on the concave side the outline cuts in sharply above the pelvis, frequently forming folds in the skin. The attitude is more like that of an exaggerated total scoliosis than like either the dorsal or lumbar form. It is not so prone to be associated with compensatory curves as are the other forms.

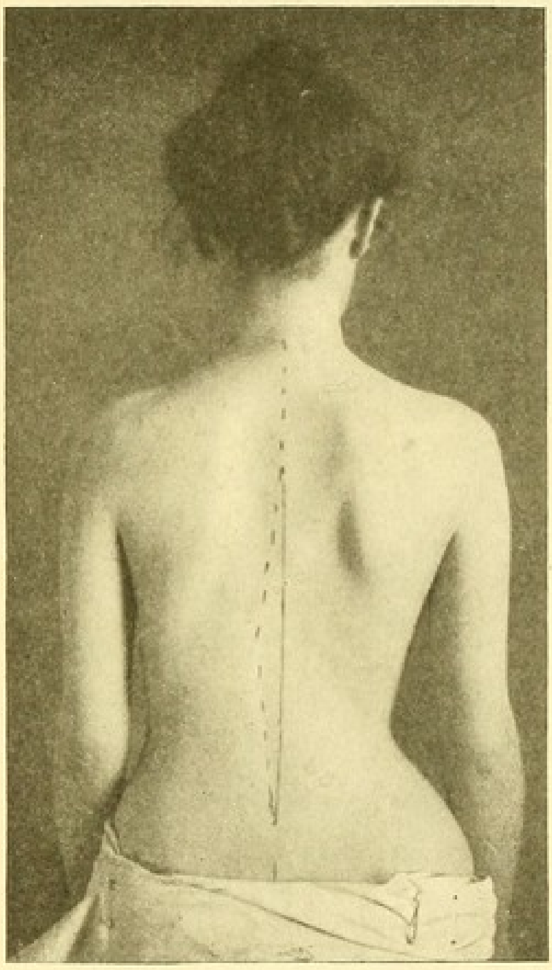


FIG. 52.—LEFT DORSOLUMBAR SCOLIOSIS.

CERVICODORSAL SCOLIOSIS.

Cervicodorsal scoliosis is a comparatively rare form of the deformity, occurring in only 3.6 per cent. of all cases. It is convex to the left more often than to the right in the relation of 3 to 2, and the greatest curve is most frequently located at the third or fourth dorsal vertebra. The head is carried forward and tipped to the concave side of the curve. The neck is obviously shortened, and the outline from the base of the skull to the shoulder is fuller and less crescentic in outline on the convex side of the curve than on the other. The shoulder on the convex side of the curve is raised and the other lowered, and the scapula of the raised side is conspicuously higher. The arm of the convex side hangs further from the side than the other. The rotation appearances are marked, and the sharp angles of the upper ribs are prominent in the lower part of the curve, while above the rotation is less evident because

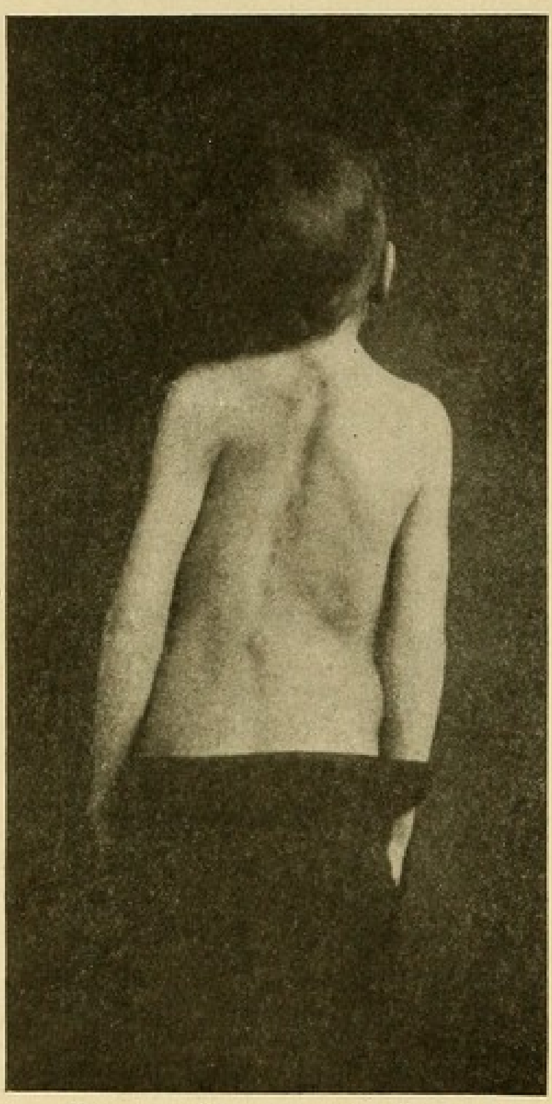


FIG. 53.—CERVICODORSAL CURVE DUE TO DEFECTIVE RIBS AND MALFORMATION OF VERTEBRÆ.

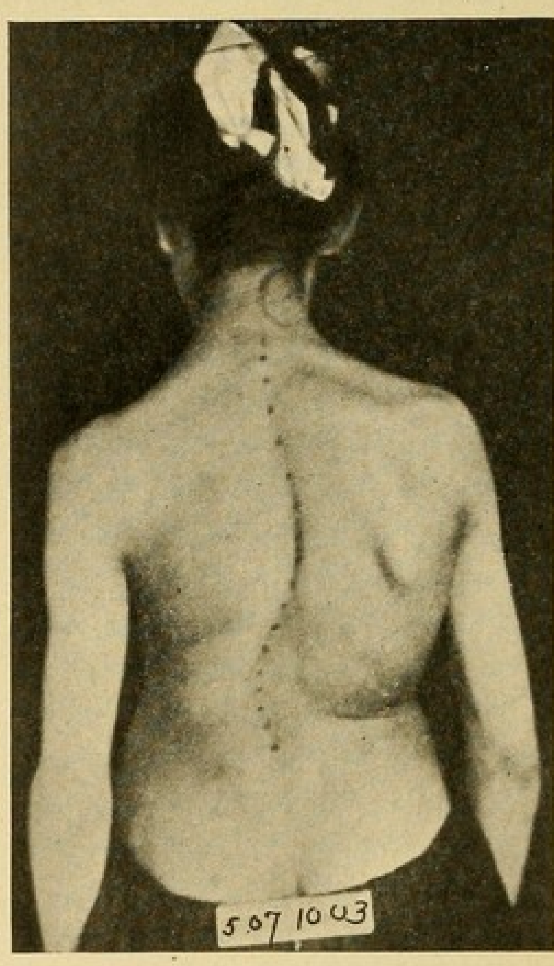


FIG. 54.—RIGHT DORSAL LEFT LUMBAR SCOLIOSIS.

there are only the transverse processes of the cervical vertebræ to make a projection. The trunk is displaced to the side of the convexity of the lateral curve.

COMPOUND STRUCTURAL CURVES.

The pictures of compound curves cannot, of course, be as simple or uniform as those of the simple types. A right dorsal left lumbar curve, for example, will present a combination of the appearances described in both dorsal and lumbar curves, a right cervicodorsal left dorsolumbar the sum of the pictures of the two factors. If the dorsal element predominates, the appearances will be more dorsal than lumbar, as is usually the case, and every grade of variation is to be seen, the predominant curve setting its stamp on the clinical appearance. The right dorsal left lumbar curve is the one most frequently seen. Dorsal scoliosis with compensating curves formed 30 per cent. of all cases in the Schulthess tables, and of these the dorsal curve was to the right in 80 per cent. of the cases. The greatest point of curve in these was from the sixth to the eighth dorsal vertebra, and the most frequent reverse curve associated was in the lumbar region. It is a type of curve most frequently seen in older children, the bulk of the cases being from ten to sixteen years old, but it may be seen in very young children. The increased susceptibility to compound curves with increasing years is shown by Scholder's statistics of school children:

8 years old	0.4 per cent.
9 " "	1.1 "
10 " "	1.2 "
11 " "	2.4 "
12 " "	2.1 "
13 " "	3.3 "
14 " "	3.3 "

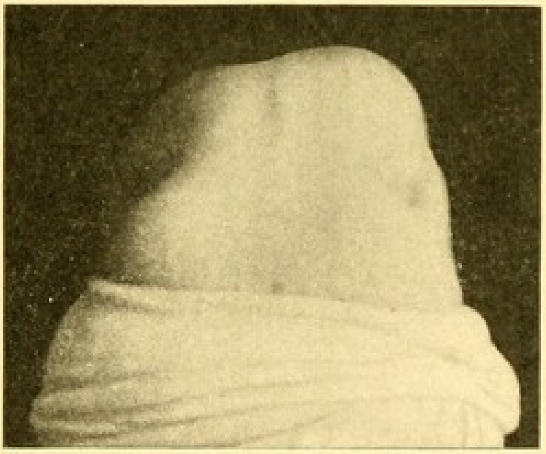


FIG. 55.—DORSAL ROTATION SHOWN BY PROMINENCE OF RIGHT SIDE IN BENDING FORWARD.

FIG. 56.—LUMBAR ROTATION SHOWN BY PROMINENCE OF LEFT SIDE IN BENDING FORWARD.

Women are more frequently affected than men, the proportion being 7 to 1.

The appearances shown in the illustration (Fig. 54) will serve to demonstrate how the appearances of two types of simple scoliosis are brought together in the same patient. In a right dorsal left lumbar curve, the appearances of the thorax are those described for a simple dorsal curve, but the overhang of the thorax is modified by the displacement of the lower trunk in the opposite direction incident to the

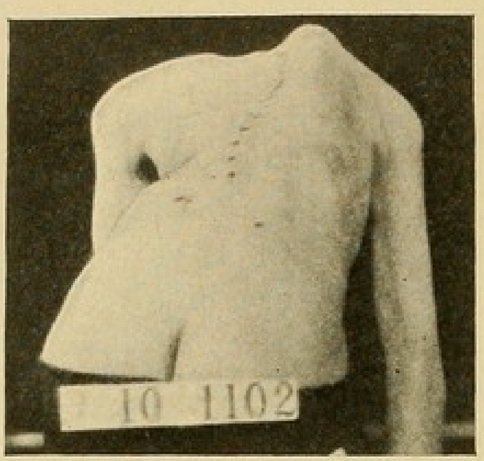


FIG. 57.—SEVERE DORSAL ROTATION ON RIGHT SIDE IN FORWARD BENDING.

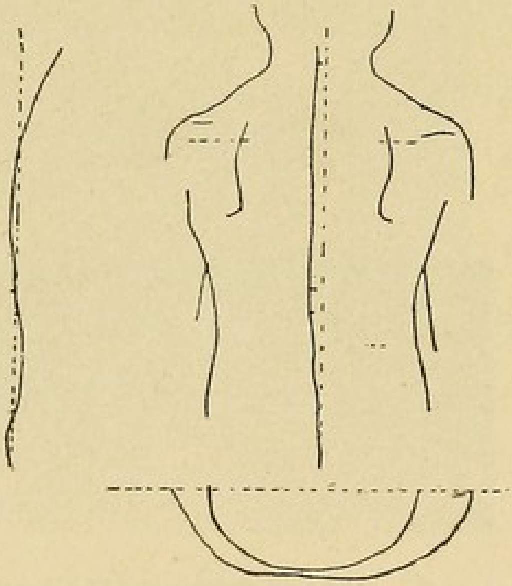


FIG. 58.—SCHULTHESS' TRACING OF A GIRL SIX YEARS OLD.—(*Schulthess.*)

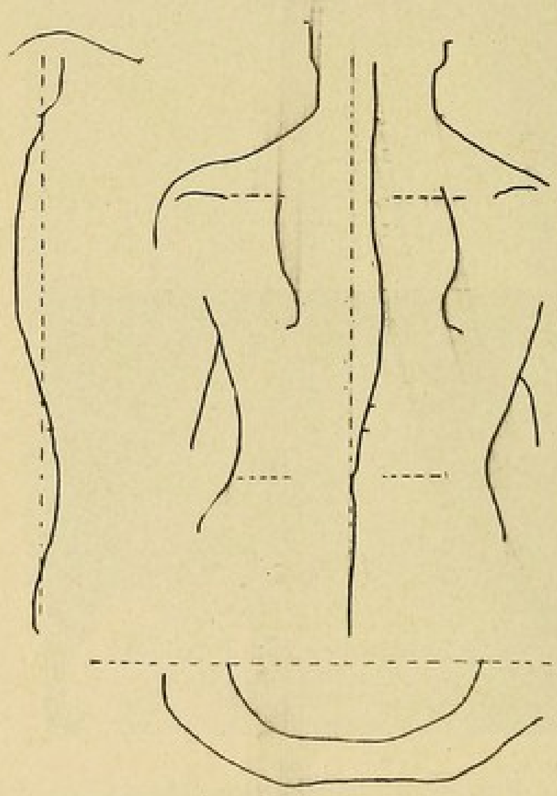


FIG. 59.—TRACING OF THE SAME CASE EIGHT YEARS LATER.—(*Schulthess.*)

left lumbar curve. The resultant position may be, as in the simple curves, either accompanied by an increase or diminution of the physiological curves.

That scoliosis may change from one clinical picture to another in the same patient in the course of years is well established. Not only does the total curve frequently change to a compound type as mentioned, but the structural curves change the body outline most frequently by the addition of compensatory curves, *e.g.*, the illustration shows the change of a left dorsal right lumbar curve to a curve of the same type causing, however, a different distortion. In general, however, the later distortion is an exaggeration of the earlier.

The relative frequency of the common types as tabulated in 1137 cases coming for treatment by Schulthess was as follows:

Total scoliosis	15.39	per cent.
Lumbar	11.7	"
Dorsal	19	"
Dorsolumbar	20	"
Cervicodorsal	3.6	"
Compound	30	"

CHAPTER V.

EXAMINATION AND RECORD OF SCOLIOSIS.

In undertaking the examination of a case of scoliosis it is important to obtain a fairly complete history of the child's early life, as throwing light on the cause of the deformity and secondly as giving information as to the child's condition at the time of beginning treatment, as indicating the probable resistance to fatigue, the existence of factors likely to complicate treatment, etc.; and, secondly, it is important to obtain as accurate a record as possible of the curve at the beginning of treatment and at subsequent stages. These two matters will be dealt with in the order named.

History. Family History.—The occurrence of scoliosis in other members of the family is of interest as possibly indicating a similar origin. A tuberculous family history would make one particularly careful about the child's hygiene.

Personal History.—The character of the labor if difficult may point to the possibility of some injury occurring at birth. The health of the child as a baby, whether it was bottle fed or nursed, and the date of the first teeth are important in their bearing on rickets, as are the existence of bowlegs or other signs indicating rickets. The history of acute illnesses in childhood are significant in showing whether the child has been sickly or not, and any mysterious feverish attack may have been infantile paralysis. The age at which the curve was noticed and its subsequent progress are proper subjects of inquiry, but the information obtained is rarely reliable.

It is important to note the child's mental make-up, whether nervous and apprehensive or easy going and careless, as it has a bearing on the formulation of treatment. Resistance to fatigue and evidences of overwork at home or at school are factors of importance.

The height and weight should be taken, first to show whether there is a reasonable period of growth ahead of the individual child and second to show whether the child is backward in growth or decidedly oversize. Great excess of height or weight or of both are important because decidedly overgrown children as a rule show diminished resistance to physical exercise and seem particularly liable to defects of posture. The height and weight should be taken and compared to the average given in the table.

AVERAGE HEIGHTS AND WEIGHTS.—(*T. M. Rotch.*)

BOYS.		AGE.	GIRLS.	
HEIGHT.	WEIGHT.		WEIGHT.	HEIGHT.
Inches.	Pounds.		Pounds.	Inches.
19.75	7.15	Birth.	6.93	19.25
24.75	14.30	5 mos.	13.86	23.25
29.53	20.98	1 year.	19.80	29.67
33.82	30.36.	2 years.	29.28	32.94
37.06	34.98	3 "	33.15	36.31
39.31	37.99	4 "	36.36	38.80
41.57	41.00	5 "	39.57	41.29
43.75	45.07	6 "	43.18	43.35
45.74	48.97	7 "	47.30	45.52
47.76	53.81	8 "	51.56	47.58
49.69	59.00	9 "	57.00	49.37
51.68	65.16	10 "	62.23	51.34
53.33	70.04	11 "	68.70	53.42
55.11	76.75	12 "	78.16	55.88
57.21	84.67	13 "	88.46	58.16
59.88	94.49	14 "	98.23	59.94

The weights at birth, and in the first, second, and third years, were without clothing. The ordinary school clothes were worn in the weighing from five to fourteen years. As the tables were made up from children in the public schools, children in private practice will as a rule somewhat overrun these figures.

EXAMINATION.

GENERAL CONDITION.

In the examination it is important to note the nutrition and development, that is, whether the child is fat or thin, flabby or firm, pale and anemic, or of good color and apparently robust. The nervous condition of the patient may be estimated by the presence or absence of apprehension, crying, twitching, or tremor, but restlessness in young children means nothing. The condition of the heart should be always examined because otherwise, harmful exercise might be prescribed for a child with organic heart disease. The following points should also form part of a routine examination.

Condition of lungs and chest expansion. Comparative length of legs. The existence of flat-foot or "weak ankles." Whether or not spectacles are worn. General gait and carriage. Manner of supporting the underclothes and stockings, whether objectionable or not.

EXAMINATION OF SPINE.

A patient with suspected lateral curvature should always be examined with the back wholly bare. The clothes should be firmly pinned or fastened by a strap around the hips at a level low enough to show the top of the cleft between the buttocks and to show the outline of the hips. In children the patients should be stripped to this level; in adolescent and adult young women the chest should be covered by an apron hanging over the front of the thorax, the strings of which are fastened around the neck.

The patient should stand, back to the surgeon, squarely on both feet with the arms hanging at the sides. It is desirable to allow the patient to stand quietly for a minute or two before beginning the examination in order to secure the fatigued or relaxed position which is the characteristic one. The patient should not be handled or touched during inspection, as the contact of the hand frequently stimulates the muscles and negatives for the time being the relaxed position.

Inspection of the natural standing position forms the first step in the examination. The surgeon notices first—(1) the body outline, whether symmetrical or not, comparing on both sides the outline from the axilla to the crest of the ilium, whether one is flatter or more curved than the other, whether one arm hangs further from the side than the other. The apparent prominence of one hip is noted. The trained eye estimates this asymmetry as a lateral displacement of the thorax or trunk with regard to the pelvis, and it is the safest guide. The appreciation of symmetry or the absence of it is essential in giving corrective gymnastics, and the most useful method to one trained, is to erect an imaginary perpendicular from the cleft between the buttocks (anal fold) and estimate whether it cuts the trunk in the middle or whether more of the trunk lies to the left or right of it. It is obvious that if any part of the spine is laterally curved, it must carry with it a segment of the body to the right or left. This *displacement* will be accompanied by a change of body outline, and a difference in body outline on the two sides is presumptive evidence of a lateral curve. The outline of the body and displacement of the trunk to one side may always be seen more plainly from the front than the back, as the outline is sharper. In children this method should follow the one described.

(2) The surgeon next notices the level of the shoulders, whether one is higher than the other, and whether this is a constant position. The elevation of one shoulder is generally a sign of lateral curvature, but may exist rarely with no perceptible curve.

(3) The position of the scapulæ should then be noted and the two sides compared. It is not of primary importance, but it is desirable to note their relative distance from the spine, whether one or both of the scapulæ are displaced forward, and whether any rotation of the bone has taken place.

(4) The habitual position of the head should be noted, whether tipped to one side or held constantly rotated.

(5) The antero-posterior physiological curves should be investigated and any increase or diminution of the dorsal or lumbar curves noted.

Estimation of the Spinal Curve.—Over the middle of each spinous process a mark is then made on the skin by a flesh pencil or by ink while the patient still stands as described. The skin must not be drawn to one side or the other in making these marks, or distortion may be caused by the movements of the skin over the bony points. This line of marks is accepted as representing the spinal curve, although it does not accurately represent the position of the bodies of the vertebræ (see Pathology). If a curve is present, the line of marks will be evident as a curved instead of a straight line, for a normal spine shows a line of marks forming a straight line which lies in the median plane of the body.

There are now two questions to be answered: (1) Is lateral curvature present? (2) if present, what sort of a curve is it?

The median plane of the body is readily determined by holding a plumb-line belind the patient, the lower part of which passes through the cleft between the buttocks. In the normal spine each mark will lie under this plumb-line. The deviation of any number of spinous processes from this line represents a lateral curve which is analyzed as described in Terminology (p. 45).

This method of erecting a perpendicular from below is preferable to the method of dropping a plumb-line from the top of the column (the Beely-Kirchoff method), which introduces a confusing element and does away with the consideration of the deviation as a problem of support, making it a problem of the overhang of the top of the column with regard to its base.

If a curve exists, as shown by the plumb-line, the second question arises as to what sort of a curve it is, whether functional or structural.

Functional curves have four definite attributes which should be looked for (see p. 46) and in the absence of anyone of them the diagnosis of a functional curve cannot be made; the case is therefore by exclusion, structural.

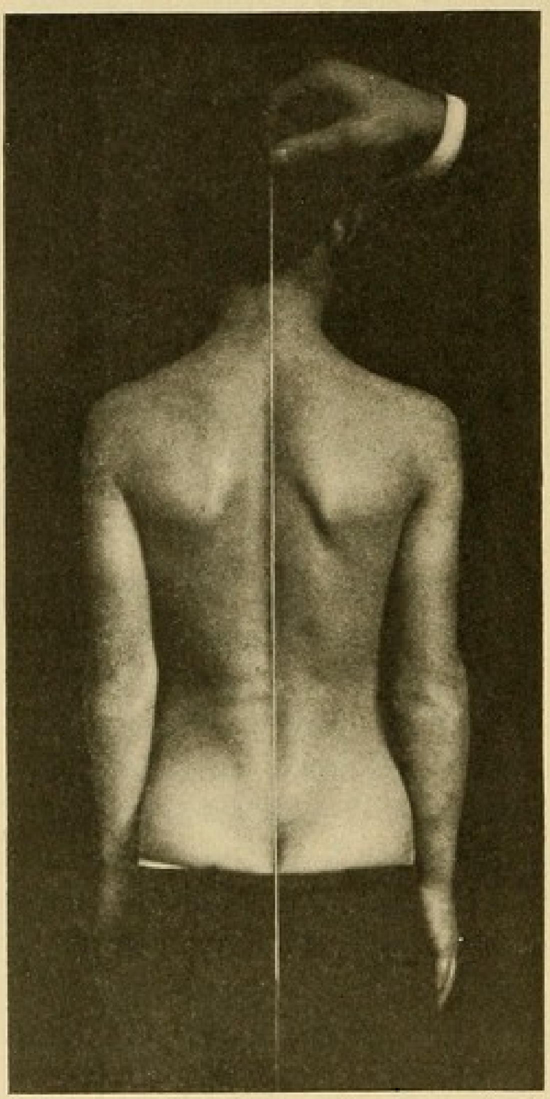


FIG. 60.—THE PLUMB-LINE IN THE CLEFT OF THE BUTTOCKS TO DETERMINE THE MEDIAN PLANE OF THE BODY.

To describe the curve accurately, the seventh cervical and fifth lumbar spines are connected by a string held along the back and the parts lying to the right of the string are to be classed as right curves and the part to the left as left curves. According to the region of the spine occupied they are also classed as dorsal, lumbar, etc. The curve may thus be accurately defined and described.

Cervical curves must be roughly estimated by the eye, for on account of the inaccessibility of the cervical spinous processes and the instability of the head, they cannot be definitely measured.

Estimation of Rotation or Twist.—The surgeon, having thus recognized any bodily asymmetry, and having identified and defined the curve, is in a position to investigate the element of rotation or twist which is essential in every case.

The surgeon, standing close behind the patient, looks down on her shoulder-girdle from above to estimate whether it is in the same lateral plane as the pelvis or whether twisted forward on one side and back on the other. This is of use chiefly in postural cases, and in structural cases is of less value. By sighting the scapulæ and back of the thorax on the buttocks it is easily seen whether any twist of the thorax has occurred in relation to the pelvis. Evidence of rotation of the ribs or lumbar transverse processes backward on the convex side of the lateral curve, which accompanies structural cases, will in severe cases be evident in the standing position, but it is generally examined for and estimated in a position of forward flexion of the trunk sometimes spoken of as Adams' position. The patient bends forward until the trunk is horizontal with the arms hanging down and the knees not flexed. In this position the patient remains while the surgeon glances along the back from behind or in front, with his head on a level with the spine, and looks to see whether either side of the trunk is more prominent upward in the lumbar, dorsal, or cervical region. Any such upward prominence represents rotation or twist and is a most important matter. If it occurs on the *concave* side of the lateral curve and involves the curved region, it will be slight and evenly distributed through the spine and designates a functional or postural curve. That is, in a left total postural curve the right side of the back will probably be more prominent upward in the forward bent position.

If it occurs as a well-defined local upward prominence occupying the curved region, it designates a structural curve at that location, the curve being *convex* to the side on which the prominence occurs and occupying the same anatomical area. That is, a right dorsolumbar upward prominence designates a right dorsolumbar structural curve. This must be clearly understood, for at times a curve which is obscure or confusing in the upright position is cleared up by a recognition of its rotation as seen in the forward bending position.

Estimation of Spinal Flexibility.—The patient should now lie on the face and the position of the spinous processes be noted. The marks on the skin will represent the curve of the spine in the erect position, and any straightening of the spine in recumbency will be shown by finding that the spinous processes form a less curved line than that marked on the skin. In postural curves the spine will become straight in recumbency, while structural curves will be perceptibly straighter than when the patient is erect. The patient should now be suspended by the arms, or preferably by a Sayre head-sling, enough to take the weight off of the spine, and the straightening of the spine noted. The modification of the asymmetry of the trunk by suspension is important and should be carefully studied, as to whether the asymmetry is practically unchanged, whether the overhang of the thorax is corrected, and whether the patient becomes wholly symmetrical. The position of the patient in suspension represents the maximum that may be expected from treatment in that individual case until further flexibility is restored by treatment directed to that end. The restoration of complete or almost complete symmetry by suspension points to an early case and one amenable to treatment, for one of the early changes in structural curves is a stiffening of the curved region of the spine which causes the persistence of the curve under suspension. So far as possible it should be noted whether the improvement in symmetry is produced by a straightening of the curve or curves or whether the modification in asymmetry is produced by the other parts of the spine. For example, in a dorsal curve, is the relation of the curved region changed or is the curved part simply pulled away from the pelvis by a stretching out of the lumbar region?

The patient should then bend forward to determine normal flexibility forward. The average child can touch the floor with the fingers while the knees are straight, while in adult life less flexibility obtains.

The flexibility of an individual spine is a matter determined by age, habit, and individual peculiarity. To know in a general way what the normal flexibility at a given age should be is important in children, but in adults it is so much a matter of individual habit that it is of less importance. One man of fifty, for example, who has taken exercise may be able to touch the floor with his hands in forward bending, while another man of the same age of sedentary life cannot get his finger-tips within a foot of the floor in the same position, yet both spines are to be classed as normal. How rapid the change in flexibility may be owing to exercise is shown by the case of a healthy boy of fifteen who could not touch the floor with his finger-tips in forward bending. He injured his knee and was obliged to wear a ham-splint. The exertion necessary to dress himself with his leg stiff so increased his forward flexibility that in ten days he could place the palms of his hands on the floor without exertion in forward bending.

The patient then stands with the elbows out and the hands clasped behind the neck, and bends to one side and to the other. The characteristics of side bending have been fully described, and modifications and restrictions of this are to be studied. Patients with curves can, as a rule, bend better to the side that makes the curve worse than to the side that improves it.

The examination has been dealt with thus at length because rational treatment cannot be undertaken without a clear formulation of the character of the deformity, and experience shows that in the loose use of terms and in slipshod examinations some of the failures to obtain proper results from treatment have their origin.

X-ray.—The *x*-ray is of use in showing the existence of bony defects, numerical variation, or other anomalies, and the presence of distortion in the bones. It is of great value in showing the character of the curve in doubtful cases, but its results do not as a rule agree with the clinical appearances, the amount of curve in the x-ray being generally

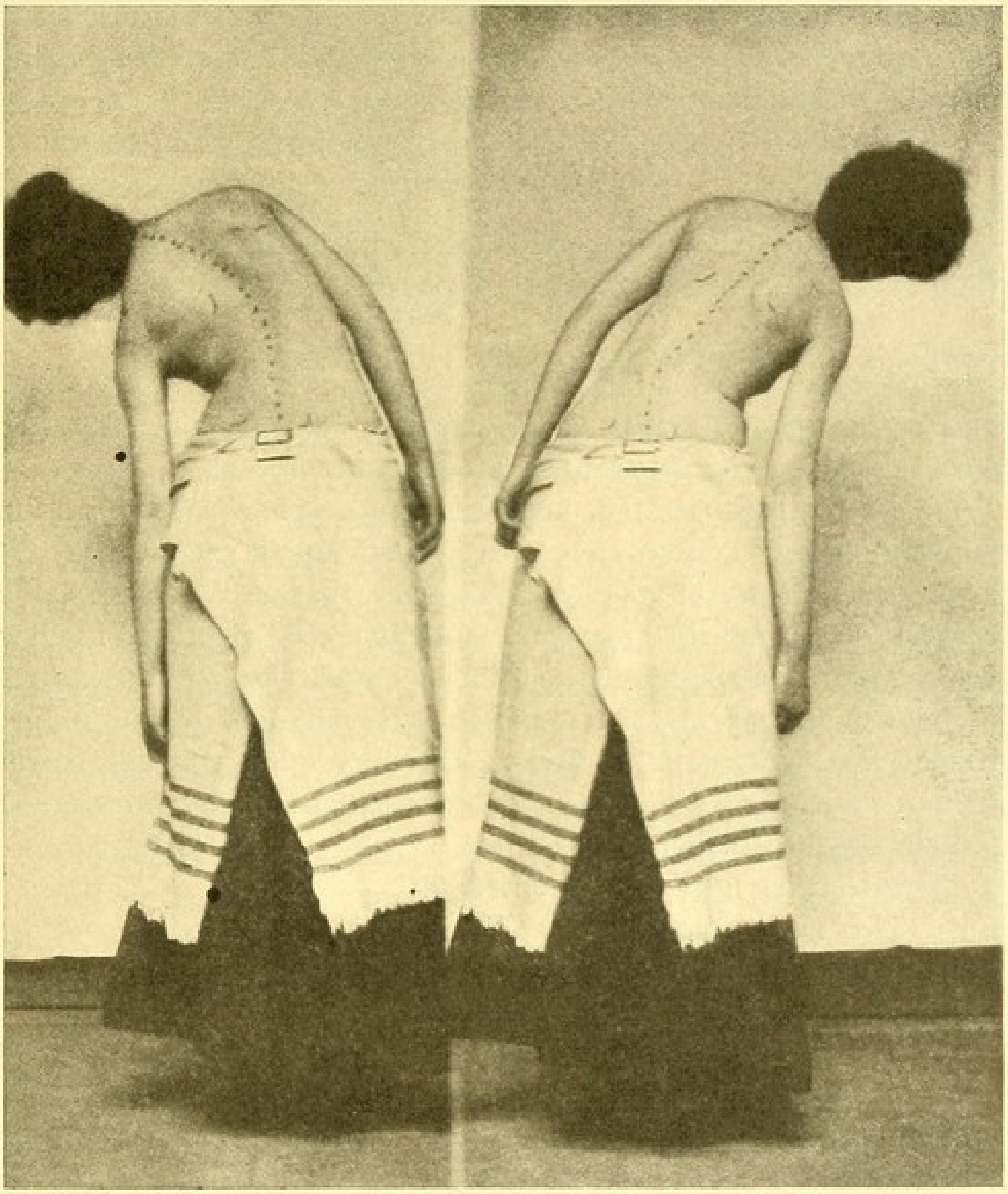


FIG. 61.—PATIENT WITH A RIGHT DORSAL LEFT LUMBAR STRUCTURAL CURVEE BENDING TO THE LEFT AND RIGHT, SHOWING THE COMPARATIVE RIGIDITY OF THE LUMBAR REGION TO LEFT BENDING AND OF THE DORSAL REGION TO RIGHT BENDING.

more than is indicated by the marks over the spinous processes. The amount of rotation is indicated in the x-ray by the position of the shadow of the spinous processes in relation to the shadows of the bodies, normally the spinous process appearing in the middle of the body.

But the element of distortion in x-rays must be remembered. A patient is likely to be twisted by lying on the back if rotation is present, and any deviation of the tube from the middle line of the body is expressed as distortion of the vertebræ, so that the x-ray does not as yet provide a method of accurate record on account of the ease with which distortion is produced in shadows. x-rays taken in the standing position obviously represent the condition more correctly than do those taken in recumbency.

RECORD.

What is required for record is some sufficiently accurate method within the reach of the average practitioner or specialist on the subject.

MEASUREMENTS OF THE LATERAL CURVE.

Photography, although open to many objections, is probably the most generally available means of record at our disposal.

The advantages are that no more than average amateur skill in photography is required to get with practice a good picture, that the record can be made in the physician's office, that the results are fairly accurate if taken with great care, and that good photographs may be translated into graphic curves by means of a device to be mentioned.

The objections are that practice is required to obtain proper results, that lights must be studied, that unsteadiness of the patient blurs the picture, that patients unconsciously pose, and that distortion is easily produced by any carelessness.

The following rules must be observed:

1. The patient must stand at ease with the legs straight and the arms hanging at the sides in the relaxed position, which comes on at the end of about one minute.

2. The heels of the patient must be on a line parallel to the lens, otherwise distortion is inevitable. This relation must be measured and not left to guesswork. The simplest solution is to have a stand for the patient which is provided with two leathers for the heels. This stand is always placed in a definite location, the relation of which to the camera is formulated.

3. The patient must stand at a fixed distance from the camera in all cases if pictures are to be used as accurate records.

4. The light must be oblique from behind, preferably diffused, and not the direct light of the sky if possible, which gives too violent contrasts between light and shadow. A light from overhead throws

the shadow of the shoulders onto the back and obscures the spinal furrow. A light directly from behind gives a flat white picture without contours. A light directly from the side throws the shaded part of the body into such blackness that the body outline of that side is lost. A crossed light obliterates contour and gives a flat and confusing picture.

5. The shadows must be diminished by a white reflector on the side of the patient away from the light. This is easily obtained by the use of a common clothes-horse, one surface of which is covered with sage green, which serves as a background, while the other wing is covered with white to serve as a reflector. The patient faces the green surface while the white surface is placed at the desired angle to throw the light onto the shaded side. By this arrangement contour may be secured in the picture.

6. The unsteadiness and swaying of the patient may be obviated in a measure by placing an ordinary photographer's rest against the chest. A photograph of rotation may be obtained by having the patient bend forward with the head away from the camera and focusing on the part of the back affected by the rotation.

Measurement of Photographs.—If it is desired to measure and study the curve from the finished photograph, the method devised by Fitz is of value.[1] A fixed distance is decided on at which to take the pictures. A large sheet of paper is then divided into carefully measured squares of any desired size. This sheet of paper is then photographed with the camera at the fixed distance to be adopted. The negative will reproduce the diagram on the paper, each square on the negative representing in measurement the square upon the paper. This diagram on the negative may then be transferred to a thin sheet of clear celluloid (20/1000 of an inch in thickness) by scratching with a needle-point the lines appearing in the negative. By laying this transparent scale upon any print taken at this fixed distance a scale of measurement is provided.

Various modifications of the simple photographic method by means of screens, etc., have been devised of which Haglund's[2] may be taken as an example, but no one of them has met with general acceptance.

Tracing.—A simple and approximately accurate record may be made by marking the spinous processes and laying on the back, while the patient stands erect, a strip of crinoline gauze, through which the spinal marks may be seen. They are thus easily marked on the

[1] G. W. Fitz: "Bos. Med. and Surg. Jour.," Nov. 16, 1905.

[2] "Festschrift für J. Berg." "Nordiskt medicinskt. Arkiv.," 1911.

gauze, which may be kept as a record. The error lies in the possible slipping of the gauze and the necessity of placing the hands on the patient.

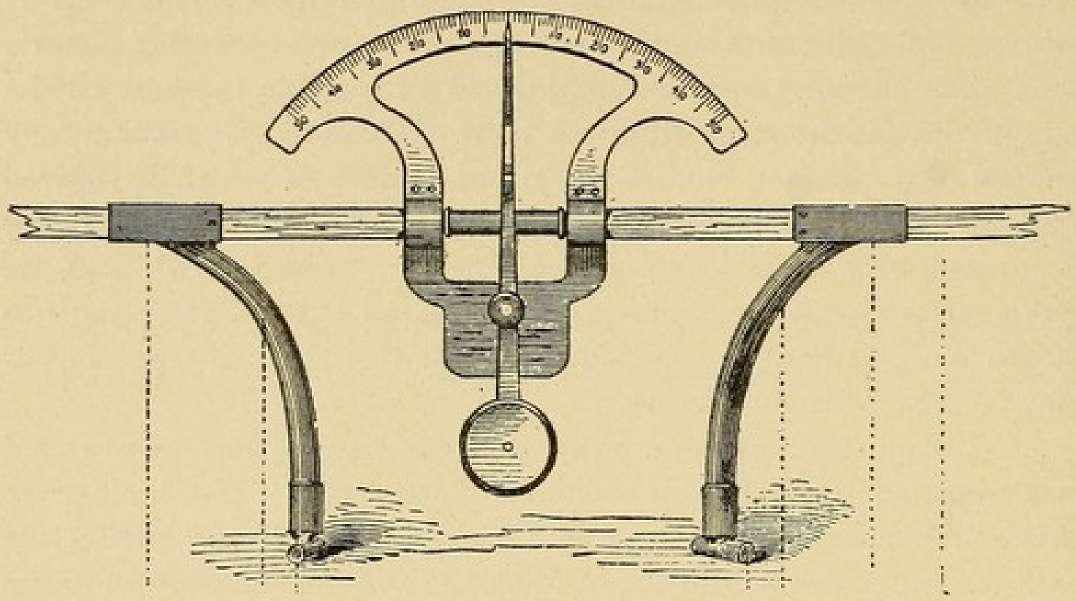


Fig. 62.—Leveling Apparatus (Nivellier Trapez) for the Measurement of Rotation in the Forward Bent Position.—(*Schulthess.*)

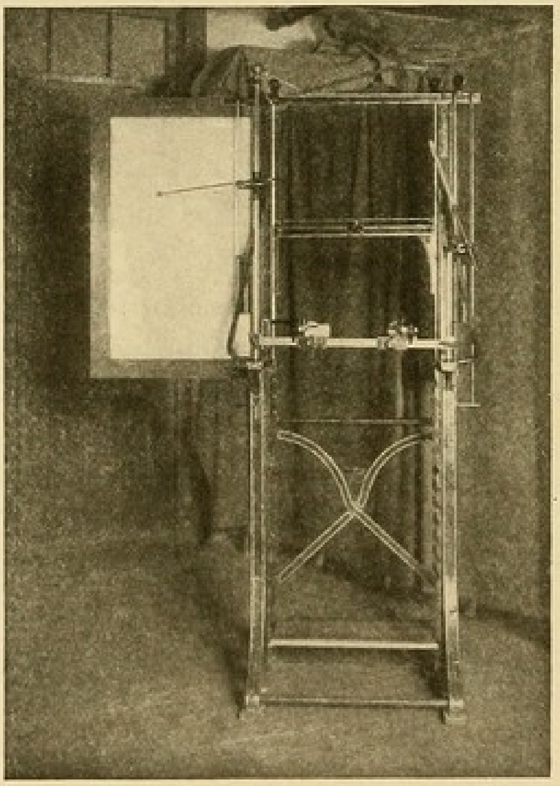


Fig. 63.—Schulthess' Measuring Apparatus.

Any one interested in the subject may find a number of methods described, together with the literature of the subject, in the reference.[1]

[1] "Ueber die Messmethoden des Rückens," Hovorka, Wien, 1904.

Rotation may be estimated in degrees with accuracy in the forward bent position by means of the Schulthess level square (Nivellier trapez), which consists of two arms sliding on a rod to which they are at right angles. These arms are placed on corresponding levels of the back at equal distances from the spine, and the rod is provided with a protractor and swinging weight to show the inclination of the rod to the horizontal plane in degrees (Fig. 62).

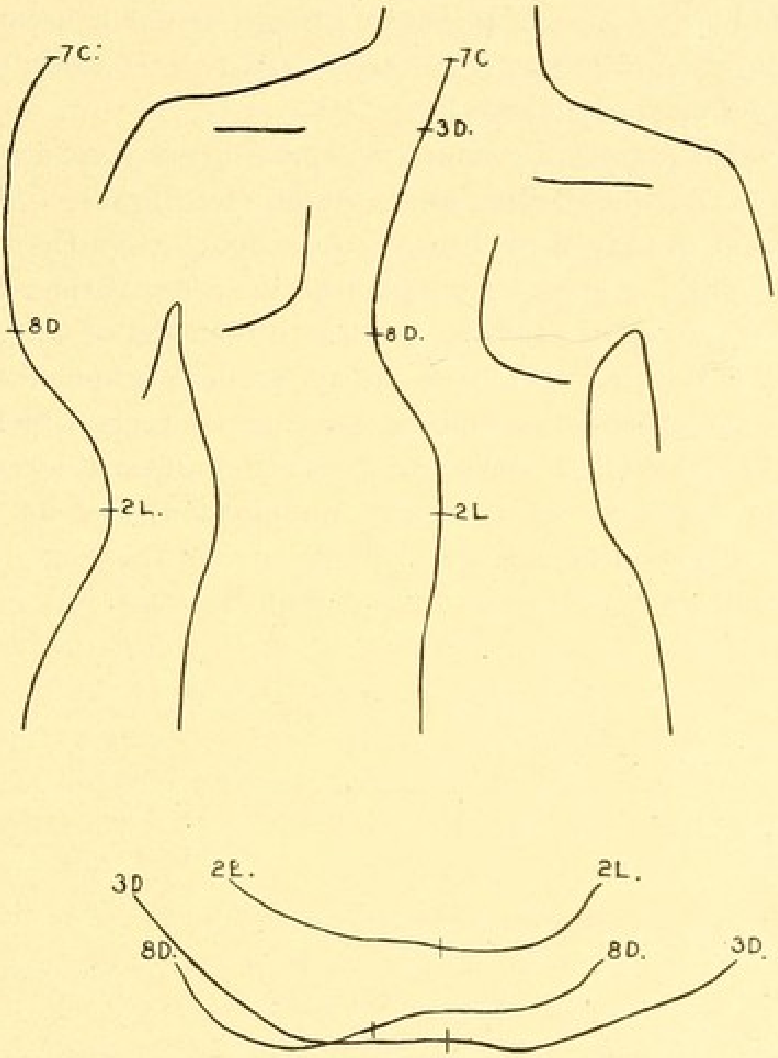


FIG. 64.—TRACING OF A LEFT DORSAL RIGHT LUMBAR CURVE MADE BY THE SCHULTHESS MEASURING APPARATUS.—(*Children's Hospital.*)

Methods which would estimate the rotation while the patient lies prone on the face are inaccurate because the pressure of the table on the prominent side of the front of the thorax tends to rotate the chest and cause distortion.

The Schulthess Apparatus for the Record of Scoliosis.—The Schulthess apparatus, which is generally accepted as being the most accurate means of record at our disposal, consists of an upright frame in which the patient stands, the pelvis being fixed by clamps and the sternum steadied by an adjustable rod. Behind the patient there is a sliding bridge with counterweights which move up and down on the uprights. Attached to this bridge is a pointer which moves forward and backward and sideways. The movements of this pointer by an arrangement of weights and pulleys are recorded upon two glass panels parallel to the sagittal and frontal plane of the body by means of pencils moving on paper attached to the glass panels. By tracing from below upward the marked lines of spinous processes on one panel the antero-posterior curve of the spine is recorded, while on the other the lateral curve is simultaneously marked.

By a longer pointer the lateral body outline is then traced in the frontal plane after the position of the scapulæ has been recorded. The two pencils in use are then thrown out of action, and by means of a third pencil working upon a glass plate on the sliding bridge horizontal contours are recorded at three levels. By means of an additional sliding bridge working in front of the apparatus a late modification of it provides for anterior as well as posterior contours which may be joined to give a complete contour of the body at different levels (Fig 63.

The apparatus is expensive and complicated, and its successful use demands much training.

Chapter VI.

PATHOLOGY.

The pathological changes in the vertebral column to be described as existing in scoliosis consist of modifications in shape and structure of the bones and soft parts. In addition to these there are found at times congenital anomalies of the vertebræ, changes due to rickets, the pathological results of empyema and infantile paralysis, all of which are to be regarded as primary and causative of the changes to be described. In other cases no pathological changes in addition to those described are to be found. These matters will be discussed more fully in speaking of etiology.

The pathological changes occurring in scoliosis may vary from moderate asymmetry to extreme distortion. In general the spine is curved to one side in some part of its length, or it is curved in one direction in one part and in the opposite direction above or below or both above and below. These curves are formed by the deviation of the vertebræ from the median sagittal plane of the body and are more marked in the column of bodies than in the column of arches. The lateral curve may be a general sweep to one side, or it may be sharp and in the severer cases angular. In the severer cases it exists not alone in the presacral vertebræ, but may also involve the sacrum and coccyx.

In addition to the lateral deviation, the curved region is rotated or twisted on a vertical axis, the bodies of the vertebræ always turning toward the convex side of the lateral curve. This rotation is the mechanical accompaniment of the lateral curve, and one cannot exist without the other, although in some cases the rotation is out of proportion to the lateral deviation, and in other cases the lateral curve predominates over the rotation.

In connection with the lateral curve, alteration in the normal antero-posterior physiological curves may occur, as mentioned. The relation of these changes to the lateral curve is but little understood.

Such being the gross pathological changes occurring in the spine as a whole, it will add to clearness in considering this most complex matter to take up individually the alterations in the separate elements.

