The orthopragms of the spine : an essay on the curative mechanisms applicable to spinal curvature exemplied by a typical collection lately presented to the Parkes' Museum of Hygiene, University College, London / by Robert Heather Bigg.

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'AN ESSAY ON

THE CURATIVE MECHANISMS APPLICABLE TO SPINAL CURVATURE

EXEMPLIFIED BY A TYPICAL COLLECTION LATELY PRESENTED TO THE PARKES' MUSEUM OF HYGIENE, UNIVERSITY COLLEGE, LONDON

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To

CHARLES HUTTON GREGORY, Esq., C.M.G.

PAST PRESIDENT OF THE INSTITUTION OF

CIVIL ENGINEERS

THESE PAGES ARE DEDICATED

IN TOKEN OF GREAT RESPECT AND IN REMEMBRANCE

OF HIS CONTINUED KINDNESS

BY

THE AUTHOR

PREFACE

A FEW months since the Council of University College, London, determining to institute a Museum of Hygiene as a tribute to the memory of Dr. Parkes, Dr. Vivian Poore, Honorary Secretary to the Committee entrusted with the formation of that museum, asked my father if he would consent to present it with a typical collection of the orthopædic instruments in use at the present time. My father, having agreed to that proposition, charged me with the duties of making the collection.

In selecting its elements I had at my command a private and very large collection of half-sized models of the orthopædic appliances which had been in use by ourselves and our predecessors for now nearly a century, as well as of those at present in vogue. To it had been added, as they were invented, the instrumental novelties of each successive year, many of which, having proved inefficient, or having been supplanted by later improvements, had become obsolete, while the more valuable others have remained in use

till the present day. The most typical and characteristic of these last were selected as examples of the best-marked mechanical remedies, and as most clearly indicating orthopædic principles, to have representative replicas in the Parkes' Museum.

I had, also, access to a long series of case-books, extending over nearly the same period, which contain drawings and detailed descriptions of almost all the cases that have passed through our hands in that time, and in which the instrumental ameliorative effects, or the reverse, are recorded and easily traceable. These were invaluable as yielding data on which could be based correct and comparative calculations of the utility of the various modes of treatment.

The expansion of notes extracted from these sources, and of memoranda made in arranging the collection, gave gradual rise to a classified series of chapters on its various parts. Those, of which Spinal Curvature is the subject, have been embodied in the subsequent pages, and constitute the first part of the whole work.

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ORTHOPRAGMS OF THE SPINE

CHAPTER I

THE NATURAL SPINE

In all the higher animals, and in man among them, there is found in developing from their earliest stage to the adult period the constant disposition to range evenly the various and varying parts around a point most suitably disposed to the organs of locomotion, which point further becomes the gravital centre of the body.

As crystals of the same kind, say of sugar or of salt, for example, whether small or great, are ever identical in shape, and as, commencing minutely at a point, they by even additions become bigger and bigger in an exact relation to that point, so the natural body of an animal ever increases in a definite relation to *its* point, and this gravital centre is invariably situated that it may best be under the control of the organs of progression, whether these be legs, or wings, or fins.

Now, a crystal once set is solid throughout, and without inherent power of altering its form. The

reverse is the case with an animal. Not only is its actual substance in a constant whirl of change, so that like an eddy it is always differing although apparently ever the same, but its members are perpetually shifting their relative positions with respect to each other, and with these changes naturally the centre of gravity also varies in proportion. This necessitates some arrangement for unintermittently bringing the errant centre of gravity back to its normal position, which normal position has been named the gravital centre. An animal, then, is structurally speaking a machine, a portion of whose mechanism is devoted to keeping the body in such a position, and its weight at such a point, that the whole may most easily be placed in movement by another portion of the mechanism, namely, the organs of locomotion.

In man more particularly, from his biped mode of progression, this is eminently apparent, the naturally normal position of the gravital centre and the active and symmetrical perfection of the human body being coexistent and relatively dependent. Round this centre are exactly reared and correctly balanced the elements of the frame in a manner best suited to the alternating motions in walking or running; and to the effort of retaining this centre in its proper and aptest position the spine, with its numerous peculiarities of skeletal structure and muscular distribution, is dedicated.

Nature preserves in her doings the strictest economy, and with this view seldom permits any organ to bear the burden of a single function only. The

spine offers no exception to this rule. It serves as a tubular protection to the great nervous mainway of telegraphic communication existent through the body, it acts as a scaffolding on which to build the larger vital cavities, and along which to conduct the major vessels in their course to distribution, it permits a bodily pliancy conformable with the more extravagant actions of life, but all these uses that it has are secondary compared with its pre-eminent and primary function of so regulating the relative position of the upper and lower extremes of the body that the *status quo* of the gravital centre may be in accordance with the principles above enunciated.

In discharging this duty its consideration will, as in the case of any other piece of mechanism, fall under two heads, namely, the motor agent, including the generation and government of the force employed, and the structural scheme by which such force is converted and adapted to fulfil its purpose. This last is best taken first.

The spine is composed of a number of mathematically moulded and superimposed segments, between which there are nevertheless arrangements for the allowance of a sufficiency of motion to permit the column to bend in accordance with the necessities of life. These segments are combined and stayed against irregular or excessive movement by ligaments or cords, which for the most part are inextensible. The column is, moreover, curved in such a manner as to give the greatest and speediest facility for relative alterations of the position of the parts in its length.

The nature of these curves is probably further determined by the exigencies of muscular disposition; motion, as the earlier function to appear in the simpler animals, being that for which most is structurally sacrificed in the higher.

These inert and passive parts of the column, to become active and efficient for the spinal function already laid down, need as much the adjunct of some controllable motor power as the wheeled works of a watch require a spring to propel them, and a fly-wheel to order the rhythm of their rate. And what the one possesses to be an accurate time-keeper, the other must have to be an accurate balance-keeper.

With this view the spine is clothed with multitudinous and complicated muscles, which control or cause the movements of its segments. These movements are never abrupt nor angular in kind, but always smooth and undulatory.

Muscle exerts its power in obedience, using a metaphor, to the telegraphic calls it receives from certain head-centres, akin to district telegraph offices. The same set of muscles may, pursuing the simile, have wires laid down so as to be in communication with several of these. The spinal muscles are under double control of this kind, that of the will, and that of the balancing regulator already referred to as analogous to the fly-wheel of a watch. These two head-centres have precise localities, distinctly if distantly situated.

Obedience to voluntary impulses, or the will is evinced in many ordinary actions, as bending or twisting the body, stooping, or bowing. Voluntary move-

ments are however entirely distinct from balancing ones, and their consideration may for the present be dismissed (to be resumed under the head of Spinal Gymnastics).

The really functional control under which the spinal muscles are ordinarily tonic is of a different nature.

As the mercurial pressure-valve of the well-known fish-torpedo so regulates its power and motor mechanism that that instrument constantly moves through the water at a desirable depth from the surface, and resumes that level should any unforseen circumstances have changed it during the course of the run, so a special head-centre, or co-ordinator as it is physiologically termed, regulates and stimulates the spinal muscles in such an even manner that the centre of gravity of the body shall constantly be at its aptest place, or, in other words, at the gravital point, and resume that position should any unforeseen circumstance change it.

This action is spontaneously performed, irrespective of volition or consciousness, and in their absence, as may be shown in cases in which animals have been successfully deprived of the portions of the brain assigned to those attributes. It was stated that motion in the spine was undulatory, and it is further remarkable that every effort performed in obedience to the special head-centre is effected by a double wave or curve of motion, each travelling along the spine in a direction opposite to the other. This duplex character of spinal action foreshadows and explains the same of spinal curvature.

The Relations of the Spine

All bodies under the influence of gravity maintain their ordinary position in one of two manners; speaking simply, they stand or they hang. The table in a room does the former—the chandelier the latter.

The properties of matter respectively called into play in these two instances differ radically the one from the other. A body stands in virtue of its inherent rigidity, hangs by its coherent tenacity. Most ordinary substances possess both these qualities in greater or less degree, in which case their matter may be so structurally disposed as to favour the exhibition of one attribute rather than the other. For instance, steel forged as links to form a chain is contrived for suspension; cast as a cylinder, is suited to prop an erection. Hence, in humanly-devised machinery material and the disposition of that material are varied accordingly as the part under construction is to be pendant or erected. The stuff and its structure differs as the nature of the strain.

In machines devised and constructed by nature—for animals and plants are machines—the same rule holds, and that with greater perfection, inasmuch as nature's mode of building, which we term growth, is more subtily exact. This being so, in pulling any of her machines to pieces, as a watchmaker would a watch, there is found a most perfect relation existent between the material and construction of any part and the function that part has to perform.

For example, in the human body the arm is palpably pendant under ordinary circumstances, and an examination into the minute details of its parts brings to light a structure in strict conformity with the exigencies of that condition. Again, the lower limb, in walking, is at one time bearing the entire weight of the body as the leading leg, at another time swinging forward as the following leg. Its intimate arrangement displays a double scheme of structure, rendered necessary by this double duty, as is easily seen in the ligamentous complexities of the knee and its other joints.

Reversing the logical process and ascertaining function on the ground of investigated structure, the human frame, as a whole generally, and the spine in particular, are built up from below, piece by piece, in as mathematically precise a way as a house is by square and plumbline, each segment being balanced and propped on the one below with equal truth, from the sole of the foot to the crown of the head.

Hence, the body being architecturally an erection, the relations of the spine to the whole will be best and most clearly appreciated by passing the parts in review as such. The consideration of the influence of suspension on the body will be reserved for a subsequent chapter.

The body is obviously divisible into the head and trunk and limbs. The two former may practically be considered as one, and their central bony structures be accepted mechanically as constituting the spine, the head being the extreme segment at the upper, the

sacrum the same at the lower end. In the intermediary length lie the arrangements for motion devoted to fulfilling the spinal function in the manner already enunciated.

The sacrum or lowest brick, so to speak, of the spine forms the keystone of an arch of which itself, the hip-, thigh-, and leg-bones are factors. This arch, in its turn, rests on the arches of the two feet, so that a triplet of arches is formed, which, if not in strict accordance with the conventional ideas of masonry, are, nevertheless, in the erect and upright position of the body, of perfect architectural truth.

To their truth the spine is indebted for a level base on which it may best be posed to perform its grave and gravital duties; while departure from correctness deranges the entire harmony of the combination, and predisposes irregularities on the part of the spine itself.

While, on the one hand, the spine is thus dependent on three arches for its erectness, it, in its turn, is in intimate relation with three cavities, whose normal shape is in great measure governed by and consequent on the integrity of its shape. These cavities are the abdomen, chest, and nervous-centre case, and contain the various vital organs, the performance of whose functions in the aggregate constitute the act of life; if working well, of healthy life; if ill, initiating disease; and if ceasing, determining death. They are the wheels of the clockwork of existence, which must all move rightly and in unison that the time should be healthily passed. These vital organs are packed in

their boxes with greater or less exactitude, having the precise amount and form of room assigned to them that the exigencies of their work demands, which work is properly performed only when such is the case.

The three protective cases vary in mobility and strength in accordance with the delicacy and importance of their contents, which may be reviewed as follows:

The nervous centres—that is, the brain and spinal cord—are situated respectively in the cavity of the skull and the spinal canal, the whole constituting the nervous-centre case. Their position there, as being nearest the centres of motion, is least liable to change, this fact, together with the strength of their bony clothing, being rendered necessary by the fragility of their structure. The brain, which is the bodily seat of government, is, in its protected position, uninfluenced actually by spinal movements; but the spinal cord, which proceeds from it and through the spinal canal, in which it is loosely packed, forms the mainway of the telegraphic communication which pervades the body, and is affected by all alterations of the spine. So long, however, as the spinal movements are restricted within natural bounds, so long the mainway is intact; but should these restrictions be, through disease, accident, or otherwise, removed, then, there being no provision for the emergency, the mainway becomes nipped and its function impaired, or even entirely interrupted, with as much perfection as electric communication is by section of the wire.