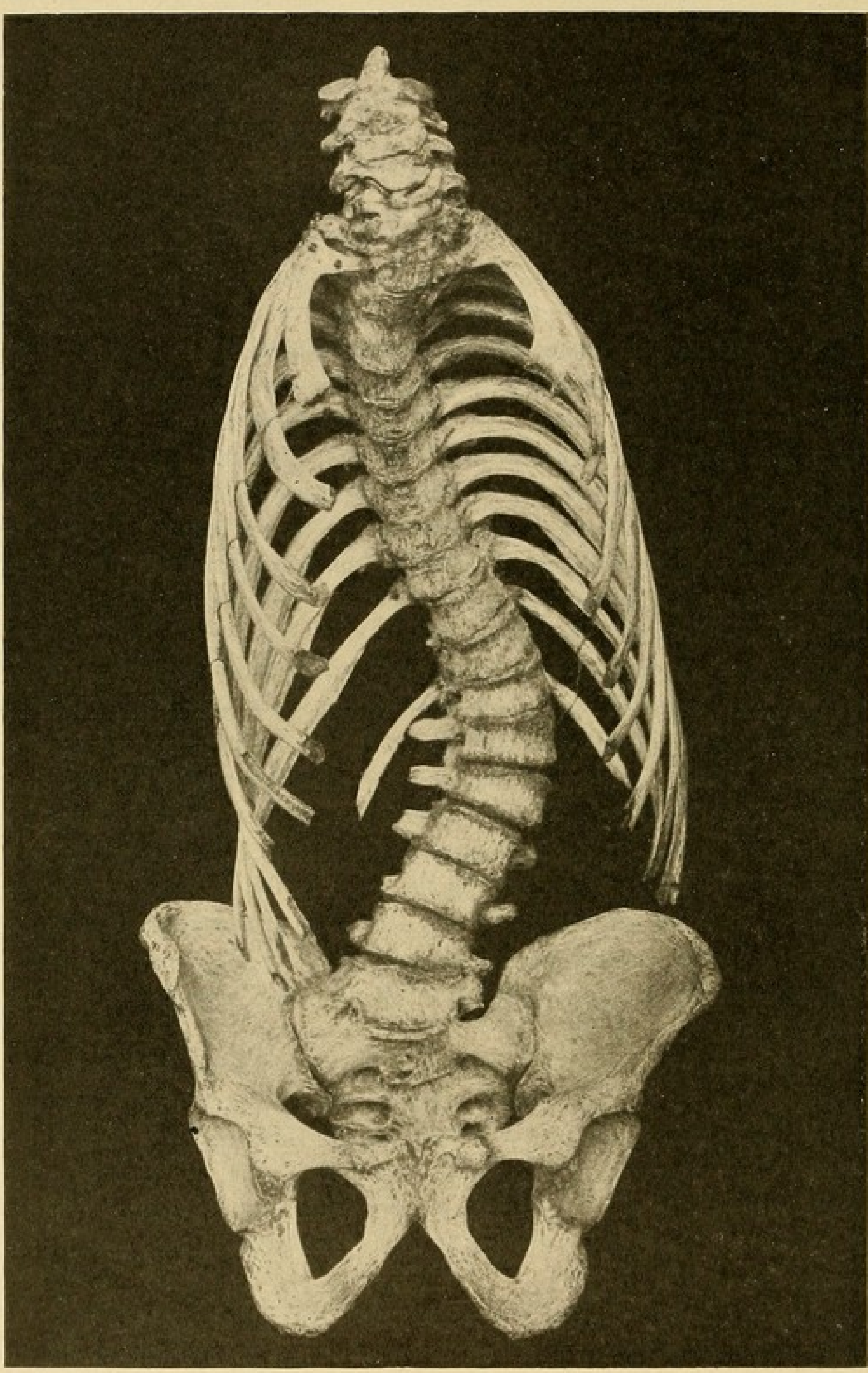


Fig. 65.—Scoliotic Spine from the Dwight Collection of Abnormal Spines in the Warren Museum.

Sacralization of the twenty-sixth vertebra on the right. Thirteen dorsal and six lumbar vertebræ. Fusion of several vertebræ and of first three ribs on the left. The changes in the vertebral bodies are characteristic of severe scoliosis.

CHANGES IN THE VERTEBRÆ.

Vertebral Bodies.—The scoliotic vertebræ are to be divided into two classes, according to their pathological changes, those in the angle of the curve being called wedge vertebræ, while those between the apices of the curves or between the apices and the normal portion are called lozenge-shaped or oblique vertebræ. Pure forms of wedge-shaped and lozenge-shaped vertebræ are rare, and both processes are common in the same vertebra.

A certain amount of rotation and also a transverse displacement of one vertebra upon another is normally possible up to a certain degree on account of the elasticity of the intervertebral discs and the play of the ligaments, but usually the pathological process is not satisfied with the normal excursions, but rotates the vertebra in its

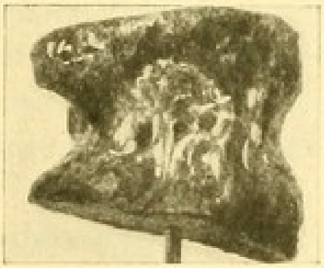


FIG. 66.—A "WEDGE" VERTEBRA.—(*Schulthess.*)
Second lumbar seen from in front; left lumbar curve.

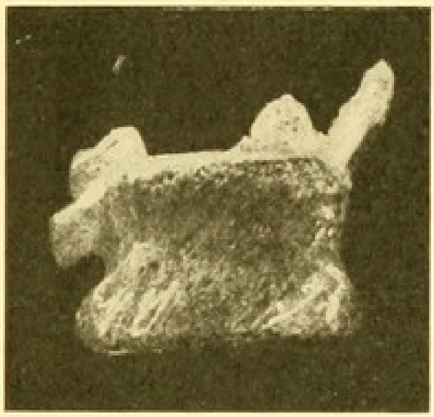


FIG. 67.—AN "OBLIQUE" VERTEBRA.—(*Schulthess.*)
Fourth lumbar seen from the front; from a left lumbar curve.

structure. This rotation is expressed in the relation of the upper and under surfaces of the vertebral body and in a twist between the body and arch.

Wedge Vertebræ.—The vertebræ at the apex of the lateral curve and just above and below it, from one to five in number, are called the wedge or apex vertebræ (Keil- or Scheitelwirbel), and are compressed on one side and consequently wedge-shaped. The obliquity may affect chiefly the upper surface when the vertebræ are below the apex of the curve, and the lower surface chiefly when they are above it, but it may affect both upper and lower surfaces nearly equally, as in the vertebra at the point of the curve, and some modification of both surfaces is generally to be noted. The thinnest part of a wedge vertebra is found on the side of the concavity of the lateral curve and generally toward the posterior aspect of the body. The side of the body toward the concavity is broadened and lipped in severe cases, and synostosis between two vertebral bodies may occur in this location. As a whole, the apex vertebræ are rotated toward the convexity of the lateral curve.

Lozenge-shaped Vertebræ (torsion vertebræ, oblique vertebræ, Interferenz- or Schrägwirbel).—The vertebræ between the apex vertebræ of the two curves or between the apex vertebræ and normal vertebræ are deformed in a somewhat different manner. The upper surface of the vertebra is displaced on the lower in such a way that the outline of the vertebra is lozenge-shaped, the longest diagonal axis being toward the apex of the lateral curve, the top of the vertebra being shoved sideways on the bottom. Such vertebræ may show oblique ridges on the front of the body. The upper part of the body, moreover, twists on the bottom part, below a right dorsal curve, the upper part of the vertebra twisting in the same direction as would the hands of a watch, while above the apex of the curve the twist occurs in the opposite direction. This is called longitudinal torsion.

The vertebral foramen in the dorsal region, instead of being round as in the normal, in severe scoliosis becomes pointed at the side toward the concavity. In the lumbar region the normal triangular shape is distorted by being irregularly blunted at the angle on the side of the concavity.

Arches of the Vertebræ. *Pedicles.*—In the wedge vertebra the original elevation of the pedicles may be retained. As a rule, they are lowered on the concave side of the curve and tend to be more oblique on the convex side, but in the vertebra at the point of the curve they may be alike on the two sides. The pedicle on the convex side is directed straight backward and the other backward and outward. In the dorsal vertebræ the pedicle of the concave side may be narrowed, but in the lumbar region it is more generally broadened and the transverse process becomes smaller. In the lozenge vertebræ below the apex the pedicles are likely to be depressed and above it elevated, according to the intensity of the curve. In severe scoliosis the shortening of the trunk is so great that the vertebræ are pressed together, and, as the bodies offer less resistance to compression than the arches, the displacement of the pedicles on the bodies is brought about.

Articular Processes.—The articular processes being connected with the pedicles share in any change that they undergo. Owing to the fact that the joint planes are so different in the dorsal and in the lumbar regions the pathological appearances differ widely in the articular facets of the dorsal and lumbar vertebræ. The crowding together of the articular processes on the concavity of the lateral curve results in an enlargement, deepening, and broadening of the joint surfaces, while on the convex side the facets are smaller and higher. In the lumbar region the superior articular facets on the concave side are hollowed out, while the inferior ones are correspondingly prominent and rounded, and the cartilage is thickened on the concave side. The involvement of these joints is a matter of some practical importance, and the changes suggest an adaptation to greater demands on the joints on the concave side of the column. Synostosis may occur in these joints, and the ligaments may share in the ossification.

Transverse Processes.—The transverse processes tend to remain more horizontal than the body of the affected vertebra, and as the vertebra becomes inclined to the horizontal plane by the changes described, the transverse processes strive to remain as nearly horizontal as possible. Not infrequently the transverse processes are shorter and thicker than normal on the convex side above and below the apex of the curve.

Spinous Processes.—The spinous processes are deflected toward the convexity of the lateral curve in the dorsal region. This, it seems, may be explained as being the natural position when the spine is laterally curved and is retained in a scoliotic position under the effect of muscular pull, while the bodies of the vertebræ, being influenced largely by weight bearing, an individual plasticity of bone, and certain unformulated conditions, are forced, as has been said, from the concavity to the convexity of the curve.

In the lumbar region in severe cases the spinous processes are diverted toward the concavity. This deviation, it would seem, is the result of a shoving to the side of the root of the spinous process from extreme rotation, as the tips of the processes show the endeavor to conform to the usual position by being in some degree approximated to the convexity of the curve. In the dorsal region the spinous processes are also displaced downward, and the direction of each spinous process is therefore influenced by its contact with the one below it.

The angle between the lower border of the spinous process in this region and the arch becomes on the convex side smaller and on the concave side larger than normal, and the appearance of displacement to the convex side is thus increased. If the arch is displaced horizontally upon the vertebral body, as described above, by the lowering of one pedicle and the elevation of the other the spinous process undergoes a rotation around its own longitudinal axis. The irregularity of

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these appearances may be explained by the pull of the muscles, a matter which is at present imperfectly formulated.

Joints between Vertebræ and Ribs.—These of course are of two kinds: first, the joints between the heads of the ribs and the sides of the vertebræ; second, the joints between the tubercles of the ribs and the transverse processes. These are both similarly affected in severe

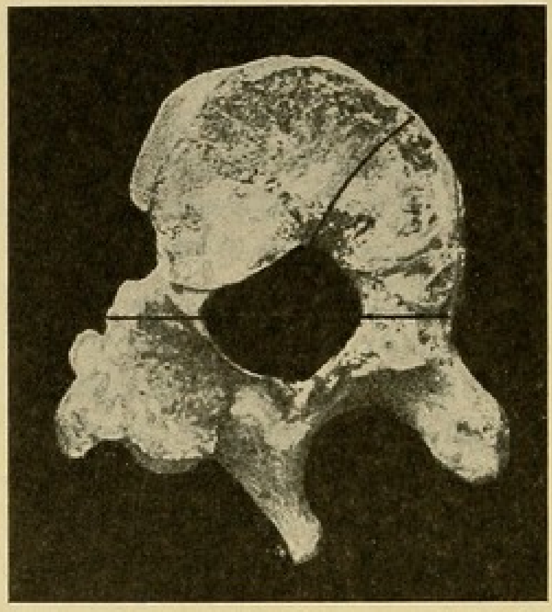

Fig. 68.—Distorted Antero-posterior Plane of a Scoliotic Vertebra.—(*Riedinger.*)

scoliosis, being deepened on the side of the convexity and faintly indicated on the side of the concavity, especially above the apex of the curve. The articular facets on the side of the vertebral body are moved forward on the concave side and backward on the convex side.

INTERVERTEBRAL DISCS.

These show the earliest changes, and at the points of greatest curve are compressed and project beyond the edges of the vertebral bodies as if the bodies had grown into them. On the convex side they are thicker than on the other.

LIGAMENTS.

On the side of the concavity the anterior common ligament is dense and thick, while on the convex side of the curve it is thinned and shows no definite lateral border. In the lozenge-shaped vertebræ the fibers run obliquely in a direction corresponding to the ridges on the anterior surface of the vertebral bodies. The posterior common ligament near the apex is found more to the convex side than normal because its insertions into the intervertebral discs do not share in the broadening out of the concave side of the vertebral bodies, and the vertebra thus grows to the concave side, while the ligament remains more nearly in the middle. The ligaments connecting the heads of the ribs and the spine are long and atrophied on the convex side and short and tense on the concave side.

MUSCLES.

Where muscles are thrown out of use they atrophy and may undergo fatty or fibrous degeneration. When increased demands are made upon them they hypertrophy. When under changed conditions they pass over a surface of bone they may become tendinous where the contact occurs. Nutritive or adaptive shortening occurs when the ends of muscles are approximated. All these changes are to be found in cases of severe scoliosis, but the muscular changes in slight scoliosis have not been formulated.[1]

The change which muscles undergo in lateral curvature is first of all a change of direction of pull caused by the displacement of the thorax in relation to the pelvis toward the right or left. For example, if the trunk is displaced toward the left, the muscles taking origin from the crest of the ilium are directed toward the left at their insertion in the spine. Under normal conditions the contractility of the muscles would be sufficient to bring them back to their normal positions, but in a strong lateral inclination of the lumbar segment above the sacrum the psoas muscle, for example, acquires a broad insertion and becomes fan-shaped, thereby assuming a different function. Under normal conditions the insertion of this muscle is more linear and placed at an acute angle to its direction of pull.

Following the loss of function of the muscles on the concave side of the lateral curve in severe cases fatty degeneration is observed. On the convex side the muscles are wasted and thin, and sometimes, in exceptional cases, fatty degeneration is found here also. On the convex side more often a fibrous degeneration is found; that is, atrophy of the muscular tissue and the formation of larger tendons. In addition to all of this the stiffness of the column which sets in fairly early in moderate and severe grades of scoliosis tends to cause atrophy of the muscles of the back in general, the atrophy of disuse.

The diaphragm assumes an oblique position and is lower on the side of the convexity of the dorsal curve. If the apex of the dorsal

[1] Phelps: "Trans. Amer. Orth. Assn.," vol. xiv

curve is situated high up and associated with kyphosis, the top of the diaphragm may be much élevated—even as high as the level of the third rib.

THORAX.

In lumbar scoliosis the changes in the thorax are slight, but some rotation of the structure as a whole is noted in relation to the frontal plane of the pelvis.

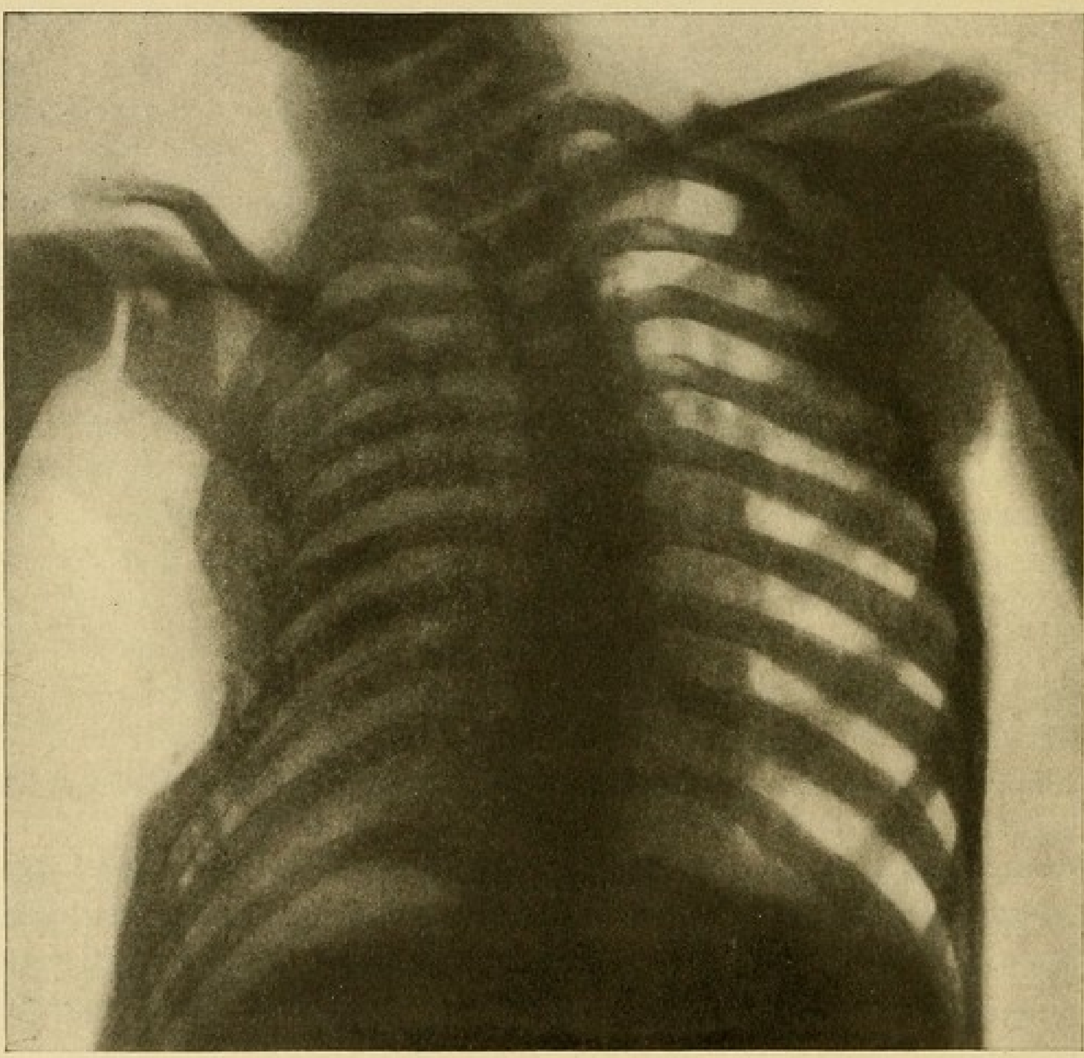

FIG. 69.—RADIOGRAM OF LEFT SCOLIOSIS, RESULTING FROM EMPYEMA OF THE RIGHT SIDE WITH RESECTION OF THE RIBS.

In dorsal scoliosis the thorax is not only displaced as a whole toward the convexity of the curve, but its structure is distorted. The thorax as a whole tends to retain its normal position with regard to the frontal plane of the body more closely than does the spine, which, as is were, rotates in the thorax. It thus undergoes a twist in the opposite direction from that of the spine. This results in a change in its horizontal diagonal diameters, by which the one from the side of the convexity behind to the concavity in front is lengthened, and the corresponding one on the other side is shortened. For example, in right dorsal scoliosis the thorax is displaced to the right and becomes prominent on the right side behind and the left side in front, and the diagonal diameter from the right side behind to the left side in front is lengthened. As a result of this the internal surfaces of the shafts of the right ribs are brought nearer to the front of the vertebral bodies, and the right side of the thorax is seriously diminished in capacity.

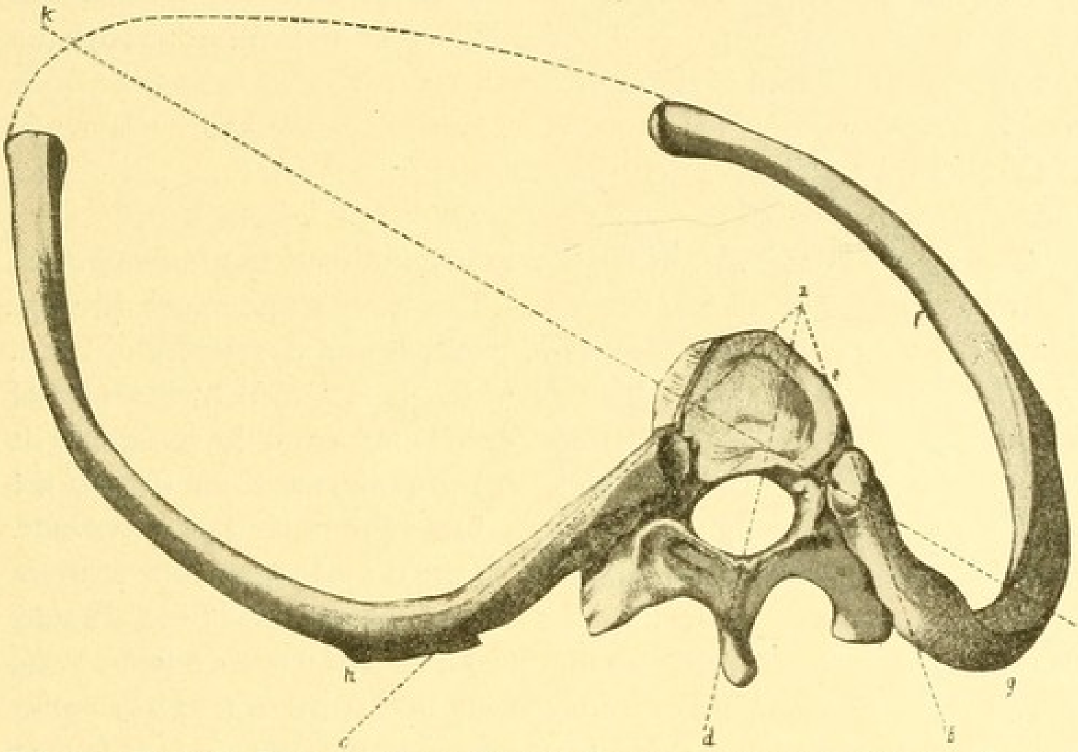

Fig. 70.—Thoracic Ring in a Right Dorsal Scoliosis, seen from Above.—(*Lorenz.*)

Ribs.—The ribs on the convex side of the lateral curve show a backward increase of their angularity, forming on the side of the back of the thorax a more or less sharp and prominent ridge, spoken of technically as "the rotation" (Rippenbuckel). In compound curves of the dorsal region these phenomena accompany each curve. From the angle forward to the sternum the ribs of the convex side show a loss of their normal curve.

The ribs on the side of the concavity of the lateral curve show a straightening of their angles and an increased outward bowing of their shafts. The costal cartilages of the concave side in front show an increased curvature forward and form on the front of the chest a prominence at the side of the sternum (vordere Rippenbuckel).

The ribs of the side of the convexity are spread apart and have a more oblique direction; on the side of the concavity they are closer together and tend to a more horizontal course. These phenomena are dependent upon the degree of inclination of the part of the spine to which the ribs are attached.

Sternum.—The sternum as a rule deviates but little from its normal position and direction except in very severe scoliosis. The variations in position consist—(1) In a lateral displacement; (2) in an obliquity of the lower end, which turns either to the convexity or concavity of the lateral curve; (3) in a rotation around its longitudinal axis, making one lateral border, commonly the one toward the concavity of the lateral curve, more prominent. A detailed study of the variations of the sternum may be found in the reference.[1]

SHOULDER-GIRDLE.

The marked deformity of the thorax cannot be without influence on the form of the clavicles and scapulæ. The *scapula* undergoes, because of the deformity, various changes of position and eventually of form. It always acquires that position to which it is forced by the form of the thorax, the weight of the shoulder and arm, and the tension of its muscles. On account of the backward prominence of the thorax, the scapula is moved away from the vertebral column on the convex side, and if the scoliosis is located high up in the dorsal region, the scapula moves upward also. If the thorax is strongly compressed from the side, the scapula may lie sidewise, so that its dorsal surface has a lateral and not a backward direction, or it may swing backward so that its inferior angle crosses the line of spinous processes to the other side. It may furthermore acquire a strong curve on itself if it lies on a thorax sharply deformed, and become convex backward.

The *clavicle*, whose first function is to keep the scapula at a certain distance from the sternum, also changes according to the situation of the spinal curve, and may be found more sharply curved in scoliosis.

PELVIS.

Sacrum.—In low curves (generally convex to the left in the lumbar region) the sacrolumbar junction becomes practically the apex point, and here one looks for rotation, and pressure changes may continue the

[1] Fauconnet: "Zeitsch. f. orth. Chir.," xvii, page 201

curvatures of the presacral vertebræ. The sacrum is affected in such low lateral curves in a way analogous to that of the other vertebræ, but modified in extent by the fixed position of the sacrum. In a right dorsolumbar curve the following changes in the sacrum were found and may be taken as exemplifying them (Schulthess):

1. A decrease in the height of the first sacral vertebra on the concave side (*cf.* wedge vertebra).

2. A broadening of the base of the sacrum on its concave side (*cf.* broadening of concave side of vertebral body).

3. Forward displacement of the left or concave half with its corresponding ala and backward displacement of the right or convex half (*cf.* rotation of vertebral bodies).

4. Broadening of the part of the sacrum corresponding to the pedicle on the concave side.

5. Lowering of the arch on the concave side.

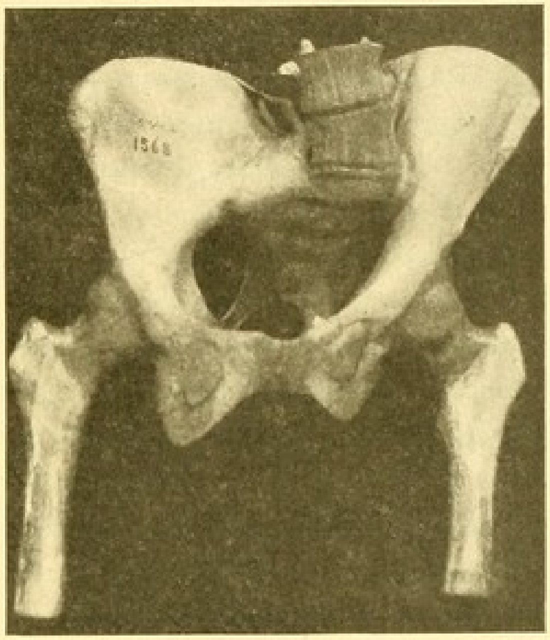

FIG. 71.—OBLIQUE PELVIS ACCOMPANYING SCOLIOSIS.—(*Warren Museum, cast from a specimen in Museè Dupuytren, Paris.*)

In addition to this there is to be seen at times a slight indication of a lateral curve of the sacrum, reaching its apex at or below the middle of the bone. In this the coccyx may share, emphasizing the curve, but the sacral curve is most easily seen by sighting along the anterior surface of the sacrum or looking down the vertebral canal. This curve shows slight indications of the same changes noted in the presacral vertebræ.

The pelvis is somewhat changed in diameter and shape in severe low lumbar curves in which the sacrum shows distortion. In a left lumbar curve the diagonal diameter from the left side behind to the right side in front is greater than the opposite diagonal; thus in an individual case of right dorsal left lumbar curve the thorax and pelvis would be twisted in opposite directions.

SKULL.

In long-continued scoliosis, especially of the upper part of the column, asymmetry of the face and skull may exist.

INTERNAL ORGANS.

In scoliosis, especially in moderate and severe forms, a shortening of the trunk is apparent which prevents the normal development and function of the internal organs. By the lateral displacement of the trunk and rotation of the thorax the pleural and abdominal cavities become distorted. The patients become anemic and show a certain disposition to tuberculous pulmonary diseases. Bachmann,[1] in 197 autopsies in scoliotic patients of moderate and severe type has found in 28.3 per cent. tuberculous disease of the lungs, while in milder degrees of scoliosis there were 66 per cent. so affected.

The secondary changes in the internal organs are essentially dependent upon the narrowing of the containing cavities. In a severe right dorsal curve the right pleural cavity is very much narrowed—so much so that in extreme cases the inner surfaces of the ribs are found lying close to the vertebral column. The narrowing of the pleural cavity on the left, that is, on the concavity, is not so important as that of the right. It follows that the right lung must suffer from the distortion more than the left. Mosse[2] found apex infiltration in 60.2 per cent. of 100 scoliotic children between five and sixteen years old. Kamine v. Zade[3] found apex affections in 73 per cent. of scoliotic women, the lung affection being predominantly of the lung on the convex side of the curve.

Affections of the pleura, adhesive pleuritis, leading to total obliteration of the pleura and atelectasis, are found very frequently. Bachmann gives the following figures: 74.6 per cent. affections of pleura, with 7 per cent. of total obliteration and 31 per cent. atelectasis of lungs. The atelectasis depends either upon the failure of the respiratory muscles to bring about expansion of the lung in certain places, or upon the fact that a real compression between bony walls, or between a bony wall and the diaphragm, has taken place. This compression is more readily possible if certain parts of the lungs are held back by adhesion. Bachmann found such compression in 24.3 per cent. of cases.

Undoubtedly the lungs of scoliotic patients, especially in cases of kyphoscoliosis, are predisposed toward a greater number of diseases than the lungs of normal individuals.

Heart and Vessels.—The same narrowing of thoracic space affects the heart. It is frequently found pushed upward and pressed against the anterior chest-wall, and it is at the same time, according to the

[1] Bachmann: "Bib. med.," Abt. 1, Heft 4, 1899.
[2] Mosse: "Zeitsch. f. klin. Med.," xli, pages 1–4.
[3] Kamine v. Zade: "Deut. Arzte. Zeit.," 1902, xx.

direction and the extent of the curvature, more or less displaced laterally. In right curves generally the heart is displaced toward the left; but this is not a constant condition. Hypertrophy and dilatation of the cavities of the heart are very frequent, especially of the right heart in severe scoliosis. Bachmann found it in 56.4 per cent. of cases, while the left heart was similarly affected in 17.5 per cent. This phenomenon was found in both right and left sides in 25.9 per cent.

The aorta in general follows the curvature of the spine, particularly in right curves. In a left dorsal curve, however, the aorta does not, as a rule, lie on the convex side of the curve, but runs straight like the chord of an arc, more often in front or even a very little to the right of the spine. The large veins show less typical changes. The vena cava in the region of the liver, where it is relatively fixed, and occasionally at the entrance of the renal veins, may show a change in its course corresponding to the change of position of the organs.

The most reasonable explanation for the hypertrophy of the heart is the insufficient depth of respiration of scoliotic patients. Even in relatively slight distortion of the thorax, respiration is more shallow than the normal, consequently the right side of the heart, in order to push the necessary amount of blood through the lungs, must do an extra amount of work.

If the scoliosis increases, the chest space is restricted still more, and the expansion of the lungs, already damaged by adhesions and thickening, is impeded. The heart is also pressed against the front wall of the chest, and the blood-pressure is changed on account of the bends in the vessels, which conditions add greatly to the work of the heart. The difficulty which the blood finds in passing through the lungs leads to a great degree of venous dilatation if the condition continues long enough. This is especially noticeable in the veins of the head, neck, and arms.

Esophagus.—In general the esophagus has a tendency to deviate in the direction of the concavity of the curve, although frequently its form and course are but little changed. The influence upon the course of the esophagus is least when the radius of the curve is a large one and the secondary curve lies below the diaphragm. In every case the esophagus follows a straighter course than the aorta, and it crosses the aorta near the point at which it pierces the diaphragm.[1]

Intestines.—The abdominal contents are, in consequence of restricted space, pressed downward and forward, and added to this is the influence of the approximation of the chest to the pelvis and the side displacement of the vertebral column. The downward pressure results

[1] Hacker: "Wien. med. Woch.," 1887, page 46.

in crowding the intestines into the true pelvis. The lateral displacement of the thorax affects chiefly the transverse colon, which may become almost vertical.

Liver.—In right curves the liver is pushed toward the left, the left half is better developed than the right half, and finally the organ on the right side may be indented by the ribs.

Kidneys.—In right dorsal scoliosis the right kidney is often displaced upward along the spine and the left one downward, and while the right kidney suffers as a rule slight changes, the left is more likely to be affected severely from rib pressure. Cystic degeneration and floating kidney are common. Bachmann enumerates, among 180 observations, 14 cystic kidneys, 31 cases of granular atrophy, 18 cases of simple atrophy, and 6 cases of hydronephrosis.

Spleen.—The spleen may be higher than normal. Perisplenitis, atrophy, and cyanotic induration have been observed (Bachmann).

Stomach.—The position of this is influenced by that of the liver and duodenum. The pylorus is depressed, while the cardiac end generally lies high.

Chapter VII.

ETIOLOGY.

It is difficult to present in a complete yet simple form a classification of the manifold causes of scoliosis, for the subject easily lends itself to a minute subdivision which would be confusing. But any classification, however simple, would not present to one unfamiliar with the condition certain aspects of the subject which are of great importance and which are so general that they do not readily come into a classification. These considerations will be first mentioned.

First it must be recognized that there are cases of faulty attitude which are not true scoliosis in the accepted sense but children with practically unchanged vertebral columns standing asymmetrically. These have been already described as functional or postural scoliosis (see p. 46), and some writers have spoken of them as "false scoliosis." It is desirable to recognize that these cases form a distinct class by themselves and either name "faulty attitude" or "false scoliosis" would define their character better than those in more general use.

Second, in real or structural scoliosis, that is, in cases where there are evidently present structural changes of the type described in speaking of the pathology, there are many cases where the changes are comparatively slight and seem no more than would be accounted for by the maintenance of a normally strong growing spinal column in a faulty attitude over a period of years. These cases are frequently spoken of as "static" and do not imply any general pathological condition in bone or elsewhere.

Third, in real scoliosis there are met many cases so severe that they cannot be accounted for by the assumption that they are the natural result of the maintenance of a growing normal spinal column in a malposition over a period of years and one must look for an additional cause. These causes are as a rule to be found in (a) congenital anomalies of the spine and its appendages; (b) rickets; (c) empyema; (d) infantile paralysis, and (e) cases where the deformity of the bones is so great that one must assume the existence of a diminished individual resistance of bone.

In the last class of cases many writers would assume in all instances the existence of rickets as explaining the softness of the bones, but as in many of the cases evidences of rickets are not to be found, it seems more reasonable to meet the situation by the statement that there is apparently a diminished resistance of bones in such cases, but that no demonstrable evidences of rickets are present and one must assume, in such cases, either the existence of rickets in the past, the evidences of which have disappeared, or assume an undefined weakness of bone for which we have as yet no name.

As a practical application of the foregoing one may assume that a short leg, *e.g.*, will cause asymmetry and faulty attitude, *i.e.*, false scoliosis, and in certain cases may be apparently accountable for mild degrees of real scoliosis, but that it is not competent to cause a moderate or severe scoliosis in a child whose bones possess a normal resistance to pressure, but if the bones do not possess this resistance because of rickets or for causes that wo do not at present recognize, it or any similar cause may result in moderate or severe scoliosis.

The following conventional schematic representation of the causes of scoliosis is therefore to be interpreted in the light of what has just been said.

A. Congenital scoliosis.
  1. Malformation of the spine.
  2. Malformation of the scapula.
  3. Malformation of the thorax.
  4. Deforming intrauterine pressure.
  5. Paralysis of intrauterine origin.

B. Acquired scoliosis.
  1. Anatomical, physiological, or other asymmetries elsewhere than in the spine.
    a. Torticollis (wry-neck).
    b. Pelvic asymmetry.
    c. Pelvic obliquity (short leg).
    d. Unequal vision.
    e. Unequal hearing.
  2. Pathological affections of the vertebræ.
    a. Rickets.
    b. Osteomalacia.
    c. Pott's disease.
    d. Dislocation.
    e. Arthritis deformans.
    f. Tumors, etc.

3. Pathological affections of the bones and joints of the extremities, causing asymmetrical position.
    a. Diseases of bones and joints of the leg.
    b. Diseases of bones and joints of the arm.
4. Distorting conditions due to disease of the soft parts.
    a. Infantile paralysis.
    b. Spastic paralysis.
    c. Nervous diseases (hemiplegia, syringomyelia, etc.).
    d. Empyema.
    e. Organic heart disease.
    f. Scars.
    g. Throat, abdominal or pulmonary disease.
    h. Acute or chronic inflammation of the spinal muscles (lumbago, etc.).
5. Habit or occupation.

A. SCOLIOSIS OF CONGENITAL ORIGIN.

The tendency of the last few years has been very strongly toward the recognition of the congenital type of scoliosis. In former years practically all cases were regarded as acquired and the congenital form considered as a great rarity, but this condition is coming to be recognized as by no means infrequent, and every year an increasing number of the moderate and severe types are being transferred from the acquired to the congenital class. This is due largely to the development of the *x*-ray and the study of the living spine thus made possible.

In certain congenital cases of marked scoliosis where a careful study of the spine is possible, no congenital anomaly is to be found and intrauterine pressure as formulated by Hoffa[1] is the presumable cause. Intrauterine paralysis is suggested as a cause by a case of Hirschberger.[2]

In the majority of cases congenital scoliosis is due to defective formation of the vertebræ or adnexa. The period at which these defects originate is discussed by Kirmisson,[3] Mouchet,[4] and Seibert,[5] the rib defects being secondary according to the view of the former.

[1] "Lehrbuch der orth. Chir.," 1894.
[2] "Ztsch. f. orth. Chir.," vii, 1.
[3] "Revue d'Orth.," 1910, 21.
[4] "Revue d'Orth.," 1910, No. 4.
[5] "Ztsch. f. o. Chir., 1911, xxviii, 415.

1. DUE TO MALFORMATIONS OF THE VERTEBRAL COLUMN.

Scoliosis may occur as a congenital condition in connection with severe malformations, such as rachischisis and the like.[1] It occurs also as the result of less severe spinal defects, such as cervical ribs, spina bifida, and abnormal formation of the last lumbar vertebra.

Congenital scoliosis may be evident—(1) immediately after birth, as in the case of the severest malformations (Colville[2] in 1015 cases of new-born children found one case of scoliosis); or (2) only when the child begins to walk, in the case of malformations not severe enough to cause a curve in the recumbent position. In these latter cases the curvature appears as the result of the superincumbent weight coming upon the defective spine or as the result of asymmetrical growth due to the malformation. Such cases as these are perhaps not strictly congenital, but might be better spoken of as scoliosis due to a congenital cause.

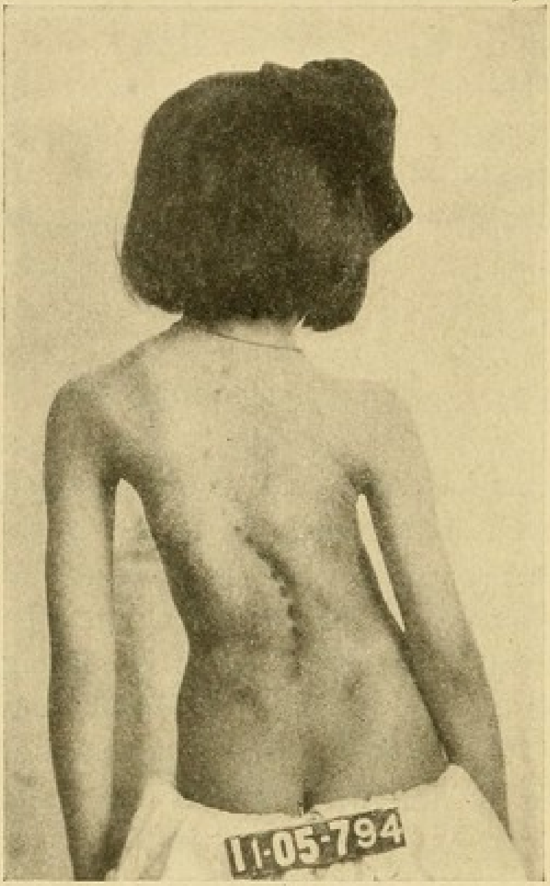

FIG. 72.—SCOLIOSIS DUE TO CONGENITAL DEFECTS IN SPINE AND THORAX, THE RIBS BEING BIFURCATED AND DEFECTIVE.

Another common location of congenital defects is in the cervicodorsal region (Fig. 53). The formation of a cervical rib is often associated with a splitting of the vertebral bodies, as shown by the x-ray, and in some cases the cervical rib is accompanied by a rudimentary extra vertebral body.[3] The shoulder on the side of the cervical rib is elevated, and the curve is a sharp cervico-dorsal one with a compensatory opposite curve below. Cervical ribs may or may not be accompanied by scoliosis. In thirty-five preparations and eleven clinical cases with cervical ribs Eckstein[4] twice found scoliosis.

[1] Schmidt: "Allg. Path. und path. Anat. d. Wirbelsaüle," Lübersch's "Ergeb. zur allg. Path.," 4. Jahrg., 1897.
[2] Colville: "Rev. d. Orth.," 1896, 7.
[3] Drehmann: "Verhdl. d. Deutsch. Gesell. f. orth. Chir.," 5th Congress, 1906 page 12.
[4] "Zeitsch. f. orth. Chir.," 1908, xx, 177.

At the lumbo-sacral junction anomalies are frequent.[1] Waldeyer found that the first sacral vertebra possessed lumbar characteristics in thirty-three out of 265 cases and in eighty-three cases of Adolphi (48 men and 35 women) the twenty-fifth vertebra was the last pure lumbar in 3.6 per cent., the twenty-fourth in 92.8 per cent., and the twenty-third in 3.6 per cent. Abnormalities of the sacral vertebræ are discussed by Breuss and Kolisko.[2]

Sacralization of the fifth lumbar vertebra, especially if unilateral, is a competent cause of scoliosis. *Numerical variation* of the vertebræ, especially if unilateral as pointed out by Böhm,[3] is a competent cause of scoliosis; but, as shown by Adams, numerical variation is not as a rule accompanied by scoliosis because in the Dwight collection of sixty-four spines in the Warren Museum of the Harvard Medical school, all showing numerical variation, there were only seven which could possibly be classed as scoliotic.[4]

Melting together of vertebral bodies and *the absence of part of a vertebra* are the chief remaining causes of congenital scoliosis so far formulated.

2. MALFORMATIONS OF THE SCAPULA.

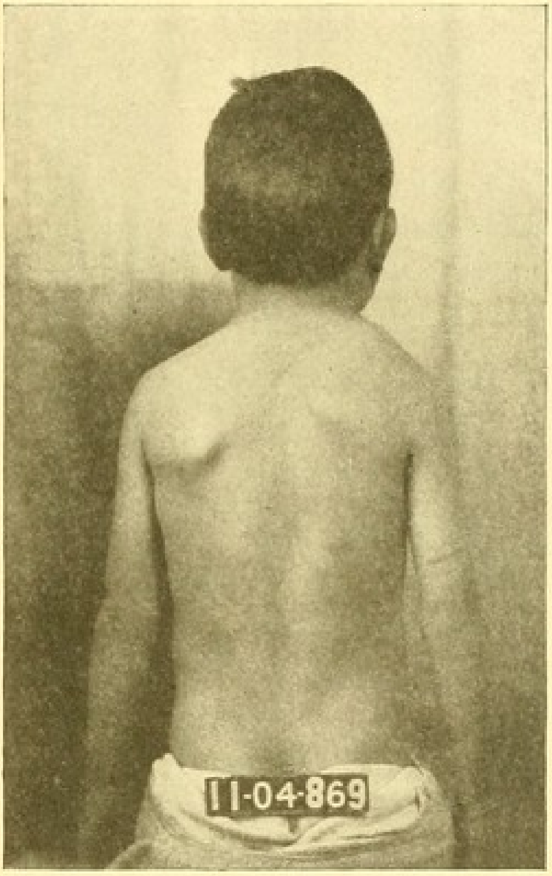

FIG. 73.—CONGENITAL ELEVATION OF THE SCAPULA CAUSING SCOLIOSIS.

Congenital elevation of the scapula (Sprengel's deformity) will cause a scoliosis which is usually a high cervicodorsal curve with compensating dorsolumbar curve. One scapula is occasionally absent or malformed (Fig. 73).

[1] Cramer: "Verhdlungen d. Deutsch. Geo. f. orth. Chir.," 1908, 68.
[2] "Pathologische Beckenformen."
[3] "Boston Med. and Surg. Jour.," Nov. 22, 1908; "Berl. klin., Wchsft.," 1910, 2; "Berliner Klinik," Feb., 1910.
[4] "Boston Med. and Surg. Jour.," Apr. 28, 1910

3. MALFORMATION OF THE THORAX.

Occasionally great irregularity characterizes the ribs of one or both sides. Some may be bifurcated, while others are deficient. Such irregularities are a cause of scoliosis.

Heredity must also be considered, as it is known that scoliosis is apparently inherited in some families, Schulthess estimating that from 10 to 15 per cent. of scolioses are hereditary. Congenital defects of form can be inherited, and would reasonably lead to similar forms of scoliosis, while an inherited weak skeleton or a disposition to rickets would not necessarily lead to a reproduction of the form of scoliosis. There are cases, however, in which the form also seems to be hereditary.

B. ACQUIRED SCOLIOSIS.

Scoliosis is to be classed as acquired when the deformity comes on after birth from some cause not apparently congenital, and this includes, so far as we know now, the greater number of cases. The experimental production of scoliosis in animals has been demonstrated and is discussed elsewhere (page 40). The acquired varieties of scoliosis may be considered as follows:

1. ANATOMICAL OR PHYSIOLOGICAL ASYMMETRIES ELSEWHERE THAN IN THE SPINE.

(*a*) **Torticollis,** or wry-neck, a condition characterized by the contraction of one sternocleidomastoid muscle, causes a tilted and twisted position of the head and necessitates a compensatory lateral curve of the spine to preserve the balance and enable the head to assume an approximately normal position. Unilateral torticollis, if sufficiently long continued, is always accompanied by scoliosis.

(*b*) **Asymmetry of the Pelvis.**—The spine is not always located in the middle of the pelvis, but at times is found at one side of the median sagittal plane of the body (amesiality of the pelvis). The pelvis may be in other respects asymmetrical. In these cases a compensating lateral curve is necessary in order to allow the head to be held over the center of the body[1] (Fig. 74).

Hasse[2] held that he had rarely seen a symmetrical pelvis and Naegele in a collection of fifty pelves, could not find one to show to his students as normal.

(*c*) **Obliquity of the Pelvis.**—Any condition which causes the

[1] "Arch. f. Anat. and Phys.," 1891.
[2] "Das Schräg. verengte Becken.," 1839.

pelvis to be held higher on one side in the horizontal plane is a competent cause of scoliosis, because such obliquity necessitates a lateral curve of the spine to secure normal balance. A *short leg* must be counted a frequent cause of scoliosis. But it must be remembered that a difference in the length of the legs is very common in children,[1] and that the frequency of scoliosis is less than the frequency of short legs. The association of short legs and scoliosis has been investigated, with varying results; and Schulthess estimates, without analyzing his cases, that from 1 to 5 per cent. show this association. The measurement taken with a tape-measure from the two anterior superior spines to the inner malleoli while the patient lies on the back is inexact and of little value

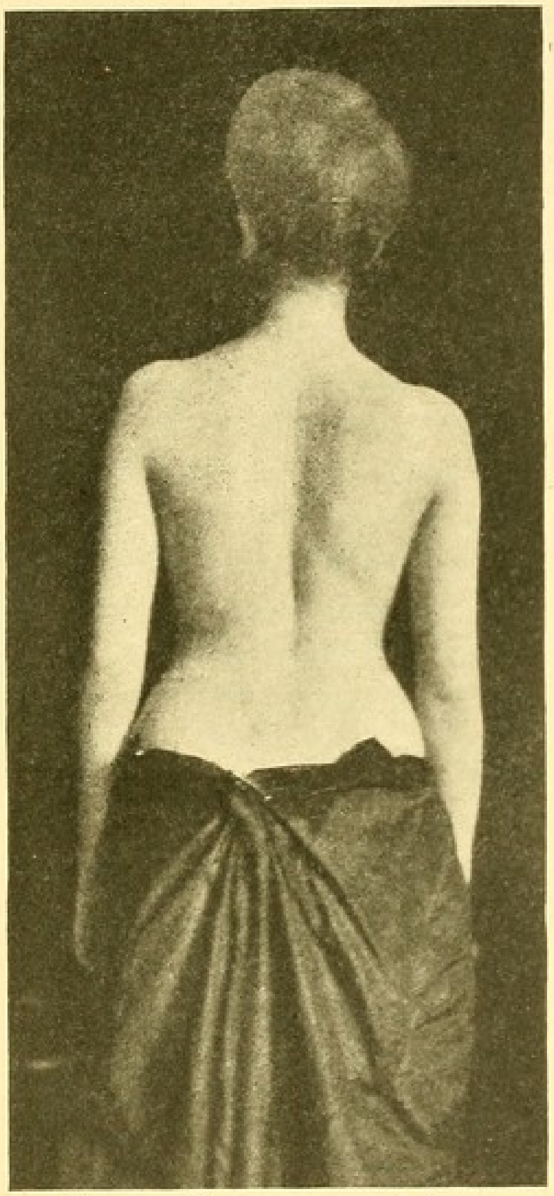

FIG. 74.—SCOLIOSIS DUE TO ASYMMETRY OF THE PELVIS, THE RIGHT SIDE BEING SMALLER.

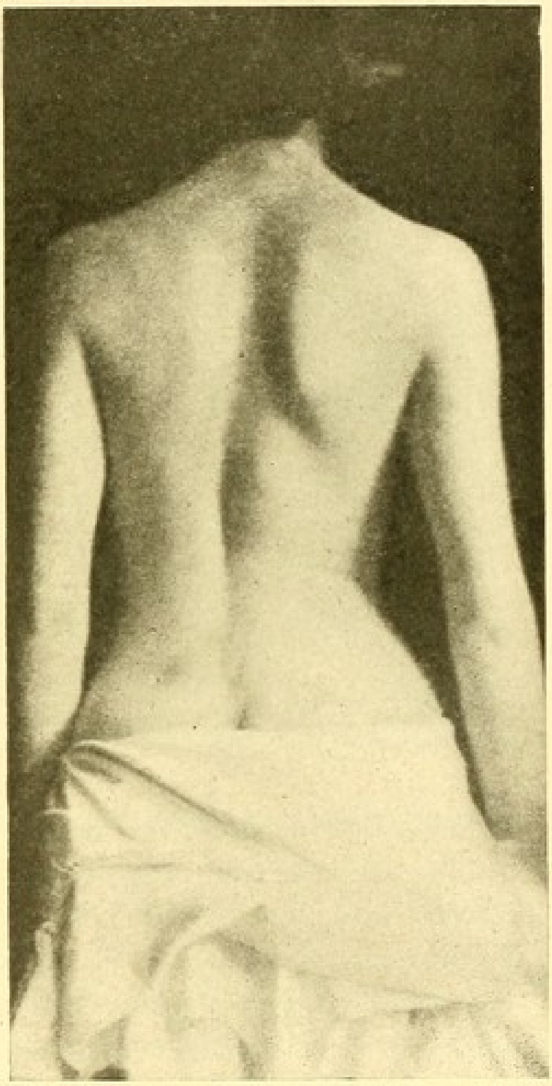

FIG. 75.—LEFT LUMBAR SCOLIOSIS FROM INEQUALITY IN THE LENGTH OF THE LEGS.

[1] Bradford and Lovett: "Orth. Surgery," 3d ed., page 476.

as determining the real position of the pelvis in standing, and much importance must not be attached to it. The most reliable method that we have of determining the horizontal plane of the pelvis and the obliquity which must exist when there is really a short leg is to make level the two anterior superior spines when the patient stands erect by means of pieces of thin board placed under one foot, but even this is inaccurate an account of the frequency of asymmetry of the pelvis just alluded to. It is not an uncommon experience to find that the spinal curve is increased by putting a block under the foot on the side shown to be short by measurement, but that the spinal curve is improved by making the long leg longer by the same method.

(*d*) **Unequal hearing** causes a tilting or twisting of the head which may produce a temporary lateral curve in the cervical and upper dorsal regions.

(*e*) **Unequal vision,** necessitating a tilting of the head to bring vertical objects into clearer vision, may cause a lateral curve. The school observations at Lausanne are of interest in this connection, as a steady increase in the percentage of scoliotic and myopic children was found from the lowest classes upward, as is shown by the table.

Class.	Scoliotic.	Myopic.
I	8.7 per cent.	3.0 per cent.
II	18.2 "	4.5 "
III	19.8 "	5.2 "
IV	27.2 "	6.0 "
V	28.3 "	8.5 "
VI	32.4 "	13.7 "
VII	31.0 "	19.4 "

The relation between scoliosis and myopia has not yet been determined.

It is obvious that astigmatism may be a cause of head tilting. The subject has been carefully worked out by Gould,[1] whose conclusion is that in asymmetrical astigmatism the axis of the dominant eye determines a tilting of the head to the right or left, but that this does not occur in symmetrical astigmatism.

2. PATHOLOGICAL AFFECTIONS OF THE VERTEBRÆ.

(*a*) **Rickets,**[2] which is a constitutional disease beginning in the first dentition which leads to a softening of the bones, has long been

[1] G. M. Gould: "Amer. Medicine," May 21, 1904; Mar. 26, 1904; April 8, 1905; "N. Y. Med. Record," Apr. 22, 1895. H. A. Wilson: "N. Y. Med. Journal," June, 1906.

[2] Kirsch: "Verhdlg. d. Deuts. Ges. f. orth. Chir.," 1910, p. 94; Böhm: "Verhdlg. d. Deuts. Ges. f. orth. Chir.," 1910, p. 49.

recognized as a cause of scoliosis. But the trend of recent opinion is toward assigning rickets as a cause of scoliosis in a very much larger number of cases than was formerly done. Indeed, some writers would go so far as to assume that practically all organic scoliosis, not obviously due to a congenital defect or some such obvious cause as empyema or paralysis, was due to rickets. The situation in this regard has been already discussed at the opening of the chapter.

Kirsch, who is an advocate of this view, asserts that among the school children of Magdeburg 60 per cent. show signs of rickets and 90 per cent. of children who come to the polyclinic are rachitic.

The typical rachitic variety of scoliosis is characterized by a sharp and severe curve oftenest in the lower spine, with shortening of the trunk. It is one of the most resistant forms to treatment and is a variety which begins early as the softness of the bones is most marked during the acute process. The recognition is made by the presence of the other signs of rickets, found in the deformed bones elsewhere and the usual diagnostic signs.

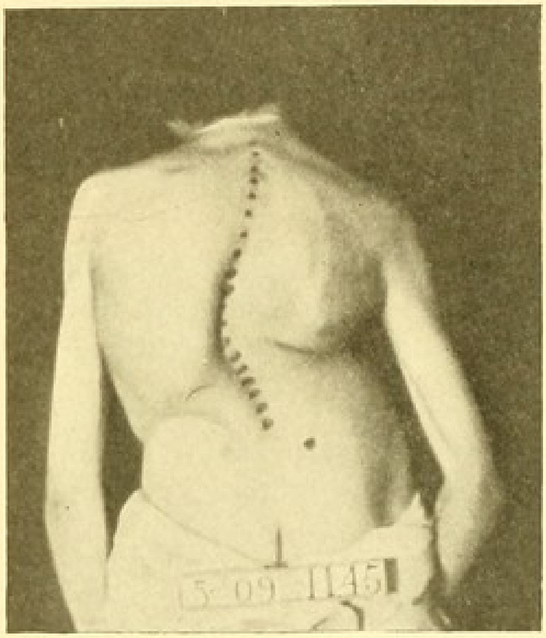

Fig. 76.—Severe Scoliosis due to Rickets.

(*b*) **Osteomalacia,** an uncommon process like rickets in causing a softening of the bones, but more frequently seen in adolescents and adults than in children is accompanied occasionally by lateral curvature.

(*c*) **Tuberculous disease of the spine,** or **Pott's disease,** is a destructive pathological process attacking the bodies of the vertebræ. Lateral deviation of the spine associated with stiffness often exists in connection with the backward "hump" or kyphosis, which is the characteristic sign of the disease. This early form is generally atypical, with little rotation. In the early stages of Pott's disease, lateral deviation is present as a symptom of irritation. In the later stages of Pott's disease lateral asymmetry may be present as the result of unilateral destruction of one or more of the diseased vertebræ.

(*d*) Severe injuries of the spine, resulting in chronic sprain of the vertebral column, dislocation of the vertebræ, and injury of the epiphyseal cartilage, may be accompanied by lateral deviation of the spine as a symptom.

(*e*) **Arthritis deformans** is characterized by a progressive stiffening of the spine due to deposits of newly formed bone on the front and sides of the column, binding the vertebræ together. The intervertebral discs degenerate and the vertebræ become fused; bony deposit occurs in the ligaments, and the articulations of the vertebræ with the ribs may lose some or all motion. Lateral deviation, accompanied by general kyphosis, is generally present, but is atypical and accompanied by little rotation (see Ischias Scoliotica, p. 102).

Other causes of this class are tumors of the spine and, it is said, hereditary syphilis.

The scolioses of this class are symptomatic of a serious condition, and except for that of rickets are not to be treated like ordinary primary scolioses and would be much injured by such treatment.

3. AFFECTIONS OF THE BONES AND JOINTS OF THE EXTREMITIES.

(*a*) **Diseases of the bones and joints of the lower extremity** play a larger part in the etiology of scoliosis than those of the arm and shoulder. Lateral curvature may be caused by the shortening of one leg due to derangement of growth; to unilateral diseases of the hip-joint causing shortening, dislocation, contraction, or ankylosis in a position of adduction, abduction, or flexion; to unilateral congenital or paralytic dislocation of the hip; to coxa vara, coxa valga, and fractures of the lower extremity; to diseases and malformations of the diaphyses of the leg or thigh bones; to diseases of and operations on the knee-joint causing shortening, contraction in the flexed position, or knock-knee on one side; and to diseases and malpositions of the foot, especially flat-foot.

(*b*) **Diseases of the shoulder-joint,** causing partial or complete ankylosis, may be accompanied by a curve of the spine in the dorsal region.

4. DISTORTING CONDITIONS DUE TO DISEASE OF THE SOFT PARTS.

(*a*) **Infantile spinal paralysis** or **anterior poliomyelitis**[1] is a fairly common cause of lateral curvature. The paralysis occurs oftenest during early childhood, and the lower extremity is more often affected than the upper. The deformities produced are due to shorten-

[1] Cordet Boise: "Revue d'Orthopedie, 1910, 5, 381.

ing of bone or to muscular paralysis. Scoliosis results in one of three ways:

1. From inequality in the length of the legs, causing a tilting of the pelvis.

2. From unilateral paralysis of the muscles directly controlling the vertebral column, which may cause a deviation of the spine either to that side or to the other side. It does not follow, as shown by Arnd experimentally and as recognized clinically by others, that a paralysis of the muscles of one side of the back is followed by a curve convex toward the paralyzed muscles, as would naturally be expected. The curve is the result of the effort of the patient to adjust his center of gravity to the new conditions induced by unilateral paralysis. This equilibration may result in a curve convex either to the right or left in a right-sided paralysis.

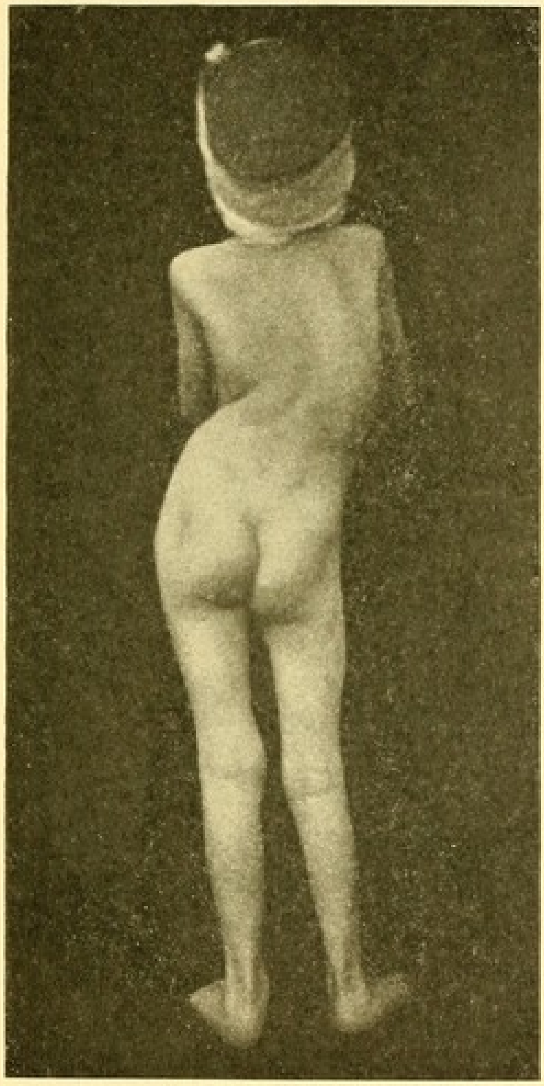

Fig. 77.—Right Dorsal Curve Due to Infantile Paralysis.

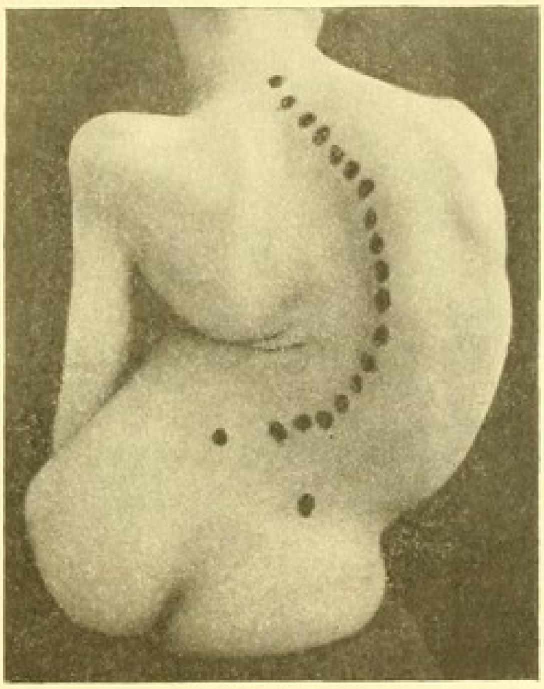

Fig. 78.—Severe Right Curve Due to Infantile Paralysis.

3. From faulty spinal attitudes assumed in consequence of paralysis elsewhere, as in paralysis of the arm.

(*b*) **Spastic paralysis** or **Little's disease** is the result of a cerebral lesion and a descending degeneration of the lateral columns of the spinal cord. The growth of bones is often retarded, and muscular irritability and stiffness are noted with contractions. Scoliosis is an occasional accompaniment.

(*c*) **Other nervous diseases,** represented by a much smaller number of cases of lateral curvature, are multiple neuritis, meningitis, cerebrospinal meningitis, syringomyelia, pseudomuscular hypertrophy, locomotor ataxia, Friedreich's ataxia, tumors of the spinal cord, and obstetrical paralysis.

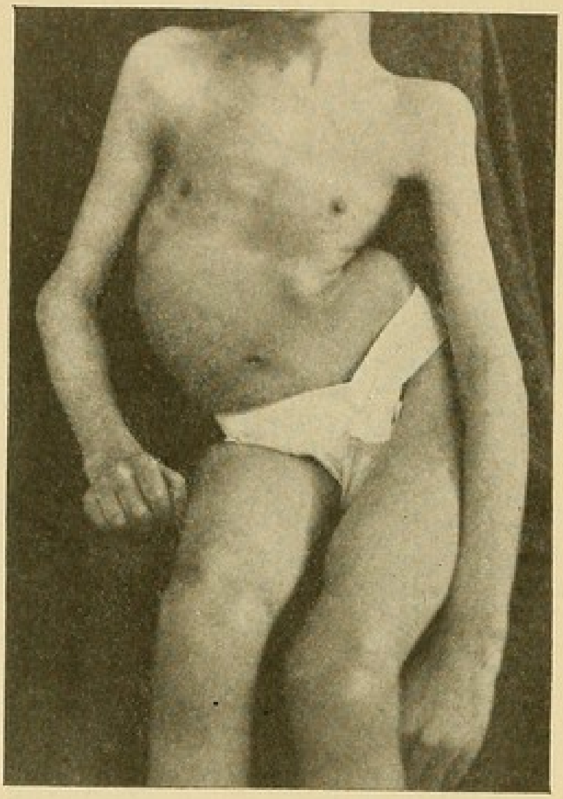

Fig. 79.—Severe Right Curve (see Fig. 78) Due to Infantile Paralysis. Showing abdominal and thoracic construction on left.

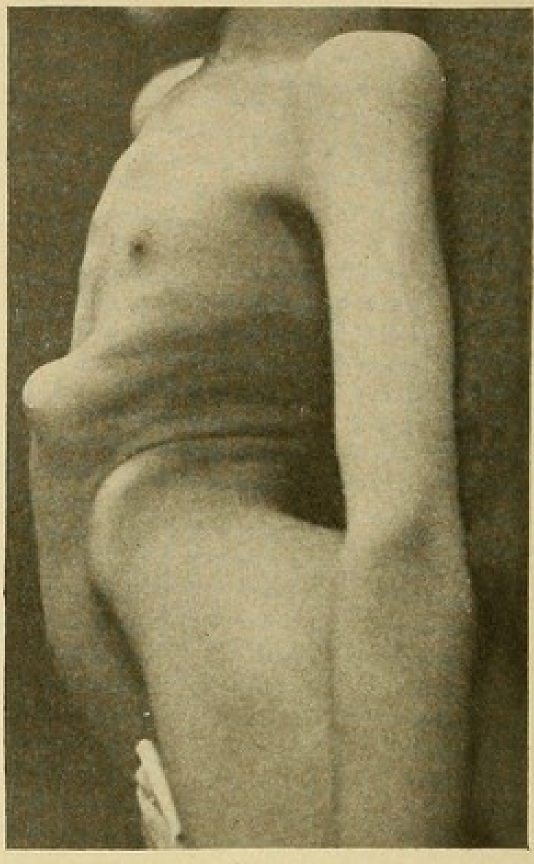

Fig. 80.—Same Case as Figs. 78 and 79 Showing Deformity of Lower Ribs Induced by Pressure.

A marked lateral deviation of the spine extensively studied by the Germans and termed by them *Ischias Scoliotica*[1] is a form without much rotation which accompanies the inflammatory affections of the lumbar region vaguely classed as "lumbago" and "sciatica." It is frequently found in arthritis of the spine and in acute and chronic sprains of the spine.

A similar malposition is observed in hysteria[2] (Fig. 81). An

[1] Stein: "Zeitsch. f. orth. Chir.," xxv, 1910, 479 (with literature.)

[2] Binswanger: "Hysterical Scoliosis," "Deutsch. med. Wochens.," Vereinsbeil., 1902, 5.

analogous deviation is found in sacro-iliac disease in which the lateral curve is induced by the instinctive effort to spare the affected joint.

(*d*) **Empyema**[1] is followed by lateral curvature in certain cases, both without operation and after the operation for removal of a rib. The scar contraction seems to be the cause of the chief curve, which is always to the right in left empyema and *vice versa*. There are likely

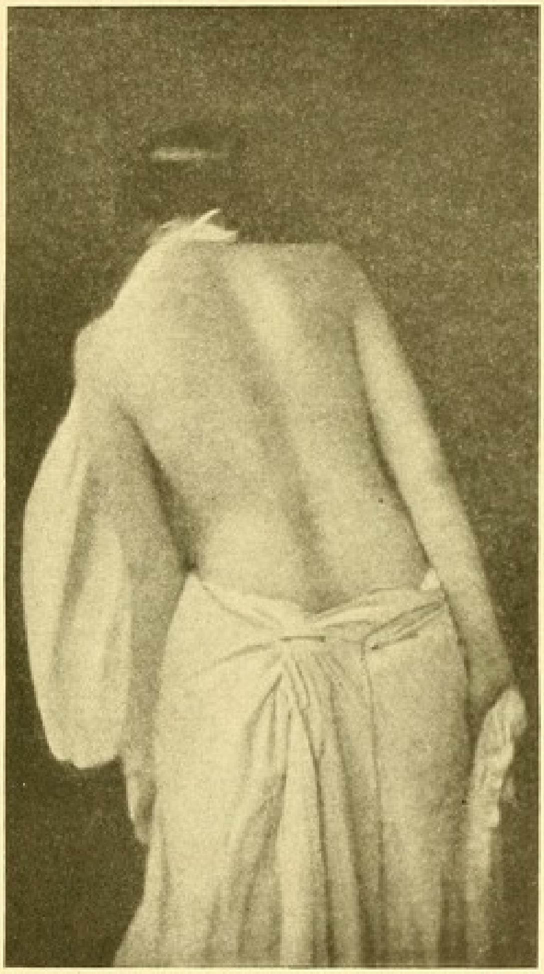

FIG. 81.—HYSTERICAL SCOLIOSIS.

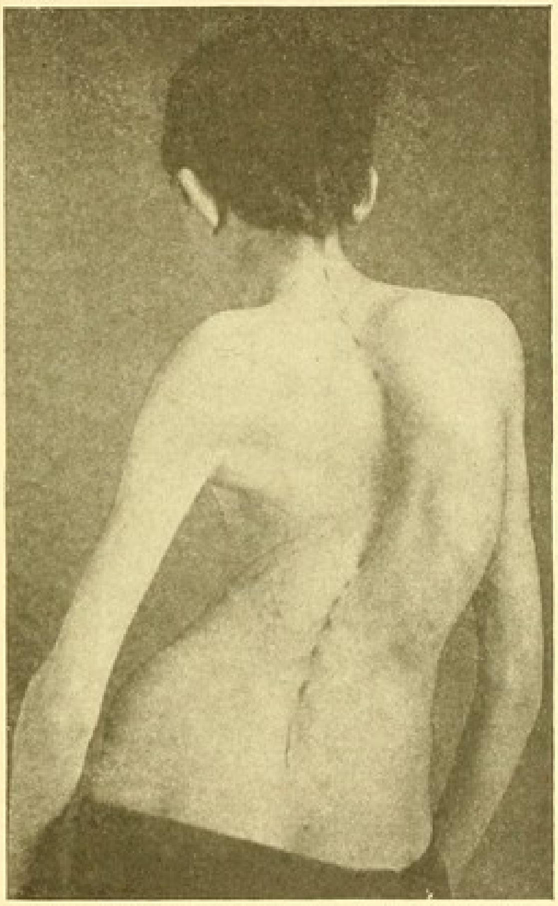

FIG. 82.—RIGHT DORSAL CURVE DUE TO LEFT EMPYEMA.

to be compensating curves above and below the main curve, the height of the shoulders is generally very different and the hypertrophy of the sound side of the chest is a marked feature (Fig 82).

(*e*) **Scars** rarely cause scoliosis, although it sometimes is found after extensive unilateral burns when the deviation of the spine is brought about by contraction of the scar tissue (Fig. 83).

(*f*) **Phthisis** and diseases of the pleura and obstructions in the nasopharynx are to be mentioned among the diseases of the respiratory organs sometimes followed by scoliosis.

[1] Walther: "Zeitsch f. orth. Chir.," 1910, xxv, 401.

(*g*) **Organic heart disease,** especially in children, is a competent cause of lateral curvature (Fig. 84).

5. HABIT OR OCCUPATION.

That the continued maintenance of an asymmetrical portion of the spine through the period of growth is likely to result in some degree of bony deformity of the growing spine is a self-evident proposition, dependent on the fact that growing bone is plastic and follows the

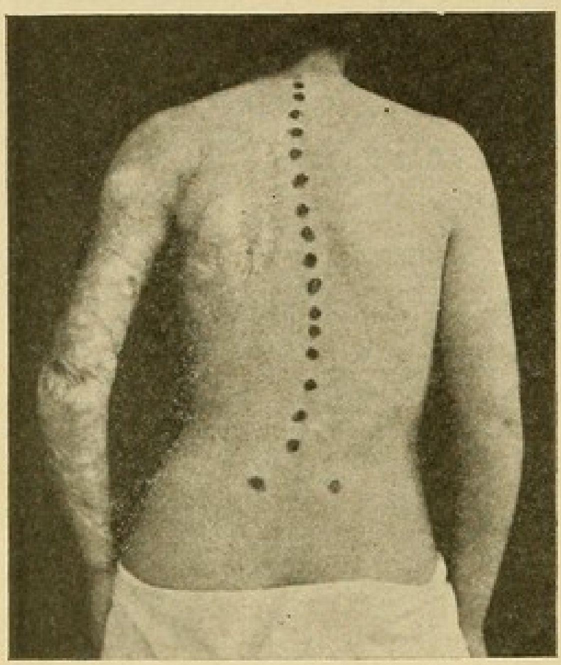

Fig. 83.—Scoliosis Due to Extensive Curve of Left Chest Received at the Age of 17. Patient now 19 Years Old.

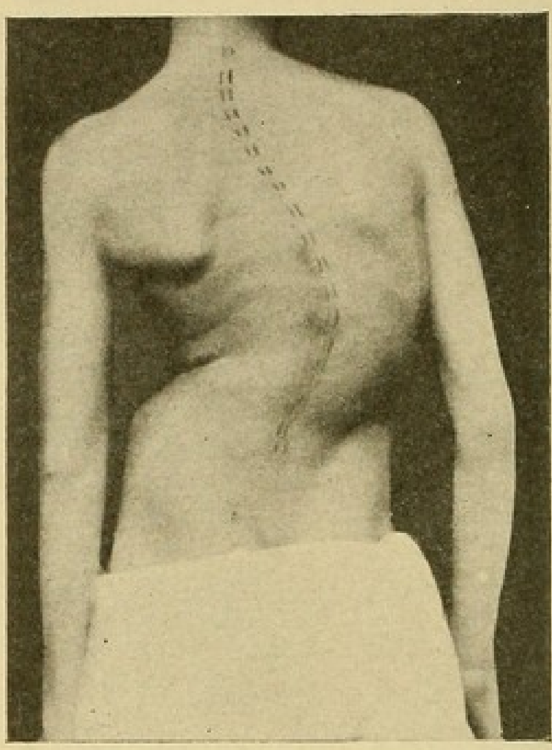

Fig. 84.—Severe Scoliosis Associated with Organic Heart Disease. Death Occurred from the Latter.

line of least resistance. But that such conditions are likely to result in moderate or severe scoliosis in normal children is not in the opinion of the writer likely. That they may result in "false scoliosis" or slight scoliosis is apparently reasonable to expect.

The commonest causes of "occupation" scoliosis are to be found in children in the assumption of faulty attitudes at school and at home, violin playing, the use of a side saddle in horseback riding, carrying heavy weights asymmetrically, etc.

The relation of scoliosis to school life has been much discussed and will be considered by itself.

Chapter VIII.

OCCURRENCE.

Scoliosis in Quadrupeds.[1]—Scoliosis in animals other than man has been observed, but is rare. Eighteen cases were found in literature by Härtel in 1909. Ten of these were fœtal malformations found in new-born horses, goats, deer, and calves; curves due to rickets were found in pigs, and in cattle an inflammation and growing together of vertebræ or parts of vertebræ. Further are to be added scoliosis in a colt one and one-half years old and in a goat, and a case of scoliosis due to congenital defect of the vertebræ in the cervical region in a horse.

Such curves in mammals consist of short sharp curves accompanied by torsion, but what corresponds to real "habitual scoliosis" in the human being has not been definitely established as existing in quadrupeds; a real static deformity, however, is the sway back observed in horses.[2]

In the lower vertebrates scoliosis has been observed in fishes, snakes, and eels. Among domestic fowls scoliosis is not uncommon in hens, ducks and geese; and Klapp and Härtel collected a dozen scoliotic skeletons from this source in one year. The study of this deformity in fowls has a certain bearing on scoliosis in man because of the fact that in birds the weight is borne on two limbs, although the position of the spine is much more horizontal. In quadrupeds the horizontal position of the spine and its support on four limbs makes the static relations wholly different from those existing in man.

In fowls the examinations of Härtel show two distinct classes of cases: first, an atypical scoliosis due to vertebral defects and unilateral numerical variation of the vertebræ, an important matter as bearing on the similar condition in man; and, second, a typical scoliosis accompanied by rotation of the vertebral bodies to the convex side of the curve, which is more frequent than the first-named variety. As bearing on the etiology of the latter, changes attributable to trauma, inflammatory processes, and rickets were absent in the ten specimens examined, and in such we must attribute the cause either to in-

[1] Härtel: "Deutsch. Ztschft. f. Chir.," 98, 277.

[2] Rievel: "Knockenpathologie der Tiere." "Lubarschs and Ostertags Ergebuisse," xi, 1907.

tra-uterine pressure or to purely static causes arising late in life. That is to say, we must assume that the bones of the individual fowl possessed less than normal strength and yielded under weight.

In quadrupeds, therefore, one finds as causes vertebral anomalies, inflammation of bones, and rickets. In fishes and snakes apparently the first named of these three causes, and in fowls, vertebral anomalies alone can be demonstrated as causes, leaving the bulk of the cases (ten out of twelve) to be accounted for as deformities due to weight, acting on bones of less than normal resistance. Experimentally scoliosis has been produced in animals by Wullstein, Arnd, and Ribbert.

FREQUENCY.

Figures with regard to the frequency of scoliosis in the population as a whole are lacking except for some figures brought forward by Schanz.[1] In five years, of 189,000 recruits available for the German army 7.2 per thousand were disqualified for spinal curves of all kinds; that is, less than 1 per cent. Figures with regard to the percentage of scoliotics in hospital practice show nothing because the clientele of various hospitals varies so largely. Fortunately there are figures relating to its frequency in school children which are available, which form our only reliable means of judging its frequency.

It is evident, however, that the percentage of scoliotics among a number of school children examined will vary with the point of view and standard of the observer, and this is shown by the very great discrepancy shown in the tables commonly quoted. These as a rule include old and new figures from all over the world from observers of every degree of special qualification. Such a table is given (Table V).

The very careful and modern investigations of Combe, Scholder and Weith, Grönberg,[2] Haglund,[3] and Lubinus[4] seem to form the safest basis for conclusions. According to these, the frequency in girls of the school age varies from 10 to 23 per cent. and of boys from 16.4 to 26 per cent.

It has been noted, however, that the percentage varies in different localities without obvious reasons, Grönberg finding in Åbo a percentage of 11.6, while in the neighboring Finnish city of Wiborg similar investigations by Grönberg showed 34.5 per cent. of scoliosis, and

[1] "Verhdl. d. Deutsch. Ges. f. orth. Chir.," 1910, page 454.
[2] "Ztsch. f. orth. Chir., xviii, 130.
[3] "Ztsch. f. orth. Chir.," xxv, 649.
[4] "Verhdl. d. Deutsch. Geo. f. orth. Chir.," 1910, 469.

TABLE V.

OBSERVER.	Place.	BOYS. No.	BOYS. Scoliosis, Per cent.	GIRLS. No.	GIRLS. Scoliosis, Per cent.
1864 Guillaune	Merchatel	350	18	381	41
? Hürliman	Gug	?	15	?	22
1882 Mayer	Furth	......	....	336	37
1885 Key	Sweden	11210	0.8–5.7	3072	10.8
1885 Drachmann	Denmark	16789	0.8	11386	2
1891 Wisser	Würzburg	280	55	217	45.6
1892 Bardenheur and Castenholz.	Cologne	......	....	439	23
1893 Brunner, Klausner and Seydel.	Munich	1052	6.2	987	8.2
		569	8.5	489	6.5
1894 Krug	Dresden	695	26	723	22.5
? Hagmann	Moscow	......	....	1664	29
? Kallbach	St. Petersburg	......	....	2333	26
1901 Combe, Scholder and Weith.	Lausanne	1290	23	1024	26.7
1906 Silfwerskiöld	Göteborg	......	....	3234	12.8
1907 Grönberg	Wiborg	4257	11.9	4093	22.1
1910 Haglund	Stockholm	819	13.2	780	16.4
1910 Lubinus	Kiel	1021	10	2204	18

Lubinus found in Kiel in different girls' schools of the same grade that the percentage of scoliotics varied from 13.1 to 34.6 per cent. without assignable cause. This has nothing to do with the variation according to age to be discussed later.

SEX.

It is generally the opinion that in adults women show a greater number of scolioses than men, although published statistics confirming this fact do not exist. Records of the relative frequency of scoliosis in adolescents and children made in orthopedic institutions where patients apply for treatment show a very much larger percentage of scolioses among girls than in boys. The difference between the sexes is less where large numbers of school children are investigated, such figures showing in general a slightly higher percentage in girls than in boys. To explain this difference we must either assume that boys outgrow scoliosis, or that they do not come to the institutions for treatment until the curves become severe or until complications arise, while in girls the effects of scoliosis upon the figure are perceptible much earlier, and treatment is sought to remedy curves which in boys would pass unnoticed by the parents.

The table which follows shows the great preponderance of girls coming to institutions for treatment. The figures for the proportion of the sexes in school children are given in the table in the section on Frequency.

FIGURES FROM INSTITUTIONS WHERE PATIENTS ARE TREATED.

	Boys. Per cent.	Girls. Per cent.		Boys. Per cent.	Girls. Per cent.
Eulenburg	13	87	Adams	12.8	87
Ever	7	93	Scholder	14.8	85
Ketch	17	83	Schanz	25	74.8
Kölliker	20	80	Rosenthal	22	78
Roth	8.5	91	Schulthess	14.2	85.5
Wedberger	15.9	84	Redard	15.6	83.3
Behrend	13.4	86			

AGE.

Scoliosis is an affection of the years of growth in a large majority of cases, but it is often extremely difficult to form an accurate idea of the age at which the deformity begins in individual cases. Scoliosis due to rickets and congenital causes may occur up to the fifth year. In general, however, the inaccurate observations of parents furnish no foundation upon which to base theories or statistics concerning the time of the beginning of the scolioses observed in older children. The relation of age to scoliosis as observed in the schools will be discussed later.

In regard to the age at which scoliotic children are brought for treatment, Eulenburg found over 50 per cent. of all cases between seven and ten years old, and but 10 per cent. between the ages of ten and fourteen years.

The clinical material collected by the Institute of Lüning and Schulthess at Zurich has been used by Sutter and Müller in preparing curves of the frequency of scoliosis at different ages. Müller finds the greatest number of cases in the fourteenth year. The number increases gradually from the eighth to the fourteenth year, and decreases rapidly from the fourteenth to the seventeenth year. Sutter found that the number of boys brought for treatment reached the maximum in the ninth, thirteenth, and fourteenth years. The number of cases under treatment at fourteen years of age is double that for nine years, and shows not only an increase in frequency of scoliosis, but an increase of deformity in curves already existing.

RELATIVE FREQUENCY OF THE DIFFERENT FORMS OF SCOLIOSIS

Statements concerning the frequency of the simple forms of scoliosis are of very recent origin. All statistics agree, however, in showing that for all forms there are more scolioses convex to the left than to the right. There is less unanimity as to which of the single forms is the most frequent. Lorenz states that left lumbar scoliosis is the most numerous. Kölliker, from the examination of 721 cases, finds the simple dorsal scoliosis the most frequent. By considering the tables of other investigators Schulthess found the compound right dorsal scoliosis the most frequent form, followed in order by the simple dorsolumbar curves, total scoliosis, and lumbar scoliosis. The cervicodorsal form was the least frequent.

Among the 571 school children with lateral curvature out of 2134 children examined at Lausanne, 401, or 60.3 per cent., showed curves convex to the left, 121, or 21.1 per cent., curves convex to the right, and 49, or 8.6 per cent., compound curves. The table compiled from these figures shows the percentage of curves as to their form and convexity. The total curve is the most frequent form in school children, and is followed by the left and right lumbar curves and by left dorsal scoliosis.

	Left Convex.	Right Convex.	Total.
Total scoliosis........	48.1 per cent.	7.8 per cent.	56 per cent.
Dorsal scoliosis......	8.4 "	4.3 "	12.7 "
Lumbar scoliosis.....	11.8 "	8.5 "	20.3 "
Combined scoliosis....	8.5 per cent.		8.5 "

Almost the only records that have been studied and tabulated for definite study are those of the Institute of Lüning and Schulthess, and it is from these investigations that much of the following material is drawn.

Age.—At eight years the left scolioses form 64 per cent. and the right scolioses 33 per cent. of the total number of curves. In the fourteenth year the number of curves convex to the left and right is about equal. The number of compensating curves increases from 27 per cent. in the eighth year to 45 per cent. in the seventeenth year.

Position of Apex of Deviation.—To ascertain the location of the point of maximum deviation Durrer has constructed a set of curves which show that for the left convex scolioses the maximum deviation is at the dorso lumbar junction, and for the right convex curves the apices are found in the region of the seventh dorsal vertebra, which showed a much greater deviation than the adjacent vertebræ, while in the left convex curves the deviation is more evenly distributed over the length of the spine.

Schulthess finds four principal apices of deviation for single and compound forms of scoliosis: (1) The upper dorsal region to the right; (2) the dorsolumbar junction to the left; (3) the upper dorsal and lower cervical regions to the left; (4) the lower lumbar region to the right.

In the eighth year the maximum deviation of the right dorsal curves is in the region of the sixth to the eighth dorsal vertebræ, and is still found there in the seventeenth year. The apex of the left convex curves in the eighth, ninth, and tenth years is at the ninth or tenth dorsal vertebra; between the ages of eleven and thirteen it is found at the twelfth dorsal vertebra, and descends to the first or second lumbar vertebra between the ages of fifteen and eighteen years.

Chapter IX.

THE RELATION OF SCOLIOSIS TO SCHOOL LIFE.

The relation that school conditions bear to scoliosis is one of the most important questions in formulating the cause of scoliosis and has been much discussed of late. It is important to examine certain practical aspects of the question.

School Fatigue.—A correct attitude is dependent upon the tone and strength of the muscles by which the upright posture is maintained, so that any cause, such as fatigue, which lowers the muscular tone, has a bearing in this connection.

Mental Fatigue.—Muscles become relaxed not alone by physical but by mental exertion and mental fatigue.[1] Mental work is at first stimulating, but if continued for a long time, especially concentrated on one topic, will produce both mental and bodily fatigue.

Continuous mental labor, though of only short duration, will produce a greater degree of fatigue, and that more quickly, than the same amount of work interrupted by brief intervals of rest. A change of work, particularly from a hard to an easy subject, will afford the same relief as a short rest. Severe fatigue comes on with great regularity in periods of the ancient languages and mathematics, while recuperation takes place during history, geography, and nature study. The modern languages occupy a middle place; singing and drawing make rather great demands on those who do well in these branches. After violent or prolonged exercise one is less fit for study, but after moderate exercise intellectual work seems to become easier. The proper relation between physical and intellectual work, in order to obtain the greatest good from each, is a question which should receive the careful consideration of educators.

Exhaustion in Children.—One of the first ways in which fatigue shows itself is in the slight amount of force expended in a movement and frequently a lessening in the number of movements. In extreme exhaustion the ordinary movements are not excited by ordinary stimuli, and such as do occur are slow and labored. This may be accompanied by irritability and occasional jerky movements not controlled by circumstances. Frequently there is manifest an asymmetry of posture and movement. The head is held on one side; the arms when extended are not horizontal—usually the left one is lower; the hand balance is weak;

[1] Kronecker: "Ueber die Ermüdung und Erholung der gest. Muskeln," Leipzig, 1871; Mosso: "Fatigue," "International Science Series." Sikorsky: "Sur les effets de la Lassitude provoquée par les travaux intellectuels chez les enfants de l'age scolaire"; Leo Burgerstein: "Die Arbeitskurve einer Schulstunde"; Hugo Laser: "Ueber geistige Ermüdung beim Schulunterrichte."

that is, when hands and arms are held straight out in front, the fingers and wrists are not extended, and the thumb is not on the same plane as the fingers; this also is more marked in the left hand. Lack of muscular tone shows itself in a "slumped" position either standing or sitting. The face may be lengthened from relaxation of the muscles and falling of the jaw. Sighing and yawning are common symptoms. Speech is slow, and the tone of the voice altered, and in general there are slowness and inaccuracy of mental response.[1]

School Furniture.—It is obviously important to furnish school children with seats and desks which do not favor improper attitudes in sitting and writing.[2] In 1842 Barnard, of Hartford, published an article on the subject, followed twenty years later by Fahrner,[3] of Zurich, Myer,[4] Cohn,[5] Schenk, Lorenz,[6] Schulthess,[7] and Scholder;[8] and a most practical study of the matter was undertaken by the Boston Schoolhouse Commission.[9]

The two things to be prevented in school furniture are—(*a*) the prolonged stretching of the back muscles by the continued maintenance of flexion of the spine, and (*b*) the assumption of distorted and twisted attitudes, children with tired muscles tending to rest them by assuming a change of position. Furniture of bad design or improperly fitted tends to favor both of these.[10] A large number of desks and seats have been devised; it is said that 150 have been proposed, and at least over 30 have been tried. The theoretical requirements which are by common consent accepted are as follows:

1. The *height* of the seat from the floor should be such that in sitting the feet rest on the floor. Too high a seat produces pressure on the back of the thighs; too low a seat induces to much flexion of the lumbar spine.

2. The *slope* of the seat should be backward and downward about three-eighths of an inch. The *depth* of the seat should be about two-thirds the length of the thighs. The *width* of the seat should be that of the buttocks. Some concaving of the seat is comfortable, but not essential.

3. The *back* of the seat should have a slope backward of one in twelve from the vertical line (Saxon regulations). The more modern

[1] Warner: "The Nervous System of the Child," London, 1900.

[2] Scudder: "Determination of the Muscular Strength in Growing Girls," "Bos. Med. and Surg. Jour.," Nov. 6, 1890.

[3] "Das Kind u. d. Schultisch," 1865.

[4] "Die Mech. des Sitzens," "Virch. Arch. f. path. Anat.," xxxv, 1867.

[5] "Beitr. zur Losung der Subsellenfrage," Berlin, 1885.

[6] Lorenz: "Ueber die Skol.," Wien.

[7] Schulthess: "Zeitsch. f. orth. Chir.," 1892, i, 1.

[8] "Archiv für Orth.," i, 2.

[9] Boston Schoolhouse Commission Reports for 1901–5.

[10] Feiss: "Cleveland Med. Jour.," Aug., 1905.

expression of this is found in two back supports, one low down, 1/2 to 1 inch in front of the back edge of the seat, and a second higher up, 1 1/2 inches behind the back edge of the seat. But in a nearly balanced sitting position a relatively low back support is ample and the upper one not required.

4. The *height* of the desk should be such that the back edge allows the forearm to rest on it naturally with the elbow at the side. The height of this edge from the edge of the seat is known technically as the "difference."

5. The *slope* of the desk has been advocated at all angles from 0 to 45 degrees. The theoretically best slope for reading is at least 30 degrees, but this is practically too steep and books slide off, and it is not practicable for writing. From 10 to 15 degrees is the usually accepted inclination. The proper distance of the eyes from the desk is from 12 to 14 inches. The width of the desk is immaterial, 22 to 24 inches being the usual size.

FIG. 85.—BOSTON SCHOOL DESK AND CHAIR. —(*Boston Schoolhouse Commission.*)

Writing Position.—Of late years there has been a tendency to blame the teaching of slanted handwriting for much of the bad attitude and the teaching of vertical writing was substituted, the patient sitting squarely in front of the desk and writing vertically, with a view of avoiding the distorted position incidental to slanted handwriting. Statistics have been reported in favor of the vertical system. These are:

	Percentage of Scoliotics. In Slanted Writing.	In Vertical Writing.
Nuremburg	24	15
Zurich	32	12
Munich	24	15
Fürth	65	31
Wurzburg	28	8

The question is by no means settled, Gould, of Philadelphia, having called attention to certain factors previously overlooked.