The chest is less sturdy in structure than the nervous cavity, and more pliant and elastic in constitution, as befitting the nature of the heart and lungs which lie within. Its walls have to rely on the ribs for the kind and constancy of their shape, and as these last are not mere appendages, but almost actually part and parcel of the segments of the spine before referred to, the consequences to the chest of abnormality of the said segments is self-evident. The contained organs will, however, submit to considerably more comparative topical disturbance than the nervous centres would, without detriment to their duly discharging their duties.

This licensed mobility is still further marked in the abdomen, where the organs, namely, stomach, liver, spleen, intestines, urinary and genital viscera, hang in apparent confusedness from the bony scaffolding behind and above, and will undergo unusual rudeness and roughness of motion without injury, or suffer only transitory inconvenience, as instanced by submission to the operation of, in pugilistic parlance, having "one's wind taken." Now, this seeming mesenteric medley is apparent only, and not actual; for as long as the staying ligaments and osseous scaffolding are normal the viscera move only within strictly prescribed limits, and each keeping its own ranges is unable harmfully to impair the vitality of the others. But if the spine which forms the scaffolding becomes so altered that the slackened ligaments fail to sustain their organs, these last interfere with each other frequently to their extreme detriment, and

becoming dislocated or malflexed are liable to severe functional disturbance.

From the train of consequences above detailed, and the dependency on each other respectively of the three arches, the spine, the three cavities and their contents, it follows that a disorder, beginning with, for instance, falling of the arch of the foot, may entail ultimately functional derangement of one of the remoter organs of the body, the precise manner of which occurrence will be followed later on.

There remain of the bodily members only the arms for consideration in their relation to the spine. These limbs are mere dependencies of the frame, outstanding detachments, as it were, whose influence would be marked rather by their absence than aught else, loss of an arm deranging the evenness of weight disposed on each side of the body. As a gun by its weight will, if constantly carried over one shoulder, depress it, on the principle of sæpe cadendo, so the removal of an arm will be productive for reverse reasons of reverse effects.

CHAPTER II

THE UNNATURAL SPINE

Classification.—The term "Spinal Curvature" has been conventionally applied to denote an unnatural state of curvature of the spine. In the ordinary and natural condition the spine exhibits the well-known curves which constitute the arch of the neck, the round of the back, and the small of the loins. These, in an unnatural manner, may become obliterated, exaggerated, or confused by other novel curves, in which case symmetry, and the mechanical perfection of which symmetry is but the outward expression, both disappear. From the briefly stated premises in the previous chapter, the rationale of the occurrence of spinal curvature is simply deducible, and a basis of classification arrived at.

For, on the one hand, below is a base of arches, while, on the other, above is the mass of the body, comprising the head, arms, and trunk, evenly disposed, bilaterally balanced, and symmetrical both in weight and form. Between these two is the spine, with the functions already enunciated. Now these three factors, base, spine, and mass, form together an integral whole, and are relatively reliant on each other for form; and what directly affects the one will indirectly involve

the others. Hence abnormality of the spine is dependent on and traceable to irregularities of one or more elements of this triplet. It follows, therefore, that the origin of spinal curvature may be *intrinsic*, that is, actually determined by getting out of gear of the spine as a piece of mechanism, no matter from what cause; or that it may be *extrinsic*, in which case, although the spinal machine is structurally and functionally perfect, yet the discharge of its duties under altered circumstances of base or to-be-balanced mass, compels a consequent change of curves to accommodate the difference.

This last consideration leads to an idea best conveyed by the term "*Restituency*," which is intended to indicate an attribute of the healthy spine or any portion of it, in virtue of which it will tend to assume a certain definite "restituent" curve constantly in relation to its own surroundings. This is easiest rendered intelligible by an instance. Suppose a very healthy but hypothetically elastic person capable of being stretched, by some such means as the orthopædic bed on which Procrastes tortured his patients, till the natural curves of the spine were entirely eliminated, and the backbone as straight as a spear-shaft; and grant that, at the end of the operation, the other parts could be mechanically unaffected and unchanged, and that the function of the spine was in tendency unimpaired; then, on that person's taking himself up and walking, the spine would in time resume the natural curves that previously existed. In short, the natural curves of the spine are restituent ones of its natural

surroundings. It was previously stated that the natural spinal curves were traceable in structure to the exigencies of motion, and this is true developmentally; it is none the less true, however, that their maintenance is due to the restituent tendency described. Nature provides for construction on a certain plan in one way, for its continuance and integrity in another.

In a similar way, for all unnatural circumstances, there is an ideal unnatural curvature, which the spine tends to adopt as the most facile for fulfilling its function; and this tendency, modified as it may be by the structure—the bricks and mortar, so to speak—of the spine, will never cease till the real curve is identical with the ideal.

Further, not only is the restituent tendency inherent in the spine as a whole, but, as will be later seen, exists in any part of the spine in relation to the other parts.

This point clear, spinal curvature can be classified in accordance with its mechanical origin rather than by reference to its position, direction, or constitutional cause.

I. *Curvature of Extrinsic Origin* may arise from a multiplicity of causes, inasmuch as while the spine itself is in every way mechanically healthy, its circumstances may be indefinitely varied. Below the spine the elements of the three arches may become subjects of irregularity; weakness at the insteps of the feet, deviation from truth of the relative axes of the ankle, knee, or hip, through accident, paralysis, contraction, or arrested development; disturbance of the stability

of the keystone or pelvis by anchylosis of the hip-joint; the spurious unevenness of assumed positions; loss of the lower limb and use of an inefficient artificial one; all these are among the causes that initiate this type of curvature. Loss of an arm and failure to adopt a correctly counterpoising substitute, or the constant carriage of a weighty body on one shoulder or side, will as infallibly induce curvature of a similar character, though through alteration of the mass above and around the spine instead of by disturbance below.

II. *Curvature of Intrinsic Origin,* on the other hand, is wholly independent of abnormality in the circumstances of the spine. The base below and the mass above are, to begin with, perfectly natural, and if they vary do so as result and not cause. It is the column itself that errs. Now, the spinal column as a machine was shown to consist of two parts, one dedicated to the generation of force, the other devoted to the conversion and adaptation of that force to its uses. Each of these parts is liable to accidental and constitutional derangements, under which each is productive of a curvature varying vastly from the other in character and course of progress.

A. *The Musculo-nervous* constituent generates the force necessary for the performance of the gravital function of the spine. The ultimate elements of this musculo-nervous system are in a natural state, all of even power, in the same manner that a number of identically regulated engines of one-horse power might be supposed to be. In ill health, however, these ultimate powers become irregular, just as in the case of

the exemplary engines, should their regulation become altered; some would work up to more than one-horse power, some up to less. Now with the ultimate musculo-nervous elements there is every grade of ability for generating force between actual impotence, on the one hand, and exaggerated power, on the other, between paralysis and hardened spastic or tetanic contraction, and further unhealthy causes need not necessarily affect all of these ultimate elements in the same way. Hence it occurs that in the same region of the body or limb some musculo-nervous elements may be much increased, and others much diminished, in power. Side by side, therefore, there may lie two "muscles" (that is, aggregate collections of musculo-nervous elements under a definite and localised head-centre), which may be much above or much below their average constitutional power.

A disturbance in the regular relations of the musculo-nervous elements of a part under voluntary control, as an arm or a leg, must be of tolerable magnitude before its results can appear as deformity, for, the will being a factor in the question, organic inability is countervailed by volition. But on an involuntary part, and the spine has been shown to be ordinarily under involuntary government, the influence of such disturbance is infinitely graver. So that, when from unnatural causes, a disparity is determined in the evenness of the power and action of the elements of the spinal musculo-nervous system, deformity ensues.

The direct deformity primarily so-called is usually

restricted in region and curved in character; but it follows, in consequence of restituency, that the other healthy portions of the spine establish a secondary and complementary curve or curves, simultaneously with the formation of the primary one.

B. *The Osseo-ligamentous* constituent forms the solid edifice of the spine, and adapts powers to purposes, as before shown. Its bony segments are unnaturally subject to constitutional degeneracy, by which their solidity disappears, in very much the same way that a piece of very hard and stale bread would, if soaked in water, while retaining its form lose its firmness. Under the influence of this disintegrating disease the segments of the spine become unable to sustain the superimposed weight, and give sharply away, as a wall whose lower bricks had rotted, and a deformity, generally angular, results. But few segments ordinarily are affected, and with a partiality dependent on the gravity of the attack, and these lie usually next each other in one locality, although occasionally the spine may suffer in more than a single spot. In the meantime the softening segments commence to fuse together. The ligaments mechanically may be considered as playing a passive and subservient part, although of course their integrity is influenced by the inflammatory processes at work.

Under ordinary and favorable circumstances a turning point in the course of the change comes; the disintegration ceases, the fused and softened bone substance rehardens, and fixes the deformity that may have occurred in a manner unfortunately and practi-

cally unchangeable. The clay, so to speak, sets and is unalterable. The spine thus may become subject to an abrupt and unbending distortion in part of its course, and it follows that, by restituency, secondary curves will become established, not simultaneously, because the process of change in the latter is incompetent to keep pace with the activity of the former derangement. It is noticeable, however, that should the provocation to the formation of a restituent curvature be sufficiently marked on account of the exaggerated intensity of the primary curvature, then, if the health of the body be not recouped, the disintegrating disease may be initiated at the region of the commencing restituent curve. In short, a second attack may follow on the tail of the first.

The above-given classification of the kinds of spinal curvature is in strict accord with its mechanical origin. This originate methodification will be found to be more reasonable and comprehensive than any of the others that have been in vogue. Regionally, for instance, curvature has been discriminated as being cervical, dorsal, lumbar, sacral, and so on, and this mode of—to use an analogy—determining kinds by countries is obviously illogical and artificial. The directional manner of classing curvature is none the less so, seeing that distinctions into antero-posterior, lateral, and rotatory, are based on results, not on causes. Finally, a constitutional classification fails to include all curvatures, as those of the extrinsic order may be, as was shown, brought about without the slightest constitutional disturbance. For the rest, the constitutional causes of

curvature, which have been frequently, lengthily, and learnedly discussed, may be accepted as wholly distinct from the static stages of the deformity, nor would they fall within the province of these pages.

Course

Every disease to which the flesh is heir presents a course over which the patient travels, while its symptoms are, as it were, the landmarks of its identification. Diseases, broadly speaking from this point of view, drop into two kinds. There are some whose path, once entered upon, must be pursued through each successive stage till the end is reached by convalescence, or the reverse. The fever once caught must run to its extremity, whether smoothly or no, and will not be stopped nor stayed. It has been doubted whether all the physic of the Pharmacopœia can check the career of a common cold. Nature, in these cases, may be assisted, but the disease will not be turned back. In contradistinction, there are other maladies the line of whose progress can be accurately mapped out from their most trivial commencements to their gravest terminations, and yet along the whole of which only an occasional patient passes, the majority of affected persons merely travelling, so to say, a certain distance along the way, and under favorable care and circumstances, retracing their steps to a natural state of health and strength.

To the latter class spinal curvature belongs, the symptoms of which will now be reviewed in their or-

derly sequence. The series so presented will indicate the entire career through which disease may carry the sufferer, but which, in its entirety, is rarely completely traversed, inasmuch as it lies fairly within the reach of human power and skill to cut the calamity short at almost any point, or even to avert it altogether. Amongst the poor, perhaps from their impecuniosity and a more callous care for external appearance, extreme cases are found; but the affluent, more sensitive, if not more sensible, happily are affrighted at the merest deviation from health or symmetry, and luckily are wont to take matters in time.