"With[1] the head and body erect, the paper straight before the me-

[1] G. M. Gould: "American Medicine," ix, 14, 562, 1905.

dian line of the body, and the penholder held as commanded, no person can or will write, for the simple reason that the writing and the writing field about the pen-point are hidden by the writing hand and the penholder. Immediately the pupil skews the paper, tilts the head to the left, and grasps the holder differently—all in order to bring the writing field and letters being made into clear view, and especially of the right or dominant eye.

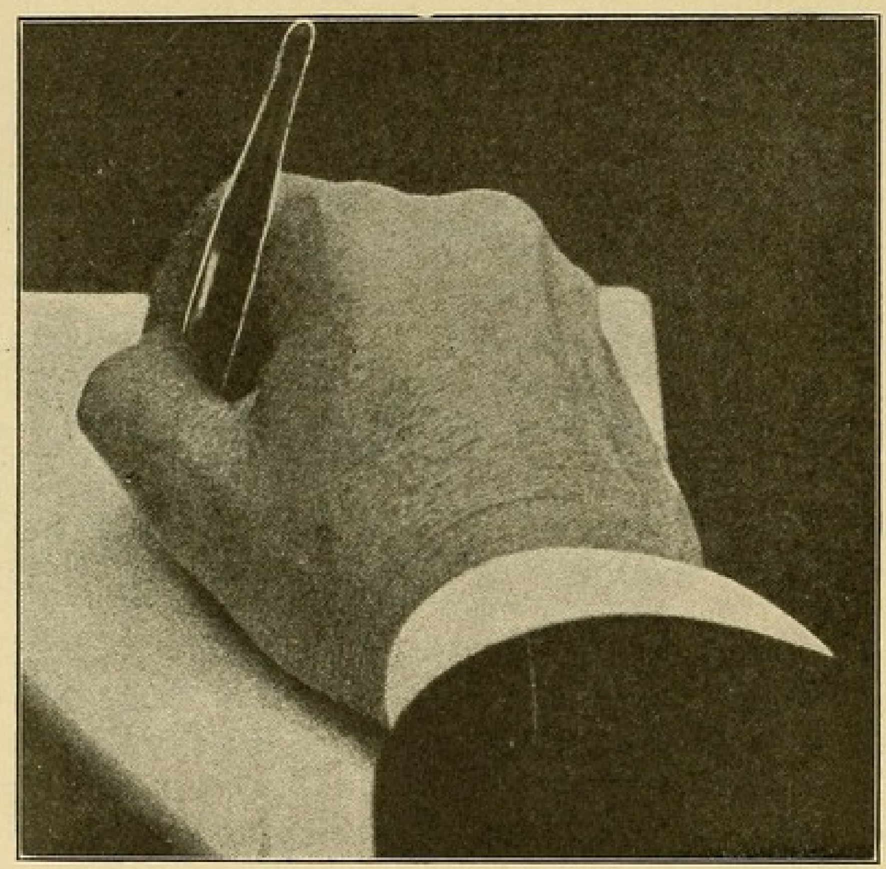

FIG. 86.—THE HAND IN THE WRITING POSTURE AS USUALLY ORDERED, BUT NOT PRACTISED, BECAUSE TO THE WRITER THE WRITING FIELD IS HIDDEN BY THE THUMB, FINGER, AND HOLDER.—(*Gould.*)
A view of the hand, as seen by the writer, with the head displaced in photographing.

"The slanted handwriting is due merely to the fact that less torsion or rotation of the head to the right is rendered necessary, and a slight easing is secured by slanting the letters to the right.

It may be assumed as reasonable (1) that bad air, fatigue and school life under poor general conditions, (2) improper school furniture, and (3) twisted writing positions favor bad attitude, and that the more constantly they are in operation the more effective will be their result in producing bad attitude. In the same way unfavorable home conditions in the way of bad food, overwork, and unsanitary surroundings depreciate muscular strength and favor bad attitudes.

It is therefore likely on general principles that unfavorable school conditions are a competent cause of faulty attitude (false scoliosis) and of slight grades of true scoliosis, but that they are the cause of moderate and severe scoliosis is not in the writer's opinion likely. The reasons for this view have been expressed at the beginning of the chapter on Occurrence.

This view is in accord with that of the best modern authorities,[1] but not in accord with former views.[2]

It is therefore necessary to investigate existing data with regard to the occurrence of scoliosis in school life to see what evidence is to be found in them.

There are practically no figures dealing with the question in America and it must be remembered that figures from foreign sources, although probably applying to our conditions, cannot be unreservedly accepted. It has already been shown that there may be a great variation in the percentage of scoliosis in the school children of two neighboring cities and between children of different schools in the same city (see Occurrence, p. 106).

Increase of Scoliosis during School Life.—When careful statistics are taken among school children they show most often, but not uniformly, a larger proportion of children affected with scoliosis in the later than in the earlier years of school.

Haglund's studies[3] were especially careful and show an increase with school age as follows:

Year	6	7	8	9	10	11	12	13	14	15	1599 cases.
Percent scoliosis		11	13	18	16	18	24	22	22	..	283 scolioses.

Gronberg, from a careful study of 8350 school children in Finland, concluded that "the frequency of scoliosis increases as age increases and as the classes become higher. Constancy of progression is not, however, always to be found."

His tables were as follows:

Year,	11	12	13	14	15	
Grammar schools	12.2	15.6	12.5	11.3	16.1	Boys.
Higher schools	9.4	7.3	8.8	9.9	12.4	
	26.1	32.7	26.9	44.4	40.3	

Year,	11	12	13	14	15	16	
Grammar schools	21.2	18.1	19.1	23.3	26.5	21.9	Girls.
Higher schools	16.9	18.9	21.5	20.9	22.3	24.7	
	48.1	49.	49.6	59.8	63.2	56.8	

[1] "Verhdlungen d. Deutsch. Ges. f. orth Chir.," 1910, pages 443–514. Schulthess, Schanz, Mayer, Spitzy, Böhm, Muskat, Lubinus and others.

[2] Smith: "Lat. Curv. of the Spine and Flat-foot," New York, 1911, page 28.

[3] "Zeitsch. f. orth. Chir.," xxvi, 649.

The figures as to the increase of scoliosis during school life from 2314 cases examined at Lausanne are as follows:[1]

AGE.	BOYS.	GIRLS.
8 years	7.8 per cent.	9.7 per cent.
9 "	16.7 "	20.1 "
10 "	18.3 "	21.8
11 "	24.2 "	30.8 '
12 "	27.1 "	30.2 "
13 "	26.3 "	37.7 "

On the other hand, certain observers have found the contrary. Spitzy[2] for 10 years has examined about 100 girls from eight to sixteen years old each year in a large private school for girls in Graz and finds a constant percentage each year of about 20 per cent. of marked defects of position, and this percentage is not greater in children who have previously been to school than in those educated at home. Hippius[3] has demonstrated that severe scoliosis is frequent in children who have never been to school.

Kirsch[4] in 1000 school children from the lower classes and 1000 from the more advanced classes investigated since 1906 found that "the greatest number of all fixed scolioses, which we find in school, are rachitic scolioses from early childhood."

In 3234 girls, Silfwerskiold found percentages as follows:

First class,	10. per cent.
Second class,	12.1 "
Third class,	12.5 "
Fourth class,	17. "
Fifth class,	9.9 "

Forms of Scoliosis in School Children.—"So far as the forms of scoliosis which are most frequent in children, they are in a certain way peculiar and vary from the forms most frequently coming to specialists for treatment."[5]

Of these curves only 24 per cent. were compound in Gronberg's series and the remainder were simple, 41.9 per cent. being left total curves. In the Lausanne series 48.1 per cent. were left total curves and only 8 per cent. of the whole were compound scoliosis.

[1] Combe, Scholder and Weith: "Jahrb. der Schu. Gesel. f. Schulgesundheits pflege," ii Jahrg., 1901, i Teil, 38.

[2] "Verhdl. d. Deutsch Ges. f. orth. Chir.," 1910, p. 462.

[3] "Der kinderarzt als Erzieher," Berk, München.

[4] "Verhdl. d. Deutsch. Ges. f. orth. Chir.," 1910, 94.

[5] Gronberg: "Zeitsch f. orth. Chir.," xviii, 156.

The conclusion from which is that apparently if one takes into account all grades of scoliosis, functional and structural (false and true), there is a tendency to increase during school years, but there apparently is no good evidence that moderate and severe structural scolioses increase during school life.

CHAPTER X.

DIAGNOSIS.

Scoliosis is an affection in most cases appearing before the tenth year; it is not a disease of the spine, but the result of mechanical forces acting upon a spine which in other than slight cases must be assumed for some reason to be abnormally formed or to possess less than normal resistance. It is not, as a rule, accompanied by any degree of pain. Stiffness, if it is present, is an accompaniment of late cases and the result of long-continued structural changes.

In the diagnosis of scoliosis the first question that arises is whether or not scoliosis is present. A plumb line is held in the line separating the buttocks and if all the spinous processes lie under that line scoliosis is not present. If any number of spinous processes do not lie under the plumb line scoliosis is present.

If scoliosis is present the question is, is it functional or structural, and what is the curve? The diagnostic signs of functional and structural curves have been described (pages 46, 54) and by aid of these the curve is classed as one or the other or as transitional (page 50). The ends of the spine are connected by a string and the parts lying to the right are called right curves and those to the left are called left curves.

If the curve is *functional*, it is desirable if possible to identify its cause in a short leg, unequal vision, etc.

If the curve is *structural* it is important, if possible, to assign it to its proper etiological division.

SCOLIOSIS OF CONGENITAL ORIGIN.

Such curves occur early, are generally severe, and are best identified by the x-ray. When accompanied by gross defects in the thorax or elsewhere they are easily recognized.

RACHITIC SCOLIOSIS.

This form occurs early, is generally severe and characterized by a sharp curve, and most often found in the lower half of the spine. To establish the diagnosis, other signs of rickets should be found. These are the high square head, the rosary, curved bones, enlarged epiphyses and generally somewhat retarded general growth. A history of a late first dentition suggests the existence of rickets. *Osteomalacia* is uncommon and characterized by severe general curvature of the bones.

INFANTILE PARALYSIS.

This is a motor paralysis beginning with a feverish attack, generally in summer, followed by loss of power in one or more limbs. The affected limbs are in the severer cases cold and wasted and reflexes are lost. In the severer cases of scoliosis of this type the deformity becomes extreme. There are occasional cases of infantile paralysis where the attack is slight and the loss of motion is apparently recovered from, but where a lateral curve of more or less severity develops later as a result of the paralysis of some spinal muscles. The investigation into the history in doubtful cases becomes of much importance and the back should be examined in every case of infantile paralysis in any part of the body.

Empyema and pleurisy are recognized as the causes of a severe form of scoliosis, especially when a resection of the rib has been performed in empyema. The curve is always convex toward the unaffected side of the chest and is dorsal or dorsolumbar. It is identified by the scar on the chest or the auscultation signs in the thorax and the history of the case. Any other scar of sufficient size is competent to produce the same result.

Other evident causes of structural scoliosis are sufficiently indicated in the table given in the chapter on Etiology.

Finally, in many cases no evident cause can be found and one is obliged to assume that the bones of the individual possess less than normal resistance to weight bearing.

Pathological Conditions Accompanied by Lateral Curvature as a Symptom.—Cases of lateral curvature accompanied by pain, especially if this is exaggerated by motion, should *not* be given exercises, but kept under careful observation until a perfectly definite diagnosis has been made. The same applies to slight curves accompanied by stiffness of the spine. Doubtful cases may often be cleared up by the use of the x-ray.

These painful conditions accompanied by scoliosis must be carefully separated from true scoliosis. The chief one of these is *Pott's disease*, or tuberculosis of the spine. The symptoms of this affection are stiffness of gait and loss of mobility in the spine, pain on motion or jar, and spontaneous pain in the chest and abdomen, elevation of temperature, and impairment of the general condition. As the disease progresses, a sharp prominence backward of the spinous processes occurs at some part of the spine. Lateral deviation of the spine occurs in the acute stage of practically all cases, but it is a leaning of the body to one side rather than a true gradual curve; there is no rotation of note, and the lateral deviation is an index of the severity of the disease, disappearing after a period of recumbency in bed and being controlled by efficient treatment. The danger of mistaking Pott's disease for scoliosis lies in the early cases before the knuckle, or backward deformity, has occurred.

A form of lateral deviation accompanies *arthritis deformans* of the spine, which is also known under the names of osteoarthritis of the spine, spondylitis deformans, ankylosis of the spine, spondylose rhizomélique, Bechterew's disease, Steifigkeit der Wirbelsaüle, etc. This is essentially an affection of adult life, but not unknown in children. The spine is stiff and painful, the lumbar convexity is diminished or lost, and the curve a gradual one with slight or no rotation.

The lateral curves accompanying tumors of the spine, dislocation of the vertebræ, etc., would hardly be mistaken for real scoliosis, the usual signs of those affections being present.

Chapter XI.

PROGNOSIS.

WITHOUT TREATMENT.

Total curves may remain as such through life, probably increasing somewhat; they may change to structural curves; or they may be cured by proper treatment, but they are not likely to disappear spontaneously. So long as they remain purely functional curves, as defined above, they will probably not influence the general health unfavorably or produce any unpleasant result further than slight asymmetry. In neurasthenic women they are frequently accompanied by backache.

Structural curves, whether simple or compound, in young children should be regarded as serious, as almost sure to increase, and perhaps to increase rapidly. They will surely lead to some deformity, and perhaps to grave deformity. They are likely to affect the general health and to shorten life by inducing phthisis and ill health. Adults with severe scoliosis are, as a rule, less vigorous than normal.

Slight or moderate structural curves in older children and adolescents which have not progressed rapidly through childhood are after puberty likely to increase but slowly, if at all, until late middle life, when the atrophy of the intervertebral discs is likely to make them more evident and troublesome. Severe structural scoliosis at any period of life is to be regarded as likely to shorten the patient's life and to induce ill health. The rapid increase of a postural or structural curve is a threatening symptom demanding attention.

WITH TREATMENT.

Total scoliosis should be entirely and permanently cured by adequate treatment.

Structural scoliosis in young children when of moderate degree should be practically cured by *adequate* and *long-continued* treatment but only by that. If severe, it should be much improved by the same means, the prognosis in both classes being better in children with a long period of growth ahead than in adolescents.

Structural curves in older children and adolescents when of moderate degree should be greatly improved by *adequate* and *long-continued* treatment, but as a rule cannot be wholly cured. Severe structural scoliosis under these conditions can be markedly improved.

When growth has been reached, only improvement and not complete cure is to be hoped for from treatment in true scoliosis of any but the mildest grade. In adults with severe scoliosis the general condition of the patient may be greatly improved by an improved position of the spine. In late adult life support of the spine in the best obtainable position is the only outlook from treatment, again often attended by improvement of the general health.

Scoliosis due to severe congenital defects of the vertebræ, scapulæ, or thorax, to infantile paralysis, or to empyema cannot be cured if a severe curve has occurred, but can be improved. Rickets contributes a class of cases on the whole resistant to treatment, and in severe cases, even in young children, a complete cure is probobly not obtainable. The existence of organic heart disease or phthisis makes the prospect of obtaining much improvement from treatment unfavorable.

Chapter XII.

TREATMENT.

The treatment of scoliosis can be most clearly considered if one separates for purposes of discussion the two types of cases already described (page 46–54)—(1) the postural or functional, and (2) the organic or structural. That such a distinction is not always sharply to be made, that transition cases are to be seen, and that many therapeutic measures are common to both classes of cases, applies here as in most other departments of medicine and surgery where functional and organic conditions are separated.

THE TREATMENT OF POSTURAL SCOLIOSIS (FUNCTIONAL SCOLIOSIS, FALSE SCOLIOSIS).

Regarding the condition as an habitual inability to stand correctly, as a postural malposition without marked structural change, it is evident that the treatment should consist in the substitution of a correct attitude for the faulty one. This is obviously to be preceded by eliminating conditions unfavorable to the maintenance of a correct upright position. The conditions requiring investigation and possible correction in every case as a preliminary to beginning treatment are—(1) seats and desks at school; (2) the manner of clothing the child; (3) the condition of the eyes and ears; (4) the existence of a short leg; (5) overwork or too long hours, leading to persistent fatigue; (6) excessive recent growth with consequent impairment of resistance. These matters are also of importance in structural lateral curvature. Having placed the patient under the most favorable conditions obtainable and having corrected so far as possible the defects above mentioned, the patient should work on the exercises to be described for from half an hour to two hours a day for a period of some weeks, which exercises should not be pushed beyond the limit of fatigue.

After a period of vigorous daily work under the direct supervision of the surgeon, which should generally be continued for two or three weeks, home work under the direction of the parents may be substituted for it, with occasional supervision by the surgeon at longer and longer intervals. But it is desirable that such patients should be under observation for at least a year.

The length of treatment, the period of the exercises, and the extent to which they can be pushed will depend on the vigor of the child, as half-way measures are not likely to be successful and exercises done at home under the supervision of careless parents are less efficient than those given by persons trained in the art of gymnastics. The treatment lies within the range of any good teacher of gymnastics who will carry out the instructions of the surgeon. The causes of failure are to be found in the fact that such children are generally in poor muscular condition and are often overworked at school or under unfavorable conditions at home, or that the exercises are given too seldom and are not sufficiently vigorous.

If flexibility to one side is limited, *i.e.*, if the child can bend further to the right than to the left in a left total curve, the flexibility of the spine must be made equal, preferably by means of passive lateral stretching in the apparatus, described on page 148, or by means of gymnastic exercises. Having restored the flexibility of the spine by this means or if flexibility to the two sides is alike, a treatment differing but little from the "setting-up drill" of the army recruit is to be instituted. Exercises suitable for the treatment of postural cases will be described in connection with the gymnastic treatment of structural scoliosis.

TREATMENT OF STRUCTURAL SCOLIOSIS (ORGANIC SCOLIOSIS, HABITUAL SCOLIOSIS, FIXED SCOLIOSIS, TRUE SCOLIOSIS).

The problem to be met in the treatment of lateral curvature with fixed bony changes is a perfectly definite one. A clear understanding of the obstacles to be met and of the means at our disposal for meeting them is essential to successful treatment.

The spinal column having curved to one side has in the course of years become fixed in the deformed position. In addition to the side curve, a rotation or twist in the length of the column has occurred at the seat of the main and compensatory lateral curves, particularly evident in the thorax. As the result of the maintenance of the vicious position over a long time, covering part of the period of growth, changes in bones, muscles, ligaments, and intervertebral discs have occurred. The individual vertebræ have become compressed on one side or twisted by the rotation. The ligaments and muscles have become adaptively shortened on one side and stretched on the other, and the intervertebral discs to a greater or less extent have become compressed on one side. The region of the vertebral column involved by the curve has lost its normal mobility and is partly or wholly stiff. There are secondary changes in the thorax and abdomen and in the contained organs.

It is obvious that in the upright position gravity works to increase the deformity by exerting pressure upon the concavity of the curves already atrophied by an abnormal weight bearing. Of the twenty-four hours in each day only some ten or twelve at most are spent in recumbency. During the remaining twelve or fourteen hours the vertical position is assumed and gravity is at work.

The treatment of structural lateral curvature presents, therefore, a much more serious and much less encouraging problem than the treatment of postural cases, and measures must be vigorous, adequate and *surgically* sound to produce a permanently satisfactory result.

The causes of failure of efficient treatment lie in the unwillingness of the parents or the patient to submit to sufficiently long-continued and effective treatment to remedy a condition which, on the slightest consideration, can be seen to be one which is necessarily difficult and resistant.

It is evident, where the pathological changes have reached a moderate degree, that considerable and continuous force would on general principles be necessary to force the column into a position approximately normal and also that on the forcing into and holding in such a position depends our sole hope of any considerable degree of favorable progress, progress necessarily due to the adaptive nature of growing bone—and to the fact that in its growth it will follow the lines of least resistance. The practical question is: how far may we depend on gymnastic treatment alone to accomplish this? Because gymnastic treatment is the traditional one for scoliosis, and is being pursued in this country to-day in the great bulk of all cases which are treated at all.

GYMNASTICS.

Gymnastics have a two-fold object—first, to loosen up the curved portion of the spine to make an improved position possible, and, second, to aid in retaining the improved position by strengthening certain groups of muscles. Most exercises tend in a measure to accomplish both of these, so that a sharp division into mobilizing and retentive exercises is not possible, and one can only point out that a certain exercise is especially valuable for one or the other purpose.

It is essential to define and limit what place gymnastics should occupy in the treatment of structural scoliosis. It is obviously unreasonable to expect free standing gymnastic exercises alone to straighten marked or severe curves or to change the shape of distorted bones. But after the greatest possible improvement has been secured in such curves by more efficient measures one must look to gymnastics to develop the muscles which will hold the improved position and make the gain permanent after the corrective jacket has been gradually discontinued. In marked and severe structural scoliosis, therefore, gymnastic treatment finds its use as supplementary to forcible correction.

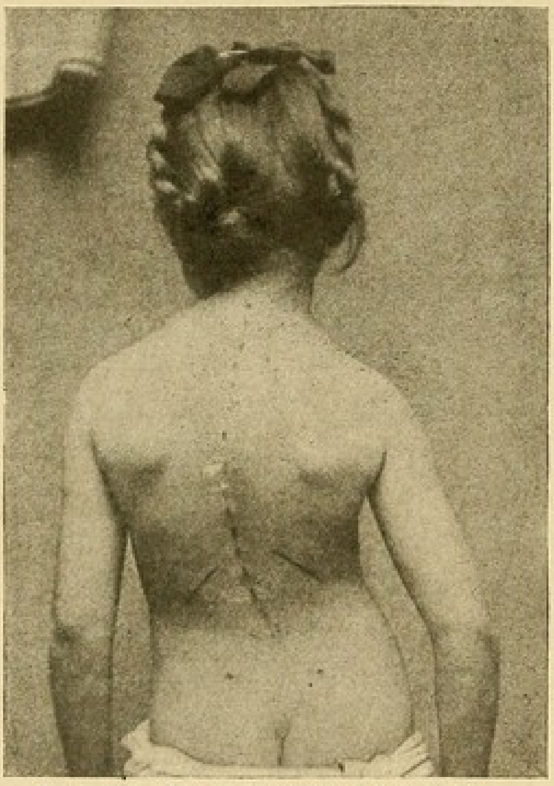

Fig. 87.—Patient with Left Dorsal Curve in 1900.

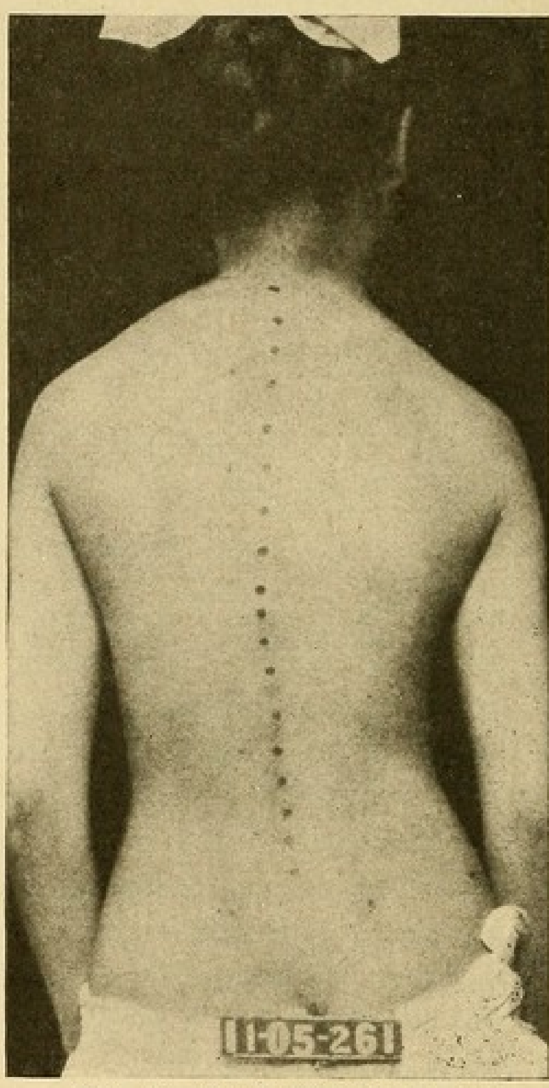

Fig. 88.—Same Patient in 1905 after Five Years of Gymnastic Treatment.

The *purely* gymnastic treatment of severe structural scoliosis is to-day being largely pursued by two classes of persons. First, by irresponsible masseurs and medical gymnasts who hold as a tradition that gymnastic exercises are curative or at least helpful in scoliosis, and second, by surgeons who do not believe in corsets or supports.[1] The

[1] Teschner: "N. Y. Med. Rec.," Dec. 6, 1903; Erich: "N. Y. Med. Jour.," Oct. 7, 1899.

former class serves only to bring the legitimate use of gymnastics for scoliosis into disrepute; the latter class use the gymnastics more or less effectively, and, take a pessimistic view of the results to be obtained in severe scoliosis. Structural scoliosis is a bone problem; a glance at the deformed column indicates that, but it has been too largely considered and treated as a muscle problem. Many well informed surgeons are deterred from the use of corrective jackets by the fear of inducing muscular atrophy of the back. But muscular atrophy of the back is quickly recovered from and the deformity is a grave one demanding measures which strike at the salient feature—the bony deformity. The history of the treatment of moderate and severe structural scoliosis as a muscle problem is a history largely of failure or of extravagant and unwarranted claims. The exception to be made to this statement is found in the work of the German surgeons[1] using gymnastics in apparatus devised for the purpose.

Not only may gymnastics in moderate and severe structural scoliosis fail to do good, but they frequently do serious harm for the following reason: scoliosis of this grade soon results in a stiffening of the affected region of the spine. If efficient gymnastics are given, the spine is speedily rendered more flexible and if it is so rendered and not supported at once it will sink into a worse position than before and the curve will be increased. The assumption made by the advocates of gymnastics is that the back muscles will be so developed by the exercises that they will immediately hold the spine in an improved position, but this does not happen, and the flexibility increases much faster than does the holding power of the muscles. Much harm would be avoided in the gymnastic treatment of these cases if this practical fact were recognized.[2]

Place of Pure Gymnastic Treatment.—In mild structural scoliosis efficient gymnastics should constitute the sole treatment, and may be continued as the sole treatment so long as the improvement from one exercise period persists until the next one. If such improvement is not held between exercises it must be assumed —(1) that the exercises are not good ones; (2) that they are not properly carried out; (3) that the amount of treatment is insufficient, or (4) that the case is too severe for purely gymnastic treatment. *Progressive improvement must be assumed as the criterion of efficient gymnastic treatment.*

[1] Chirurgie u. Orthopädie in Kindesalter. Lang and Spitzy, p.124, Leipzig, 1910.
[2] Chlumsky: "Verhdlg. d. Deutsch. Ges. f. orth. Chir.," 1908, 317.

It is impossible to draw a general line either theoretically, or in practice at the outset between cases which are likely to be cured by gymnastics alone and those which are not. The line comes somewhere between the mild and the moderate cases and doubtful cases should be tried on the purely gymnastic treatment and kept on it only so long as they progressively improve.

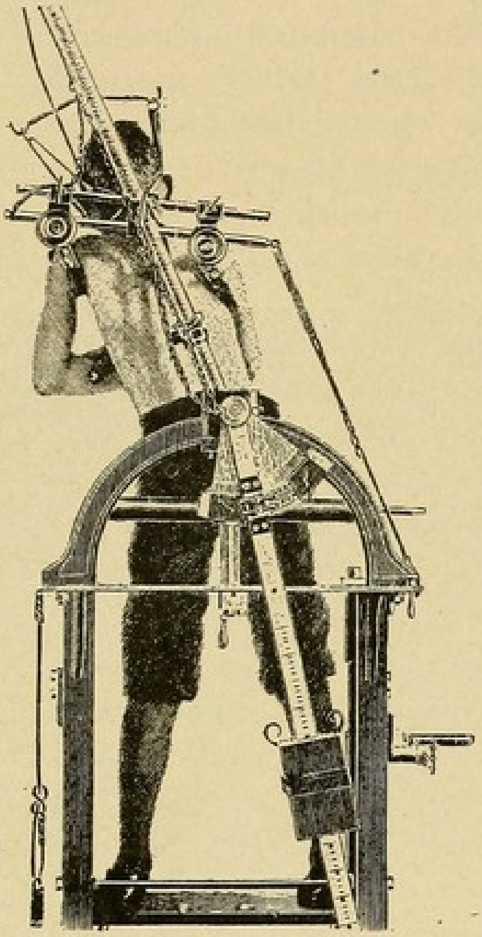

FIG. 89.—TRUNK BENDING APPARATUS.—(*Schulthess.*)

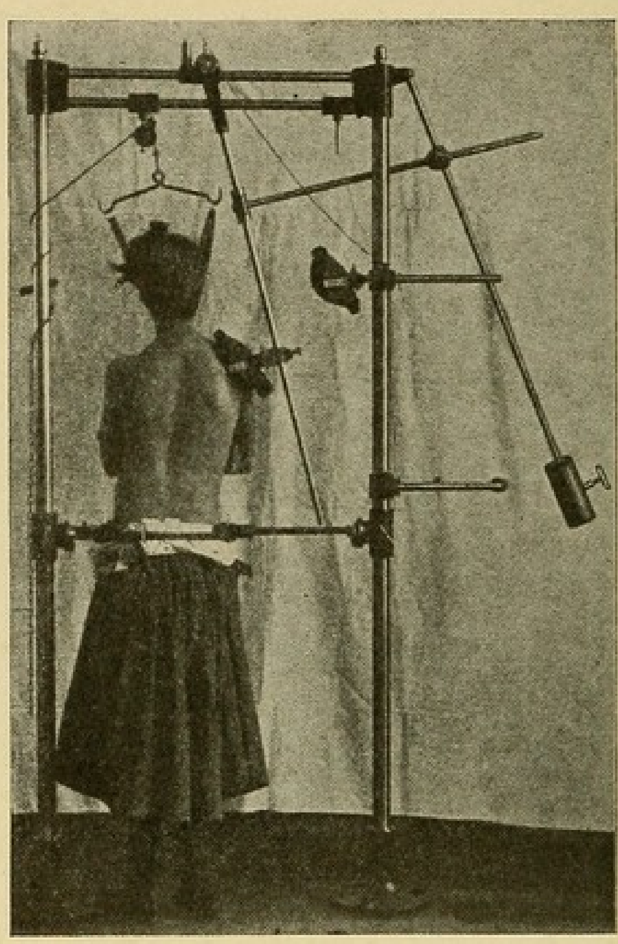

FIG. 90.—SHOULDER PUSHING APPARATUS.—(*Schulthess.*)

Scheme of Treatment.—The treatment by gymnastics alone may be supplemented (*a*) by the use of supporting jackets, braces, or corsets, or (*b*) by the use of intermittent passive stretching, or (*c*) by both. If the case is too severe to be controlled by these measures, forcible correction followed by gymnastics and corsets is the proper treatment. The use of braces and corsets alone is not to be considered a treatment for lateral curvature.

Gymnastics Given in Apparatus.—By means of apparatus gymnastic exercises can be very much more correctly localized, and the work of loosening the spine and of strengthening the desired muscles can go hand in hand. This method, which is in general use in Europe, has never found a foothold in this country on account of the complicated and expensive apparatus.

The system of apparatus devised by Schulthess and its modifications the apparatus of Zander and the simpler apparatus of Lange are the best examples of the kind. The aim of his method of treat-

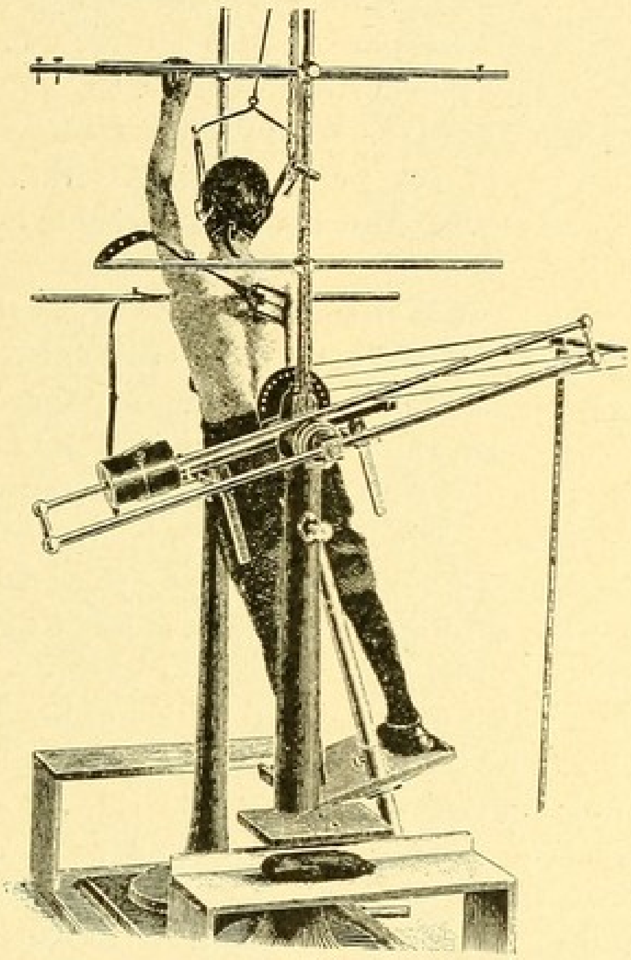

FIG. 91.—HIP-PENDULUM AND SHOULDER-RAISING APPARATUS.—(*Schulthess.*)

ment, as stated by Schulthess, is "to correct, and in the corrected position to allow exercises to be done, or through the movements carried out in the apparatus to shape over the body from the pathological to the corrected form." The various forms of apparatus are as follows: (1) For side bending with the pelvis fixed; (2) for side bending with the shoulders and pelvis fixed; (3) for forward and backward bending; (4) for trunk rotation; (5) for active transverse pushing of the shoulder-girdle; (6) for active raising of the shoulder; (7) for active movement of the thorax with shoulders and pelvis fixed. In some of these the pendulum principle is used.

The daily periods of work are limited by the patient's endurance; periods of recumbency are insisted on, and the child is kept under the closest supervision generally in a special institution under the close supervision of the surgeon for many months.

The precision of the apparatus, its adaptation to anatomical needs, and the principle of securing correction and the development of desired muscles at the same time make the system sound and efficient. It is described in detail in the reference,[1] and is not dwelt on here as it is a treatment not often available in America (Figs. 89, 90, 91).

Gymnastic Exercises Given Without Apparatus.—This method of treatment is the one in most general use in America. It is open to the objection that the force exerted is not sufficiently localized, but is distributed over the spine.

Fixation of Pelvis.—It is essential that the pelvis should be fixed during such exercises, as otherwise the pelvis is displaced and the movement becomes a general and not a local one. A simple wooden apparatus may be constructed which holds the pelvis and does away with the necessity of holding the hips of the patient between the knees, which must otherwise be done. This saves labor on the part of the person giving the exercises, and permits a closer supervision of the back than is possible when part of the attention must be fixed on holding the patient firmly.

The apparatus, which was suggested by that of Bade,[2] consists of a wooden clamp made by two flat boards set at right angles to a horizontal board on which they slide to hold the sides of a pelvis of any width. The whole apparatus moves up and down on an upright fastened to a large round floor platform and may be inclined at any angle to the horizontal plane. The patient is secured in place by sliding in and fastening the lateral clamps at the sides of the pelvis, and by securing the front of the pelvis by a broad leather strap passing from one arm to the other. The floor platform is so large that the apparatus cannot upset (Fig. 94).

General Routine and Precautions.—It is desirable that the back should be exposed during the exercises in order to note the effect of each one. For this purpose the patient should wear during exercises a loose cotton dressing jacket, fastened around the neck and opening

[1] Schulthess: Joachimsthal's "Hdbch. der orth. Chir.," Lief v, page 1104.
[2] "Zeitsch. f. orth. Chir.," xii, 4, 799.

in the back. This protects the front of the body but permits inspection of the spine.

Such exercises should be simple and corrective in the strict sense; that is to say, an exercise which is of use should be seen to straighten the spine visibly. Complicated exercises are dangerous and unsur-

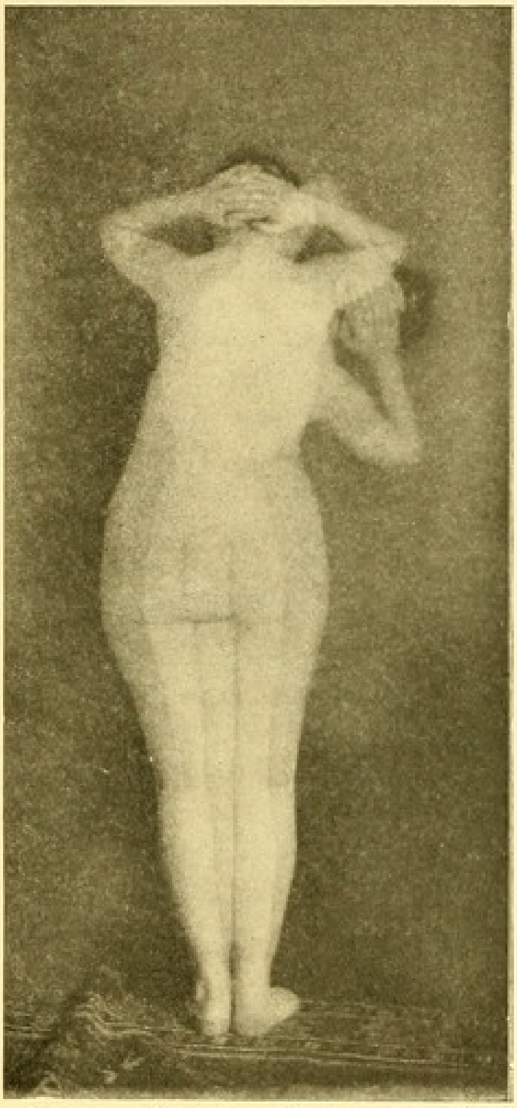

FIG. 92.—COMPOSITE PHOTOGRAPH (TWO EXPOSURES ON THE SAME PLATE) SHOWING THE MODEL STANDING ERECT AND BENDING TO THE RIGHT WITHOUT FIXATION OF THE PELVIS. THE MOVEMENT IS A GENERAL ONE.

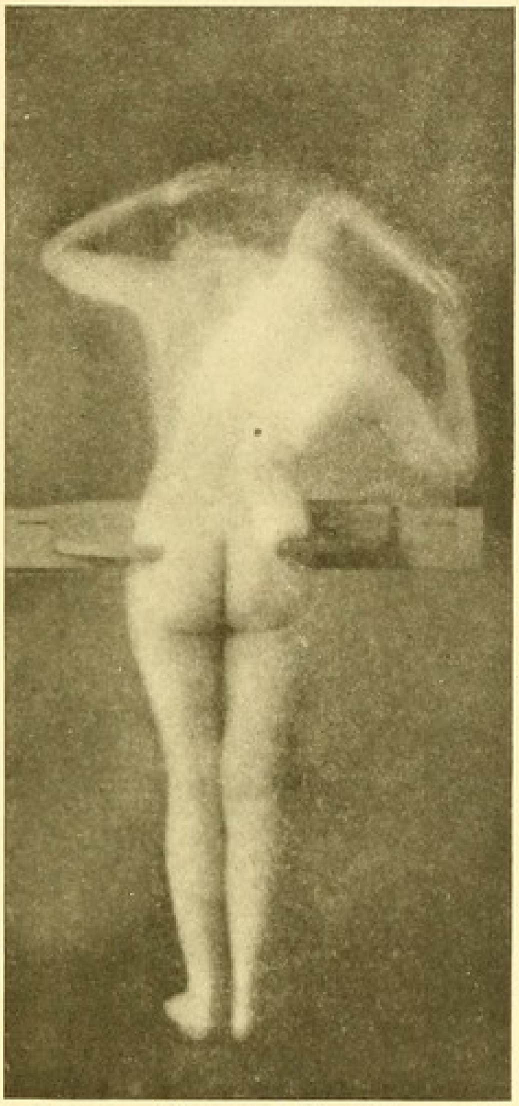

FIG. 93.—COMPOSITE PHOTOGRAPH OF THE MODEL STANDING ERECT AND BENDING TO THE RIGHT WITH THE PELVIS FIXED. THE MOVEMENT IS LIMITED TO THE SPINE.

gical. Work to yield results must be given by a competent gymnast for a period of from one to three hours a day, according to the vigor of the patient, and must be continued under personal supervision for a period of some weeks or months to obtain satisfactory results. After this, exercises at home can be substituted for part of the personal work.

As a preliminary to gymnastic work the heart of the patient should have been, of course, examined afterwards the weight should be taken each week as persistent loss of weight is an indication for moderating or discontinuing temporarily the exercises, providing that the patient is not being overworked at school, in which case the school conditions should first be remedied. During menstruation, gymnastic exercises should be suspended. Persistent fatigue, anemia, loss of appetite, nervousness, and frequent or profuse menstruation should cause a careful investigation of the patient's environment, as they may arise from excess of gymnastic work.

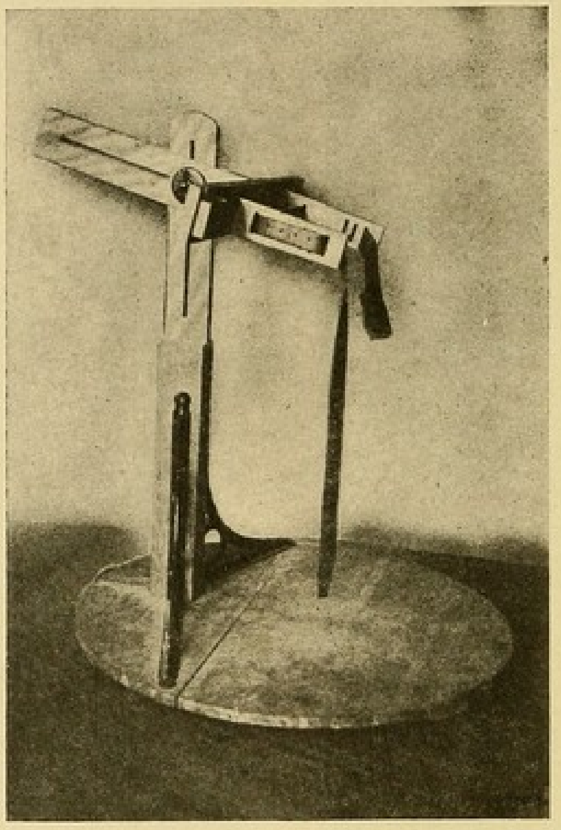

FIG. 94.—APPARATUS FOR FIXING THE PELVIS DURING GYMNASTIC EXERCISES.

The following list of gymnastic exercises, selected from a large number, may be regarded as representative of the kind of gymnastics likely to be of use *within the limits mentioned above*. They will first be described individually and then analyzed, and their application to different conditions will be indicated. The selection of exercises must depend on the requirements of each case. Simple developmental exercises have not been included here, as a description of them can be found in books on gymnastics.

In the explanations to be given in connection with each exercise the general mechanical features will be discussed, but it must be remembered that conditions observed in the normal do not necessarily hold true in the deformed spine of scoliosis, although they form the best basis for analysis. The more nearly a spine approaches the normal, the more likely is such analysis to be correct.

SYMMETRICAL EXERCISES.

Exercises in the Standing Position.

In all exercises given in this position *the pelvis should be fixed* unless otherwise stated. It must be remembered that exercises in this position call into play in varying relations all muscles concerned in maintaining the upright position, and therefore cannot be as highly specialized as can exercises given in the lying position. It must also be remembered that the superincumbent weight rests on the laterally curved spine, and that the curves are therefore not in as favorable a condition in such exercises as in the lying position. On the other hand, they are useful because any improvement of scoliosis must be interpreted as meaning improvement in the upright position, and all muscles concerned in that are therefore of importance.

Fundamental Standing Position.—The patient stands with the knees extended, the hands on the hips, the back straight, the head erect, and the scapulæ brought close to each other. The patient should not exaggerate the lumbar curve, and should press down with both hands on the hips.

I. *Shoulder Raising and Sinking.*—(1) From the fundamental standing position the patient stretches the whole spine upward. The surgeon holds his hand slightly above the patient's head and urges her to stretch until she can touch his hand with her head, keeping both heels on the ground. The position of the hand is made higher as necessary. (2) From the upward stretched position the patient relaxes to the fundamental standing position. In count (1) the patient breathes in and in count (2) breathes out (Fig. 95).

This is a general exercise calling upon the muscles which maintain the proper erect position, notably the spinal extensors. The elevation of the shoulders elevates and fixes the shoulder-girdle, giving a fixed point for the pull of the inspiratory muscles, thus tending to increase chest capacity, and a general stretching of the spine is also made easier by the fixed shoulder-girdle. The exercise is applicable to any case of scoliosis, especially to postural curves, as a general mobilizing and corrective one.

II. *Trunk Bending Forward with Shoulders Raised.*—(1) The shoulders are raised as in Exercise I (1). (2) The patient bends her trunk forward to the horizontal position, the spine being held straight and the shoulders raised, movement occurring only in the hip-joints. (3) The patient raises the trunk to the upright position with the shoulders still raised and the spine straight. (4) The patient relaxes to the fundamental standing position (Fig. 96).

This combines the essentials of Exercise I with the weight of the trunk thrown on the extensor muscles of the back and on the glutei, which must be held contracted to maintain the forward bent position and which must contract to bring the trunk again into the upright position. It has the corrective effect of Exercise I, in addition to which it is a fairly strong extensor spinal exercise with the lumbar curve flattened. It is a general mobilizing and corrective exercise which may be safely used in cases with a tendency to exaggeration of the lumbar curve. The patient inspires in (1), holds the breath during (2) and (3), and breathes out in count (4).

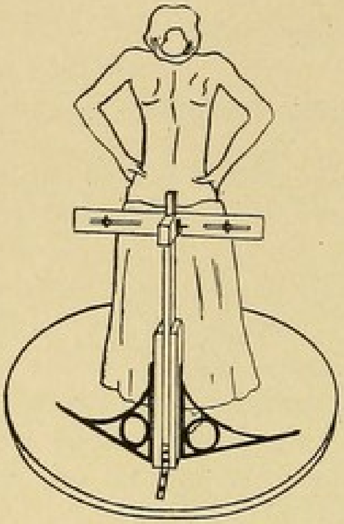

Fig. 95.

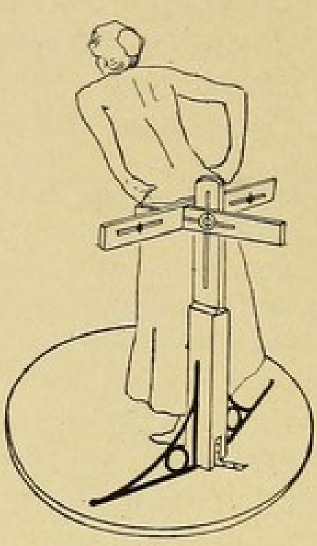

Fig. 96.

The above exercises may be modified and made slightly harder by having the patient place both hands behind the neck with the elbows square back as far as possible. This raises the center of gravity of the trunk and therefore increases the leverage against the muscles.

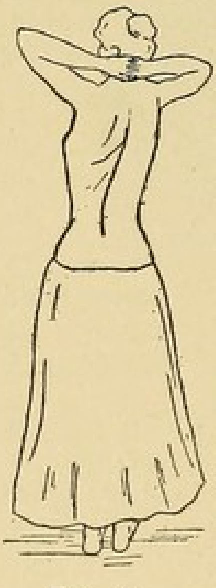

Fig. 97.

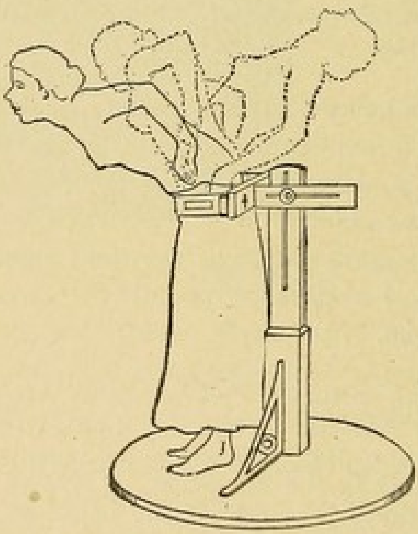

Fig. 98.

III. *Trunk Twisting.*—Position: Without pelvic fixation, the feet parallel and touching, the hands on the neck, the head and spine erect. (1) From this position the patient twists her whole body as far as possible to the right or left, the head being turned as far as possible in the same direction. (2) The original standing position is resumed (Fig. 97).

Trunk rotation to the right causes a left dorsal curve and *vice versa;* in addition to this the exercise is intended to be mobilizing to the whole body, especially the hip-joints, and greater trunk excursion is possible with the feet parallel than with the legs rotated outward. The exercise is suitable for general spinal mobilization, and when given only to one side is a mild corrective exercise for lateral deviation. The effect of rotation upon the spine, esp^cially in causing a lateral curve, may be located higher in the spine by giving the rotation in the forward bent position, and located lower by giving it in the hyperextended position.

IV. *Trunk Circling.*—Position: Hands on the hips, the trunk flexed to th horizontal, the spine straight. From this position the patient describes a circle with the trunk about a vertical axis passing between the feet. The horizontal plane of the circle described is quite irregular, and the movement is divided into four counts: (1) From the position of forward bending the trunk passes to the right or left through side bending with flexion and rotation to extreme side bending

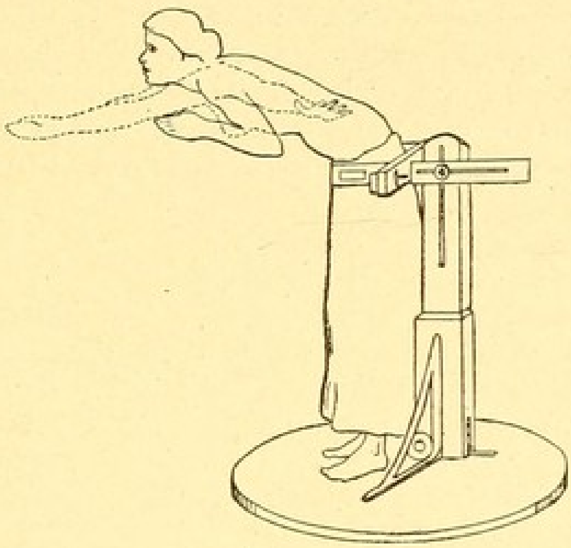

FIG. 99.

(2) From extreme side bending the circle is continued backward through side bending with its accompanying rotation to extreme hyperextension of the median plane. (3) The reverse of count (2). (4) The forward bent position is assumed. The face is directed forward during the entire exercise (Fig. 98).

This is a general mobilizing and strengthening exercise. When a marked lumbar curve is present, the exercise is preferably made unilateral to the side that improves rather than increases the lumbar curve, *e.g.*, in a left lumbar curve half circling to the left is preferable to the complete circle so far as any corrective aspect is concerned.

V. *Swimming.*—Position: The patient bends forward until the trunk is horizontal, the arms are held at the sides, the elbows flexed, and the hands together against the chest. (1) The arms are extended upward beside the head. (2) The arms describe a half circle outward and are brought to the sides of the body. (3) The arms return to position (Fig. 99).

In this exercise the pelvis is flexed on the hip-joints and the weight of the trunk is thrown forward. The extensor muscles of the spine and the glutei are called upon to maintain the position during the movements of the arms. All the muscles of the shoulder-girdle, especially those concerned in drawing the scapulæ together, take part in the movement. This is a general strengthening exercise, especially addressed to spinal extensors, and is also valuable in cases of flexible round shoulders.

VI. *Head Movements from the Fundamental Standing Position.*—The head and cervical spine as far as possible, alone should participate in these exercises. *A*. (1) Head flexion, (2) original position. *B*. (1) Head hyperextension, (2) original position. *C*. (1) Side bending of the head to the right or left, (2) original position. *D*. (1) Head twisting, right or left, (2) original position. *E*. Head circling with the face to the front, a combination of *A*, *B*, and *C* following one another.

General mobilizing exercises for the cervical regions. For corrective effect in a cervical curve they should be given only to the side that improves the curve.

Exercises Given in the Horizontal Position.

In this group of exercises one set of muscles may be more readily picked out for exercise than in the erect position. The spine when prone is less curved than in the upright position, and is slacker and more easily capable of side displacement. The fact that symmetrical hyperextensions are so much used for their corrective effect is explained by their empirical value and by anatomical reasons (page 25).

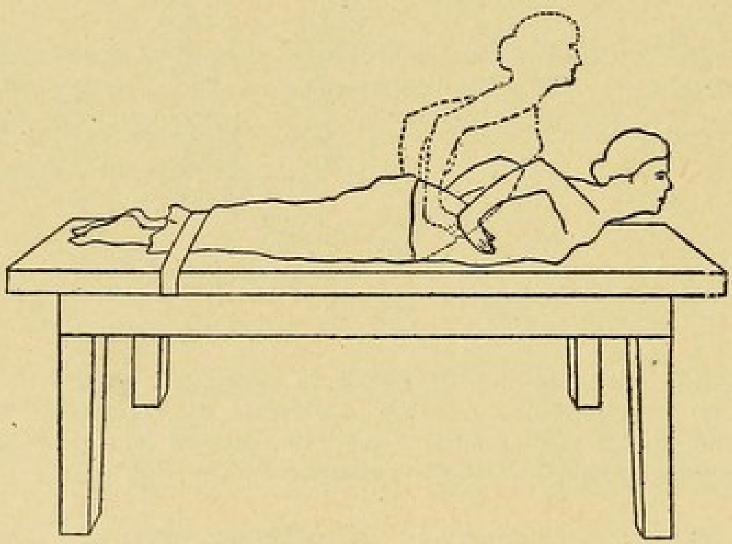

Fig. 100.

Lying on the Face.—VII. *Trunk Raising.*—Position: The patient lies face downward on a table with the spine straight, the hands on the hips, the scapulæ approximated to each other, and the legs secured to the table by a strap passing around the table and legs just above the ankles, or the legs may be held by the hands of an assistant. (1) The patient inspires and raises the trunk from the table, hyperextending the spine as far as possible, keeping the head back and the face up, with the elbows still held well back. (2) The patient breathes out and sinks to the original position (Fig. 100).

This is an extension of the spine from its normal position to extreme hyperextension in which the spinal motion occurs largely below the tenth dorsal vertebra, where hyperextension anatomically takes place. The weight of the trunk is raised by action of the back extensor muscles which are very generally called into play.

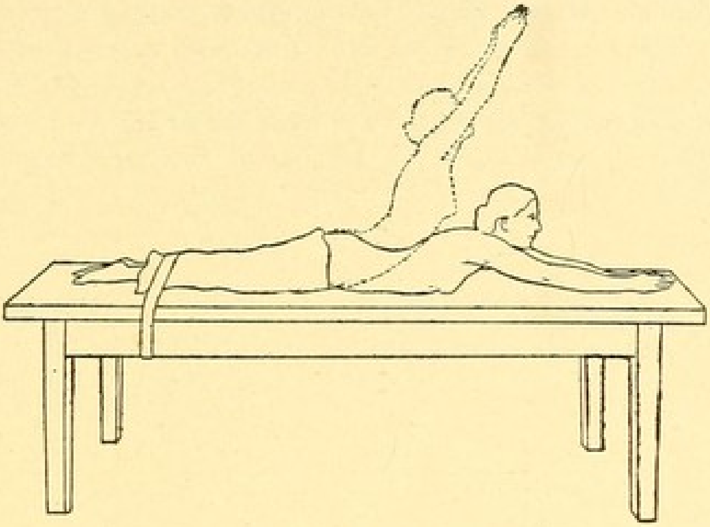

FIG. 101.

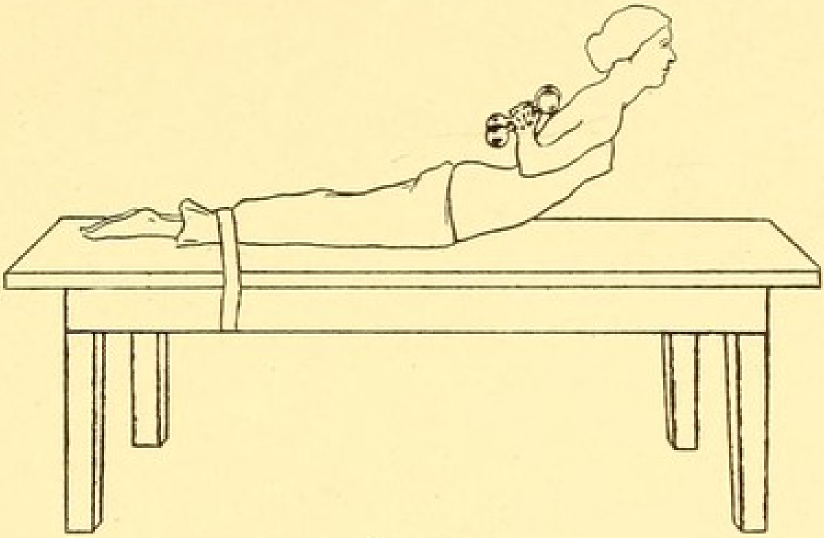

FIG. 102.

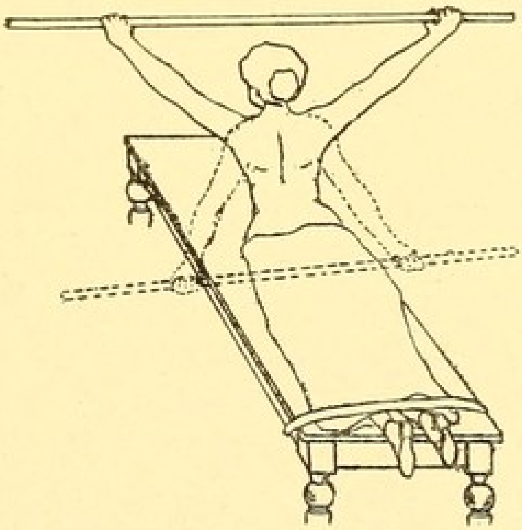

FIG. 103.

It is a general strengthening exercise for these muscles, but in cases with marked increase of the lumbar curve it must not be used to increase this, in such cases Exercise II being available. The latter is probably a weaker exercise, because in it the extensor muscles do not contract to their fullest extent. The exercise may be made harder by placing the hands behind the neck and squaring the elbows

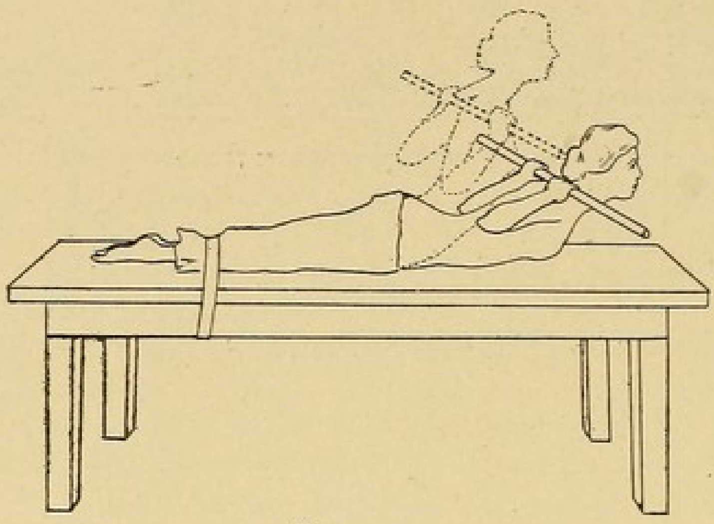

FIG. 104.

back or by extending the arms beside the head, which raises the center of gravity (Fig. 101).

The above may be modified in the following manner: The patient clasps his hands behind his back above the level of the waist-line, with elbows flexed and hand closed against the back, and, as he hyperextends his trunk, stretches his

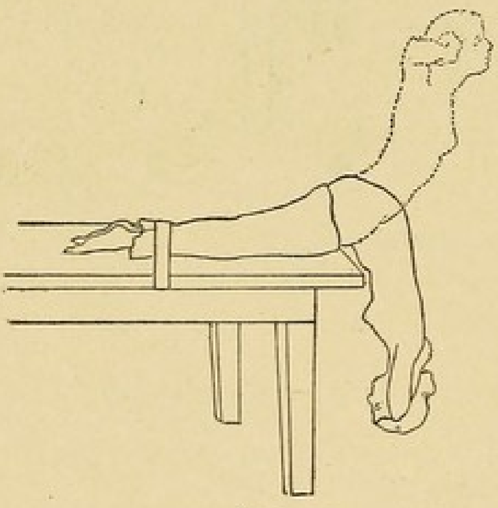

FIG. 105.

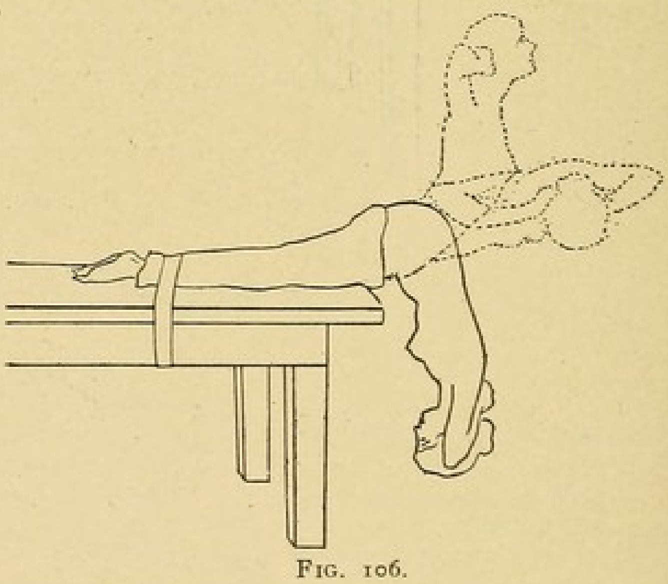

FIG. 106.

arms backward forcibly, extending the elbows, and keeping the hands clasped. By this modification the scapulæ and shoulder-joints are carried back and the hyperextension done with an improved position of the shoulders. This is particularly suited to round shoulders.

This exercise may be made stronger by the use of dumb-bells or a staff as indicated in Figs. 102, 103, and 104.

Exercises Lying on the Face, the Trunk Projecting over the End of the Table.—The legs rest on the table, the surgeon making the ankles secure by means of a strap or by holding them. The body above the hip-joints hangs over the table end, head downward. The hands are placed behind the neck with the elbows squared back.

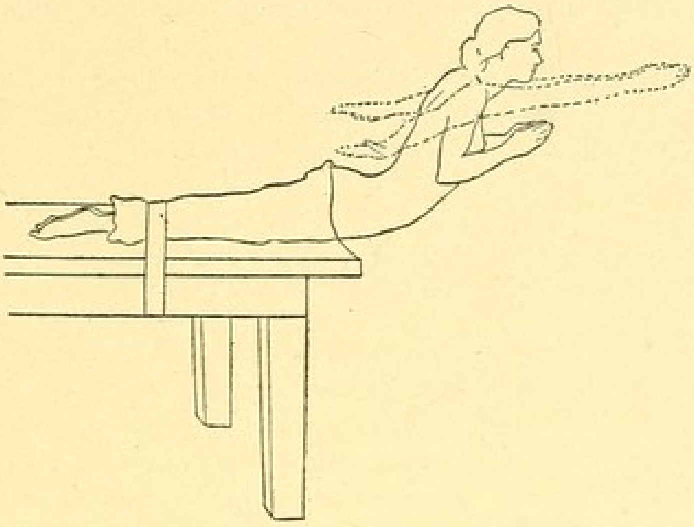

FIG. 107.

VIII. *Trunk Raising from Head Downward Position.*—(1) The patient inspires, and raises the trunk as far as possible by hyperextending the hip-joints and the spine. (2) During the expiration she sinks to the primary position. The spine should be kept in the mid-plane and the head not allowed to flex (Fig. 105).

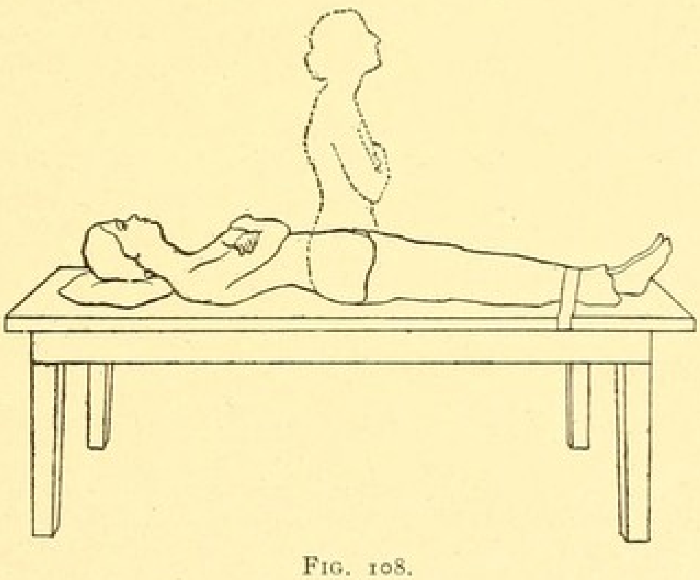

FIG. 108.

This is a spinal extension movement mostly without superincumbent weight, beginning at forward flexion and ending in marked hyperextension, calling the extensor muscles into activity from a stretched to a completely contracted condition. It thus combines the range of motion in Exercise II with that of Exercise VII. It is a heavier exercise than either. From the start of the exercise till the horizontal position is reached the spinal extensors and glutei are the muscles chiefly active, as the maintenance of balance does not require the contraction of other trunk muscles. The exercise may be made easier by placing the hands on the hips. It is of use as a general strengthening exercise for the back muscles in any case where the patient is strong enough to take it.

IX. *Trunk Circling.*—The position is the same as in Exercise VIII. The exercise is done in four counts, as described under Exercise IV (Fig. 106).

This is a heavier exercise than IV because the weight of the trunk is a factor entering into each component of the movement. For corrective effect it should be given only to the side that improves the lateral curve.

X. *Swimming.*—This exercise is done in the same way as Exercise V, except that the patient first raises his trunk as high as possible, and holds the position while he goes through the movements of swimming (Fig. 107).

It differs from Exercise V because the spine is held in a position of hyperextension, and is not flexed on the pelvis. It thus exercises chiefly the spinal extensors in a position necessitating their maximum contraction. It is not suitable to cases with increased lumbar curve.

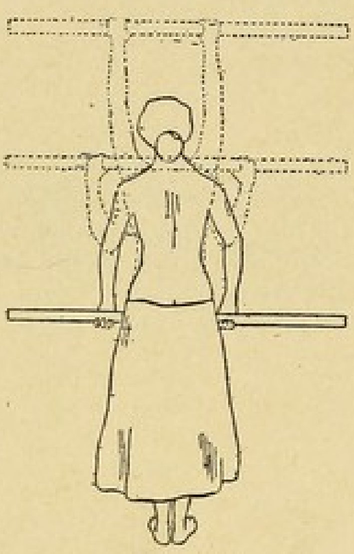

FIG. 109.

Exercises Lying on the Back.—The patient lies on a table or on the floor with the head, trunk, and legs straight, and the feet secured either by a strap or by being held. The arms are folded on the chest.

XI. *Trunk Raising to Sitting Position.*—(1) The patient rises slowly to the sitting position with the spine stiff and not allowed to flex. (2) The patient sinks to the primary position with the spine still stiff, the head touching the table before the back (Fig. 108).

The exercise is made easier by placing the hands on the hips, and harder by placing the hands behind the neck with the elbows squared back. The upright position is brought about by the contraction of the abdominal muscles, which aid in maintaining the upright position, and require exercise in cases of prominent abdomen and of increase of the lumbar physiological curve accompanying scoliosis and round shoulders.

MISCELLANEOUS SYMMETRICAL EXERCISES.

XII. *Heavy Weight Raising*[1] (Teschner).—The patient stands facing a table, which touches the front of the thighs or pelvis, against which she rests. She then raises slowly a heavy bar, weighing from 10 to 30 or more pounds, over the head as high as the arms will reach, keeping the eyes fixed on the middle of the bar and keeping the bar horizontal. It is then lowered slowly, but should be held or rested at the level of the shoulders and not allowed to drag on the arms. The exercise is repeated as often as may be. The patient should use as heavy a bar as can be put up steadily and will produce a corrective effect on the curve when the point of upward stretch is reached. The weight should be steadily increased as the muscular capacity of the patient increases (Fig. 109).

[1] Teschner: "Ann. of Surgery," Aug., 1895; "Orth. Trans.," vol. ix.

The exercise tends to develop all the muscles of the trunk, as its correct performance necessitates a contraction of the muscles maintaining the erect position. It is not particularly corrective to the curve, but fills out the flanks, improves the body-outline, and tends to strengthen the muscles, maintaining a correct upright attitude, in this way tending to fix the improved position. It is a developmental exercise suited to any curve, of retentive rather than corrective value, and therefore best used as supplementary to other and more corrective work.

XIII. *Weight Carrying on the Head.*—A bag filled loosely with sand, weighing from 3 to 15 pounds, is placed on the top of the patient's head, and she walks slowly to and fro with the arms preferably clasped behind the neck and the elbows squared back. The exercise may be made more difficult by having the patient walk on tiptoe. The attitude assumed should be as erect as possible and the weight as heavy as can be carried steadily.

It is a matter of common information that the habitual carrying of baskets and loads upon the head induces an erect carriage and a straight spine. The presence of weight upon the head necessitates holding the spine as straight as possible under the weight, as it is thus most economically carried, and this instinctive adjustment to superincumbent weight is depended on for its corrective effect. The exercise is suited to mild cases with noticeable bad carriage and poor balance.

XIV. *Mirror Self-corrective Exercise.*—The patient, bared to the hips, faces a mirror in front of which hangs a plumb-line. The patient then stands in such a position that the plumb-line cuts the middle of the pelvis, and by a muscular effort brings the middle of the thorax and the vertical line of the face as nearly as possible under the plumb-line, bringing three important landmarks into the median line of the body, thus securing an improved position. This is held for a few seconds and then the relaxed position resumed. The exercise is repeated several times, the improved position being held longer each time.

The exercise is a muscle training and is not in any way a mobilizing exercise, but enables the patient to associate a certain position with a certain muscular effort, and is of great value in enabling patients to identify by muscular sense the corrected position. The exercise requires but little effort and may be done at home without assistance. It may be modified in various ways by adding free-arm, staff, or dumb-bell exercises, which change the center of gravity, strengthen muscles approximating the scapulæ, and prolong the corrected attitude.

ASYMMETRICAL EXERCISES.

XV. *Hip Sinking* (Hoffa).—Position: From the fundamental standing position the patient advances the foot, on the side opposite to the convexity of the lateral curve, forward and outward about two foot-lengths. (1) The patient bends the forward knee, sinking the hip on that side. (2) The patient resumes the primary position (Fig. 110).

A passive side correction of the lumbar curve, due to a lowering of the pelvis on the side of the advanced leg when the knee is bent. Suitable for lumbar curves.

XVI. *Self-correction* (Lorenz).—The patient assumes the fundamental standing position and places the hand of the side to which the dorsal spine is convex upon the side of the thorax opposite to the greatest dorsal curve; the other hand is then placed on the ilium. (1) By a side thrust of the hand on the thorax the patient corrects the dorsal curve as much as possible, maintaining the correction for a few seconds. (2) The patient relaxes to the primary position. The exercise may be modified by placing the hand on the side to which the dorsal spine is concave on the top of the head, as it thus tends to raise a low shoulder. The rest of the exercise is performed as described (Fig. 111).

A side thrust of the dorsal spine with pressure applied to the convexity of the dorsal curve against resistance furnished by the other hand on the ilium or the head. Suitable for dorsal scoliosis, but not powerful, and useful as a means o stretching; chiefly good because it can be done by the patient unaided at frequent intervals. Exercises XV and XVI may be combined for a double curve with one element dorsal and the other lumbar.

XVII. *Hip Sinking from Stool.*—Position: The patient stands erect on a stool on one foot (the foot on the side of the convexity of the curve). (1) The patient lets the free leg sink as much a possible, thus lowering the pelvis and hip on that side. The knee of the supporting leg must be kept straight. (2) The patient resumes the original position (Fig. 112).

A passive side stretching of the lumbar curve suitable for lumbar scoliosis. The leg and pelvis drag down on the side of the concavity of the lateral curve, tending to stretch contracted structures and straighten the curve.

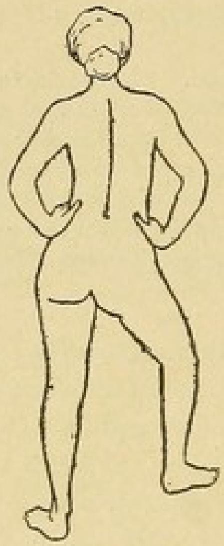

FIG. 110.

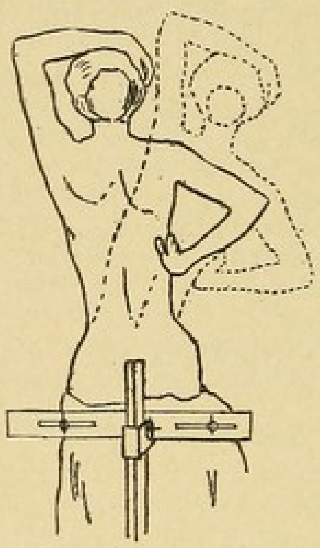

FIG. 111.

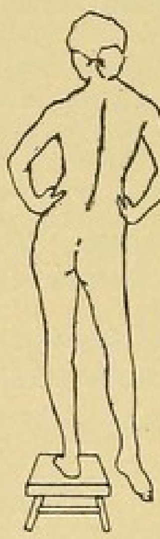

FIG. 112.

XVIII. *Trunk Hyperextension with Side Bending—Lying on the Face.*—The patient lies face downward on a table or on the floor as described in Exercise VII. (1) The trunk is raised from the table as far as possible by hyperextending the spine. (2) From this position the trunk is bent to the side toward which the lumbar curve is convex. (3) Position 1 is resumed. (4) The prone lying position is resumed (Fig. 113).

This exercise is an active lateral flexion of the spine in the position of hyperextension. As hyperextension locks the dorsal region against side flexion, the movement is almost wholly confined to the lumbar region. If there is a right dorsal curve in connection with a left lumbar curve, bending to the left, while it corrects the lumbar curve, does not at the same time greatly increase the dorsal curve, as that part of the spine is locked against side bending. The exercise is, therefore, suited not only to lumbar curves, but especially to compound curves in both dorsal and lumbar regions.

XIX. *Drawing up the Hip—Lying on the Face.*—Position: The patient lies prone on a table, holding the end with both hands, the arms extended and the spine and legs in a straight line. (1) The surgeon grasps the ankle on the side of the lumbar convexity and resists while the patient draws the hip up as far as she is able, the knee being kept straight. (2) Position 1 is resumed (Fig. 114).

The approximation of the side of the pelvis and the thorax on the side to which the lumbar curve is convex is brought about by an active contraction of the muscles on the convex side of the lumbar curve which it is desirable to develop. The amount

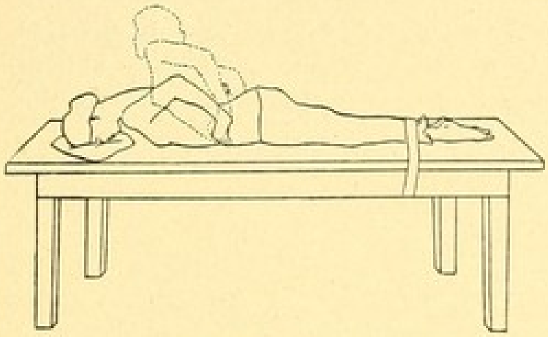

FIG. 113.

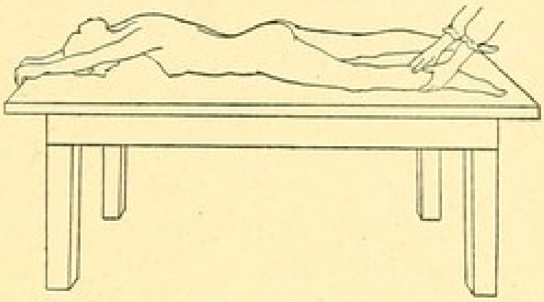

FIG. 114.

of work thrown on these is determined by the amount of traction made on the ankle. The exercise is suited to cases of lumbar curves or to the lumbar element of compound dorsal and lumbar curves.

XX. *Side Flexion of the Trunk from the Side-lying Position.*—Position: The patient lies on a table with the concavity of the lateral curve downward and the trunk projecting over the edge of the table above the pelvis, the patient being supported in this position, and the ankles secured by means of a strap. The spine

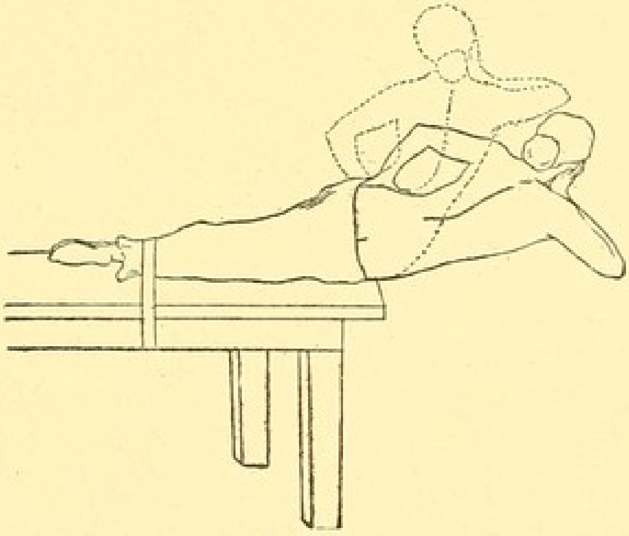

FIG. 115.

is held in medium extension, the upper hand on the hip and the lower hand on the back of the neck. (1) The trunk is bent laterally and upward as far as possible. (2) The original supported position is resumed (Fig. 115).

In this exercise the weight of the trunk is thrown on the muscles of the convex side of the lateral curve. The raising of the trunk tends both to diminish a curve existing near the dorsolumbar junction and to exercise strongly the muscles which aid in its correction. It is suited to total, lower dorsal and dorsolumbar curves.

XXI. *Trunk Bending to Both Sides with Hand Pressure* (*Mikulicz*).—Position: In the case of a right dorsal left lumbar curve the patient places the right hand on the prominence of the ribs just under the shoulder-blade, and the left above the ilium on the lumbar curvature. (1) She then bends the body slowly to the right side, while the right hand and thumb press against the dorsal prominence. (2) The upright position is resumed. (3) The patient bends to the left and backward, pressing with the left hand against the lumbar curve. (4) The upright position is resumed (Fig. 116).

This is a combined mild active and passive correction for a double curve. Opposing forces are applied to the convexities of the curves, thus tending to straighten the spine, which is at the same time bent by means of muscular action, first to the side of the convexity of the dorsal curve and then to the side of the convexity of the lumbar curve.

a. *b.*

FIG. 116.

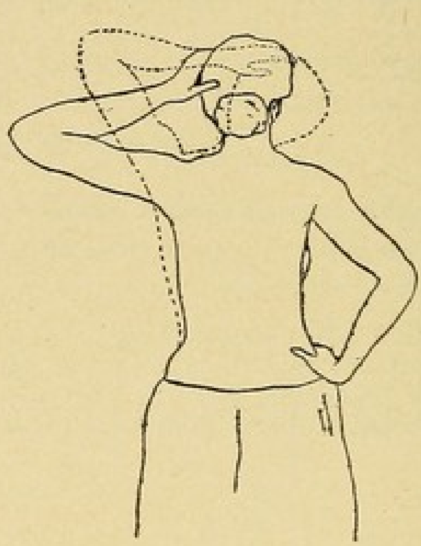

FIG. 117.

XXII. *Passive Head Side Bending.*—Position: The patient stands with the hand on the side of the concavity of the lateral curve against the side of the head above the ear. (1) The head is pushed as far as possible to the side that corrects the curve. (2) The original position is resumed (Fig. 117).

A passive correction of the cervical lateral curve by a side bend of the upper part of the cervical region which tends to diminish the curve. Of use in cervical and cervicodorsal curves, either alone or existing in combination with others.

XXIII. *Trunk Raising with Asymmetrical Position of Staff—from Prone Lying Position.*—Position: The one described for exercises with the patient lying on the face (Exercise VII) with a staff grasped in both hands, the arms being extended beside the head. (1) The trunk is raised from the table and the staff brought over behind the head obliquely, the hand on the side of the convexity of the curve being carried down toward the feet and the other carried up over the head until the staff is brought as nearly as possible into the long axis of the body and pressed against the back. (2) By a reversal of the movement the original position is resumed (Fig. 118).

The scapula on one side is raised, and the position of the staff tends to correct an existing curve in the dorsal region. The exercise amounts to a spinal hyper-extension in a corrected position of the dorsal spine. The exercise is suited to total curves, to simple dorsal curves, and to compound dorsal and lumbar curves.

XXIV. *Partial Suspension by One Arm with Other Arm and Leg Locked.*—Position: The patient standing by a ladder or under a bar that can be reached without rising on the toes, grasps one rung of the ladder or the bar with the hand of the side to which the spine is concave. On the opposite side, the convex, the arm passes under the knee, the thigh being flexed at the hip, and the shoulder and pelvis are thus approximated. (1) The patient thus standing on one leg flexes that knee and allows the body-weight to come upon the arm. (2) The original position is resumed (Fig. 119).

When the arm is placed under the knee the pelvis and shoulder are approximated on that side and the spine made convex to the other side as far as it will go. The structures on the concave side are thus put on the stretch and, by allowing the body-weight to come on the arm holding to the ladder, a further stretching force is exerted on the structures on the concave side. The exercise is suited to total and dorsal curves.

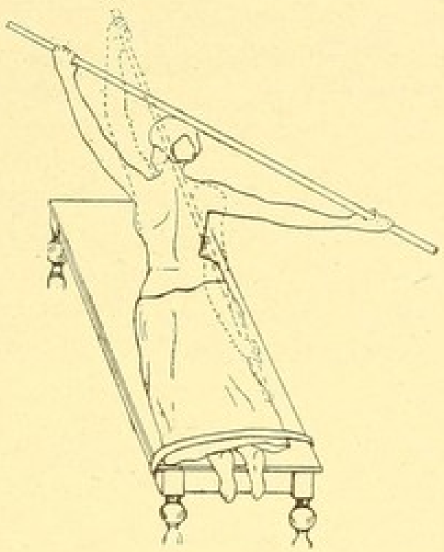

FIG. 118.

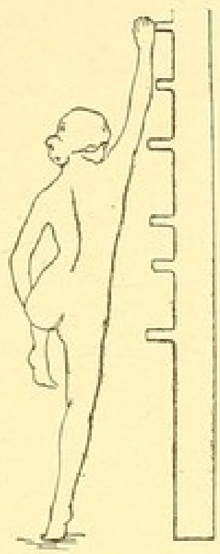

FIG. 119.

Creeping Exercises (Klapp).—In these exercises the patient supports the trunk in a horizontal position with the hands and knees or feet on the floor. The hands, knees, and toes should be protected by leather pads which are strapped on.

XXV. *Symmetrical Creeping.*—The hand and knee of the right side are placed close together with the hand to the outer side of the knee, the head is twisted with the face to the right, and the trunk is rotated with the left shoulder upward. The left arm is extended beyond the head and the hand placed on the floor, palm down and fingers forward, as far forward as possible and directly in front of the right knee. The left knee is placed as far back and as near the median line as possible; the spine is strongly bent to the right. The creeping consists of forward locomotion by a series of reversals and regainings of the position described. The mechanism of the first reversal is as follows: the left knee is drawn forward to the inner side of the left hand in its original place and position, the right arm is extended above the head, and the hand placed as far in front of the left knee as possible with the palm down and fingers front. At the same time the spine is rotated to bring the right shoulder high, the face is twisted to the left, and the spine flexed to the left. The restoration to the first position is secured by again moving the back knee (right) and the back hand (left) (Fig. 120).

This is a general muscle strengthening and spine-mobilizing exercise. It is comparatively mild and may be continued for long periods of from twenty to forty minutes. Symmetrical creeping is properly that which is done rapidly, and is of most value in restoration of flexibility.

A modification is made by creeping slowly, holding each position and putting force into the stretching, usually holding the position longest which stretches the concavity of the most marked curve (Fig. 121). Another modification is creeping in place, which differs from the above in that the patient does not attempt locomotion. The position is somewhat as above except that the fingers of both hands are placed on the floor pointing opposite to the side to which the face looks. The trunk is rotated till the side with the forward arm is uppermost, and the arm is

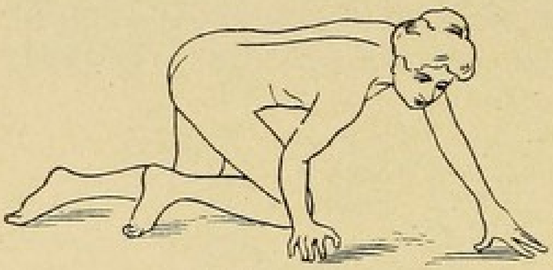

FIG. 120.

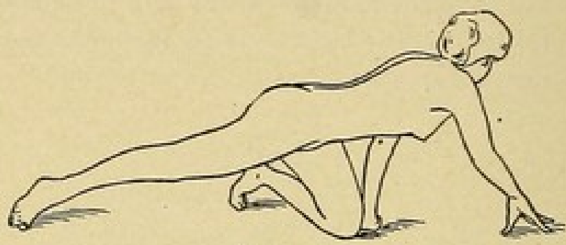

FIG. 121.

carried directly over the head, while the under arm is flexed at the elbow which points to the side toward which the face is turned; the posterior knee is straightened, and the foot only of that limb touches the floor. The patient then endeavors to look upward beneath the forward reaching arm (Fig. 122). This is best employed as an asymmetrical exercise to correct the dorsal convexity and stretch the side of the concavity.

XXVI. *Creeping Sidewise.*—There is a third asymmetrical variation in "creeping sidewise" toward the side showing the concavity of the curve to be corrected, for

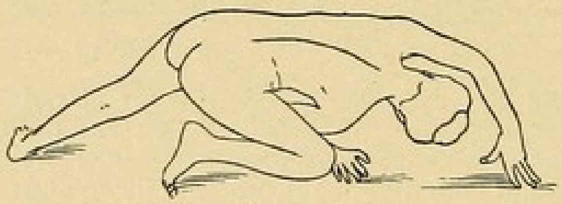

FIG. 122.

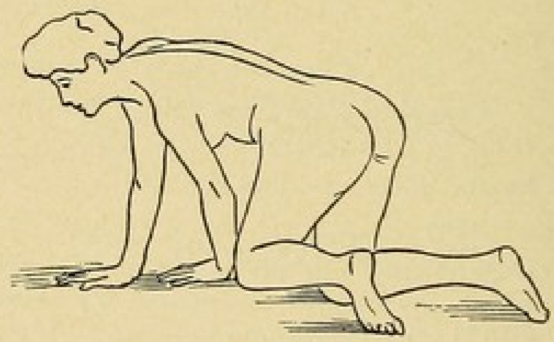

FIG. 123.

example, in a left total curve. The patient creeps sidewise to the right. The left hand and knee are placed under the trunk, and as far as possible to the right of the right hand and knee. The right hand and knee are then advanced to the right and the above is repeated. The face should look to the left (Fig. 123).

This is a corrective exercise similar to other forms of creeping, and may also be used for dorsal curves as well as for those of the total type.

XXVII. *Creeping with Arm Flinging Upward.*—Another kind of creeping in which the upper part of the spine is especially concerned is the creeping with arm flinging upward The starting position is the same as for ordinary creeping—

hands and knees on floor, hand and knee of one side touching, hand and knee of opposite side stretched far apart. The patient brings up the backward knee until it touches the forward hand, then raises the opposite hand from the floor, and with elbow straight swings the whole arm upward so that the impetus of the swing twists the dorsal spine and causes the whole trunk to turn. At the same time the patient turns her head and looks up at the hand that is raised. This stretched position is held for a second, then the arm is swung downward again and the hand placed as far forward on the floor as possible.

PASSIVE STRETCHING OF THE SPINE.

It is at times desirable to increase flexibility of the spine more rapidly than can be done by free standing gymnastics alone and stretching of the contracted structures is in all cases of structural scoliosis except the mildest more easily to be obtained by intermittent passive stretching in apparatus than by gymnastics alone. The following considerations bear on the use of stretching force as applied to the spine whether in intermittent stretching or in forcible correction.

The least economical use of force in straightening, for example, a bent stick is to pull the two ends away from each other, *i.e.*, to straighten it by a pull in its length. The most economical use of force is to take it by the two ends and press the point of greatest convexity against some resisting point which shall push it straight.

Again, if one wishes to secure the greatest side displacement in a flexible rod, such displacement is more easily secured when the rod is not stretched in its length. If a rubber tube, for example, is fastened to a table by two pins, one at each end and is not put on the stretch,the middle of it can easily be pulled an inch to one side by the forefinger. If, however, it is pinned to the table by two pins separated enough to hold it on the stretch, it will require much more force to displace it one inch to the side. The same is true of a strip of sponge rubber or a piece of rattan.

To be sure that this theoretical consideration applied to the human spine the following experiment was made at the Harvard Medical School by the courtesy of the late Prof. Thomas Dwight.

Head suspension is a passive stretching of the spine, corrective through its entire length, tending to improve both rotation, and side deviation at the curves, but exercising still more force upon the more nearly normal parts of the spine because the latter are more movable. Suspension by the arms is less efficient, and does not affect the cervical vertebræ as does head suspension.

A young male cadaver was laid on the face, and straps passed around the body at the level of the right shoulder and the right hip. These straps were then fastened to the left side of the table, holding the shoulder and hip against pressure from the left. A strap was then passed around the left side of the thorax and by means of a spring balance pulled to the right. The side deviation of the spine was then measured at four levels, the measurements being taken from a base-line connecting the cervical spine and the sacrum. The measurements were all made from pins driven into the spinous processes. Three experiments were made with a side pull of 25 pounds and the results were recorded.

A Sayre head-sling was then put around the head of the cadaver still lying on the face, and a traction force of 75 pounds was made in the length of the spine, the feet of the cadaver being fastened to the table. While the traction on the head was thus in force the same side pull of 25 pounds was made as before and the results noted. Two experiments of this sort were made. It was found that the spine without traction was displaced to the side nearly twice as far by a definite side pull as by the same amount of side pull when traction was being made.

A confirmatory experiment was made on a healthy boy of fifteen, using 75 pounds of head traction and 15 pounds of side pull. The result was the same.

The conclusion is that extension of the spine by an upward pull on the head is a corrective force in the normal spine, but that much more force is required to accomplish a certain amount of side correction than is the case if the force is applied from the side.

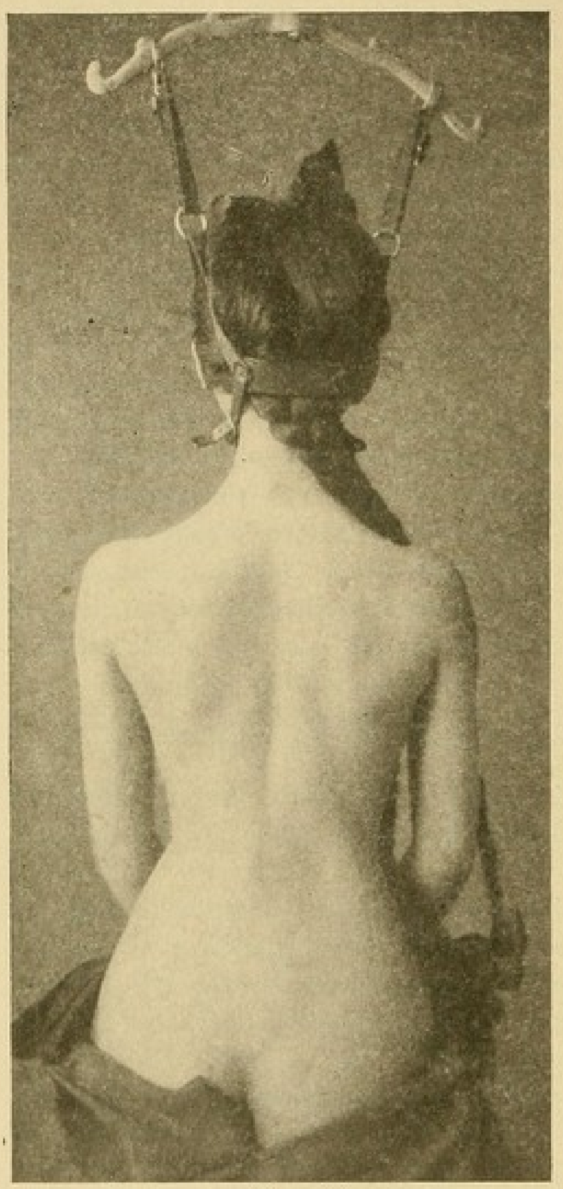

FIG. 124.—HEAD TRACTION.