Now, touching the trains of symptoms, it must be presumed generally that, as the spine, in the opening chapter, was considered *per se*, on the one hand, and on the other, in respect to its relations with the rest of the body, so likewise the symptoms of curvature will fall into the category of those which directly and primarily concern the spine itself, and of those which indirectly and secondarily involve or affect the organs in relation to the spine. This distinction is the more defined in consequence of the fact that, while the primary symptoms are specially different in each of the three classes of curvature before enumerated, the secondary ones are, roughly speaking, common to all, and as such can be conjointly considered.

Curvature of Intrinsic Origin

1. The musculo-nervous elements of the spine radically comprise these constituents—the nervous centres, the muscle, and the line of communication between the twain. A rough idea of this combination is conveyed by picturing two bodies connected by an intermediary string and where a change in the one body is followed by an answering change in the other. A bell, its wire, and handle, form a familiar instance in point. The changes that occur in muscle may be viewed massively or minutely. As a whole, muscular tissue when excited varies its form in one direction at the expense of the other, and that with a power that is enormous when compared with the lightness and delicacy of its structure. Microscopically, in active muscle there is observed the approximation to each other of regularly arranged particles floating in and controlling an elastic medium. What occurs at the nervous centres to initiate and excite these changes in muscle, or whether the nervous ways are more than passively concerned in transmitting such excitation, has not been followed out, as the delicacy of live nervous tissue precludes its subjection to intimate examination.

The relations of matters being such, the continuance of the spinal musculo-nervous elements in a healthy state, and one fit for the discharge of their duties, will depend on a proper persistence of their physiological nutrition and an absence of actual disease or accidental injury to any of their parts; and it will be therefore

observable that while, on the one hand, there may be certain impoverished or morbid states of a person's system which may detrimentally and equably affect the entire set of musculo-nervous elements throughout the body, so, on the other hand, local injuries or lesions may arise impairing the power of but a few, the remainder resting healthy and intact. This distinction determines a difference in the imperfectitudes to which the spinal musculo-nervous elements are liable, and in the deformity thereby initiated. In the former instance the conditions of balance become generally unfulfilled, in the latter partially deranged. Taking the general first, and the partial presently.

A. General debility or atonicity as the cause of curvature is liable to overtake any one in times of great constitutional weakness, and more particularly those whose growth is as yet incomplete, and whose less vigorous tissues are, as a consequence, more unstable under strain than those of adults. For obvious reasons girls in the years between maidenhood and womanhood, and especially those who in the extravagant rapidity of their growth have taxed nature beyond its powers, are very frequently victims to this consequence of an exceedingly enfeebled condition. So also are patients convalescent after trying illness, more especially fevers, or collapse resultant on great mental or nervous exhaustion, when the vital energies of the bodily economy sink to a very low ebb.

The successive alterations in form, which become apparent to those in the society of such a sufferer, are fairly as follow. The weakly person manifests an

extreme indolence of disposition, a sluggishness of gait, and a disinclination to keep the body well and smartly braced up either when walking or sitting. The natural curves of the shoulders and loins become changed, the former markedly increased, the latter diminished. The small of the back is no longer well held in, nor the chest thrown fully up, and the elastic pliancy of the figure seems lost. As time progresses, and no attempt is made to correct this bodily laxness, lateral curves commence to arise in the back and loins, and the more subtily so as their origin is scarcely ever noticeable, owing to the fact that persons' nude backs are not commonly seen, and even were they the fleshy groove over the eminences of the spine has rarely sufficient definition to serve as an indicator of the error. Nothing graver is thought to be the matter with the sufferer than an addiction to wilful stooping and lounging habits ; misnomered so, as the will is not answerable for the fault. As the spinal curvature laterally increases, being palpably double, one of the shoulders—the right in ninety-five cases out of a hundred—becomes materially enlarged and elevated, the opposite one in greater or less degree undergoing the reverse change, and marking the differences between the two with greater distinctness. Further lapse of time is coincident with a continued exaggeration of this state, although now with an irregularity which precludes an exact definition of the course. As, however, the general form of the body and relations of its parts are subject to more severe disturbance, the secondary organic symptoms arise,

complicating considerably the state of affairs. Setting these aside for future and systematic consideration, suffice it to say that the actual deformity of the patient may become very monstrous, provided no natural check occurs; but that such extreme cases are few and far between, and confined to the poorer or colonial classes.

As regards natural checks, it by no means follows that the course of curvature is regularly unintermittent. On the contrary, constitutional cessation of the causes of this kind of curvature may be partial as well as permanent, and relapses take place by fits and starts, as it were; and it is even not unusual to find patients who have suffered during their early youth pass through the middle stages of life without further progress of the disease, but become affected on getting into years by its resumed activity.

Of the foregoing obvious and external changes, there are the internal contemporaries, which it is advisable, for the sake of clearer consideration, to dispose sermonwise under four heads, corresponding with the separate stages of the disease.

The first premonitory stage of bodily sluggishness and indolence has its origin in the fact that the entire muscular system, including the spinal, has become constitutionally atonic, and refuses prompt obedience to the impulsive orders of the nervous centres, whether the will, or the gravital, or any other. An actual absence of vigour equally pervades the spinal muscles, or, more correctly, musculo-nervous elements, and as a result of this there is a loss in the perfect vital power

of erection of one vertebra above another. At this time the parents of the patient not unfrequently fling taunts of idle disposition at the sufferer's head, imagining that mere exercise of the will will overcome spinal lassitude; whereas the muscles are as stimulatively indifferent to the voluntary as they are thoroughly disobedient to their natural gravital centre. Thus, the spine, its erectile power waning, is permitted to follow any course to which it may be predisposed, or to which the inclination of the contingent surfaces of its segments may lead it, and that in a degree accordant with the loss of power it has suffered.

The results of this perdition prelude the second stage, in which, while the spine retains a position true to the middle line, its natural curves become modified peculiarly, and for the following reasons:— The entire body from foot to crown is arranged in a series of curves, of which the ordinary and natural spinal ones form but a portion. The entire muscular system governing and maintaining this arrangement acts in subordination to the gravital centre and law, in a manner identical with that more particularly described hitherto as spinal. When, therefore, the musculo-nervous system is so far atonic as to begin to fail to maintain these curves, by diminished obedience to gravital impulses, then a static compromise is struck and a more facile mechanical position assumed by the substitution of longer and fewer curves for more and shorter. This tendency, affecting the spine *inter alia*, initiates the obliteration of the lumbar curve, with alteration of the pelvic plane and the modification of

the combined dorsal and cervical ones, in the manner before mentioned, as externally recognisable as straightening of the loins and rounding of the back. Nature during development makes provision for the undisturbed pursuance of natural tendencies; unnatural tendencies have no such provisions, and are therefore modified by the opposing passive conditions of the parts in their relation. So the passive predispositions of the spine must be examined to aid appreciation of this effect on the undertaking of novel unnatural curves.

The bony segments of the spine touch each other by three surfaces—a broad centre one and two side smaller ones. Throughout the entire column the central principal surface is, roughly speaking, horizontal. The other two vary in plane in different parts of the column, and are symmetrical to, but the converse of, each other. They it is which govern the range and direction of motion of the parts of the spine in which they are located. In the neck and loins they permit to-and-fro movements with facility, and, as a consequence, offer no opposition to the curve change mentioned. In the back the case is different, there being an obstinacy on the part of the segments in this region to admit of much more than what is needful for the rising and falling of the chest in the act of breathing; and, further, if overstrained in this particular direction, they will, in accordance with their attachments and the inclinations of their surfaces, assume the curved and rotated position which characterises ordinary lateral curvature, and which also, on the dried bones,

can be shown to be the predisposed position assumed under the circumstances mentioned.

The commencement of the third stage is synchronous with the beginning of lateral deviation. This predisposition of the dorsal segments or vertebræ to combined lateral and rotatory alteration would be presumed to be as strong towards one side as the other. This is not so, as in only a small percentage of instances does the convexity of the dorsal curve point to the left. Many reasons have been advanced to account for this, but none of sufficient strength to bear reliance, and the fact remains as inexplicable as the one-sidedness of a flounder's face.

The dorsal segments further differ from those elsewhere in having the ribs as intimate relations, and such is the closeness of these two that what moves the one moves the others in kindred manner. Every one is fairly familiar with the nature of their connections, and how the ribs, lying in seried sequence, form, with the spine and the breast-bone, the walls of the chest. Without pausing at present to dwell on these points in detail, it suffices to say that, in the ordinary to-and-fro movements of the dorsal segments, as in breathing, or bending, or bowing, the ribs preserve their relative parallelism, and the chest its symmetry, but that should anything arise to cause lateral deviation of these segments, then the ribs will, fan-like, separate on the convex side of the curve, and collapse on the concave one.

Hence it happens that, when from atonicity of the spinal musculo-nervous elements there arises loss of

erectile power over the vertebræ, and an impotence to maintain the natural curves, then the dorsal segments tend to follow their predispositions, and the ribs in turn follow their suit. So (taking the common case) the spine curves with its convexity to the right, and the segments are rotated back on that side, on which also the ribs, *à priori*, separating expand that half of the chest, and revolving also with the vertebræ, give rise to the appearance known as growing out of the shoulder.

The actual shoulder-blade, overlying as it does the ribs in these parts, follows them in their erratic course, and, being further irregularly controlled by its own muscles and connections to the clavicle, under the novel circumstances, assumes a characteristic position on the side of the altered thorax. On the opposite side the reverse changes take place.

It is very apparent that such a metamorphosis entirely upsets the lateral symmetry of the body's form and weight; for the right side of the chest becomes greatly preponderant over the left, in virtue of its increased bulk, while the right arm acquires, from the more distant position in relation to the middle line it has assumed, an additional dynamic leverage, and the person becomes in a similar plight to any one carrying a heavy weight in the right hand.

And what takes place temporarily when one so carries a weight, and may be observed by watching a maid carrying a pailful of water, becomes the permanent condition in this case. The restituent tendency of the spine initiates the formation of a lateral curve

in the loins with a direction the opposite to that in the back. For although the tonicity of the musculo-nervous elements, having fallen below par, as it were, is insufficient to continue naturally the more normal curves of the spine, there is amply sufficient potency left to them to determine the formation of a restituent curve, if needs be. This restituent lumbar curve has been styled "secondary." As regards the time of its formation, this term conveys an erroneous impression, it being simultaneous with the dorsal one in the period of its occurrence. The energy exerted in the production of both curves is identical; the obstacles to their progress may vary, the tissues in one part offering greater opposition than in the other. On the other hand, respecting the manner of origin, the lumbar curve is secondary, being only restituent, whereas the dorsal is initial, and arises from the reasons given.

The third stage, then, will be observed to include a great number of complexities, having a mechanical connection, and the right to be so grouped together.

The fourth stage commences when accommodative absorption of tissue, more particularly bony, takes place. The term accommodative is advisedly used in contradistinction to morbid absorption (which last will be later discussed). The former it is which, to quote a familiar instance, determines the absorption of the fangs of a child's first teeth, in subordination to the second ones, which are growing up through the jaw at shedding time. The case is somewhat similar with the spine.

All tissues absorb or atrophy under direct unnatural

pressure; some, as fat, can be regenerated, but most, bone amongst them, cannot. The changes described in the three prior stages may proceed a considerable way without actual destruction of irregenerable tissue, but there arrives a point where the bony surfaces, becoming closely and intolerably brought into pressing contact, are strained beyond their material endurance, and disappearance or absorption sets in. The gravity of such a state can barely be overestimated, as the spinal mechanism undergoes a process of actual destruction, the ravages of which are irreparable.