The other conclusion is that to secure the maximum of side displacement from a given amount of side pressure the spine must be slack and not stretched in its length.

PASSIVE STRETCHING BY SUSPENSION.

The patient stands erect, and the head is pulled vertically upward by means of a Sayre head-sling, which embraces the chin and occiput. Traction should be made by a compound pulley, and the patient or the surgeon may hold the rope. Suspension is mildest—(1) when the feet are not made to leave the floor; next in grade comes (2) the position of tiptoe induced by the traction, and (3) a greater pull is secured by lifting the whole body until the feet swing free. In this case the traction force equals the body-weight. The maximum traction can be secured (4) by strapping the thighs down to a seat on which the patient sits. An upward pull greater than the body-weight can now be exerted on the head (Fig. 124).

Apparatus for the purpose has been devised, and is known as the Weigel-Hoffa frame, in which the patient is suspended by the head, while pads are run in from the sides of the frame, making lateral pressure in various directions.

Correction of the lateral curve of the spine is, however, to be obtained more economically by having the patient lie prone, and the corrective force should be divided into two elements, the force to correct the rotation and the force to correct the side deviation. A simple apparatus for this is as follows (Fig. 125):

The patient lies face downward, with the knees flexed, on a board three feet wide by four feet long. Assuming the case to be of a right dorsal curve, a broad canvas strap is passed around the left thorax, over and under the patient, and

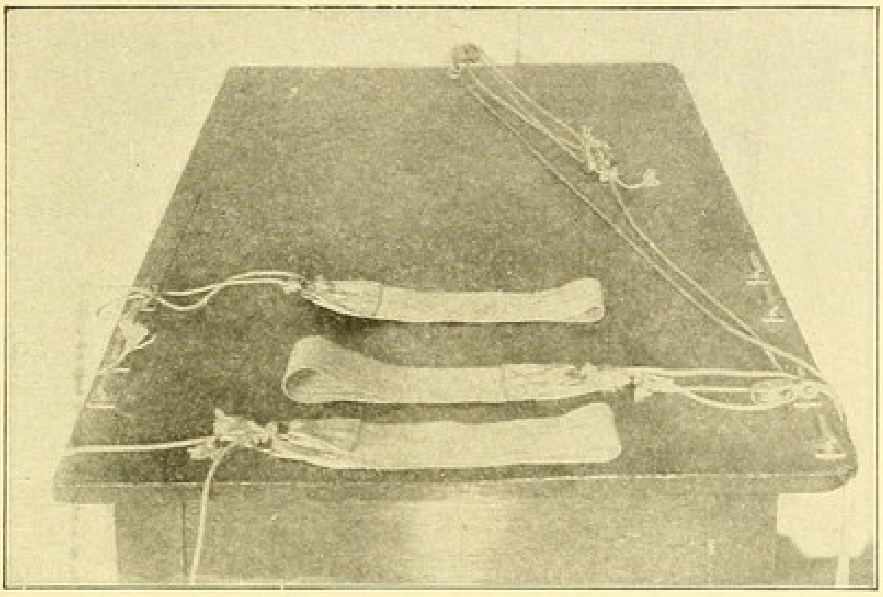

FIG. 125.—STRETCHING BOARD WITH LOOPS, READY FOR APPLICATION.—("*Jour. Am. Med. Assn.*")

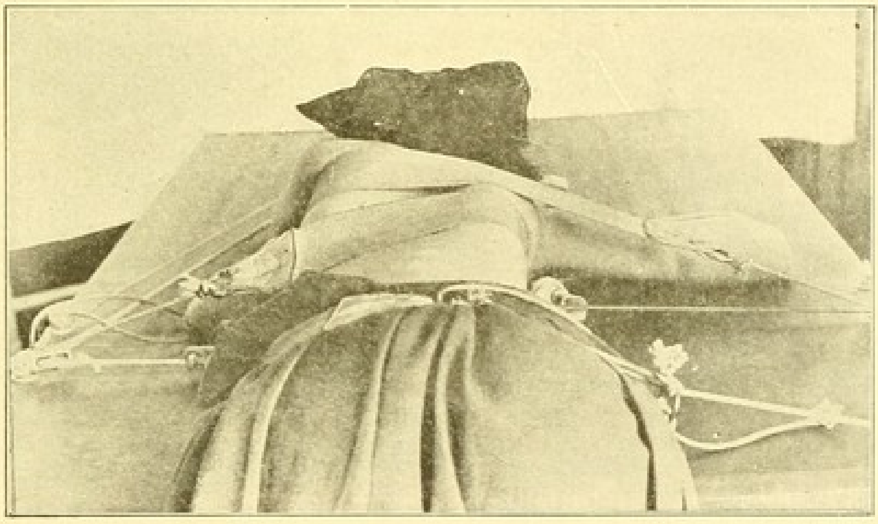

FIG. 126.—STRETCHING BOARD WITH LOOPS APPLIED TO A PATIENT. Reverse side of Fig. 125.—("*Jour. Am. Med. Assn.*")

fastened to a cleat on the right side of the board. This furnishes a point of pressure to the left against the upper thorax at the level of the axilla. A broad canvas strap is then passed around the pelvis of the patient above and below, and is fastened to a cleat at the right side of the board. This furnishes a point of pressure to the left at the level of the pelvis. A broad canvas strap is then passed around the thorax at the level of the greatest point of curve; it passes above and below the thorax and its upper end is fastened to a cleat at the left side of the board (Fig. 126). Its lower end is fastened by means of a string into a compound pulley attached to a cleat at the left side of the board. By means of this pulley any reasonable degree of force may be exerted against the right side of the thorax, pulling it to the left, and at the same time that it pulls, it tends to reduce the rotation from the fact that its upper end is fastened and its lower end moving toward the pulley.

CONTINUOUS STRETCHING BY MEANS OF PLASTER-OF-PARIS JACKETS (FORCIBLE CORRECTION).

In marked moderate and in severe structural lateral curvature no means of treatment is in the opinion of the writer so efficient as continuous stretching by means of plaster jackets applied under force. This method is spoken of as "forcible correction." Such jackets are applied with the purpose of stretching the contracted structures and of inducing an improvement in the curve.

The treatment of severe scoliosis by plaster jackets applied in a corrected position is not new. But the force has generally been applied to the spine during suspension. Bradford and Brackett[1] described a frame in which the jacket was applied as the patient lay prone, but even here head traction was used. Nebel,[2] Calot,[3] Redard,[4] and others have used the horizontal position.

The whole question was given a new impetus by Calot's work on the forcible correction of the deformity in Pott's disease published in 1896.[5] The later tendency has been toward the use of greater force than was previously employed.

The most noteworthy advance in the forcible corrective treatment of scoliosis was made by Wullstein, who applied the above-mentioned principles with force and precision and who published photographs showing marked improvement in patients (Fig. 127).

Application of Corrective Jackets in Suspension.—The original plaster jackets of Wullstein were applied in suspension with the patient seated on a revolving stool to which the thighs were strapped. This stool could be tilted to produce obliquity of the pelvis. Traction on the head up to 250 pounds was used and this traction was so great that a chain had to replace the usual rope between the pulley and headpiece; after extension had thus been used, side pressure was obtained by rods run in from the sides of the frame and here again

[1] "Bos. Med. and Surg. Jour.," May 11, 1893; Oct. 10, 1903.
[2] Nebel: "Zeitsch. f. orth. Chir.," iv.
[3] Calot: XII Internat. med. Kongress zu Moskau, 1897.
[4] Redard: "Trans. Amer. Orth. Assn.," xi, 447.
[5] Calot: "France Méd.," 1896, 52; Schanz: "Berl. klin. Wochens.," 1902, 48.

great force had to be used to overcome the stiffening of the spine caused by the traction. The method, admirable as it is, requires an unnecessary expenditure of force which must be carried to a degree distressing and alarming to the patient.

The method of Schanz is simpler and in connection with the after-

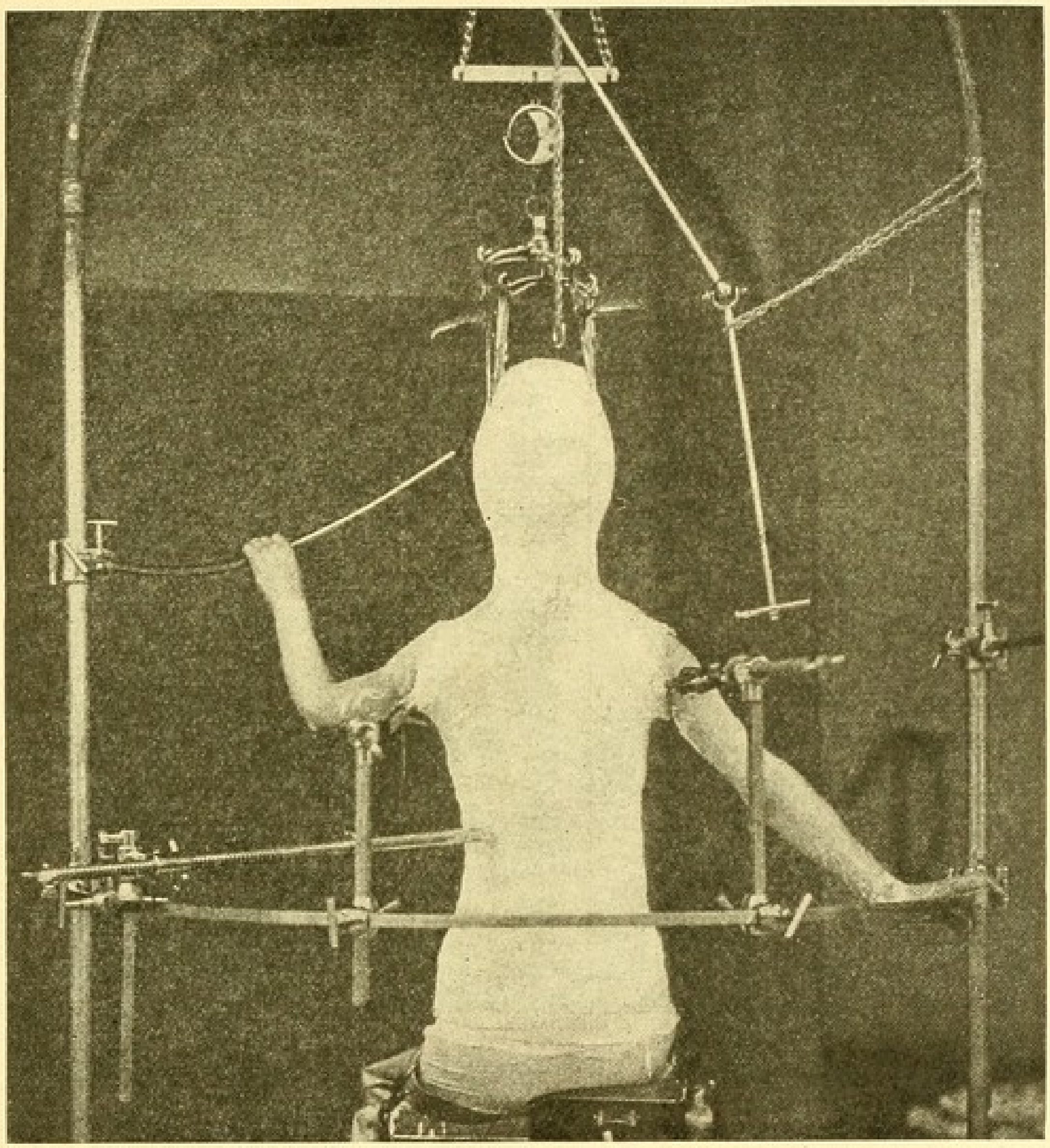

FIG. 127.—PATIENT WITH PLASTER JACKET APPLIED IN WULLSTEIN'S APPARATUS.—(*Wullstein.*)

treatment highly efficient if one may judge by the admirable results obtained, but at the same time an amount of traction is used which is objectionable if the same results can be obtained by other means. The patient stands and the ankles are fastened by anklets to rings bolted to the floor. By means of a Sayre head sling extension is produced by means of a windlass to the point of the patient's tolerance. A plaster jacket including the shoulders is then applied and as it is hardening the surgeon passes his arms around the pelvis of the patient and with his shoulder protected by a pad, presses against the rotated and curved portion of the spine. The after-treatment followed by Schanz consists in prolonging recumbency in a corrected posterior plaster-of-Paris shell with head traction. The patient is turned once a day onto the face to have the back massaged, but no exercises are

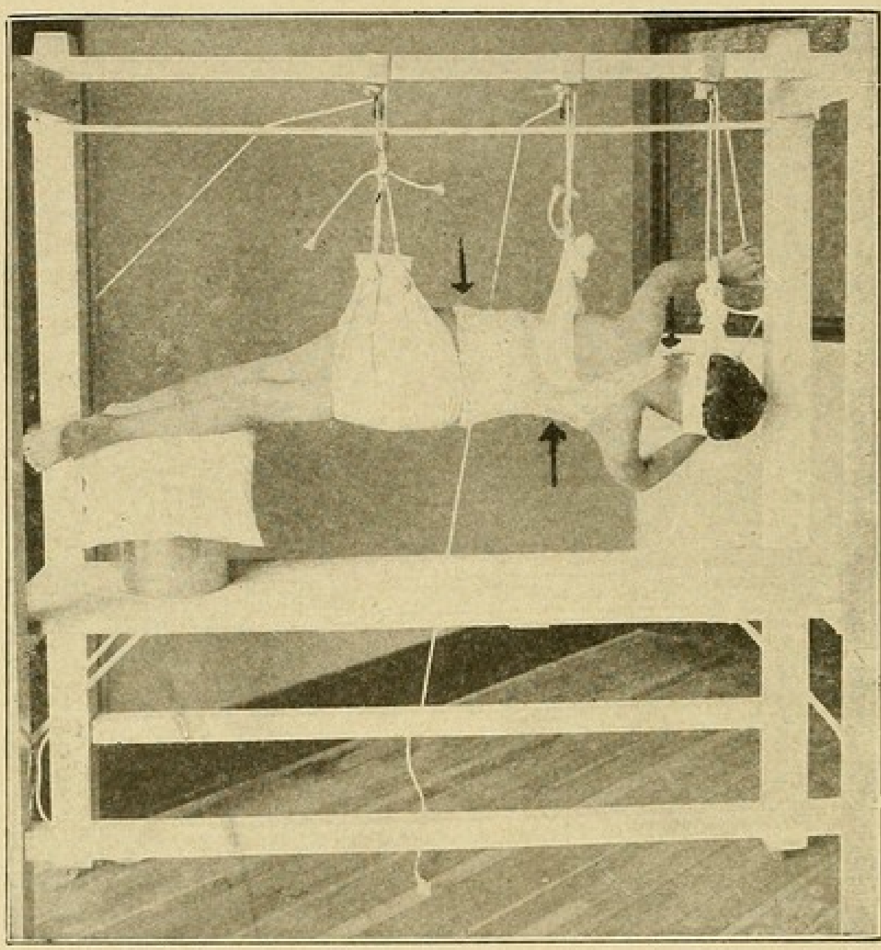

FIG. 128.—APPLIANCE FOR LATERAL SUSPENSION AND THE APPLICATION OF RETENTIVE CASTS.—(*Rich*, "*Jour. Amer. Med. Assoc.*," Dec., 1911.)

given at this period. After months of recumbency a corset and head-piece are applied and the patient allowed gradually to sit up. At a later period exercises are begun.

Application of Corrective Jackets on the Back or Side.—The application of plaster jackets while the patient lies on the back on a slack hammock inducing a flexed position of the spine has been advocated by Abbott[1] as more corrective than other positions. Rich[2] has

[1] N. Y. Med. Journ. June 24, 1911.
[2] Journ., Am. Med. Assoc. Dec. 30, 1911, p. 2120.

devised a method of suspension on the side the weight of the patient coming on the rotated and curved portion of the spine.

Application of Corrective Jackets in the Prone Position.— When corrective jackets are applied to the patients prone, it is desirable to flex the legs, as this diminishes the physiological curves of the spine and simplifies the problem. With a patient thus lying prone, the spine is open to inspection and relaxed. In this improved position the jacket is applied.

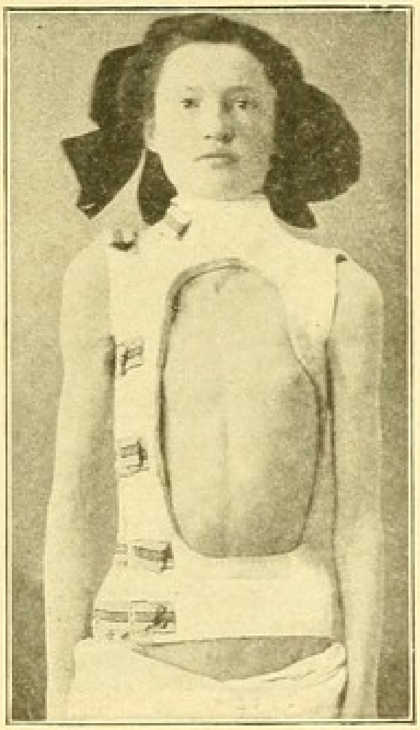

FIG. 129.—ANTERIOR VIEW OF PATIENT SHOWING FREEDOM OF CHEST OVER AREAS OF CONCAVITY.—(*Rich*, "*Jour. Amer. Med. Assoc.*," Dec., 1911.)

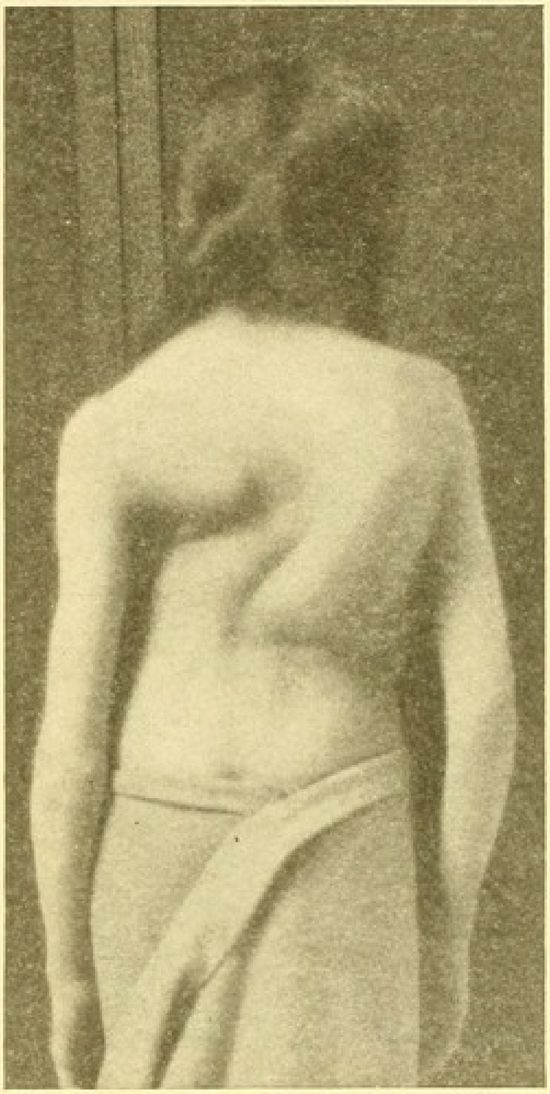

FIG. 130.—PATIENT THIRTEEN YEARS OLD. CURVATURE DUE TO RICKETS; NEVER TREATED.

A simple application of this method is to be found by having the patient lie prone in a rectangular gas-pipe frame on two straps of webbing running from end to end, cross straps supporting the pelvis and shoulders. By means of webbing straps attached to the side of the frame, in a right dorsal curve, one going around the left side of the pelvis and another around the left upper thorax, while a third pulls on the right side of the thorax against these as points of resistance, great force may be exerted on the spine, much more force than can be safely used. With the patient lying prone on the webbing strips which are padded, the pelvic and axillary straps are adjusted to the proper tension and tied around the side of the frame. A heavy pad of felt is then applied over the rotated and curved portion and a webbing strap attached to the side of the frame and tied at one end. This strap is then passed over the rotation, under the patient and back to the frame. By pulling on this end of the strap (the upper end of which has already been tied) the curved portion of the spine is pulled to the side and the rotation acted on by the twisting action of the strap. When sufficient tension has been obtained the end of the strap is fastened to the frame. The jacket is then applied with the side webbing straps in place, the bandages being worked around the straps. When the plaster is sufficiently hard these side straps are cut off where they emerge from the jacket and a finishing bandage applied. The patient then stands up; the

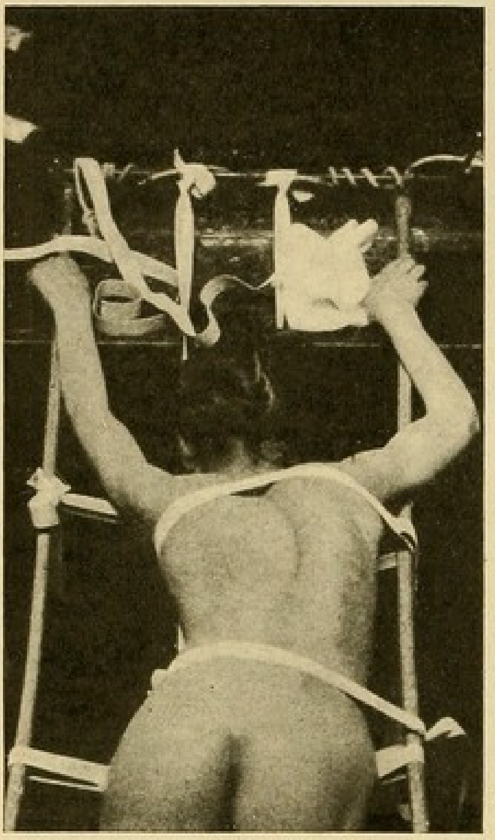

Fig. 131.—Patient Lying in Corrective Frame, Showing the Improvement Gained by the Horizontal Position. Photographed from above. Patient same as in Fig. 130.

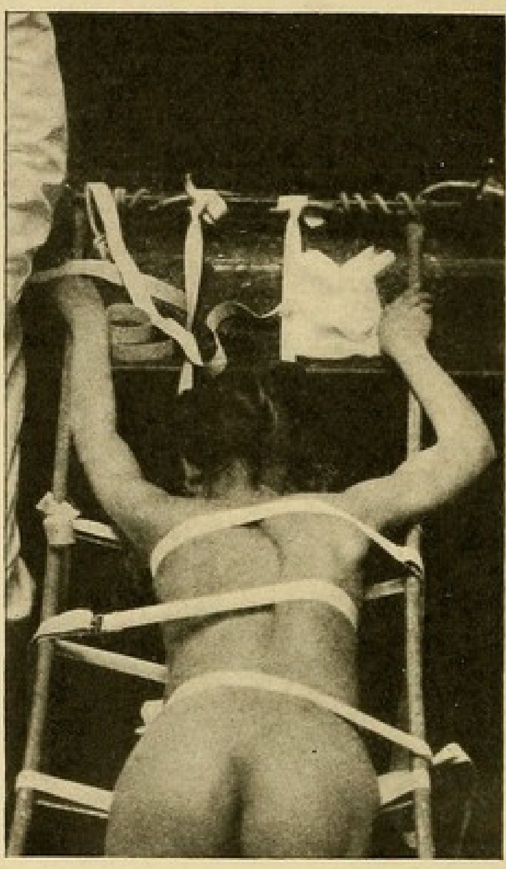

Fig. 132.—Patient in Corrective Frame with Side Pressure Applied by Strap. Showing additional correction to that in Fig. 131.

longitudinal straps are pulled out, the jacket is cut out under the arms and by plaster bandages the jacket should be extended to include the shoulders, which is always desirable, but not always tolerated.

Choice of Method.—The position which permits of the greatest side displacement of the scoliotic spine is obviously the best position for the application of a corrective jacket because the aim of the corrective jacket is to hold the spine in the best obtainable position. The spine is most easily corrected if the patient lies horizontal without head extension. This can be easily demonstrated on any scoliotic patient. The mere fact of lying prone diminishes the deformity as is shown in Figs. 131, 132. But when it comes to the application of corrective force it must be remembered that there are two elements in the deformity, namely, side deviation and rotation. A single correcting force would therefore have to be oblique, *e.g.*, in a right dorsal curve forward and to the left. But for practical purposes it is desirable to use two forces, one forward and one laterally toward the spine, thus dealing separately with the two elements of the deformity. To attempt to correct the side curve by lateral pressure without attacking the rotation is likely to result in increase of the rotation by pressure on the already flattened shafts of the ribs.

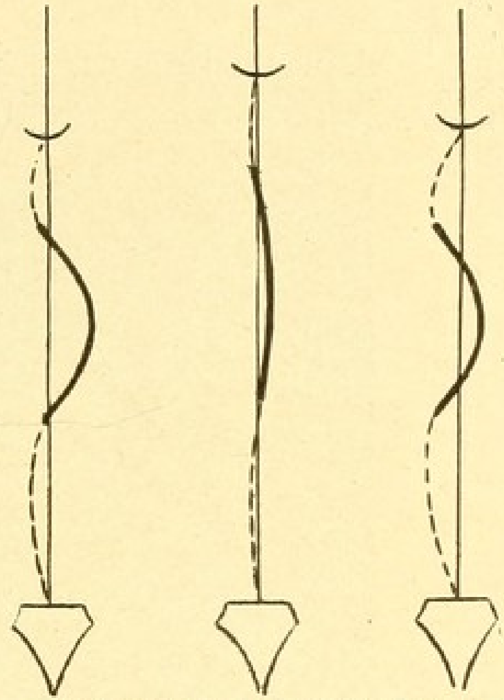

FIG. 133.—ON THE LEFT IS A DIAGRAM SHOWING A RIGHT DORSAL LEFT LUMBAR CURVE.
In the middle diagram the curve is shown straightened; on the right the curve has been pushed over to the left unchanged.

That this is not new may be appreciated by a quotation from Schreger[1] in 1810: "*Der seitliche Druck auf die Rippen biege diese an den ohnehin schon mehr spitzen Winkeln noch mehr spitzig zu.*" That plaster jackets may cause increase of the rib angles is demonstrated by Hüssey.[2] The same point, that plaster jackets may increase the bony rotation apparent in the back, has been alluded to by Schulthess and Vulpius.[3]

It may, therefore, be stated that attempts to diminish the lateral curve, by pure lateral pressure, not carefully antagonized, will result, in fixed curves, in an increase of the rotation.

The solution lies in dealing separately with the rotation and with the lateral deviation. Having corrected the lateral deviation first, this correction is held, as will be described, while the rotation is corrected or *vice versa*. In this way one element is not improved at the expense of the other.

Technic of Application.—The patient should preferably be stretched once or twice daily for two or three days preliminary to the correction, but this is not

[1] Fischer, quoted by Hüssey.
[2] Hüssey: "Zeitsch. f. orth. Chir.," viii, 2, 235.
[3] Vulpius: "Volkmann's Samml. klin. Vort.," 276.

essential. Anesthesia is never necessary, as all endurable correction may be obtained without much pain. A seamless undervest is put on and the iliac crests padded with heavy felt; a pad should also be placed over the sacrum. Under the side straps heavy felt or cotton pads are required.

The correction is pushed to the point of causing mild discomfort, and difficulty in breathing is a sign of too much correction. The amount to be obtained in any case is better decided by the patient's sensations than by any theoretical standard. The danger lies on the side of obtaining too much rather than too little correction, for the jacket will be much more uncomfortable when the erect position is assumed.

After correction the patient should remain in a hospital under close observation for at least twenty-four hours. Some shock is not infrequently experienced and in a case of the writer's very serious collapse and cyanosis followed the correction of a severe curve due to infantile paralysis in a child of six. Wullstein has recorded the occurrence of somewhat serious symptoms following correction.

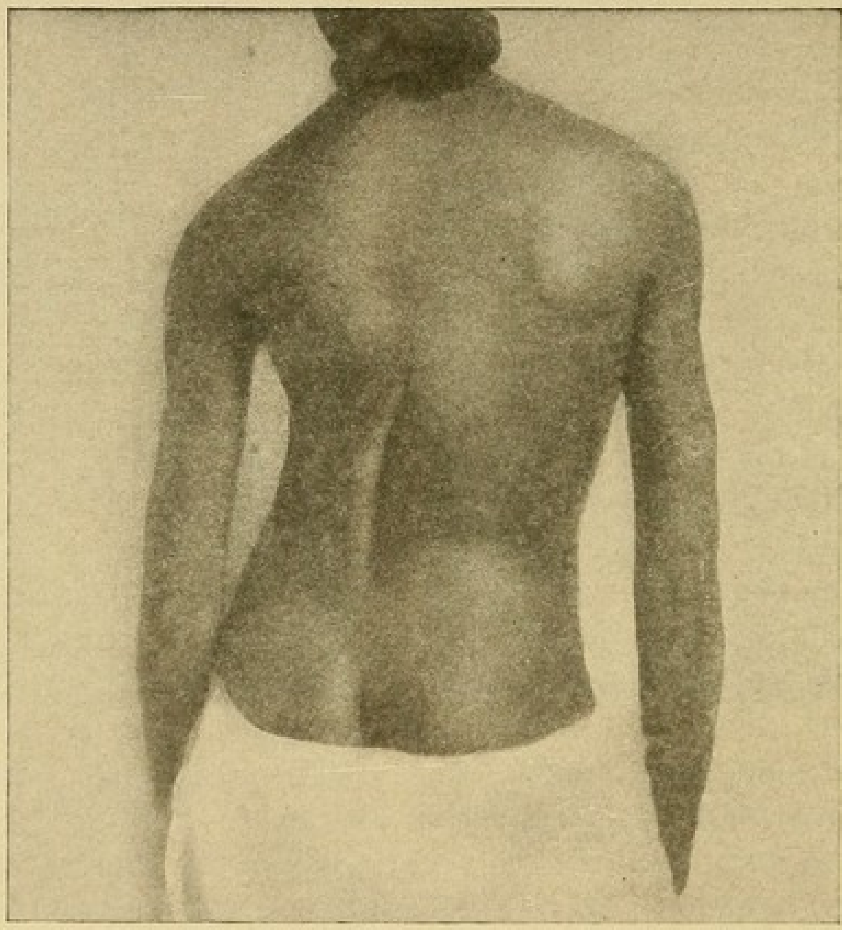

Fig. 134.—Patient of Whom Radiograms were taken before Treatment. (January, 1906).—("*Am. Jour. Med. Assn.*")

Treatment Subsequent to Application of Jacket.—Starting from the application of the corrective jacket two methods of treatment are available; (1) the original jacket may be left on or (2) after one or more corrective jackets have been applied a removable jacket or corset or brace may be used.

(1) *Permanent Corrective Jackets.*—When the jacket is hardened, it is left solid over the parts that are made prominent by the rotation behind and in front, that is, in a right dorsal curve the right back and left front are not touched, but large windows are cut over the depressed side of the chest behind and the corresponding portion diagonally opposite in front, so that in a right dorsal curve the left side would be cut out behind and the right side in front. This makes it possible for the depressed parts of the chest to be expanded by

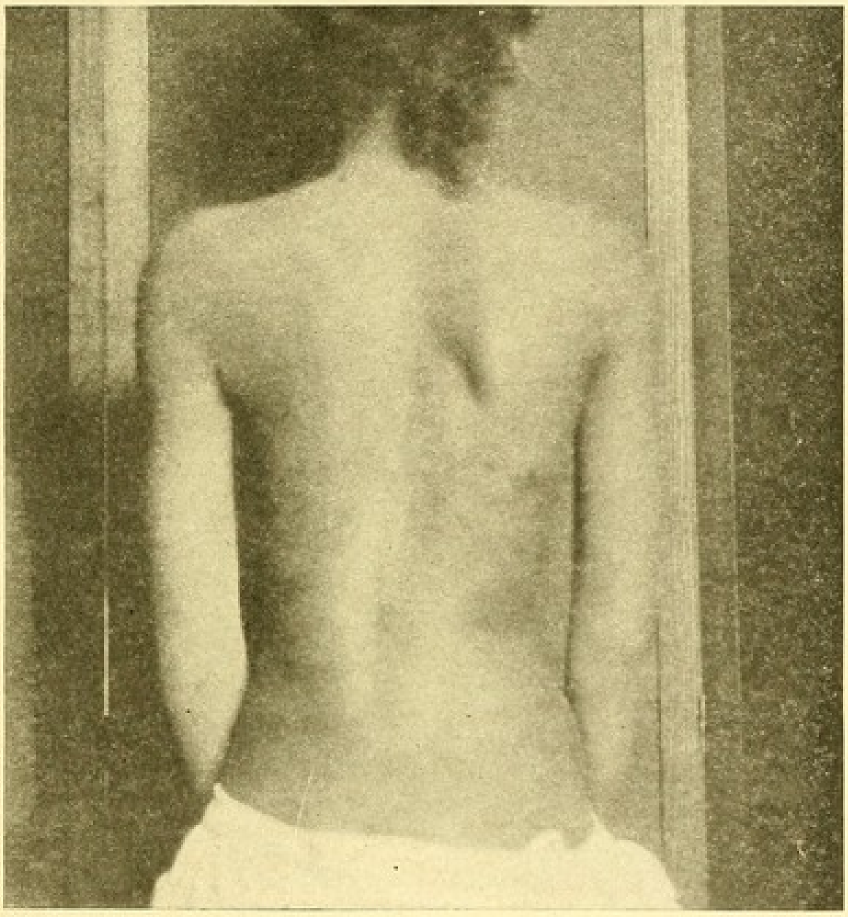

FIG. 135.—PATIENT SHOWN IN FIG. 134 AFTER WEARING CORRECTIVE JACKET FOR OVER A YEAR. (MARCH, 1907.)

respiration, while the prominent parts are compressed. Pads of felt are now inserted between the prominent part of the chest behind and the jacket, and sometimes in the corresponding region in the front, thus making the jacket more corrective, and thicker pads are substituted each week without changing the jacket, these being drawn through without difficulty by means of a bandage. In this way, a continual diagonal side-pressure is kept up on the curved portion of the spine and is steadily increased. At the end of two or three months, it will be found that it is advisable to apply a new jacket, to cut it out in the same way and to begin on the progressive padding. The use of such a permanent jacket is continued for a period of from one to two years, being changed at long intervals, and at the end of this time a removable jacket is substituted for the permanent one and gymnastic treatment is begun. The removable jacket is then gradually discontinued while the patient's muscular condition is being improved by gymnastic exercises.

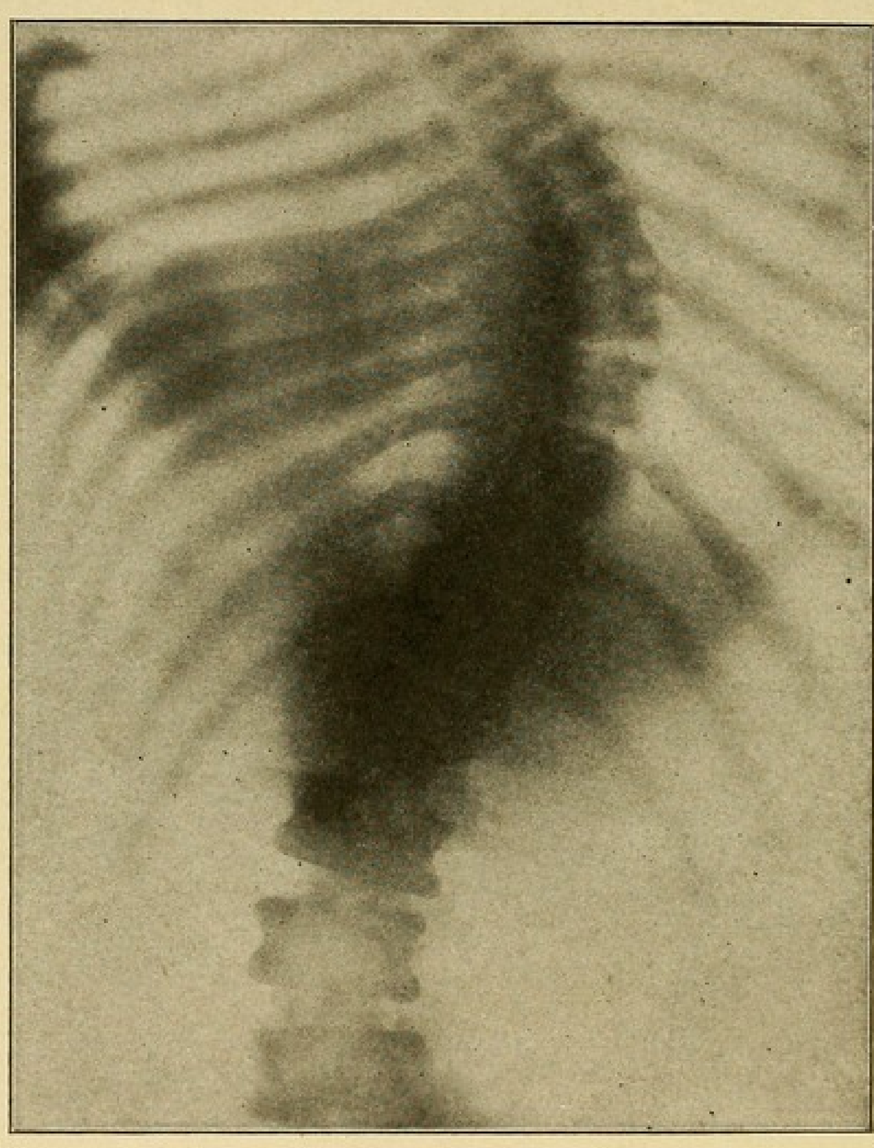

FIG. 136.—RADIOGRAM OF A PATIENT SEVENTEEN YEARS OLD (FIG. 134) LYING ON THE BACK, BEFORE THE APPLICATION OF JACKET. (JANUARY, 1906.)—("*Jour. Am. Med. Assn.*"

Removable Jackets.—As in the former method, the second treatment, that by removable jackets, is best started by the application of a forcible jacket either in recumbency or suspension. This may be followed by a second jacket at an interval of a week if it seems advisable. For the construction of the removable jacket, the patient is suspended and a plaster jacket is applied which is immediately cut off to serve as a mold, and a forcible jacket is best applied to be worn while the removable apparatus is being made. The jacket which is to serve as a mold is then bound together and filled with plaster of Paris and water, a torso thus being obtained. This torso is then remodeled by cutting off on the prominent side and building up on the other side, until it has become decidedly more symmetrical than

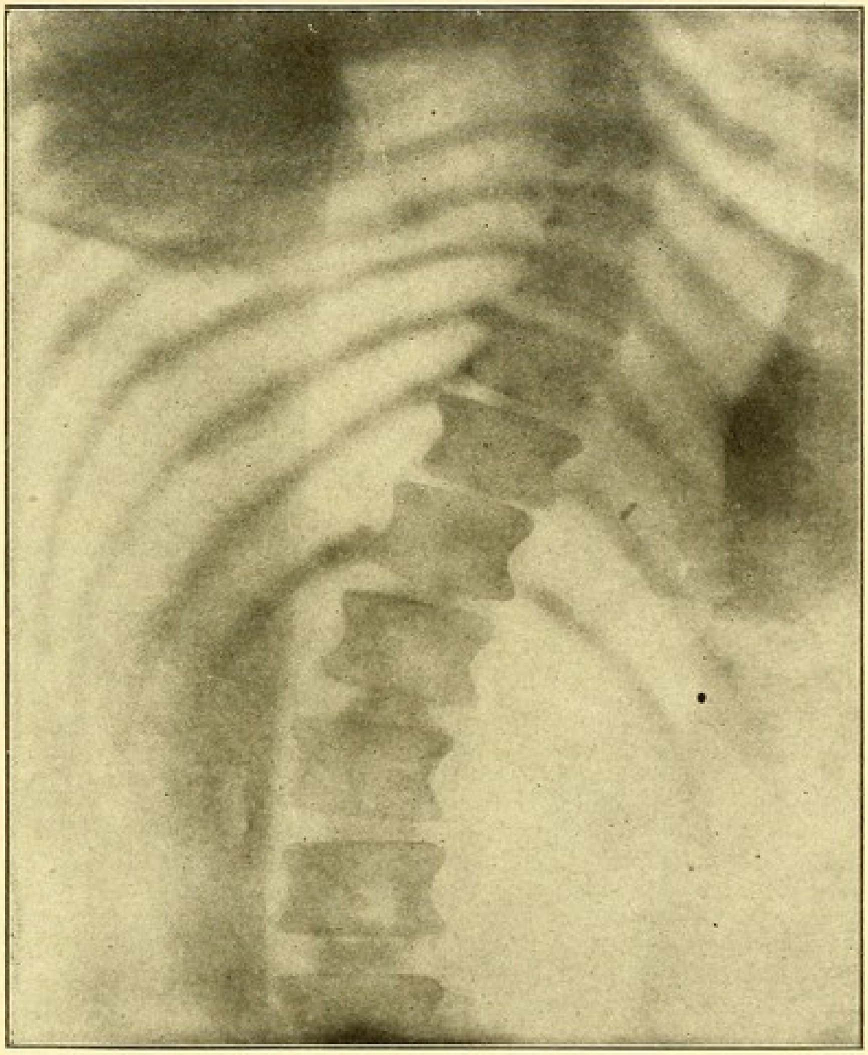

Fig. 137.—Radiogram of Same Patient as shown in Fig. 134, Taken after the Application of a Plaster Jacket through Windows Cut in Front and Back of Jacket. (January, 1906.)—("*Jour. Am. Med. Assn.*")

the patient. It is also sawed in halves at the waist and set apart about an inch in order to secure continued extension.

On this corrected torso a plaster jacket is applied which is to be the removable jacket worn by the patient. This removable jacket should be supplied with shoulder pads, to hold the shoulders in position, and should open down the front, being supplied with buckles and traps or lacings. It may also be advisable to slash such jackets over the iliac crests. The addition of 5 per cent. Portland cement to the plaster with which the jacket is made gives greater strength and durability. This jacket is to be worn by the patient night and day and to be removed only for the exercise period, which should consist of one hour or more daily, the exercises being of the type mentioned above. When the jacket is applied, it is sprung open and slipped on the patient, who then lies on the back, and the arms and legs are pulled on to extend the

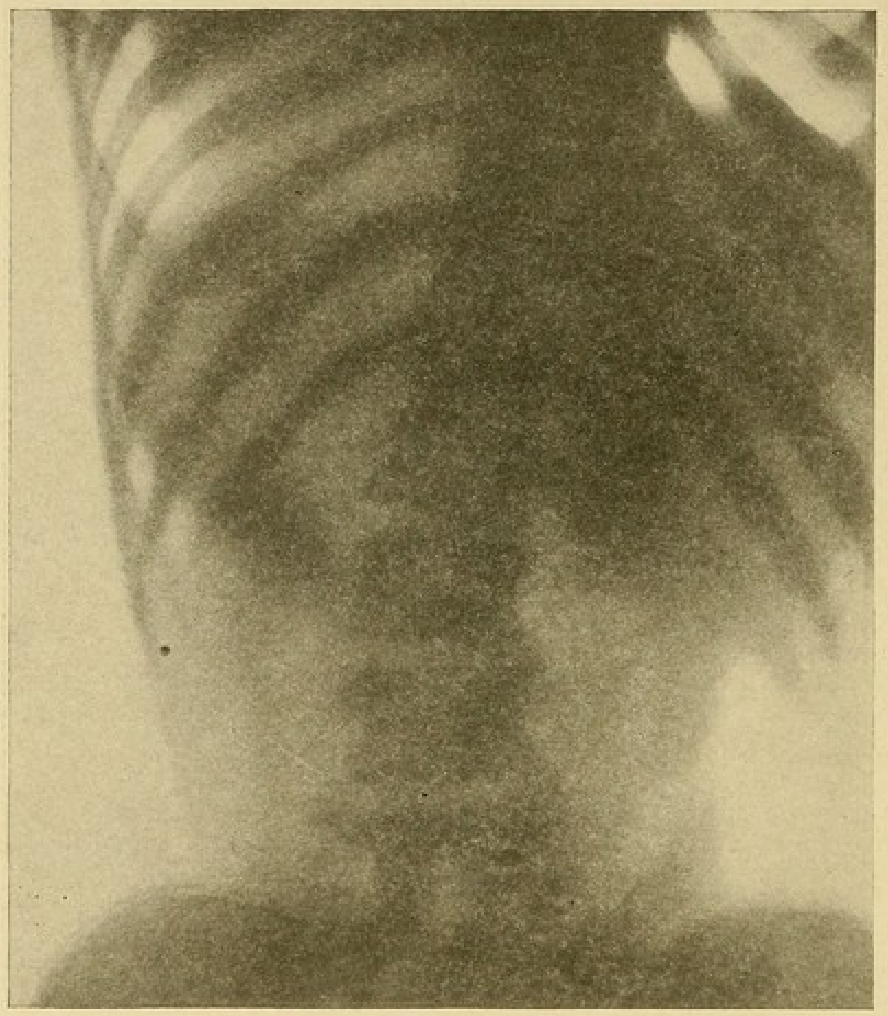

FIG. 138.—RADIOGRAM OF PATIENT SHOWN IM FIG. 134 AFTER WEARING CORRECTIVE JACKET FOR OVER ONE YEAR. (MARCH, 1907.)

spine. It is then buckled tightly in place before the patient stands up.

Jackets of either kind should be tested for efficiency by measuring the height of the patient with and without the jacket. Without the jacket the patient places the hands on the hips and pushes up, making himself as tall as possible, and his height is taken in this position. The jacket is then applied and the patient's height is again taken. If the jacket does not hold him, in as good a position, as estimated by height, as the patient can possibly assume with the hands on the hips, it is discarded and a more corrective one is made. In these jackets it is often advisable to cut the windows as in the permanent form, and to use padding in addition to the correction of the torso.

If such a jacket is worn by a patient who is making good progress, in a few weeks from the beginning of treatment it will be found to be inefficient and not to be holding him on account of his improvement.

FIG. 139.—PERMANENT CORRECTIVE JACKET APPLIED.

Under these conditions the torso must be again remodeled, more cut away from the prominent side and greater pressure exerted. In the course of a year, probably two or three such remodelings would be required. These jackets may be made of leather or celluloid if preferred rather than plaster, but the plaster is perfectly efficient, although heavier.

Objections to the Use of Corrective Jackets.—Corrective jackets are most effective in low dorsal curves, and unless they embrace the head are of little or no use in cervical and cervico-dorsal curves. In pure lumbar curves they are of little value as effective side pressure cannot be obtained on the soft parts lying at the sides of the spine in that region. It is a self evident requisite that to straighten a curve by side pressure one must have counter points at or near the ends of the curve and many dorsal curves are so high that effective counter pressure cannot be obtained at their upper end by pressure against the thorax. In such cases one can hold the pelvis and secure side pressure

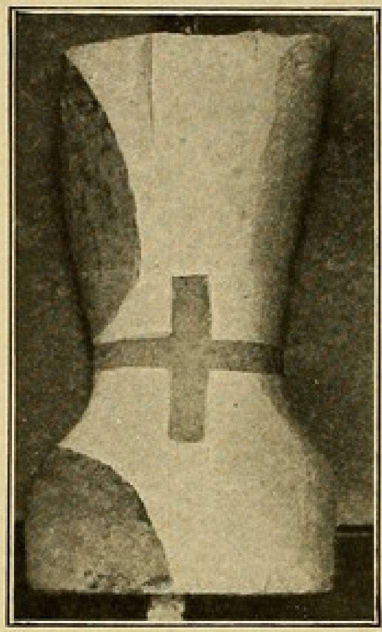

FIG. 140.

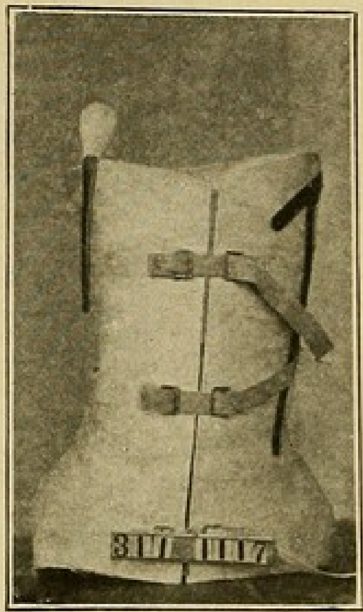

FIG. 141.

FIG. 140.—REMODELED TORSO READY FOR APPLICATION OF JACKET.

In a case of right dorsal left lumbar scoliosis which has been cut in two at the waist and set apart 1 inch, so as to increase the upward pressure on the ribs. The dark areas on left of the torso show where plaster has been added on the concave side to allow for correction of displacement and deviation.—("*J. Am. Med. Assoc.*")

FIG. 141.—FRONT OF JACKET, MADE OVER TORSO SHOWN IN FIG. 140. NOTE SHOULDER PAD.—("*J. Am. Med. Assoc.*")

against the lateral curve but cannot secure counter pressure above it. In this fact consists the chief objection to plaster corrective jackets. Attempts have been made to secure counter pressure above, against the root of the neck but it is obvious that the underlying structures will not tolerate great pressure in this region and the incorporation of the head in plaster and the use of head supports to stretch the upper curve and thus to secure some degree of counter pressure is greatly objected to by most patients.

The fact must however, be recognized that where counter pressure above the curved portion cannot be obtained against the side of the thorax, the jacket should include the head or a head piece used to secure the highest degree of efficiency.

The muscular atrophy induced by the wearing of permanent jackets is marked and on the removal of such jackets the back muscles are found distinctly weak and wasted but this condition is soon

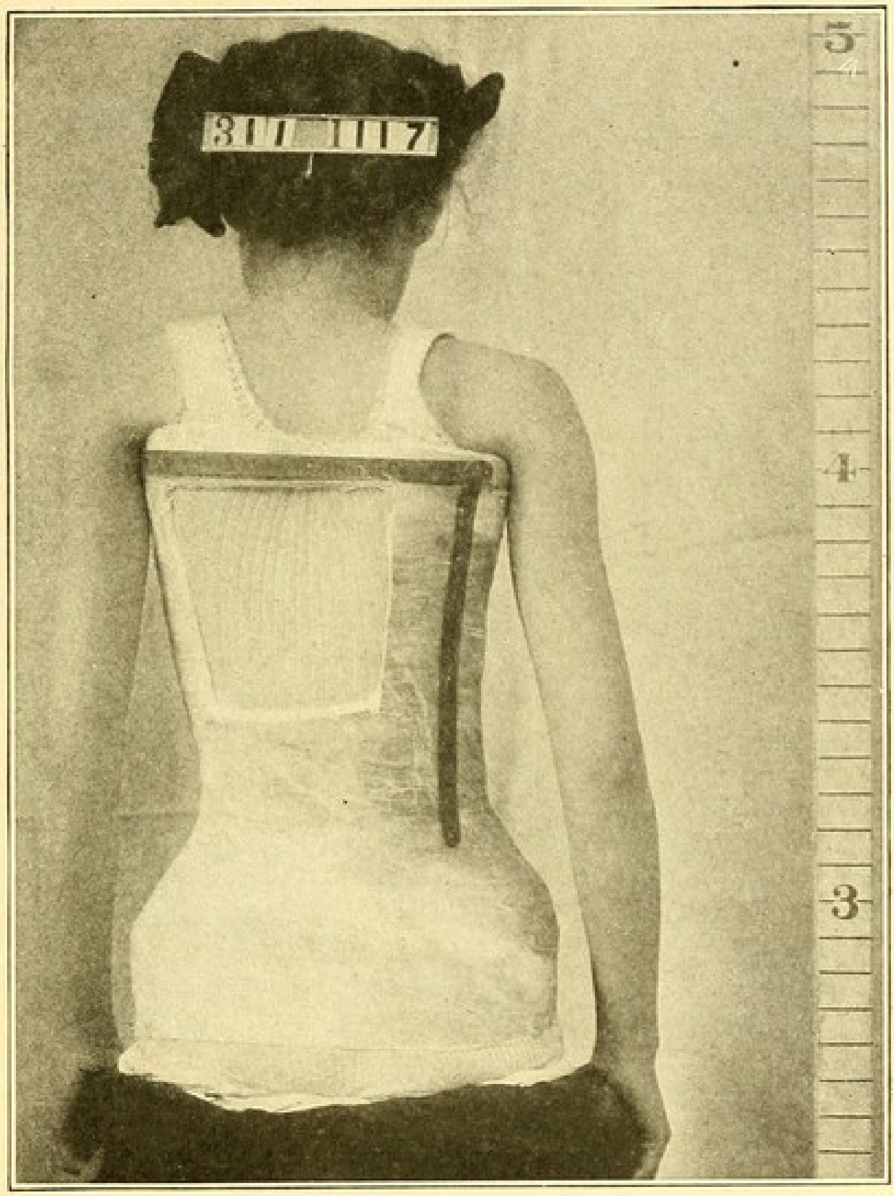

Fig. 142.—Patient in Jacket Shown in Fig. 141. Note Window on Concave Side. Jacket Reinforced by Steel Strips.—("*J. Am. Med. Assn.*")

recovered from under massage and judicious exercise and leaves no permanent bad effects.

Curves due to congenital defects infantile paralysis, rickets, and empyema are available for forcible correction.

Permanence of Results.—Successful permanent results can be obtained in hospital practice only in selected cases, the average patient being unable to appreciate the importance of following out the treatment sufficiently long. The criticism that such correction is not likely to be permanent at once presents itself. The grounds that lead one to suppose that retention of the growing spine in a corrected position over a sufficient period will lead to a change in the shape of the bones of the vertebral column and to a permanently improved position are as follows:

(1) Club-foot may be cured by a similar proceeding.

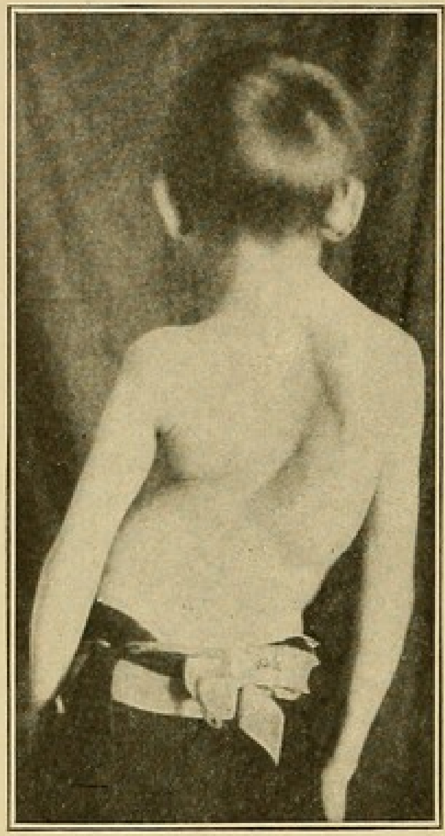

FIG. 143.—BOY AGED 12, BEFORE TREATMENT.—("*J. Am. Med. Assoc.*")

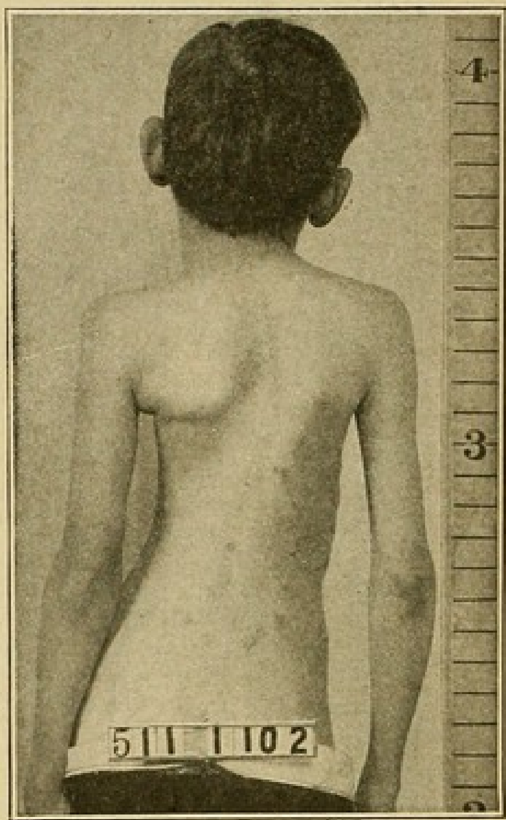

FIG. 144.—BOY AGED 14, AFTER TWO YEARS' TREATMENT BY MEANS OF PERMANENT JACKETS (SEE FIG. 143).

(2) The bones of the feet of Chinese women of rank are seriously misshapen by retention in an unnatural position.[1]

(3) Wullstein produced bony changes in dogs by a few months of abnormal position.

(4) Arbuthnot Lane[2] has demonstrated that the carrying of heavy loads by laborers will produce changes in the bony skeleton and that the changes vary according to the habitual position of the load, the bones subject to the greatest pressure undergoing changes in shape.

(5) The fact that bone under pressure changes shape after growth

[1] P. Brown: "Jour. Med. Research," Dec., 1903.
[2] Guy's Hosp. Rep., xxviii.

has been reached is shown in the fact that scar tissue pressing on bone will cause a change in shape,[1] *e.g.*, on the chin.

(6) Pressure of tumors or aneurysm will cause absorption of bone.

These facts all point to the conclusion that bone alters its shape under changed conditions of pressure, and that although this would be more marked during growth, the phenomenon is not unknown in adult life.

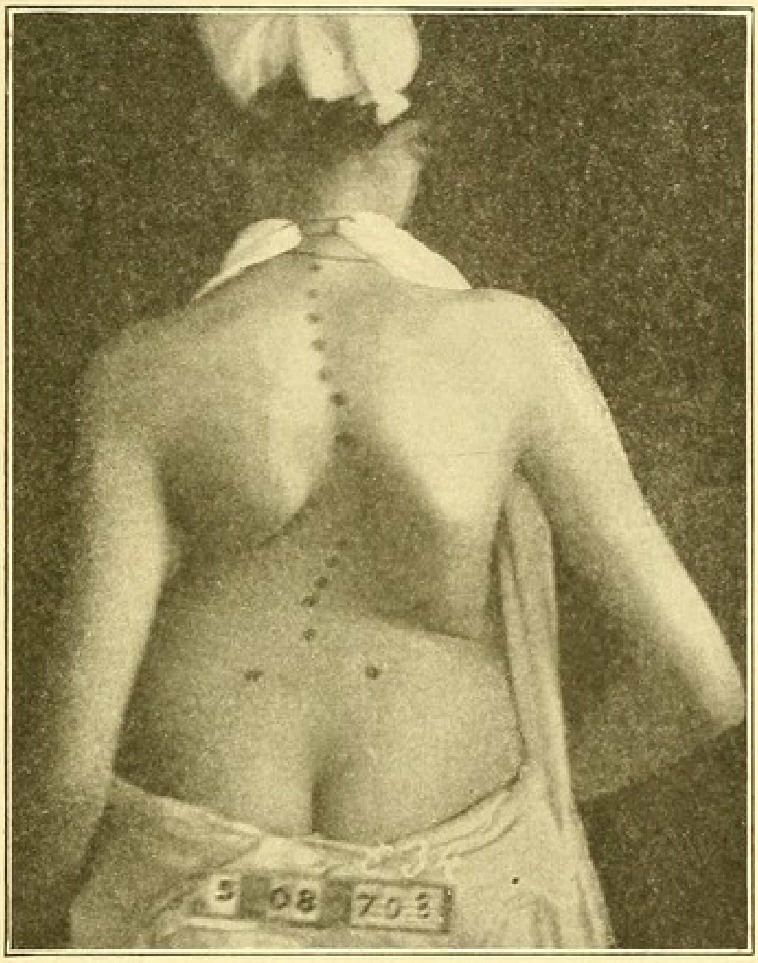

FIG. 145.—GIRL AGED 16, BEFORE TREATMENT.—("*J. Am. Med. Assn.*")

That a practical gain in the curved part of the spine may be secured by this method is demonstrated by the x-rays shown in the illustrations. The patient was a girl of seventeen, with a severe right dorsal curve, which was extremely rigid and had never been treated. The first x-ray was taken with the patient lying on the back. A corrective jacket was applied, the front and back of the jacket were cut away to permit another x-ray, and the improvement in position is evident.

It seems reasonable to hope that the maintenance of such an im-

[1] Ziegler: Pathology, English ed., 1896, ii, 146.

proved position may be expected in time to produce a change in the shape of the vertebræ. It is obvious that such a corrected position must be maintained over a period of many months to secure permanent results. Schanz[1] has provided clinical evidence that his results have been permanent in the time during which they were observed.

The choice between these methods must be determined by the circumstances of the patient, the temperament of the child, and simi-

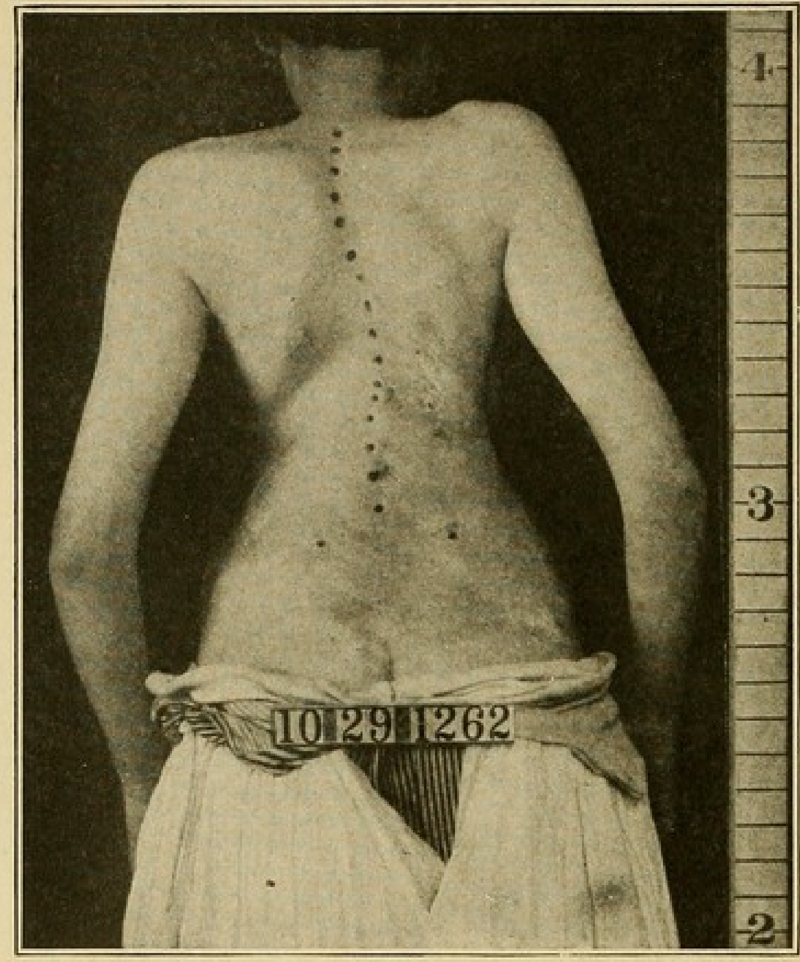

FIG. 146.—GIRL AGED 18 AFTER TWO AND A HALF YEARS' TREATMENT BY A SERIES OF PERMANENT CORRECTIVE JACKETS. See Fig. 145.—("*J. Am. Med. Assn.*")

lar considerations. Careless hospital patients will do better in a fixed jacket for a year or two, while nervous girls in private practice will do better in split jackets.

Gymnastics Following Forcible Correction.—So soon as the final corrective jacket has been removed and replaced by a removable one, gymnastic treatment should be begun. The exercises to be used have been described in the section on Gymnastics. Such treatment to accomplish results must be given from one to four hours a day for

[1] "Verhdlg. d. Deutsch. Ges. f. orth. Chir.," 1908, page 57.

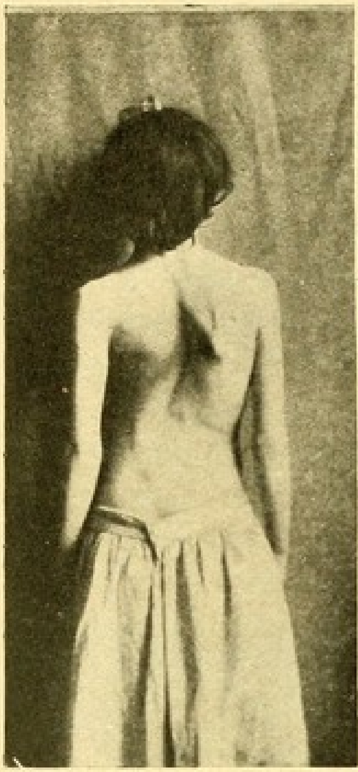

FIG. 147.

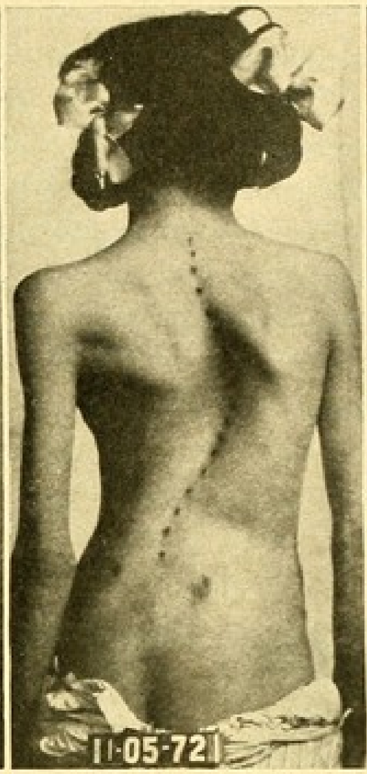

FIG. 148.

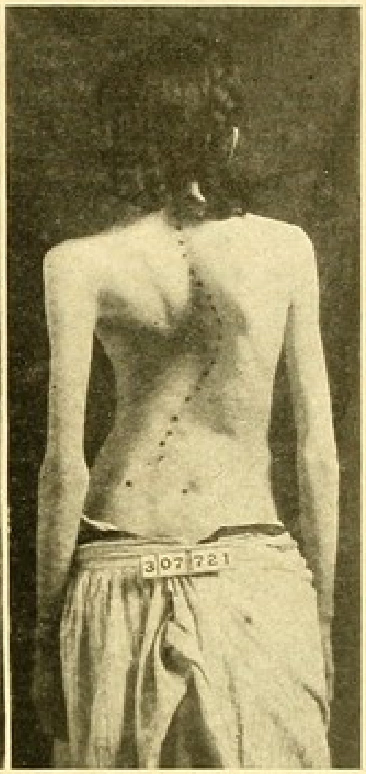

FIG. 149.

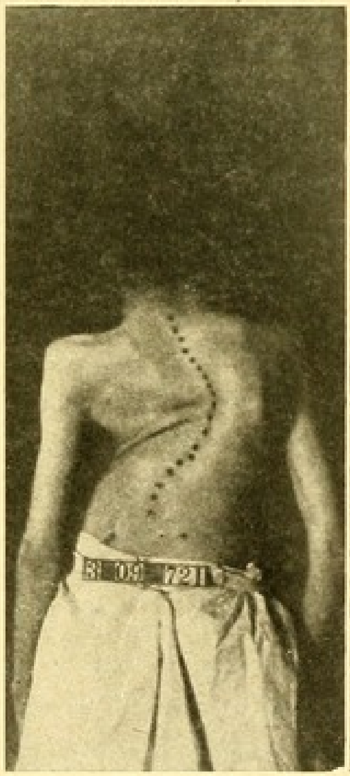

FIG. 150.

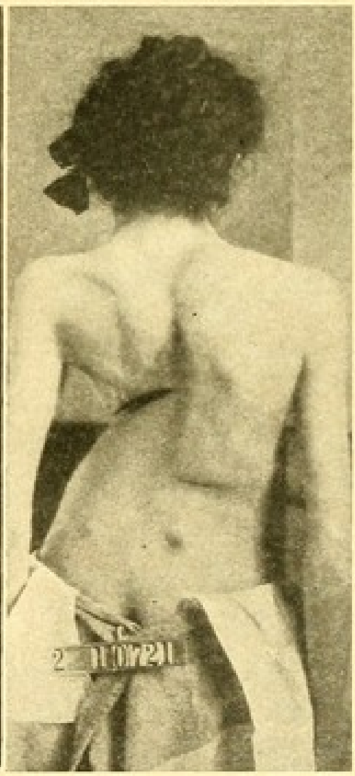

FIG. 151.

FIGS. 147–151.—HISTORY OF A CASE OF SCOLIOSIS FROM 1903–1910.

FIGS. 147, 148.—1903–5. Increase under gymnastics and imperfect jacket treatment.

FIGS. 148, 149.—1905–7. Treatment by jackets (one forcible) and gymnastics.

FIGS. 149, 150.—1907–9. Left clinic and had gymnastics twice a week outside with no jacket.

FIGS. 150, 151.—1909–10. Returned to clinic but heart displacement was so great that only a mild brace was possible with no gymnastics.

a period of at least six months from the removal of the final corrective jacket, after which less frequent and vigorous exercises may be sufficient. Exercises must be continued until the corrected position is maintained without apparatus from month to month, and the supporting apparatus discontinued at first for short periods, gradually increasing in length. The length of time that active treatment must be continued will depend on the age of the child, the severity of the case, the efficiency of the treatment, and similar factors, but any case of scoliosis severe enough to require forcible correction will not, as a rule, occupy less than two years, and often a longer period.

The present discredit of gymnastic retentive treatment is due to its use in too small dosage and to a failure to appreciate that a problem so grave as the permanent maintenance of the corrected position in a spine, which has suffered some degree of bony distortion, is only to be obtained by a long continuance of accurate and mechanically sound treatment.

BRACES AND CORSETS.

Braces and corsets of themselves have no place in the corrective treatment of lateral curvature, and are only to be regarded as a means

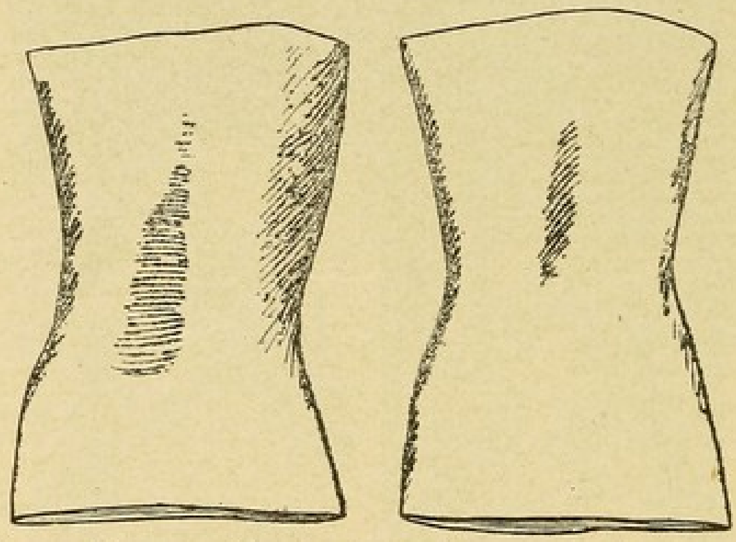

Fig. 152.—On the Left is a Plaster Torso Made from a Corrective Jacket. On the Right is the Same Torso Made More Symmetrical for the Application of a Removable Jacket.

of retaining the gain secured by other methods. They must be regarded as having in themselves little corrective value, for such apparatus applied to the spine not previously loosened up by treatment is not able to secure any considerable correction by pressure on the spine because the base for the leverage to be obtained from the pelvis must consist in a pressure obtained from the space between the crest of the ilium and the top of the trochanter. Direct pressure on the crest of the ilium is not tolerated, and pressure on the trochanter interferes with walking and sitting. It is manifestly impracticable from this small space to obtain a hold which will exercise a sufficient side thrust on the thorax to be corrective. The current practice of the instrument-makers of fitting corsets and braces to such patients and allowing the parents to hope for any considerable benefit is therefore to be condemned.

The complicated braces in former use have been largely displaced by the jacket or corset. They may be found described in the references.[1] The corset used in Germany is shown in the illustration (Fig. 157).

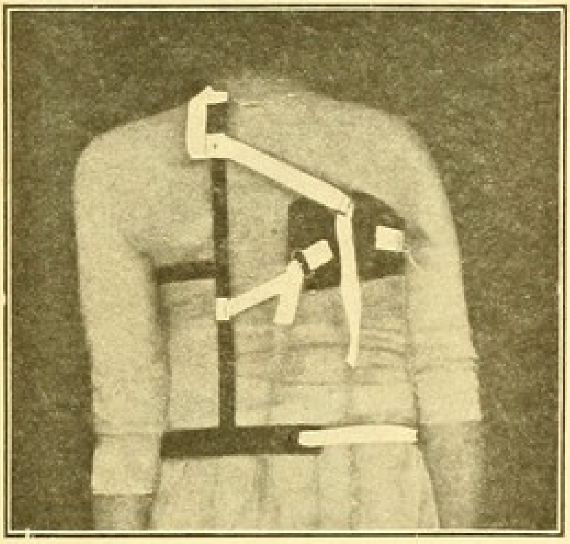

FIG. 153.—BRACE FOR SCOLIOSIS, BACK.—(*E. H. Bradford.*)

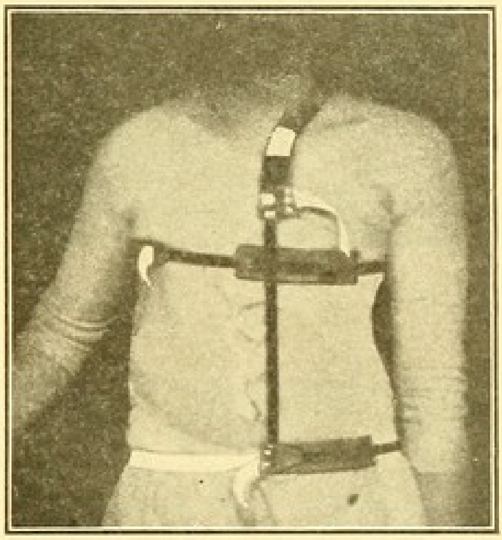

FIG. 154.—BRACE FOR SCOLIOSIS, FRONT.—(*E. H. Bradford.*)

The braces of Bradford, Adams, and Keene are representative of the best types of modern retention braces, but in the writer's experience better correction is maintained by removable jackets than by braces.

Operation.—The question of the operative relief of scoliosis is still *sub judice.* An operation was proposed by Volkmann[2] in 1889, consisting of resection of the ribs on the convex side of the curve, and this operation was also performed by Casse[3] and Hoffa[4] with fair results.

[1] Hoffa: "Lehrb. d. orth. Chir.," fourth ed., 1905, page 429; Redard: "Chirurgie Orthopedique," Paris, 1892, page 382; Bradford and Lovett: "Orth. Surg.," first ed., 1890, page 168.

[2] Volkmann: "Berl. klin. Wochens.," 1889, 50.

[3] Casse: "Bull. de l'Acad. Royal de Med. de Belgique," Dec. 30, 1893; Jan. 27, 1894.

[4] Hoffa: "Zeitsch. f. orth. Chir.," 1896, 401.

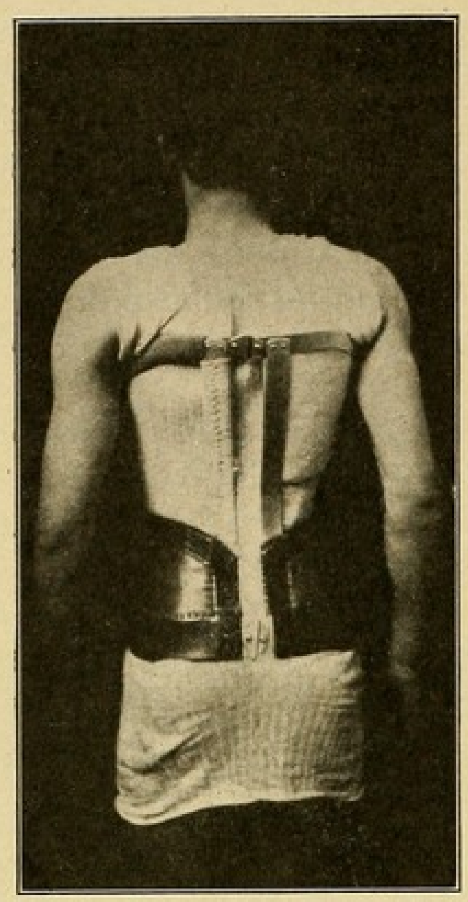

FIG. 155.—BRACE FOR SCOLIOSIS, BACK.—(*Z. B. Adams.*)

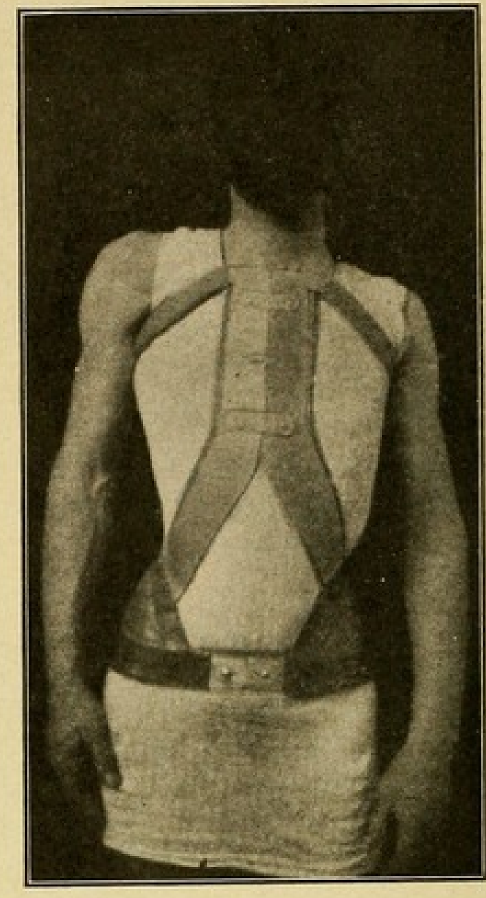

FIG. 156.—BRACE FOR SCOLIOSIS FRONT.—(*Z. B. Adams.*)

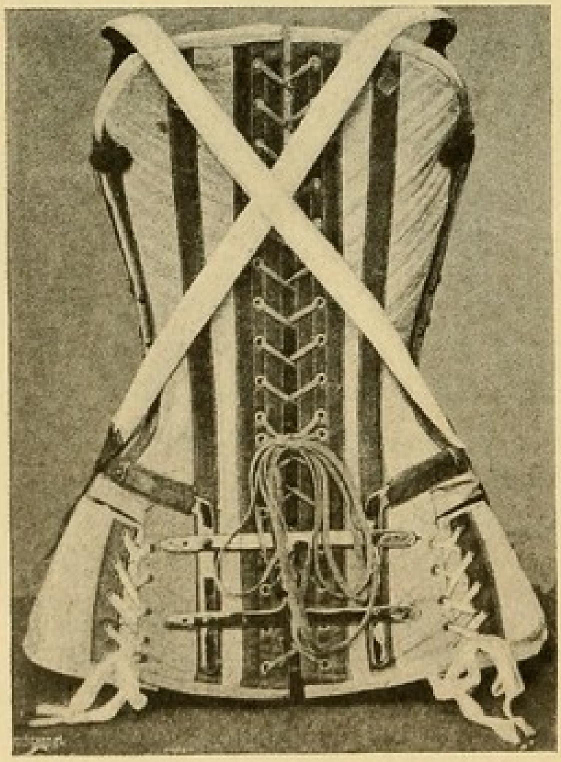

FIG. 157.—CORSET FOR SCOLIOSIS STRENGTHENED BY STEEL.—(*Dolega.*)

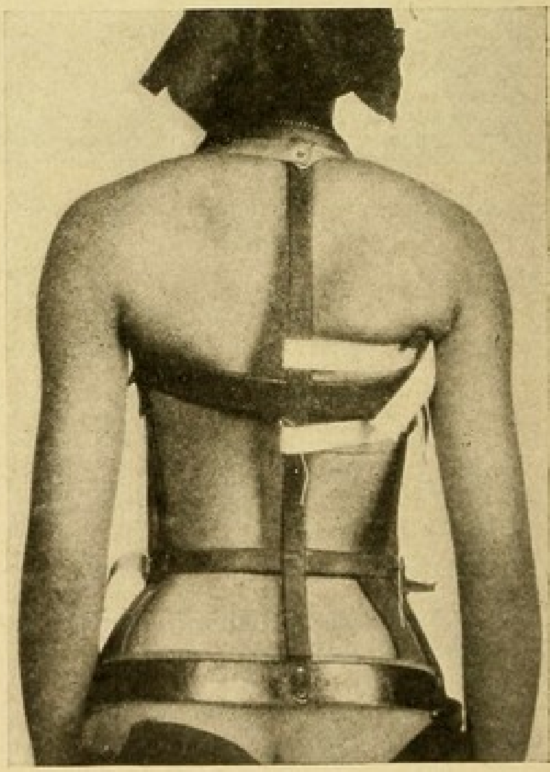

FIG. 158.—BRACE FOR A CASE OF RIGHT DORSAL SCOLIOSIS, APPLIED.—(*C. W. Keene.*)

A similar operation was thought out by N. M. Shaffer, of New York, about fifteen years ago, and spoken of to the writer at that time but never put on record, as the general surgeons to whom it was referred refused to sanction it.[1]

A good operative correction has been obtained by Hoke,[2] of Atlanta, Ga., who resected the ribs on the convex side of a girl of nineteen and lengthened those of the concave side in a severe dorsal curve. By the application of a corrective jacket great improvement was obtained.

Jaboulay[3] divided the cartilage of a single rib with a view of improving the shape of the thorax. Bade[4] has reported a case where he resected the ribs, but cautions against the use of narcosis in severe scoliosis.

[1] Shaffer: "Amer. Surg. Bulletin," Jan. 1, 1894.
[2] Hoke: "Amer. Jour. of Orth. Surg.," i, 2.
[3] Jaboulay: "Prog. Med.," Nov., 1893.
[4] Bade: "Klin. Mittheil. in Centralbl. f. Chir.," 1903, 38, 1045.

Chapter XIII

FAULTY ATTITUDE.

NORMAL ATTITUDE.

In addition to curves to the side in the spinal column, which have been described as scoliosis, there are modifications of the normal forward and backward spinal curves which demand consideration. Although it is comparatively easy to say whether or not a patient is normally symmetrical when seen from the back it is not so easy to say whether or not a given attitude as seen from the side is normal because there is no generally accepted normal attitude in the standing human figure as seen from the side. It is necessary first to consider those facts which are known with regard to the normal attitude before passing on to analyze its abnormalities. Normals have been described by Weber, Meyer, Langer, Parow, Henke, Staffell and others, which differ much among themselves as would have been expected, from the lack of a uniform or satisfactory system of measurement and also because the standing position is influenced by sex, age, race and occupation.

As the problem is one of balance from the feet up, it is evident that any reliable method of analysis must take into account the base of support and the line of gravity in order correctly to represent the normal standing position as seen from the side. Merely to draw a spinal outline and construct an ideal figure without regard to the relation of such spinal curve to the legs or base of support is misleading. One has only to read the appended literature to realize that we have no reliable normal of the standing position as seen from the side.[1]

[1] Borellius, J. A.: "De Motu Animalium, Lugduni Batavorum," 1679.

Braune, W., and Fischer: "Ueber den Schwerpunkt des menschlichen Körpers, Abhandl. d. k. Sachs.," "Akad. d. Wissensch., Math.-physik Klasse," Leipsic, 1889, xv, 7.

Dickinson, R. L.: "The Corset; Questions of Pressure and Displacement," "New York Med. Jour.," Nov. 5, 1887.

Duchenne: "Etude physiologique sur la courbure lombo-sacrée et de l'inclination du bassin pendant la station verticale," "Arch. gen. de méd.," series 6 viii, 534.

Goldthwaite, J. E.: "The Influence of Pelvic Joints on Posture," "Physical Education Rev.," June, 1909.

Goldthwaite: "The Relation of Posture to Human Efficiency," Borton: "Med. and Surg. Journal," Dec. 9, 1909.

Gerdy: "Détermination des levriers que forment la colonne vertébrale, les fémurs et les tibias dans l'attitude verticale," "Rev. méd.," 1834, 323.

Horner, F.: "Ueber die Krümmung der Wirbelsaüle im aufrechten Stehen," "Inaug. Diss. Zurich," 1854.

Kellogg, J. H.: "Experimental Researches: Relation of Dress to Pelvic Diseases of Women," "Tr. Mich. State Med. Soc.," 1888.

Kellogg, J. H.: "The Relation of Static Disturbances of the Abdominal Viscera to Displacements of the Pelvic Organs," "Proc. Internat. Periodical Cong. Gynec. and Obstet.," 1892.

Kohlrausch, E.:;"Physik des Turnens Hof.," 1887, page 17.

Lane, W. Arbuthnot: "Lancet," London, Nov. 13, 1909.

Meyer, G. H.: "Die Statik und Mechanik des menschlichen Knochengerüstes," Leipsic, 1873.

Mosher, Eliza M.: "The Influence of Habitual Posture on the Symmetry and Health of the Body," "Brooklyn Med. Jour.," July, 1892.

Mosso: "Application de la balance á l'étude de la circulation chez l'homme," "Arch. ital. de biol.," 1884, v. 131.

Parrow, W.: "Studien über die physikalischen Bedingungen der aufrechten Stellung und der normalen Krümmungen der Wirbelsaüle," "Virchows Arch. f. path. Anat.," 1864, xxxi, 74.

Schmidt: "Unsere Körper," 1903, page 63.

Staffel, F. M.: "Die menschlichen Haltungstypen und ihre Beziehung zu den Rückengratsverkrümmungen," Wiesbaden, 1889.

Taylor, C. Fayette: "Spinal Irritation, or the Causes of Backache among American Women," New York, William Wood and Co., 1870; "Tr. Med. Soc., New York," 1864.

Weber, M. and E.: "Mechanik der menschlichen Gewerkzeuge," Göttingen, 1836.

A new method of record which promises to enable one to analyze the normal standing position and its abnormalities is that of Reynolds and Lovett,[1] but until a very large number of normal studies have been made, no reliable statement of what the normal really is, can be made, and no very accurate information can yet be given of variations from the normal in this plane. This method gives a side elevation of the erect standing position of the individual, with at the same time, the position of the line of gravity in its relation to the body and to the base of support.

On the platform of a dial scale registering up to 100 pounds is placed a sharp edge which supports one end of a flat board (B), the other end of which is supported by a similar sharp edge placed on a rigid block (C). The distance between the edge is 508 mm. (20 inches). A short distance behind the rigid block is placed an upright post (E) with a horizontal sliding arm (D, shown in section only), which furnishes a plane of reference from which the antero-posterior position of each of the important landmarks of the body can be determined by measuring their horizontal distance from this sliding arm. (Fig 159).

The determination of the antero-posterior position of the center of gravity in the standing subject is made as follows:

The subject is weighed on an ordinary set of scales. He is then placed on the balance plane (B) at a known point facing the scales. (The exact point is unimportant, but after experimentation there was selected as most convenient that in which the heels are situated at one-fourth the length of the plane from the posterior

[1] Reynolds, E., and Lovett, R. W.: "Method of Determining the Position of the Center of Gravity in Its Relation to Certain Bony Landmarks in the Erect Position," "Am. Jour. Physiol.," May 1, 1909; "Jour. Am. Med. Assn.," Mar. 26, 1910.

sharp edge.) A removable ledge (F) against which the heels are placed is provided here.

Since the balance plane on which the subject stands acts as a lever, in which the weight is borne between the fulcrum (the posterior sharp edge) and the supporting force (the spring whch governs the scales), it is evident that the weight recorded on the dial (the balanced weight) will bear to the total weight the same proportion as that which obtains between the total length of the balance plane and the distance between the perpendicular dropped from the patient's center of gravity and the posterior end of the plane. That is: As the total weight is to

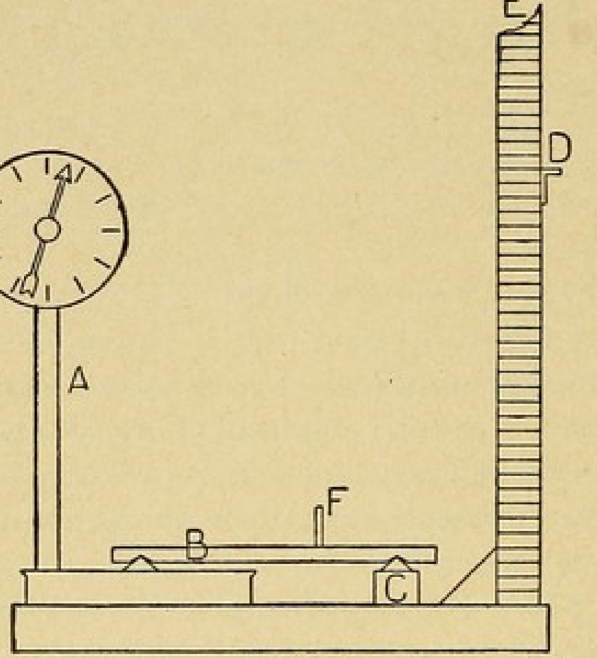

FIG. 159.—DIAGRAM OF THE APPARATUS FOR ESTIMATING THE CENTER OF GRAVITY; A, scale; B, balance plane on which patient stands facing A.; C, block supporting triangular edge; D, movable horizontal arm on upright for obtaining horizontal distances; E, vertical upright for standard plane; F, ledge against which heels are placed. ("*American Journal of Physiology*.")

the balanced weight, so is the total length of the board to the horizontal distance of the center of gravity of the patient from the posterior sharp edge (the fulcrum), or, to illustrate by a specific instance: The subject's total weight is 140 pounds; when placed on the balance plane his weight is 50 pounds, and the total length of the board is 20 inches.

The formula reads then:

$$\frac{140}{50} = \frac{20}{x}$$

This is then worked out as follows:

140)1000(7.1
980
200

The center of gravity of the subject then lies perpendicularly above a point 7.1 inches forward from the posterior sharp edge.

After the determination of the position of the center of gravity, which should occupy on an average one or two minutes, the position of the following points which have been marked on the skin are measured and recorded.