Up to this point deformity with correct care can be obliterated; after it such a result can scarcely be so feasible. Henceforth the processes of change lack regularity, for accommodative absorption is fickle in its course and variable in different persons. The regularity of the proceeding stages depends on the existence of structures which, by their shape and firmness, determine the line pursued. Absorption destroys shape and regularity at the same time; exaggerated increase of the curves and deformity follow, involving derangement of the other parts of the body (which, as already mentioned, are like the spine under gravital law), but in such an indefinite manner that, although when an extreme case comes under observation it is not difficult to determine the rationale of its production, it is, nevertheless, impossible to predicate with exactitude the track that will be pursued in the later stages of another case, whose initial ones were identical. Their description, therefore, is practically impracticable.

B. It is to be noted that in the previous and typical account of perhaps the most common kind of curvature, it has been assumed that a general and equable musculo-nervous debility, and not a local or irregular affection, is the *prima causa* of the ill. The theoretical consideration of the results would justify this premise, even were stronger evidence lacking.

There is, however, a large class of curvature falling within the musculo-nervous category which does depend for its origin on local and irregular imperfections, most usually referable to nervous lesions or muscular injuries or infirmities. The government of the career of such curvatures lies vested in precisely the same laws as those regulating atonic curvature, and a similar subjection to the modifying influences of the structures involved and to their predispositions obtains. Thus, the primitive curve commencing disturbs the balance of the body, while a restituent complementary one arises to restore that balance within the more fusile scope of gravital control, and this see-saw continues till a natural or artificial check is put to it.

2. The osseo-ligamentous or passive portions of the spine as a machine are the bones and ligaments, which by their cunningness of device, divert and adapt the powers generated by the muscles to the requirements of the gravital head-centre in its constant work of regulating the balance of the body.

Morbid disintegration of these passive parts (using

now the term morbid in contradistinction to accommodative) may apparently attack any one at any age. Its initiation is usually attributed to a blow or a jolt; still there is no evidence to show why it should not spontaneously originate, and the statement of its invariable connection with a strumous or rheumatic constitution may be fallacious. Its external evidences or symptoms form a course which lacks the same restriction to a set track as that adhered to in musculo-nervous curvature. Their commencement is preluded by general malaise. Pain is experienced in the course of the spinal column, at times distinctly referable to a particular spot, at others, vaguely diffused over a greater area, which becomes oversensitive to touch and temperature. A palpable point of weakness and tenderness becomes apparent in certain segments of the column, to throw as little strain as possible on which every effort, consciously or otherwise, is made by the patient. A constrained gait and strong disinclination to stoop or in any way jar the body is evinced, while all its natural pliancy is usurped by a self-imposed stiffness. Opposite the weak point referred to an irregularity or eminence from the evenness of the spine arises, over which the covering tissues generally show signs of an inflammatory kind, and the column changes its form not in an undulatory way, but in so abrupt a manner as to be styled angular. The health is impaired, and the seat of evil becoming a field for abscesses of an aggravated kind, a further strain is thrown on the already injured system. Secondary symptoms, more

especially of a nervous kind, set in, and complicate the condition.

The natural check and termination to the disease consists of cessation of the morbid processes, and a patching up of the injured structures, involving bony union of the damaged segments. Inflammation disappears; deformity remains, and with it such secondary symptoms as its permanence may entail. Subsequently there succeeds a stage, very frequently ignored, during which the entire spine becomes the subject of restituent changes, consequent on the existence of an unnatural curvature and rigidity in part of its course, out of working harmony with the remainder.

The time through which these processes may extend is vaguely variable. Sometimes a few months will comprise all; on the other hand, chronic abscesses remain unclosed occasionally for years. Accurate determination of the continuance of the malady is therefore impracticable.

The more hidden and occult operations which determine the appearance of the foregoing changes are simple. The deteriorating disease attacks the segments of the column, rendering them soft and depriving them of that consistency on which their utility depends. At the same time the results of disintegration, the débris as it were of this morbid destruction, are collected at the spot and left for nature to deal with.

Now, as regards the softening and resolution of the segments, it is obvious that if the stability of any of

the three surfaces by which each touches its fellows above and below should be impaired, and these surfaces give way, deformity must arise; a breach in the static continuity of the segments being made, and the spinal mechanism put out of gear. Should it happen, however, that, the surfaces of contact being left intact, those parts only of the segments to which muscles or ligaments are fixed be injured, then although intense pain and much inflammation are produced, the spinal mechanism may be but slightly involved, only in fact in so far as the play of the said muscles and ligaments are concerned, and the symptoms may appear and pass off without great after detriment to the spine as a machine. Most usually the surfaces are impaired, and the breach in continuity made. Then the spine is practically divided into two healthy parts, meeting in an inflamed and painful part, and being in the condition of a fractured bone every effort is made against its movement.

In the case of atonic curvature, the integrity of the tissues was, until the advent of accommodative absorption, respected. In the present instance this is not so; and, further, such is the nature of the manner in which the morbid action sets to work that the entire neighbourhood of the destruction becomes pervaded by inflammatory phenomena, which appear in the outlying tissues, and preparations have to be made for the removal of débris.

At this point things are clearer and more interesting under metaphor. The entire human body is a republic, and is constituted of the relics of dead and

the bodies of multitudinous and minute living workers, whose constant birth, life, and death make them analogically resemble the generations of men. Each human being begins his life as one of these, and this said unit starts the family whose increases are concordant with the growth of the man. And thus man, so particularly esteemed individual, is really a kind of locomotive country with myriads of inhabitants, little busy bodies, technically termed "corpuscles," who build up their own continent and inhabit it.

Their birth-place, their nursery, and their manner of education, affords interesting matter for the researches of curious histologists. These wee workers, notwithstanding the republican advantages they enjoy, are gifted either through natural talent or through their educational training with varying aptitudes, and assume positions in accordance with the powers they have developed.

Some hold exalted offices in the brain, some responsible positions in the vital organs, others subsidiary posts elsewhere. All display the strongest sense of the subservience of individual interests to those of the community, their actual lives terminating in the performance of their duty. Taking the skin as a simple example. In the vast dermic region a corpuscle is born, eats and drinks, reaches reasonable and adult age, takes a good situation, doing duty like a brick, and placing himself *in sitú* among his fellows, to die and dry and form a piece in the beautiful tesselation which epidermically paves the surface of the body; this pavement being a veritable catacomb of conscien-

tious corpuscles. And so through the entire commonwealth, each has his work to do and does it; and even those whose inherent idleness may suffer them to grow gross, degenerate, and fat, become utilised in time of need to satisfy the cannibal cravings of their more industrious fellow countrymen.

As might be expected among so perfectly organised a people, the regime is most stringent, and the government as powerful and invisible as that of antique Venice, and as severely secret; and the council of its constitution has baffled the inquisition of the profoundest philosophers in their attempts to determine its character, although the locality of the council chamber may be said to have been approximately ascertained.

Reverting from the people to their works through the country. The hygienic dispositions are perfect, the public buildings miracles of architectural art, the machineries display consummate evidence of engineering ability, and an order pervades in everything so exact, and a subservience to authority so grand, as to be a pattern to shame the governments of the world. The entire country is pervaded by rivulets, streamlets, canals, and reservoirs, which form waterways, serving as a complete system of irrigation for supply as well as of drainage, by which superfluities are carried away for dispensation. They form further highways, along which travel (as every microscopist knows) the redcoated officials of the commonwealth. It is equally well known that a less numerous aristocracy of white-garbed grandees are more hardily in the habit of

journeying, so to say, by land, passing as knight-errants through the tissues, ready ever to right what is wrong that may arise.

These things being so, a more lucid idea of the processes that go on in the region of the spinal segments may be pictured. The substance of the segments is morbidly attacked, and softening, breaks up. The onus of carrying off the débris is ordinarily borne by the waterways, before referred to, in their capacity as drainage works. The rivulets and canals accommodatively alter and enlarge to meet the exigencies of the work imposed upon them, and this enlargement involves those of the adjoining neighbourhood. In accordance with the amount of débris to be removed, so the enlargement takes place, there being more or less inflammation both in degree and in area. Strict supervision has also to be maintained to preclude the possibility of an excess of morbid material being at any time thrown into the waterways, for, unless this were controlled, the corpuscles and tissues along their course would be as effectually poisoned as are fish and plants in a river below a manufacturing mill, whose deleterious waste products are discharged into it, and the entire commonwealth would be injured. When, however, the waterways prove inadequate to effect immediate removal of the rubbish, then another procedure is resorted to. Troops of errant corpuscles hurry under orders to the spot and commence a series of operations, the object of which is to gather together the débris and form for it a reservoir in which to await a convenient time and method of dispersion.

This reservoir is occasionally the sole necessity, and acts as a mediator between the accumulating débris and the waterways, receiving the former and discharging with sanitary safety and regularity into the latter. When, however, the engineering department of the commonwealth esteem the case of sufficient gravity to justify stronger means, then a direct cutting is formed to the surface, and the offensive matters got quit of. More briefly, an abscess may form; and, if so, be either absorbed or opened.

Now, there naturally comes the time when morbid disintegration of the spinal segments ceases, and when reparation for the damages done has to be made. In the human body this is effected by a kind of patchwork; actual reconstruction in shape is not practised by animals so high in the scale as man. Those of lower grade are luckier; a newt, for instance, will undergo six or eight successive amputations of its tail, each time reproducing a new tail as perfect as its predecessor. But in man the reparative process, in this spinal instance, is confined to the deposition of new bone, without any provision being made for the renewal of former form, or for preserving the individuality of each segment. A detachment of errant corpuscles, wearing the same uniform as, but with different aptitudes from, those which construct the reservoir and cutting alluded to, proceed to the spot, and supervise the laying down of new bone of structural identity with the previous, but in such a way generally as to solder the segments that were involved rigidly into one piece. This, with the final removal of

the débris of the operations, and the restoration of the neighbourhood to its quiet condition, comprises the natural recovery of the spine from its injury. But although as a machine sound and secure again, it labours in action under this disadvantageous difference from its former self, inasmuch as the function of the injured parts is marred, and further, during their softened condition, such change of shape occurred at the weakened point as to alter the relations of the spine as a whole, so that it no longer holds that position which is most facile for the performance of its duties, but which it will continuously tend to adopt in virtue of restituency. The restituent alterations which ensue may or may not be serious. If slight they cause no inconvenience, and are barely perceptible, the only fact noticed being that the patient apparently becomes more used to the original deformity. On the other hand, they may be so excessive as to produce grave increase of deformity, or to start afresh through overstrain, at any particular part, an attack of the osseo-ligamentous malady.

The manner and degree in which the formation of these restituent curves should be aided or interfered with will fall for consideration into a later chapter.

Curvature of Extrinsic Origin

Curvature of intrinsic origin, as just reviewed, has been seen to originate from direct disease of the spinal machine, either involving its musculo-nervous functions or its osseo-ligamentous structures, and to be wholly independent of other bodily disturbances. Extrinsic curvature, on the contrary, presupposes a completely healthy and orderly state of the spinal mechanism, and may be regarded as arising from an accident indirectly affecting that mechanism, such accident disturbing either the symmetry of position of the arches which bear the spine below, or the symmetry of mass of the parts borne by the spine above, and initiating the restituent assumption by the spine of novel directions in accordance with these changes.

As every person, at any time, may be liable to these deranging accidents, so no age nor individual can enjoy a certainty of immunity from this form of curvature.

The causes of extrinsic curvature, as embraced in the above epitome, are exceedingly numerous, and form a somewhat lengthy, if not uninteresting, category, but can be classified from the build of the body, in accordance with the level of the injured parts, as damage to a house would be by the number and position of its storeys.

Respecting the spine, however, the whole thing resolves itself into a question of alteration of base or burden. The lowermost segment of the spine is, as

already explained, the keystone of the pelvic arch, of which the legs constitute the piers, and being, under ordinary circumstances, an actual part and parcel of the pelvis as a whole, the pelvis as a whole may be esteemed the base on which is balanced the spine.

The naturally placed pelvis is symmetrical, and swung at the hip-joints on a couple of pivots, similar to those of a ship's compass, which said pivots are propped in position by the right, real, and practical length of the legs.

The pelvis so pivoted is capable of to-and-fro movements under government of certain muscles, and within the restraint of certain ligaments. It is subject, also, to lateral deviations through alterations in the real or practical length of the legs. The pelvis is naturally also in a position which depends for its stability on muscular control, which control subserves the same gravital law as that which governs the spine itself.

The usual *status quo* of the pelvis as a base being such, disturbance will depend on one of three things: deformity of the pelvis, recognisable by manipulative tact; to-and-fro alterations (more scientifically expressed as change of the pelvic plane), with more difficulty determined, as the means of gauging it have been somewhat indefinite; or, lastly, lateral deviation, easily marked with exactitude, as the natural and symmetrical identity of each side makes error the more obvious.

Proceeding, then, to consider these causes more particularly.

In rickets, or osteomalacia, the pelvis sometimes softens and loses, at the same time, its firmness and its form. This loss invariably violates the truth of the spinal base.

The pelvic pivots not unfrequently become, through disease, fixed, through accident fractured, or by injury dislocated. The harmonious regularity of their clique of guardian muscles becomes disturbed in consequence of contraction or paralysis of some of its members. These states are inevitably fatal to the fairness of the pelvic position, which changes to an unnatural one in the two-and-fro direction, the plane being altered.

Correctness of the pelvic position laterally depends on the due maintenance of the practically even length of the legs. It is possible for the two legs to be identical in length, but for one to be, through impaired efficiency, practically shorter than the other, and to produce effects identical with what would arise if it were really so. This is made clearer by comparing the ordinary pin artificial leg, such as Government supplies to its old soldiers, with an artificial limb naturally jointed in imitation of the ordinary bony parts. In the first instance the rigid pin, although making with its stump a length the same as that of the sound leg, yet never is capable of use, so as to keep the pelvic pivot of its side at a right height, and, therefore, though really true in length, is practically untrue. In the second instance the imitation is really and practically as true as the original.

Real shortening results from arrested development or arisen deformity. The most fruitful causes of the

latter are rickety curving of the thigh or leg, ligamentous weakness at the joints of the knee, ankle, and feet, and contractile changes.

Practical shortening is produced by stiffness in joints, checking their natural mode of action, by even so trivial a trifle as a sore foot, and for the same reason, or by having an ill-constructed artificial limb, in the event of loss of the carnal one. This closes the category of base deranging causes.

The alterations in symmetry of burden borne by the spine are simple and few, being comprised chiefly in differences that may arise between the weights of the arms, owing to one of them having been abortive, withered, or amputated, or in serious displacement of the head such as are seen in wry neck.

Reviewing so many diverse provocations, it becomes readily intelligible that the deformity ensuing from restituent efforts to place matters on a better gravital footing, must be equally various and liable to be excited in any direction and at any point of the spine. Detailed descriptions of their varieties are unnecessary, as the governing principle is in all cases the same, and once clear, gives the key by which causes can be deduced from results, the unnatural be reverted to the natural from which it has lapsed, and the deformed be reformed. The restituent processes follow the path already laid down, but from the presumably perfect health of the muscles are more vigorous than in the atonic class of curvature.

In the light of these considerations, curvature of

extreme apparent irregularity can be seen to be rationally much the reverse.

Complicated Curvature

There have been described three great types of curvature as separately existent. There is no reason why they should not be coexistent, why one unfortunate individual should not at one time be afflicted simultaneously with the causes of all three, the case being a knotty tangle of three threads as it were. To disengage the knots, however, each thread would separately have to be held in view, and so also each type of curvature would present its own bearings in the mechanical diagnosis of the case.

Congenital curvature has been passed over in silence, because, if the deformity has arisen from an oversight of nature in the construction of the infant, if in fact the child is structurally deficient as a machine, then the case is constituted an extraneous one, and the rationale of its production is beyond scientific ken. If, on the other hand, as appears possible, in the latest stages of pregnancy, a child has acquired curvature of an ordinary type, then although the acquisition must be admitted to be precocious, the case falls simply under the foregoing types.

Secondary Symptoms

The human body has thus far been viewed as an unfurnished house. To its stability certain shocks have been considered offered and their effects scanned; how its uprightness was destroyed, its walls injured, its interior form impaired. Meanwhile the rooms and furniture, as it were, have remained unnoticed; the building was alone examined, the upholstery ignored. The chambers of the body, with their contained organs, are the metaphorical rooms and furniture, and the secondary symptoms are the evidences which are exhibited of the mechanical dislocation and derangement to which in all the kinds of curvature enumerated they are subjected, in a degree of course corresponding with the severity of spinal alteration.

Passing then from room to room. The brain is the head telegraph office, and from it emanates the spinal cord or entirely collected bundle of telegraphic wires. This in its turn splits into smaller congregations of wires, the spinal nerves in which the process of splitting up is continued till the individual wires are conveyed to their terminal offices in the muscles, skin, or other tissues. The brain and spinal cord occupy the chambers, pointed out previously as existing in the skull and spinal column, and the spinal nerves make their exit from the spinal canal through numerous little doorways situated at the junctions of the spinal segments. The brain rests as well protected in the skull as a kernel in its shell; the spinal cord is com-

paratively thin and lies very loosely in its bony clothing; but the nerves are sufficiently corpulent that they more fairly fill their doorways in their passage through. Hence it happens when the spine itself becomes unnaturally curved, that the brain is obviously unaffected; the cord but slightly so, save in extreme flexions; while the less fortunate nerves from their positions in exit get more mercilessly pinched or dragged. Now the nervous wires have messages transmitted along them in both directions. Those from the brain outwards are the impulsive orders which set muscle at work, those from the terminal stations brainwards convey general intelligence of the condition of the regions from which they are sent, and if aught is wrong are usually of a painful nature. The nervous system of telegraphy further makes and receives communications to and from a subsidiary system, the sympathetic which may be stated to be one of surveillance over the bodily organs in their performing their functions. As in the case of a submarine cable, an injury in its course may completely cut communication between the terminal offices, or may so derange the transmission of electric impulses that they pass with wanton and useless irregularity; and as further, it is found that the ocean itself at the injured portion transmits meaningless messages both ways; so in the case of a nerve being nipped, analogous phenomena are exhibited. If the nerve is functionally cut, then the muscles it commands are under paralysis, and the regions generally, to which it is distributed, fail to keep the head-centre

cognisant of their condition, and become ill governed, suffering chilliness and other disagreebles, as well as lapsing into insensibility and lack of feeling. If the nerve is but partially impaired, then partial or intermittent modifications of the same mishaps result, spasmodic disobedience of muscles; if the locomotive ones, locomotor ataxy; if the respiratory ones, difficulty in breathing. Further, at the point of injury meaningless messages or impulses are initiated, those brainwards conveying the sensation of pain in the regions to which the finer fibres course, those outwards producing convulsive twitchings of the muscles. Lastly, the sympathetic system may be vaguely affected, and through it the functions of the organs it governs.

Proceeding next to the chamber of the chest, the repository of what may aptly be termed the gas- and water-works of the body. It contains, packed with extreme nicety, the heart and lungs, both of them pumps, one of fluid, the others of air. The heart, although very intricate in its mechanism, and in the most delicate subjection to mental or physical shocks, is nevertheless fairly independent of the pliancy of the chest, and has its action impaired only by serious dislocative changes which upset the relations of its parts and pipes. In antithesis to the heart, the lungs do not pump for themselves, but rely in great part on the ribs for this labour; and they in turn discharge that duty with full propriety only so long as their natural mobility and shape is undisturbed. How their pliancy and form is deranged has been shown, and of this

conjunction is bred difficulty and shortness of breath, deficient aeration of the blood in the lungs, pallidity and the other sequences of respiratory inefficiency. Descending to the abdomen. This is the kitchen of the human body; its organs the utensils of cooking. By them the food is prepared, treated, and dished up in fit form to be taken as nourishment by the economy. They are slung within this chamber from its walls and ceilings with the greatest apparent laxity. Really their dispositions are perfectly ordered, and they are ranged one above the other with a precision on the nicety and aptness of which depends the due discharge of their digestive duties. Some are subject to the freest movement, but always within proper and prescribed limits. So long as the ordained tether is not exceeded, great liberties of motion are capable with immunity. On the contrary, when the legal bounds are broken, when the spine, the mast to which these said organs are directly or indirectly rigged, so changes that their lines of suspension become lax, then they fall into a huddled heap one on the other, and their functions are fouled, there being loss of alimentary tone, digestive derangements, and such constitutional disturbances as are dependent on ill or perverted nutrition.

There is a further piece of furniture in the female abdomen—the womb and its accompaniments. It is one of the drawbacks of the dignified and upright position mankind, in contrast to other beasts, has assumed, that this organ becomes exposed to notable disadvantages and dangers. In lieu of being slung,

it is in woman moored as it were in a bony basin; it does not hang, it is rather propped. Naturally, it maintains an intact and uninterfered-with situation by right of its own rigidity, the tension of its moorings, and the correct level of the bony basin. But these elements of its even disposition are somewhat unstable, and over it, like the sword of Damocles, impend the other viscera.

Now, alterations in the shape and position of the organ are among the commonest causes of many of the uterine maladies which so afflict the civilised sections of the human family, and such alterations originate either from tissue-changes of the organ and its appendages, from loss of level of the basin, or from aggressive descent of the other intestines. Of these origins, the first, being wholly unconnected with spinal curvature, will need no further comment; but the two latter, equally common, are intimately dependent on the state of the spine, and the clean and logical connection between the spine and the uterus in these respects, as well as the practical mode of influencing the latter through the former, will be later reviewed.

CHAPTER III

PRINCIPLES OF REVERSION FROM UNNATURAL TO NATURAL

Of the two previous chapters the first was devoted to viewing the natural spine, the second to recording its lapse with various unnatural conditions. This chapter will be given to the broad consideration of the possibility of reverting the unnatural to the natural again, or, in homely words, of curing spinal curvature.

Recapitulating briefly, the spine has been shown as a piece of machinery with distinction into motor agents, and the devices for converting such agency into work. The real restituent aim of this machine and the gravital law by which the whole is governed has been described. The effects of its unnatural derangement on the body and the organs have been detailed, and the derangements themselves exhaustively classified in accordance with their causes.

As, however, reversionary cure has to begin, as it were, at the distant end of the lane, one faces now the deleterious results, and with them the fact that all cases presentable for reversionary treatment must exhibit either active disintegration of the spine itself, or erring relations of the balancing mechanism, and the parts it connects and controls.

Nature, or, more strictly speaking, that innate constitutional power which, in living beings, presides over the commonwealth of their parts, organs, and members, making one and all subserve the general welfare of the being, and modifying through the changing circumstances of life that being, so as best to adapt it to its shifting relations—Nature is ever ready to remedy in a definite way, and to the best of her ability, the damages disease may do to the creature under her control; and against the attacks of many human maladies she has such perfect ability to cope that the sufferer, after the battle fought, comes off as sound as before it.