1. The position of the back edge of the malleolus.[1]

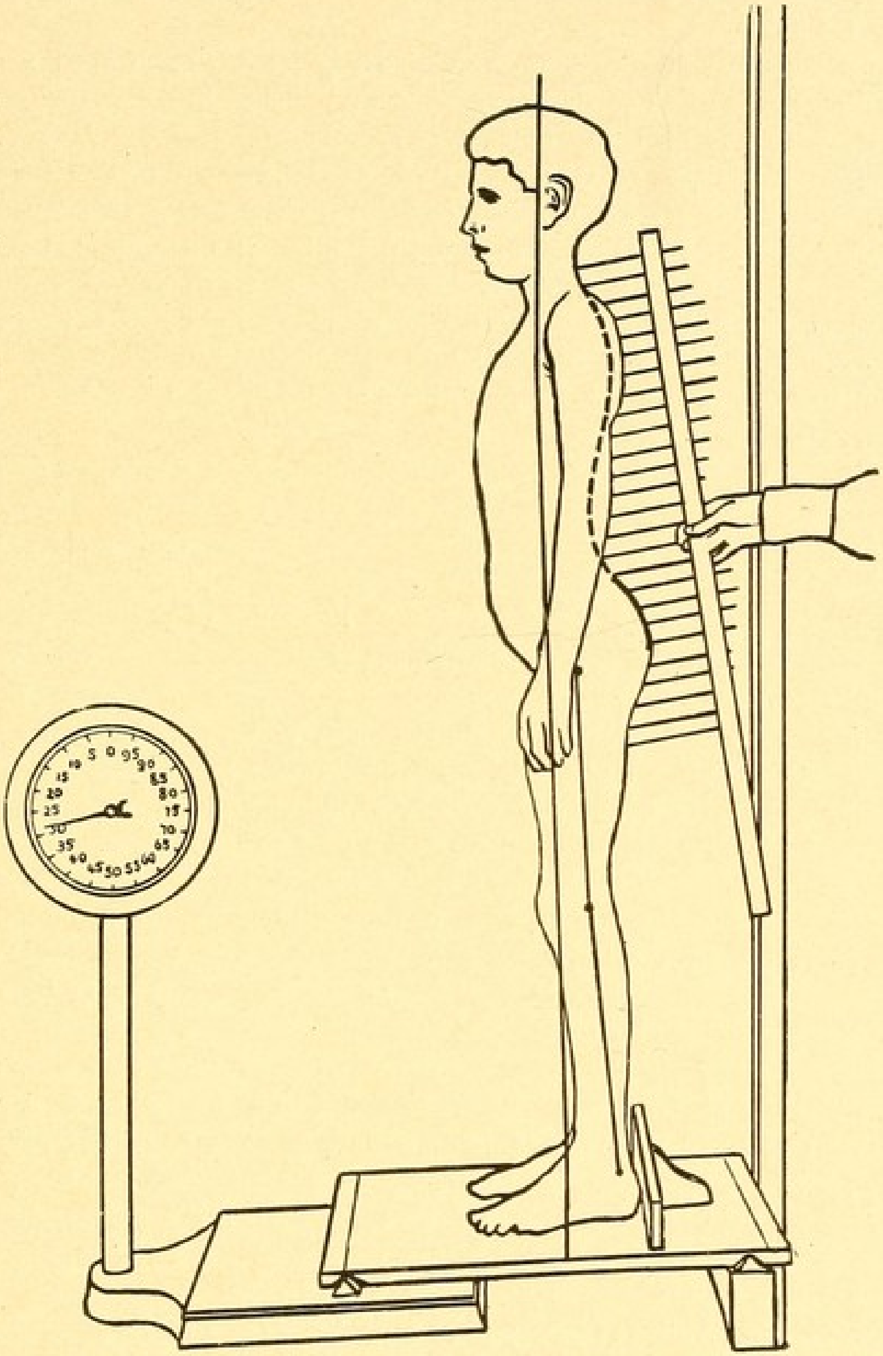

FIG. 160.—APPARATUS IN USE. THE LINES DRAWN REPRESENT THE LINES SHONN IN THE RECORD TRACINGS. THE LONG LINE RUNNING VERTICALLY IS THE PERPENDICULAR OF THE CENTER OF GRAVITY.—("*J. Am. Med. Assn.*")

[1] In this and the following determinations the horizontal difference is obtained by a footrule, one end of which is placed against the marked point, while the body of the rule is held by the thumb against the upper surface of the sliding arm. Since this surface (and therefore necessarily the rule) is horizontal, the height of the point observed may be read at the same time, from a graduated scale which is marked on the upright post.

2. The position of the back of the head of the fibula.
3. The position of the middle of the trochanter.
4. The position of the posterior part of the spine of the fifth lumbar vertebra.
5. The position of the posterior part of the spine of the seventh cervical vertebra.

All these points are taken under the usual conventions of somatologic measurements on the living.

The measurements having been recorded, are then easily translated into graphic form by the reproduction of the observed measurements on a sheet of paper, of which the bottom represents the balance plane and the edge of the paper the posterior plane of measurement.

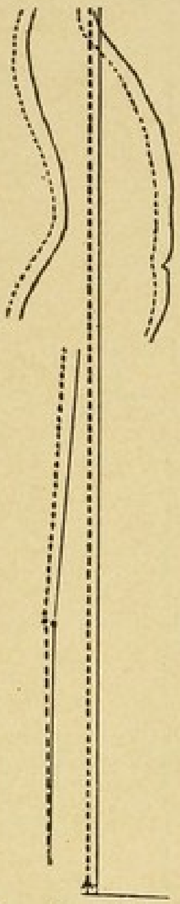

Fig. 161.—Record of the Normal Position and that Induced by High-heeled Shoes the Normal in Solid Line, the Induced Position in Dotted Line.—("*J. Am. Med. Assn.*")

These five comprise all the exact measurements which we have taken, but since the value of their graphic representation is considerably enhanced by its combination with some sort of representation of the body profile of the individual, we have completed the examination by the use of a device which obtains this with fair accuracy and which is illustrated in Fig. 160.

A series of horizontal metal arms, tipped with celluloid, slide easily through holes in the vertical wooden arm. These metal arms are shaken out to their full length, and their ends pushed rapidly and lightly against the subject's back in the median line, the point of the uppermost horizontal arm being applied to the seventh cervical vertebra. In the construction of the graphic record (Fig. 161), the position of this profile is known by its relation to the seventh cervical and fifth lumbar vertebræ; that is, these points are marked on the paper from the measurements taken, and the end of the uppermost arm of the profile instrument is laid against the mark which represents the seventh cervical, while a lower point is in contact with the mark representing the fifth lumbar vertebra. The curve is then traced on the paper containing the other measurements from the ends of the pins throughout its length.

The body curve of the ventral surface is obtained in the same way. The uppermost arm of the profile instrument is applied to the anterior surface of the neck at the level of the seventh cervical vertebra. The position of this curve on the chart is ascertained by using as points of reference the horizontal distances between the posterior parts of the seventh cervical and fifth lumbar vertebræ and the points horizontally opposite on the ventral surface, measured on the subject by a pelvimeter or other calipers.

It would be very desirable that this graphic record should be completed in every instance by a representation of the inclination of the brim of the pelvis, which would, of course, include its relation to the trochanter, but after much experimentation we have been unable to measure with accuracy the inclination of the pelvic brim in the living subject.

The use of the profile curves in the graphic representation involves the disadvantage that the chart must be drawn life-size, but it can be reduced later by a pantograph to any desired size.

The sources of error incident to the method are swaying of the subject, errors in measurement from the vertical plane, distortion of attitude during observation, inaccuracy in locating on the skin the bony landmarks selected, varying position of the feet, horizontal rotation of the pelvis and psychical influences. These errors and their prevention are dealt with at some length in the original description of the method.

So far as the observations by this method have gone they show that in the erect position the center of gravity of the body lies in front of the ankle-joints, which are held from dorsal flexion in this position by the gastrocnemius muscles. The center of gravity lies also in front of the knees, which are similarly held in position by the hamstring and quadriceps extensor muscles. The center of gravity lies also anterior to the sacro-iliac joints and most of the vertebral joints. The position of the acetabula cannot be determined in the erect position in the living individual because we have no means of locating them from any available landmarks. If we were able to determine the position of the acetabula in the antero-posterior plane it would be possible to state definitely, from the relation of the center of gravity to them, whether the trunk in the erect position would tend to fall forward or backward at their level. But from the impossibility of obtaining definite data on this point we are obliged to resort to another line of observations to determine this matter.

It has been shown by many experiments that when the cadaver is stood erect and the legs and ankles are fixed (to prevent the cadaver from collapsing on the ground), the trunk falls forward from the hips. In the erect position then the trunk is held extended on the legs by the combined and continued action of the posterior musculature, the chief factors here being the hamstrings, the glutei and the erector spinæ muscles.

After a consideration of this theoretical side of the subject which will in time enable us to obtain exact information as to abnormalities of the standing position it becomes necessary to formulate our present knowledge with regard to these abnormalities.

When the antero-posterior and lateral variations coëxist, as frequently happens, the lateral variation is in general considered the more important one, and the case is classed as scoliosis.

ROUND SHOULDERS.

Stoop or slant shoulders, round back, round hollow back, stooping, faulty attitude, kyphosis, bowed back.

German—Schlechte Haltung, runde Rücken, Kyphose, hohlrunde Rücken, kypholordose, habituelle Kyphose.

French—Dos Voutè, Cyphose.

Italian—Schiene rotonde.

Grouped under this name are various types of faulty attitude. Variations from the normal antero-posterior attitude are in general grouped under the name of round shoulders. These shade into each other and are characterized by a disposition to economize muscular

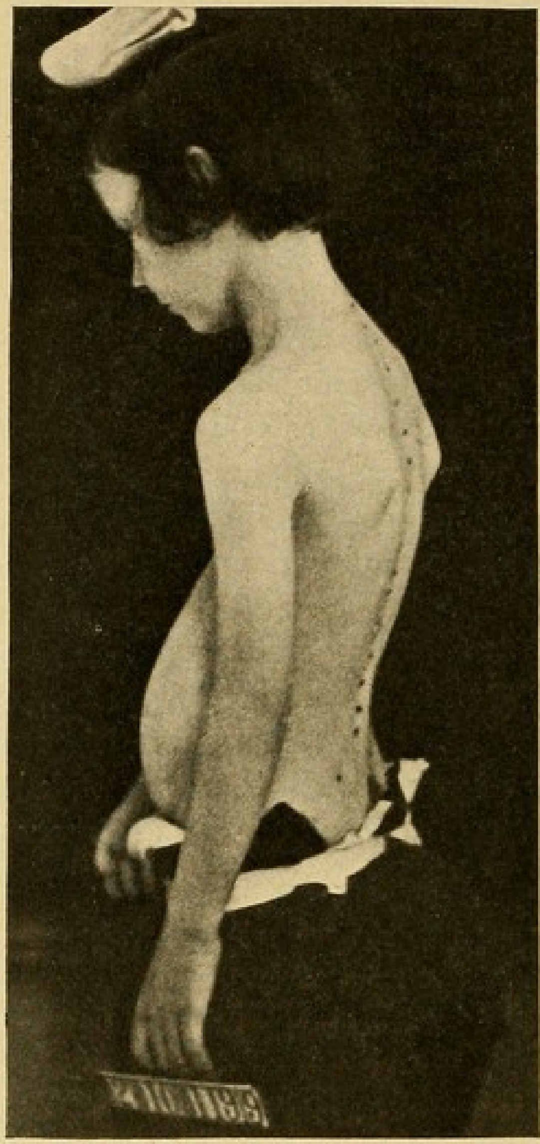

FIG. 162.—ROUND BACK WITH FLAT CHEST AND PROMINENT ABDOMEN.

force in maintaining the erect position. These deviations have in general been grouped as round shoulders because an increased convexity of the dorsal spine is the most common characteristic.

In general the attitude is familiar, the head is carried forward and is somewhat flexed, the physiological curve in the dorsal region is increased and the dorsal region unduly prominent behind, in which backward curve the lumbar region may share, or there may be also an increased lumbar curve forward. The shoulders are drooping and the chest narrow and flat, while the scapulæ behind are prominent on their posterior borders and the inferior angles may stick out markedly (scapulæ alatæ). The abdomen is prominent, especially in its lower part. Flat-foot or pronated foot frequently coëxists.

Children with round shoulders are, as a rule, below the average in muscular development and lack vigor; they are clumsy in their movements and walk heavily. In some cases the deformity can be removed by a muscular effort on the part of the patient or by gentle pressure with the hands, but in most cases of even average severity the deformity cannot be wholly corrected by gentle passive force, as the maintenance of the malposition has led to adaptive shortening of the soft parts concerned. The cases may therefore be considered as flexible or resistant, an important distinction in treatment. Great injustice is done to children with resistant round shoulders by the continual commands to "sit straight," a position which it is impossible for them to assume.

If such a child is laid face downward on a table with the arms at right angles to the body the arms may by passive force be carried back of the middle line of the body. If in this position the arms are carried up beside the head and then lifted back they cannot as a rule be carried so far as the median plane of the body. If such a child is told to put the arms up in the air in the standing position it is done by making the back hollow in the lower part and protruding the abdomen, because the soft parts between the chest and arms have become contracted and do not permit a free movement.[1] Lateral curvature of the spine frequently coëxists.

The affection is not wholly one of the spine, but implies a disturbance of relations from the feet upward because an increase in the backward curve of the spine implies a forward curve or forward displacement somewhere else to balance it. The dorsal spine in other words cannot become more convex without a compensating lumbar curve forward, or a forward displacement of the pelvis and legs if the lumbar spine is involved in the backward dorsal curve.

Round shoulders, therefore, is not to be considered or treated as an affair wholly concerning the dorsal spine and shoulders. On closer analysis these cases will be found to fall into four not very well-defined groups. Transition cases of all grades are seen, and the division is mentioned simply to aid in the study of the cases and their treatment. The groups are as follows:

[1] E. H. Bradford: "Round Shoulders," "Orth. Trans.," vol. x, page 162.

1. **Round Back.**—The dorsal and lumbar spine form one convexity backward, which is physiologically a persistence of the infantile position. A lordosis is apparently often present, but on identifying the landmarks this will be found to be merely the upward and forward slope of the sacrum and that the lumbar spine does not share in it.

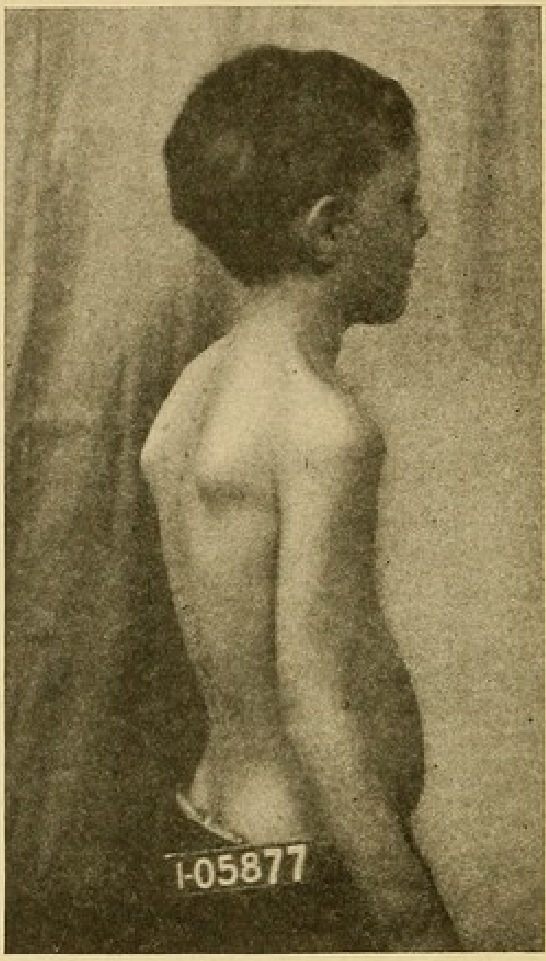

Fig. 163.—Round Back.

2. **Round Hollow Back.**—The dorsal spine is bowed backward, but the lumbar spine is bowed forward. The appearance of round shoulders is present, but the general attitude is modified because the pelvis apparently has a greater inclination than in round back, the abdomen is prominent, and the gross appearance is the same as in round back (Fig. 164).

3. **Round Upper Back.**—In certain cases the dorsal backward curve occurs in the upper part of the spine and gives an especially noticeable forward thrust to the head and a prominence between the scapulæ. These cases are rather likely to be rigid and respiratory capacity is poor. The lumbar physiological curve is not necessarily abnormal (Fig. 165).

4. **Flat Back.**—In certain cases the vertebral column is flat and has apparently nearly lost its dorsal and lumbar physiological curves. The pelvic inclination is obviously diminished and a frequent association with this attitude is a forward resistant position of the shoulders.[1] This forward position of the shoulder girdle may, however, accompany other forms of antero-posterior deviation, such as round back.

In certain cases as noted by Haglund[2] the back is rounded from side to side without especial kyphosis.

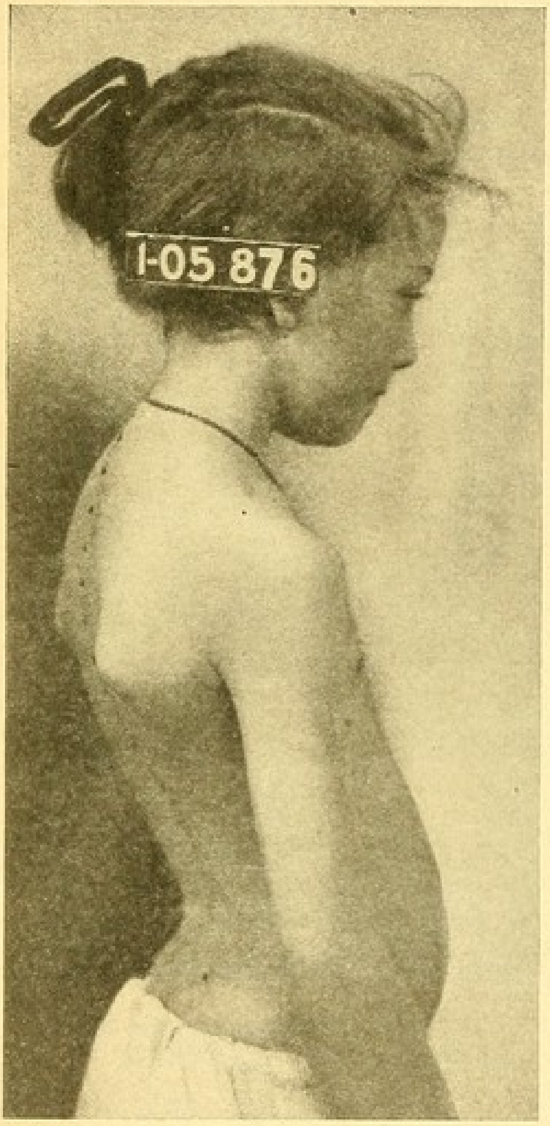

FIG. 164.—ROUND HOLLOW BACK.

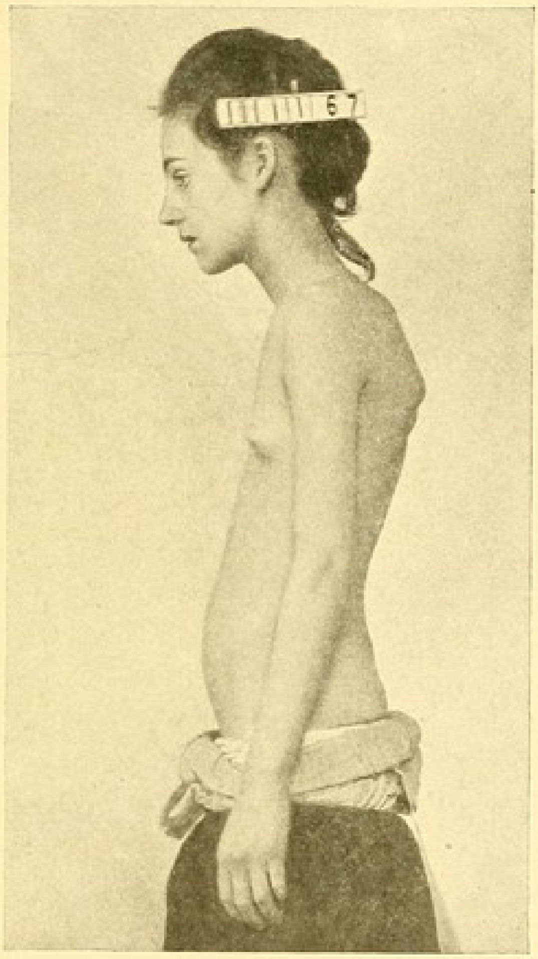

FIG. 165.—ROUND UPPER BACK.

It must be recognized how very superficial and unsatisfactory this classification is and it must be evident that we are a long way from recognizing the essentials which cause this condition. For purposes of discussion these four divisions will still be spoken of as round shoulders in spite of the fact that this is merely one expression of faulty antero-

[1] Hasebrook: "Zeitsch. f. orth. Chir., xii, 4, 613.
[2] Haglund: "Zeitsch. f. orth. Chir.," xxv, 649.

posterior attitude which involves the whole body from the base of support to the head.

ETIOLOGY.

The shape of the figure is as characteristic of the individual as the form of the features and some children inherit straighter spines than others. A certain amount of importance must therefore be attached to the type of spine with which the child starts. Further evidence of a congenital origin of round shoulders than this (except in gross congenital lesions of the spine), is on the whole wanting.

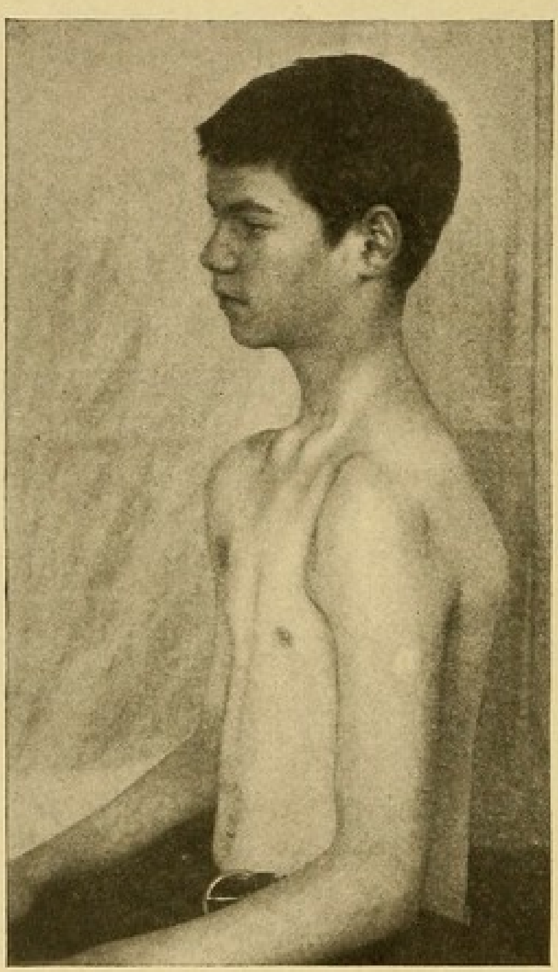

Fig. 166.—Flat Back; Forward Position of the Shoulder-girdle.

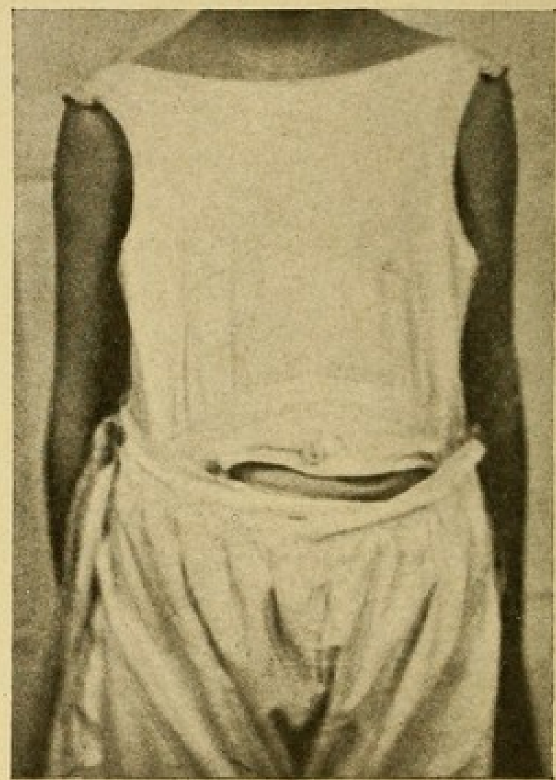

Fig. 167.—Waist with Garters Pulling Shoulders Down and Forward.

In general the causes of round shoulders are to be sought in—(*a*) conditions causing muscular weakness; (*b*) conditions causing a flexed position of the spine for long periods, and in (*c*) overweighting of the shoulders by improperly arranged clothing; (*d*) rickets. Some German writers incline toward the view that a weakness of the will is a more important cause than weakness of the muscles.

a. Conditions causing muscular weakness are found in rapid growth, overwork and bad air at school, improper school furniture, acute illness, bad hygiene at home, and similar conditions.

b. Prolonged flexion of the spine is induced by school furniture which fails to support the back, by errors in vision which necessitate stooping over the books in reading, and in careless attitudes of reading and sitting permitted at home. The child with normal eyes should not have to hold the book nearer than twelve to fourteen inches.

c. The customary method of supporting a child's clothes in this community consists in the use of a waist, loose around the abdomen, to which drawers and skirts or trousers are buttoned.[1] To this waist are also attached side elastic stocking supporters which are kept tight to prevent the stockings from wrinkling. This waist is supported above by two shoulder-straps passing over the shoulders near their tips. The whole weight of the clothes and the added pull of stout elastics is thus transferred to the child's movable shoulders, of all parts of the body the least suited to hold against a steady downward pull. This pull is transferred in a measure to the spine by the muscles, clavicles, and thorax, and tends to produce flexion.

The remedy of this condition consists in supporting as much as possible the clothing from a belt, in using round garters, in having a waist made in which the pull comes at the root of the neck instead of at the tips of the shoulders, and in cases with markedly prominent abdomens the use of the corset waist to be described.

OCCURRENCE.

In examinations of school children the observers find antero-posterior curves less frequent than lateral, but as before explained it is often impossible to say what is an antero-posterior curve and what is a normal.

At Stockholm, Haglund found, in 1599 children, 280 scolioses and 170 antero-posterior curves (90 boys and 80 girls).

The Lausanne series of 2314 children showed 571 scolioses (24.6%) and 135 antero-posterior curves (5.8 per cent.), with 47 combined cases included in the above.

Gronberg found 715 antero-posterior curves in 8250 Finnish children. They were divided as follows according to his classification:

Kyphosis (round back), 478 (66.9 per cent.).
Kypho-lordosis (round hollow back), 149 (20.8 per cent.).
Lordosis (hollow back), 88 (12.3 per cent.).

[1] Bradford: "Orth. Trans.," vol. x, 162; Goldthwait: "Amer. Jour. of Orth. Surg., vol. i, 64.

The age of occurrence of round shoulders covers the period of childhood from shortly after the time that walking begins to adolescence; most cases are seen by the surgeon in middle childhood and about puberty, when in girls especial attention is paid to the figure and carriage.

PATHOLOGY AND MECHANISM.

The pathological changes in round shoulders must be determined rather by inference and interpretation of clinical symptoms than by postmortem examination.

Permanent kyphosis in a healthy growing dog was produced experimentally by Wullstein, who approximated the pelvis and shoulders by straps, causing a flexed position of the spine. In children who continue to grow with the spine in flexion analogous adaptive changes must occur in the spine and its surrounding structures to those found in scoliosis.

Hasebrook[1] considered the cause of resistant forward displacement of the shoulders to lie partly in the costoclavicular and coracoclavicular ligaments and partly in the pectoralis and serratus muscles. He divided the cases into two groups—first, those due to contraction of the muscles holding the shoulders forward, and, second, to weakness of the muscles holding them back.

PROGNOSIS.

The attitude of round shoulders is not to be regarded as one which will be spontaneously outgrown. On the other hand, it requires treatment, and with adequate treatment and proper hygiene the prognosis for recovery is good in young children. In older children and adolescents improvement and perhaps cure are to be obtained. Even in young adults an improved position of the shoulders and a better expansion of the chest are to be secured by adequate treatment.

If the attitude of round shoulders is allowed to persist into adult life there are certain respects in which it may affect unfavorably the health of the individual. The flat chest and diminished chest capacity mean impaired respiratory capacity, and diminished room for the heart, and the large abdomen favors ptosis of the abdominal viscera, both factors leading to impaired efficiency.[2] Moreover, the bowed spine is generally a weak spine and such patients are liable to static

[1] "Zeitsch. f. orth. Chir.," xii, 4, 613.

[2] Goldthwait & Brown: Am. Journ. of Orth. Surgery Nov., 1911

backache,[1] that is, a backache due to strain of the posterior muscles described under the names of "hysterical spine," "irritable spine," etc.

DIAGNOSIS.

The diagnosis of round shoulders, when it is present in any marked degree, as a rule, presents no difficulty, but at times it is not easily distinguished from more serious affections, causing a backward bowing of the spine. The means of distinguishing between the different varieties of round shoulders have been sufficiently indicated in the description of them. The important point is to distinguish a static bowing of the spine from one caused by disease. In the former there is no marked stiffness of the spine, pain is absent, the bowing is gradual, and x-ray appearances are normal.

Differential Diagnosis.—*Pott's disease* (tuberculosis of the spine, angular curvature of the spine) was discussed in speaking of the diagnosis of scoliosis. At certain stages of dorsal Pott's disease the attitude may resemble round shoulders. Arthritis deformans of the spine was discussed under the diagnosis of scoliosis.

No gymnastic treatment for a case of round shoulders should be undertaken in a patient where pain or stiffness of the back is present without a very careful preliminary period of observation and a careful elimination of the first two conditions mentioned above.

TREATMENT.

The treatment of round shoulders is different in flexible or non-resistant cases and in resistant cases.

Non-resistant Round Shoulders (Flexible Round Shoulders).—The treatment does not differ radically from that of postural scoliosis in that both are of the type of the "setting-up drill" of the army recruit. In both, one tries to substitute a correct attitude for the incorrect or faulty one. What has been said with regard to the treatment of postural or functional scoliosis applies to the treatment of flexible round shoulders, the routine and exercises being described in that place (page 133) for both conditions, and certain exercises being designated as especially adapted to round shoulders.

Resistant Round Shoulders.—The treatment of these cases is similar in plan to that of structural scoliosis where first mobilizing and then retentive measures must be separately recognized, even if both are carried out simultaneously.

[1] Reynolds and Lovett: *Loc. cit.* Journ. Am. Med. Assoc. Mar. 26. 1910.

Mobilization.—When the shoulders are held forward by contraction of the soft parts and cannot easily be replaced in the normal position, simple gymnastics are likely to prove unsatisfactory and some stretching of the contracted parts is necessary in order to save time and make gymnastics more effective. To stretch these soft parts by gymnastic exercises is slow and often unsatisfactory, and when it is done must be accomplished by passive stretching, induced by pulling back the

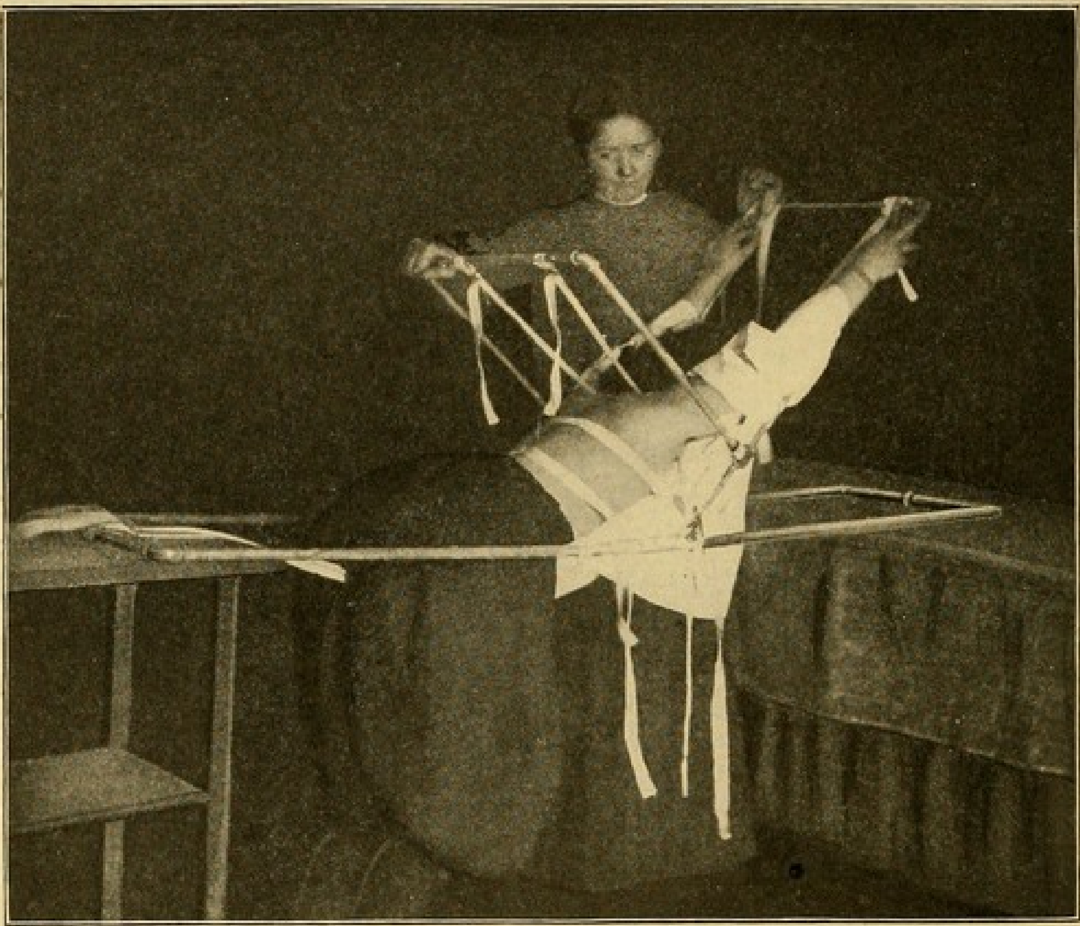

FIG. 168.—APPARATUS FOR STRETCHING ROUND SHOULDERS AND FOR THE APPLICATION OF FORCIBLE JACKETS.

shoulders either with the arms at the sides or on a level with the shoulders whichever position offers the greatest resistance.

Passive stretching, however, by means of an apparatus is more efficient and quicker. The means to be described offers a simple method.

The apparatus consists of an oblong gas-pipe frame of the ordinary pattern. Fastened to this near the middle, and hinged so as to be raised to any degree, is another section of gas-pipe lying on the frame proper and of the same shape and size as the upper half of the frame. To this movable section is fastened, at right angles to it and movable on it, a gas-pipe bridge rising about eighteen inches from the movable section (Fig. 168).

When prepared for use two strips of webbing, lying one over the other, run from each of the buckles at the bottom of the frame. The lower two strips are tightly drawn, and run to the buckles at the end of the movable section. The upper two are loosely fastened to the bridge over the movable section. The cross-pieces are tightened and the patient laid face downward on the webbing strips, which may, if desired, have laid over them a folded piece of sheet wadding. The strips, however, even in adults, are not uncomfortable. The thighs are flexed and the feet rest on the floor, so that the lumbar spine is flattened. Two pieces of webbing are passed over the middorsal region from side to side, tied to the lower non-movable frame on each side. These furnish the resistance for the straightening of the spine when the upper end of the frame is lifted, carrying with it the head and upper chest. The upper part of the frame is lifted after the patient is in place and as much force as seems advisable is exerted. This should never be pushed beyond the point of mild discomfort. Several stretchings are first made of a few seconds each, and the movable part of the frame again let down to rest the patient.

Forcible Correction.—In average cases intermittent stretching is sufficient to loosen up the contraction and to make an improved position possible. In the severer cases, however, a plaster jacket should be applied in the improved position.

The patient's spine is hyperextended as described, by raising the movable part of the frame, which is then fastened in this position and a plaster-of-Paris jacket applied, including the shoulders, which must be well padded by felt on their anterior surface. This jacket holds the dorsal spine somewhat extended[1] and the shoulders back, by firm pressure, and the pressure can be increased from day to day by inserting more felt between the jacket and the shoulders.

Such jackets should be worn from two to four weeks, and on their removal efficient gymnastic work begun, supplemented by braces, if necessary, to hold the improved position between treatments.

The use of corrective or retentive braces in round shoulders is often unsatisfactory because they are as a rule constructed only to pull the scapula and arms backward, without making efficient forward pressure on the curved dorsal spine or making any marked improvement in the general attitude. The "shoulder braces" sold in the instrument shops are notably unsatisfactory in most cases.

In flexible cases of moderate grade or in rigid cases of the same degree which have been made flexible, a properly constructed corset-waist to support the abdomen has in the experience of the writer, in many cases proved more satisfactory than a brace in inducing an improved attitude. The abdominal element in these cases has been too much overlooked and the relaxed and stretched abdominal wall is

[1] R. W. Lovett: "Amer. Jour. of Orth. Sur.," ii, 2, 200.

a very important feature of the symptom-complex roughly called "round shoulders."

Efficient abdominal support by means of a corset-waist not only enables the stretched abdominal muscels to shorten and recover tone, but by supporting the abdominal contents enables the patient to assume a better general position. A better position of the thorax at once becomes easier and the whole attitude is improved.

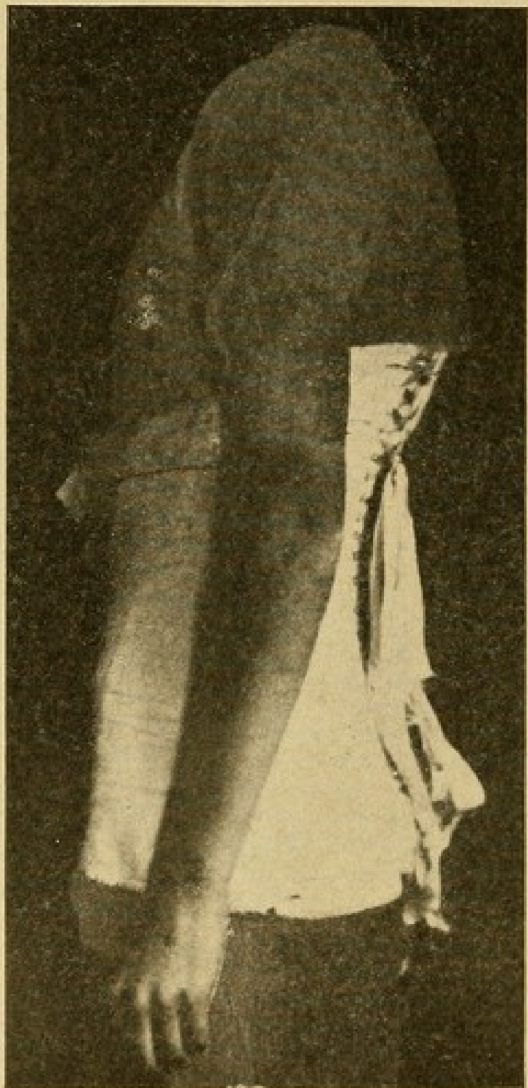

FIG. 169.—CORSET WAIST FOR THE TREATMENT OF ROUND SHOULDERS.

Such corset-waists should fit tightest around the bottom just above the trochanters and should diminish in pressure from below upward, the upper part of the abdomen being free from constriction. They should button in front but be laced in the back, and from them may be hung skirts and stockings.

There is no objection to their use in young children and the fear of the parents that they will "weaken" the abdominal wall will be dispelled as soon as the improved abdominal outline is seen after a short use of them. They should be used of course only in connection with and accessory to gymnastic treatment.

Corsets and Braces.—The use of supports to maintain the spine in a correct position is indicated—(1) in the case of children with lax muscles who are unable to hold an erect position between gymnastic

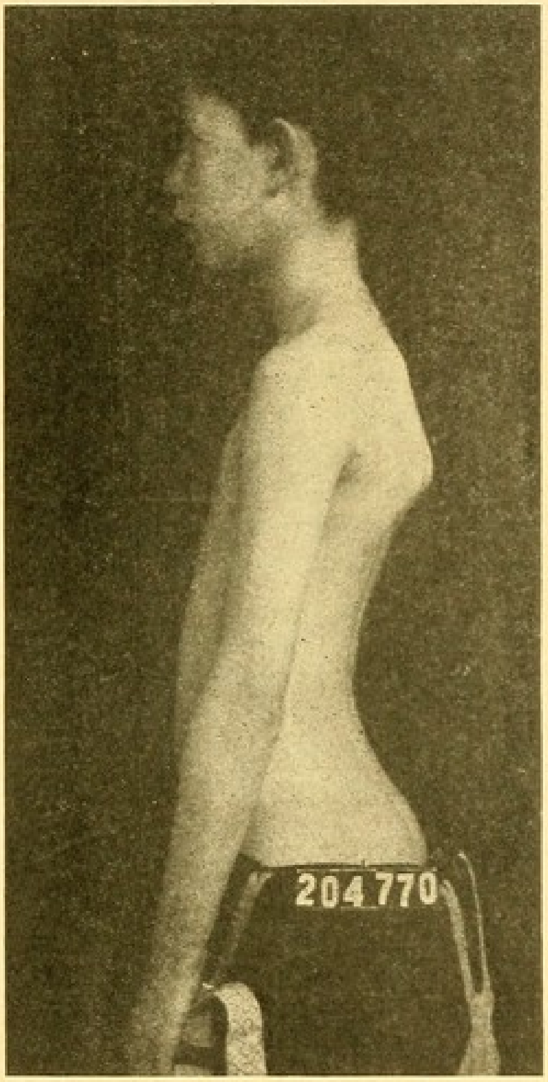

Fig. 170.—Round Shoulders Before Forcible Correction.

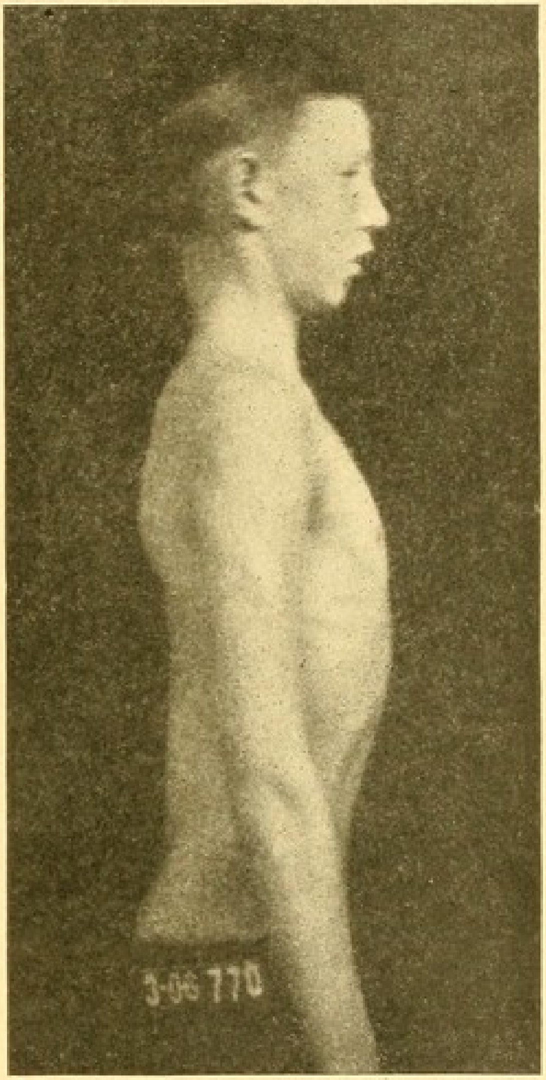

Fig. 171.—Round Shoulders after Treatment Following Forcible Correction. See Fig. 170.

treatments; (2) after forcible correction to retain what has been gained, and (3) in resistant cases which are being stretched, but which cannot maintain between stretchings the improvement secured by each one. In all of these the brace is to be regarded as a temporary measure supplementary to the other treatment, whether gymnastic or mobilizing, and to be given up as soon as it can be dispensed with. As the sole treatment of resistant round shoulders the use of a brace, which by its corrective effect is to cure the malposition, is not to be advised. The brace which, on the whole, is the most generally effective is the tempered steel upright support. It is made as follows:

[1] This form of apparatus consists of (*a*) a horizontal pelvic band, (*b*) two uprights, and (*c*) a cross-bar.

a. The horizontal pelvic band encircles the posterior part of the pelvis from a point one inch posterior to the anterior superior spine on one side to a similar point on the other side. It is curved to fit the contour of the pelvis and should lie close against it. It is made of No. 15 gauge sheet steel, one and one-eighth inches wide. The uprights run from the posterior pelvic band along the sides of the spine to a point about on a level with the acromion process. At this point they are curved outward on the flat on an angular turn at an angle of forty-five degrees or more, and run upward and outward to a point just behind the anterior border of the trapezius. In their upper part they are curved to fit the contour of the shoulders and should lie flat against the skin when the axillary straps are tightened.

b. The uprights at their lower part are farther from each other than they are at the top. At the bottom their outer edges should be separated by a distance somewhat less than the distance between the two posterior superior spines. At the top they should lie over the transverse processes. They are made of No. 16 gauge sheet steel, five-eighths of an inch wide, and should follow the outline of the back in general, but whatever correction is desired in the standing position is to be made by bending the uprights to fit the curve of the back in a corrected position rather than in the faulty position.

c. The cross-bar consists of a piece of steel, which in length should be one inch less on each side than the breadth of the body at the level where it is placed. It is riveted transversely to the uprights at a point just below the posterior fold of the axilla. The projecting ends beyond the bars should not rest on the scapulæ, but, if necessary, should be set backward by an angular curve to clear the scapulæ. These are made of the same material as the uprights.

Buckles are placed on the ends of the pelvic band, and the cross-bar and axillary straps are riveted to the upper ends of the uprights, one on each side. The brace is finished by being covered with leather, or by being nickel-plated, with leather covering to the front of the brace. The brace is attached to the body at the top by means of axillary straps and below by means of a broad belt of sheep-skin or cloth, which fits the abdomen and supports the lower part of it.

Such a brace is worn continuously between exercise periods but not during the night.

Summary of the Treatment of Round Shoulders.—Flexible cases are treated by gymnastics like postural scoliosis; a corset waist or brace may be necessary to maintain a correct position between treatments.

Resistant cases must first be made flexible—(*a*) by gymnastics; (*b*) by manual stretching; (*c*) by stretching in apparatus; (*d*) by forcible correction, after which the problem is to maintain the improved position, just as in cases originally flexible.

[1] "Am. Jour. Orth. Surg.," i, 64.

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