Roughly regarded, however, her readiness and competency in matters of destruction of form or tissue are unfortunately unequal. A glaring example of the impotence of human nature on these points as compared with that of inferior animals was instanced in the case of the newt, previously quoted, as the subject of sundry caudate experiments. Gauging, then, Nature's capacity in spinal matters. In active disintegration of the bony segments of the spine the natural structural cure is osseous repair. New bricks, it is true, cannot be made, but a creditable patch is possible. This is better the more favorable the circumstances, and the circumstances required are constitutional invigoration and passive quiet of the diseased parts. The former nature may insure, the latter is without her province, neither is it within her control any more than the weather is within that of a bricklayer; the frost comes and his work is marred. When, however, the

structural cure at the patch-point is completed, there is greater or less angular change of form; nature then directs her efforts to bring the machine within more facile subjection to gravital impulses by inaugurating restituent curves further destructive of symmetry, and often injurious from their hurried execution to the entity corporate. Nature, in fact, overleaps herself.

Turning next to curvature from erring relations of the balancing mechanism, or the parts it connects and controls, nature offers but one course, and no cure. She increases the departure from symmetry by her restituent efforts. She reproduces in reverse, but in duplicate the losses of shape. Disease strikes an intaglio, nature moulds by it a bas-relief. Disease starts a primary curve; nature, heedless of form, and for ever bent on function, initiates a secondary one. The cure of nature, curious as it sounds, is check only, not reversion. It is obvious, then, that nature sole is a poor proficient in matters of symmetry.

Nature being thus inept, there devolves the necessity for considering to what power one may appeal in the predicament. Now, the word nature (and prolixity on this point will prove pardonable as the link in a line of logic) has been used to express that power which ordains the prescribed order that exists among created things, and which governs the similarity creatures have to each other according to their kind. To enlarge: one dog resembles another dog broadly, those of the same breed each other more closely, while a cow or a lobster are dissimilar in their degree from dogs; yet in their earliest stages they all present no

possibly perceptible difference; they start as ova along the same highway; nature determines the choice of byeways. In obedience, as it were, to nature, a boy grows into a man in a prescribed manner, and, as far as presumption can go, there is no precedent reason for imagining that a boy should change his natural course and develop into any other animal. This eductive definition of nature may seem a somewhat sorry one; it is possible to draw closer. The identity of form between things of the same kind is the result of identity of forces in their creation; and, further, as the pole of a tent is held *in sitú* by cords pulling with even forces in opposite directions, so all things that are maintain their *status quo* by the balance of opposing powers, and alter it by preponderance, for the time being, of one of the elements in the balance. All things are by opposition; if the forces of the universe were unanimous, creation itself would be swept away.

Building, then, on this basis, nature is the power personified that balances and regulates this opposition, and to whom obedience constitutes the natural, disobedience the unnatural.

Lastly, the sciences comprise man's recorded experience (while diving in search beneath the surface of his circumstances) of the arrangement and derangements of the forces that enter into the said balances.

This throws light along the way of escape from the horns of a dilemma on which the line of argument hung in suspense. The spine and body were described

in ordered obedience to nature, their disorders then detailed, and the inability of nature spontaneously to restore order affirmed. The puzzle arose as to what coercive agency could be employed to attain this restoration; the key lies embodied in the sciences. And of the sciences, those which have the power to respond to the call are the medical and mechanical. It will be well then at once to draw a clear line of distinction between the provinces of these two colleagues; because, when the exact junctures at which the services of either can be utilised have been determined, it is intended to enter more minutely into the mechanical powers; but to leave the medical untouched, as the property of more qualified pens.

The present Houses of Parliament were built of magnesian limestone. It was discovered, when too late, that this element in their constitution had a hapless incapacity for withstanding the humid atmosphere of a riverside situation: and that there was threatened in consequence a consumptive disintegration of the stone under whose influence the walls would crumble away, and the beautiful tracery perish. To meet this misfortune, and to check such atmospheric vandalism, there was with wisdom concocted a solution, whose virtue lay in the fact that it permeated and saturated the stonework on which it was washed, and chemically conferred on it immunity from the injury. Damage from damp became impossible. The leaning belfry of Pisa, on the contrary, marble-made, has withstood the weather's inclemency for centuries, but its base has lapsed with time and it has lost the

original uprightness its maker gave it. All the sousing with solutions imaginable would fail to restore its lacking erectness. Propping would stay its passage into a more precarious position, but restitution of the base would alone effectually reform the vagrant inclination it has assumed. These two instances mark, by an architectural metaphor, the broad distinction that lies, in this special instance, between medicine and mechanics, whose capacities can now be separated so as to eliminate the one while considering the other.

Extrinsic curvature (if its distinctions have been followed) will have been found to be, *per se*, wholly devoid in its origin of constitutional miscarriage; nay, the more perfect the constitutional condition, the more confirmed the impulse with which restituent deformity asserts itself. Medicinal modification of the constitution would then, in this class of cases, be unneeded. Intrinsic curvature is circumstanced differently. Its origin being constitutional, the body is like a house into which disease or ill health hurry to enter. Medical science stands as the hall porter, with power in that post to bar the door, or to show the intruder out, if his entry has necessitated this. But it has no power in this instance to correct the material mischief the aggressor inflicts. The damaged walls and furniture must be set right by proper workmen, and these proper workmen are Mechanics. Putting this point more particularly. Granted that the constitutional condition necessary to start curvature impends, then it is perfectly practicable to stave off the incipient malady by medicinal alteration of the constitution for

the healthier. This is slamming the door in the face of disease. Or, when disease has entered, the constitution can be aided to rid itself of the nuisance, to eject it, or, in the parlance of the hall porter, to kick it out of doors. But neither bodily deformity, nor that organic deformity or dislocation which is manifested in the secondary symptoms, are medicinally remediable; their treatment lies within the province of mechanics. In short, then, prevention or determination of the lapse from the natural to the unnatural spine may, in some cases, be effected by physic; but, in all cases, the reversion from the unnatural to the natural is a mechanical problem, and as such will be now reviewed, together with certain subsidiary auxilliaries, as gymnastics and electricity, which will be discussed *en passant* in their proper place.

This leads to the necessity for inquiring into the mechanical means at command and their manner of employment, and for introducing the word "Orthopraxy" to embody the idea of that science which, by material means, converts, adapts, and applies the mechanical forces extant, directly to and for the benefit of the human frame; a science whose scope and aim will be with greater clearness conceived by the considerations following.

The human body has been shown to be a magnificently constructed machine. Under ordinary and natural circumstances its formation is mathematically perfect, its material strengths and motor powers entirely adequate to its wants, and its integrity unimpaired. Under extraordinary ones its symmetrical

accuracy becomes lost or lapses into distortion, its inherent abilities diminished, and its members abortive or accidentally removed. The human machine in short becomes in some point defective, and in these conditions a complementary mechanism or "Orthopragm" is adapted to *make good* the deficiency. What the one machine lacks the adjunct supplies, and to rightly effect this object and coadaptation in harmonious subservience to the complex peculiarities of the frame is the end and object of orthopraxy. Illustrating this matter by instance; a man has the mischance to lose his leg, and at the same time his previous power of walking. The artificial member which supplies its place, and makes good the lost form and function is an orthopragm, and the more perfect and natural the substitute, the more accordant with the principles of orthopraxy is it. Or, again, a person suffers by paralysis loss of power in certain muscles of his leg. The movements of the joints around which these muscles play cease to be rightly balanced, and a halting gait preludes the way to actual deformity. Here none the less is an orthopragm necessitated to make good the perdition of power and restore evenness of equilibrium. Lastly, choosing a minor and more homely example, one cuts their leg and the continuity of tissue at the wound is destroyed. The piece of plaster which by its coherence makes good the lost cohesion of the skin and flesh is an orthopragm, although a very modest one. And in the diverse degrees which lie between the complexity of the first and the simplicity of the last of these three

exemplary instances there are many kinds of orthopragms, and although at first and casual glance they bear no relation to one another, yet all fall easily within the terms of the definition given, and are subject to the general statements which succeed.

All orthopragms are passive or active; many are both.

The passive impart through a diffuse hold their own properties to the parts to which they are applied, to wit, the sticking plaster just quoted. They exercise no motive, no kinetic force. A moulded leathern splint for instance, has for its object the quiescence of the parts to which it is adapted, and with the greatest generality and spread of hold combines the minimum of actively exerted power, the intrinsic immobility of the hardened leather being alone called on to resist the instability of the parts protected.

Active orthopragms are less simply constituted. When Archimedes, years since, stood godfather to Mechanics, he gave his benediction to the science in this dictum, "If you are given but a sufficiently stable point you can move the universe." In this material world of gravity every action must have its basis, the more fixed the which, the more efficient the act. So every acting orthopragm must have its hold and that doubly so, the one being the secure *point d'appui* from which the agent acts, the other the grip through which the force is transmitted to the mass to be moved. For as a man bodily barring the door against intruders plants his feet firmly on the floor to gain a hold from which to push, and forces his hands and

may be his shoulders against the panels to grip the woodwork, and then puts forth the strength of his intermediate body in efforts to overbalance those of his opponents, so, in analogy, the orthopragm must have its two holds, that of basis and that of transmission, while to the exertions of the intermediate agent its efficacy as an active orthopragm is due.

Now the said holds, forming as they do points of coadaptation between the body and the orthopragm, have to be judiciously and carefully chosen with a view both to the mechanical necessities of the orthopragm as well as the anatomical delicacies of the body. Gracing this statement by example. The man mentioned above would have intuitively picked the positions of greatest vantage for feet and shoulders whilst guarding his door; and just in like manner the orthopragmatic holds must be knowingly selected to yield to the agent the fullest facilities for action. Again, as the holds are usually compelled to have such firmness that their grasp may be transferred through the medium of the softer tissues to the skeletal framework of the body, so also immunity must be reserved for these tissues, that their vitality be not impaired nor their function deranged; this being especially the case with a powerfully alterative orthopragm (as a clubfoot appliance) where instrumental force is pushed to its extremest limits compatible with the soundness of the softer tissues, in overcoming the resistance of the harder ones.

In passing next to the agents, a similarly duplex view has to be taken, and the exigencies of both the

body and its adjunct respected. For the body is like a dress in which, although only a certain fabric is externally apparent, yet there are others underlying, as bones and buckram for stiffness, wadding for padding, linen for lining, and so on. So there are varying tissues of the body with differing properties, some pliant, some firm, some feeble, some powerful; and as the tissues are, so must the orthopragmatic agencies be which chance to have to oppose them.

The orthopragmatic agencies themselves or mechanical powers employed by the orthopractician are of the simplest kind, and it is wholly needless to compile several pages of elementary mechanics to render them intelligible; they lie within the scientific repertoire of every schoolboy. Yet, in passing, there is amongst them a broad and clear distinction to be made of fundamental moment, namely, the differences between irresilient and elastic forces.

Of the former screw force can be taken as the type. Inelastic, irresilient, and at will irresistible, the tissues of the body are impotent against it in opposition, and the bounds to its alterative action are alone set by the pain and inflammation attendant on its extreme use, and by the excessive burden laid on the holds above mentioned.

In contending with strong ligamentous adhesions, and generally in overpowering tissues in which the fibrous element preponderates over others, it is invaluable, and in these cases only. Its application is ordinarily gradual, but there is no reason why many of the anæsthetic operations for breaking down resisting

tissues could not be performed instantly by screw force with more precision than is manually attainable, and with this further advantage, that the instrument would subsequently serve as a passive splint during the convalescent processes.

But it is to the elastic powers that one must turn for true alterative correction, when this has to be actively administered to the body, and for the reasons following. Every one is tritely cognisant of the fact that all things that live tend in growing up to assume, and when fully grown to maintain, a certain definite shape, according to the vital power of the being. This vital power has been nicknamed the plastic. Again, elastic force is that in virtue of which bodies capable of exerting it tend to resume, and on resumption to maintain, a certain definite shape, if in any way they have been deranged from it, and with more or less strength, according to the nature of their material. Hence, material elastic force and vital plastic power are theoretically marked as fit antagonists, and although this logic may seem sophistical, and as such may not appear conclusive, the fact is, nevertheless, a practical truth.

With the body, as with the judge in Scripture, untiring persuasion prevails where violence would only provoke resentment, and it yields to the unceasing importunity of elastic opposition, where more forcible measures would only excite angry and inflammatory action.

This broad and general statement is capable of bearing refinements to particular points. For instance,

taking the muscular system, how perfect is the easy erectness of a well-trained soldier; shoot him, and how flaccid and uncontrollable all the joints become, and what a mass of inertness the man is. This difference is due to the loss of the muscular power which balances the pieces of the body's structure one on the other in the manner described in a previous chapter. The pieces remain as before, but the power of rearing them is gone. Now, every joint has its balancing muscles, and many are the deformities that arise from disturbances of their even influence. There are many stages of muscular influence between the sternness of spastic contraction and the imbecility of paralytic impotence. Mean and midway between these two extremes is the ordinary, healthy, and tonic influence, and it is to its universality that truth of the balance of power is due.

To quote, as a simple example, the ankle-joint. The foot is in it hinged to the leg and at will the toe or the heel can be depressed. The fore and aft muscles to which these actions are due are balanced as two equal children on a seesaw, and the voluntary impulse that governs these heel and toe motions is as the will of the child that jumps to rise. So that, although there is constant action, there is constant balance. But should the balance at the ankle be broken and the fore or the aft set of muscles become relatively weaker or stronger, it is as a heavy child trying to play seesaw in the same place against a light one. In such a case the light boy must be weighted or the seesaw shifted; and so it is with the ankle, if the balance be not in some

way restored, the foot will be shifted, and deformity established. Now, in so trivial a matter as the restoration of childish balance to a seesaw, it would be barely worth while to fatten the light boy till he attained the weight of his more ponderous antagonist, but in the graver instance of the ankle, it is not only necessary to give the weak such aid that it may cope with the strong on even terms, but also to invigorate the weak that it may attain the strength of the strong, and ultimately get quit of aid altogether. This double problem has its simple solution in the following facts.

Exercise is (excepting extraordinary circumstances) the right remedy for weakened or atonic muscles, always provided that such exercise is within their reasonable scope. Beyond that scope excessive exercise only fatigues and further debilitates, it is the moderation within it that invigorates. Thus it is paradoxical, yet true, that exercise can produce reverse effects. Now, with the ankle under consideration, the weaker muscles are so completely overpowered by their domineering opponents, that they lack the least opportunity to take the moderate exercise they require, nay, their every effort being necessarily immoderate, is also deleterious. The aid then that the weaker require is such as shall fully antagonise the superfluous power of the stronger, and enable the former to make the fair exertions necessary to regain their old healthy tonicity. Art must help nature till nature can help herself.

This aid is practically rendered by rightly directed elastic force and by nothing else. If an india-rubber cord be applied to the foot and leg so as to make up,

by the exertion of its elasticity, the differences between the weak and the strong, then the equipoise will be restored, the weak will be placed in a position to act continually for their own reinvigoration, the resistance of the stronger will, if unhealthily spasmodic, be reduced, deformative tendencies of the passive parts (in this case the bones and ligaments of the ankle-joint) will be reversed, and the elastic force requisite will gradually lessen as the weaker muscles reacquire their strength. In short form and function become renewed. Now, the law which underlies and governs these changes is clear in theory and proved by practice. It finds expression thus. That the muscles which are in mechanical relation to any joint are, during their health, tonically balanced around that joint, and that should any of them through ill health become enfeebled, atonic, or overpowered by their respective opponents, the balance is broken and deformity initiated and in time consummated. And further, that balance can be immediately, and form gradually, restored by the addition of an artificial elastic force auxilliary to the weaker muscles; and that under the influence of such addition the natural power of the weaker muscles becomes renewed and the necessity for the artificial aid gradually ceases.

This dictum seems somewhat wordy, but its ordinances, which have been traced in the simple instance of an ankle, are general throughout the body; and its evidences are the more numerous in the matter of the spine, seeing that that organ has a multiplicity of joints, and that its very function is of a balancing nature.

The law therefore serves as a valid basis for the posi-

tive affirmation that those types of spinal curvature, whether incipient or advanced, which have their origin in atonic or spasmodic variations of equilibrium of the muscular system, are remediable only by the active application of *elastic force*, and that passive or other brute means are neither indicated in theory nor attended by practical success.

Now, a muscle when it contracts and exercises itself, does so in obedience to some stimulus, whether natural or artificial, stimulation being a *sine qua non* of action.

The electrical, for example, is an artificial stimulus. One sees occasionally in places of public amusement a person who has taken the ends of the wires of a galvanic machine, and who when the current passes is wholly unable to drop them again, being compelled against wish and will to clench them. This shows the potency of even mild currents to compel muscular action—and electrical stimulation has been advocated as a remedy for muscular impotence, more especially where the latter is very complete. Whatever advantages accrue from this treatment, it is obvious that these are secondary as compared with the necessity of restoring balance first by elastic force which simulates the lost labour of the practically missing muscles, the reasons for this being cogent on the grounds previously given.

Of natural stimuli there are two kinds, those of which we are conscious, and those which act in our ignorance. To take cases in point—a man stands about in every day life without any thought of the act, and keeps his balance unconsciously; if he loses it, it is re-

gained instinctively, barely by will. In contradistinction, a climber hanging by his hands from a rope consciously clenches his fingers on it, and if he lacked the thought or the will to do so, would fall. In the first instance the nervous centres unconsciously govern the act; in the latter, the will does so consciously. Now it is the will that systems of gymnastics, in training debilitated muscles, use as the tutor, and the will is easily wearied. There is compelled and continued consciousness of the operation; this, therefore, becomes irksome. The lessons are naturally intermittent, and their effects are proportionate to their brevity. The feebler muscles act undivided under such disadvantages against the stronger, that they risk incurring fatigue that is deleterious, in lieu of animation that is beneficial. In contrast to this, the elastic system enunciated simply puts the weakened muscles in a position to perform their normal duties, which they do mostly in unconscious obedience to the centres they naturally should obey; there is therefore no weariness, no irksomeness. They go without intermittence through their ordinary daily quota of continuous work, and this being within their scope does not fatigue. They undergo the operation of drill, but anæsthetically. To sum up then: elastic force in its active influences on the body is diplomatically diverse. It can subtilely and surely change or control the form general of the tissues by overcoming their plastic power, while in particular respect to muscle it can act as substitute for the absent, can coax the weak into action, can reduce the arrogant to their proper tone, and can restore around joints the

true balance of power and the fair equilibrium needful for functional ability. The means ordinarily used in orthopraxy for evolving elastic force are compression and traction of india-rubber, or torsion and flexion of tempered steel. On the properties of india-rubber comment is barely needed, one becomes sufficiently acquainted with them in everyday life. Most people are also fairly cognisant of the capacities of steel, and if one is guilty of now introducing facts that are very trite and hackneyed, it is but that they may serve as a stable basis for an important orthopragmatic proposition.

If two thin pieces of steel be put in the centre of a very hot fire, and one on reaching the intense temperature of its surrounding coals be suddenly removed and instantly dropped into cold water, while the other is allowed to remain in the fire as it dies out, to lose its heat with the cinders, and be removed from them only when quite cold, it will be found that the former has been, technically speaking, hardened, the latter softened. If the process is performed with perfection, the one piece is so soft that it will bend in every direction without breaking, the other so hard that any practical attempt to bend it will shiver it to pieces. In the range that lies between these extremes there are various degrees possessing a blending of both qualities, that predominating to which there is nearest relationship. These degrees are termed "tempers." There is thus a kind of scale, whose various degrees have varied properties. Progressing from the hard and fragile temper that lies at the high end towards the softer

end, pliancy increases. There are tempers such that the steel subservient to them will flex more or less, and return sharply to its original shape on the force of flexion ceasing, with strong elastic reaction, but is fragile beyond a certain point of flexion. Descending there is reached the most virtuous temper known, that of a Damascene sword blade, so pliant that it bends till tip meets hilt; so elastic, that it flies instantly to its original form when let go; without fragility, not breaking beneath such flexion; without ductility, not losing its form. Into lower tempers ductility gradually steps, fragility having ceased and elasticity diminishing. These offer a fair opposition to flexion, but suffer the metal under their control to lose its shape immediately to wrenches, and slowly and gradually to less pointed means. Ultimately the lowest and softest temper has but the quality of ductility left.

This may sound intolerantly technical, but the value of these diverse tempers is so great as to need explicit statement. For as in engineering there are perfect and precise methods of attaining the exact combination desirable of the virtues above reviewed, so in orthopraxy it is apparent that such similar and varied conjunctions are needed in correcting defects or exercising control over the form and the tissues. The employment of steel permits this.

Steel in the higher tempers offers a substance for passive orthopragms unparalleled for combined strength and lightness. In the sword tempers it presents with like laxity an activity of elasticity that is most apt for being placed in antagonism to the plastic power of the

body, or for being thrown into the balance to restore muscular equilibrium in the manner previously mentioned. The lower tempers are equally invaluable and might be called governing tempers. For the metal being ductile in them tends to lose its shape with any difficulty or ease one may will. When therefore a part of the body has a proclivity to change its form in a manner too rapid for the welfare of a patient, the apposition of an orthopragm in which steel of such temper is adjoined to the changing part will curb and control the changes, the two, steel and body, changing together only, and the steel having the power to retard such change in any degree according to its temper. The utility of such a capacity can easily be recognised in retarding the restituent changes which not unfrequently take place with injurious rapidity after osseo-ligamentous disease. Lastly, in its softest and most ductile tempers steel can be moulded to the body like lead, and fitted with similar accuracy. By hardening metal so adapted the fit is rendered permanent.

From the aptitude of steel to take spring temper arises the power, perhaps one of the most perfect in orthopraxy, of attaining what may be termed *fitted force*. The extent of this power is verbally couched in the proposition, that to any form a spring can be fitted exerting at any point a force of any needed strength and any desired direction. This multitude of "anys" argues a sweeping width of assertion, a width not however beyond the tether of truth. A very simple illustration of this is an ordinary truss for hernia. The body at the hips is the form to be fitted, the aperture through

which the hernia passes is the point at which the exertion of force is required, whilst the force itself must accord in amount and direction with the impulse and inclination of the hernia. Now, the variability of the human body is such that even in hernia the four factors for satisfaction by a truss spring can be rightly qualified as any. What can be done in the case of a truss spring can be done in all cases, and that with no haphazard indecision, but with mathematical surety and exactness. For a truss spring when open and in action on the body has one shape, but when removed and coiled into kinetic quiescence it has another. These two shapes have naturally a mathematical relation, so that the one is always to be found by the other. Hence it is asserted that the profile of any part of the body being taken, as can easily be effected with gutta percha, then from this a spring can be designed to rightly fit that profile, and to satisfy the factors above mentioned. The calculation depends naturally on the knowledge of the mathematical laws that govern the strength, and the geometrical ones that rule the shapes of springs in action, as well also as on the comprehension of the capacities of steel and the working modes of tempering; but as none of these things are occult, so their use in computation is simple.

Of course ordinary trusses are not each separately schemed on this plan, experience having yielded rules of thumb that render such a method unneeded, but were it necessary to find anew the true form, it could with ease and certainty be established on the manner laid down.

While the statement has been made that form can by steel be fitted with force, the orthopragmatic holds have been left behind out of view. Turning again to them, a further advantage in the employment of steel appears, and to point this out a simple truss can still be retained as instance. Being an active orthopragm it should by the rule, some time since stated, exhibit the two holds of basis and transmission with the intermediate agent. The truss head is the hold of transmission, and the spring is left as representative of both agent and hold of basis. This double privilege it enjoys by right of its power to act in two capacities, its form fulfilling the one, its force the other. The orthopragm is therefore more compact and simple, and simplicity is ever to be sought for.

Lastly, while on the subject of steel, there should be exploded an idea which is at once popular and fallacious. Steel is ordinarily associated in the mind with the massive machinery and gigantic girders of engineering. Its very mention conveys a sense of crude, cold, resistless force. Warped by these associations, people shrink from the bare idea of "wearing steels," and of forfeiting their freedom by encasing themselves in a mediæval manner. They instinctively calumniate the servant whose qualities are the finest, whose character is the most valuable. Steel is of all substances that most suited for the construction of orthopragms. It can yield the greatest combination of strength and levity, while its toughness permits of its being used in strips so thin and slender, that they are wholly invisible through the clothes when fitted to

the form. While these points were in the past unappreciated, orthopragms were most usually clumsy, cumbrous, and uncomfortable; those of the present need never be so.

To conclude this chapter with a summation from the foregoing pages, of the principles which must on mechanical grounds govern all attempts to revert the unnatural to the natural spine, and which must rule the treatment of spinal curvature.

It has been shown:

That the body is mathematically erected piece by piece and arch by arch, and that this erect and balanced position is kept by muscles obeying a gravital law, the exhibition of which is termed restituence. That the spine, as a part of the body, maintains its natural shape by the integrity of its pieces and by its restituent powers. That spinal deformity arises from failure of the pieces or from restituent perversion, and that efforts at reformation must be made in accordance with these facts, and therefore be erectile, gravital, and equipoisal.

That the spine is subject to curvature from three distinct causes.

Firstly, from disintegration of its pieces, the mechanical treatment of which must be in the first stage purely passive, art holding the part while nature repairs the breach; and in the second stage active government is usually requisite to control the restituence which ensues.

Secondly, from unhealthy perversion of its own restituent powers, the counteragent to which is rightly directed active elastic force.

Thirdly, from restituent perversion where the restituent powers are perfectly healthy, but become misdirected by disturbance of the base or burden of the spine; the results of this misguidance if serious, also requiring active elastic intervention, after the causative disturbance has been obviated.

Further, it was shown that an orthopragm should be regarded as a real adjunct to the body forming part and parcel of its mechanical system, and that while thus obedient to laws, anatomical and mechanical, it nevertheless had a type of its own as universal through orthopraxy as the vertebrates have through their domain.

Lastly, the material advantages that steel has over other substances for orthopragmatic uses were pointed to.

CHAPTER IV

PRACTICE OF REVERSION FROM THE UNNATURAL TO THE NATURAL SPINE

THERE remains in this present and final chapter to pass from principles to practice, from method to means, and to consider the actual and real solution of the problem whose theoretical clews have been unwound in the previous pages. This problem, as it at present stands, is, what are the holds the body is capable of affording to a spinal orthopragm, and these once secured, what forms of orthopragms are appropriate for the prevention or reversion of the varied types of spinal curvature formerly and fully defined?

The possible holds are pelvic, spinal, costal, axillary, and capital.

The pelvic hold demands studied stability. It has to serve as the base from which the agents in active orthopragms operate, as well as the area over which their reaction must be dispersed. As the bony pelvis is the *point d'appui* of the natural forces in their exercise of control over the spine, so the pelvic hold, being made part and parcel with the bony pelvis, must form an analogous point for the artificial forces.

Now, the bony pelvis is a massive ring, practically

solid and continuous, and it happily happens that its circumference is, in a certain line (that of an ordinary truss spring), so conveniently near the surface of the body that a metal band can be brought to surround it with very intimate contact; it further chances that the tissues intervening between such a band and the bone are so unimportant and so tolerant that a fair amount of constrictive pressure does them no injury, but imparts to the band a coherent ability to cling. In short, the ring remains firm on the hips as a garter is fixed on the knee—that is, by compression.

Where a weak hold only is wanted, the band need be but narrow; where greater strength is requisite greater breadth will render it, and special width will, at particular points, countervail special strain. There is, however, a limit to this amplification of the band, as well as to the degree of compression the tissues will suffer without offence, and when strains of a gravity beyond their bounds are contemplated, then further contributory holds to the ring must be requisitioned.

Now, the pelvic ring is as restricted in motion as a ring worn on the finger. Fitting, it must move either up or down, tilting being, of course, a combination of these two. The contributory holds, therefore, resolve themselves simply into those that will stay the ring from slipping down, or will preclude its rising up.

Of the former the best is artless enough, and has the merit of antiquity, dating from the advent of petticoats into the world. If a fabric be fashioned to the form, and fitted into the waist like the top of a skirt,

and reaches down to the position of the pelvic ring, then this latter can be attached to it, and can depend on it for power to resist depressing overstrain, just as a dress does on its band. This faculty of dependence is due to the slope of diminution there is from the swell of the hips into the small of the waist, and as this shelving slope varies in the circuit of the body, so will the capacity of the hold be affected for better or for worse. Thus, where the slope is *nil* or the undesired way, as across the abdomen in front, there no hold can be gained; where the inclination is tolerable, as below the loins, a fair field for grip is offered; where the greatest acuteness and abruptness exists, as at the sides of the body, and especially just above and within the crests of the hip bone, there the maximum vantage is permitted.

Now, to this entire moulded or petticoated adaptation, which circles the body in one broad band from the waist to half way down the hips, the name "cinctural" may be empirically ceded as a distinction for future reference; and it will be seen later that such a mould may be used wholly or in part—may be rigid or the contrary.

Reverting again to the primitive pelvic ring, and considering next how it can be prohibited, if needs be, from rising from its right place on the body. There are three means, different in degree.

The first is quaint. There is in the fields a grass whose ears resemble barley in being feathered with minute hairs like an arrow end. These the schoolboys are wont to put up the sleeves of their coats, along

which, after a minute's motion in walking, the little ears travel and reappear usually at the collar of the coat. The rationale and rapidity of their journey lies on the fact that the feathering compels their passage one way, and prohibits it the other; thus with every movement of the body there is an impulse forwards, and retrogression is precluded. Now, there is a kind of plush manufactured, whose surface and behaviour simulate those of the grass-ears; and the pelvic ring will, if rightly lined with this, tend with every motion to travel down, this tendency being counter-agent to any disposition it may have to ride up.

If this counter-action prove insufficient, recourse must be had to the reserve and stronger measures, and the ring must be either absolutely anchored to the pelvis or attached to the legs. The anchoring is simply done by the passage of two strong straps from the front to the rear of the ring, between the legs and across the perinæum—hence called perineal straps.

Attachment to the limbs is effected by a rod on each side of the body connecting the pelvic ring to a band round each thigh, and having, in its course, a joint truly placed with axial respect to the hip-joint, and being an external representative of the internal bony arrangements.

This method permits all motions save that of the ring, against whose lateral tilting it affords greater security than any other known plan.

Having so far established the ability of the pelvis to serve as a secure base from which to rear an ortho-pragm about the spine, there arises next the necessity

for seeing how the spine can be grasped, either directly or indirectly, in order that it may be submitted to proper government and control. For to govern, one must gain a hold over those to be governed, whether people or things.

Now, the sole opening presented for direct hold over the spine is in the rear of its course along the back. The well-known range of bony prominences which betoken each segment, comes here very near the surface, and on either side of the ordered line they form, lies a more even and expanded area of the vertebral segments, reaching from head to hips in one continuous track, overlaid with muscular tissue. It is along these two tracks (technically over the transverse processes) that there is a direct possibility of purchase on the column. The bony prominences themselves being knobby and naked are intolerant of precise or pointed pressure; but the transverse processes are smooth and coated with muscle, and as muscle is of all the tissues the best to intermediate between bone and pressure, their aptitude to receive the latter is apparent. That the spine offers no other hold to direct mechanical influence can be manually made out; it is, as it were, so involved in the body that it is accessible in one direction only; when called on to give a good hold, its poverty through corporal encumbrance becomes obvious. It can present one aspect only, and this is insufficient to constitute a true clutch. When one grips a wrist, the fingers must lightly environ it; if one grasps a waist, the arm must closely circle it. But the spine can no where be thus intimately sur-

rounded, and as a consequence its facile control when in error has never been entirely a matter of ease.

Failing then adequate direct influence over the spine, there has to be requisitioned the pressure that can indirectly be brought to bear on it, through its intimate relations the ribs, the arms, and the head.

The ribs rise and fall with the tides of human breath. They form as a whole the pair of bellows whose perpetual play fans on the progress of life. Their prime and practical business is breathing; by this they live and support also the rest of the corporate community. The body, therefore, can brook nothing that interferes with their actions; if they are impeded it languishes; if stopped, it dies. As a consequence, whatever hold one may be desirous of exercising over the ribs must offer no restraint to their respiratory acts; and further than this, as curvature generally decreases their freedom, so whatever orthopragm may be called into service, should radically increase their liberty, not the reverse.

The ribs stand on the spine, as the handspikes on a windlass, levers by which mechanical rotation is facilitated. In this office they are none the less effectual for being a little loose and rickety in their attachments, nor does such employment form a bar to their necessary restlessness in respiration. They are equally adapted to be recipients of forces to be transmitted to the spine whether rotative or centripetal, that is either to circle the spinal segments while in position, or to alter directly their position. For as in the windlass instanced, the handspikes may be

so loose in the up-and-down direction that a man working one might vary the level of his end so as to raise it to his shoulders and lower it to his knees (analogues of the respiratory up-and-down motions), and yet be in no way precluded either from rotating the windlass, or from pushing directly or centripetally against it, so it is with the ribs. In short, they have, like all other things, three ranges of motion; respiration monopolises one, the other two are free for use. It is further impracticable to act on the anterior half of the ribs, or the part lying in front of the chest, as from their peculiarity of slope pressure there depresses them, and contracting the chest interferes with respiration. Over their hinder half, that is, in the back and sides of the body, such an effect is not produced.

Now, in utilising them thus, it might seem that the ribs themselves would be liable to changes of form under the pressure employed, or to slow dislocation at their joints to the spine; but as these joints are, if loose, secure, and as the spine is being simultaneously coaxed in the right way by the other auxiliary means employed, this risk is reduced to a minimum, and practically proves nil. Where there is, however, constitutional softening of the bony substance of the ribs, the matter falls under another category. One cannot build on a rickety scaffolding,

Like the spine, the ribs present but one surface to direct mechanical attack. They are usually acted on by plates shaped to their form, and comprising as many of their number as it is wished to control.

Passing next to the arm. The surgical arm is less lengthy than the popular one. The former is very partial, and limited to the space between shoulder and elbow; the latter takes in everything, shoulder-blade, arm, forearm, and hand, all in pendant sequence one below the other. Now, this entire arm is slung to both spine and ribs by so many muscles, which muscles are its strings of government. While the spine and ribs are the more fixed and the arm the freer, the latter is controlled by the former. Reverse the comparative fixity and hold the arm, then the spine and ribs fall under rule instead of ruling. But the ribs were shown to be directors of the spine. Hence the arm can be used to govern the spine both directly and indirectly.

The hold most ordinarily taken on the arm is by a semicircle, in which it reposes at the axilla. This hold is practically above the shoulder-joint, whose motions are unimpaired. The arm can thus be given a definite relation with respect to the pelvis, and the muscles referred to as governing strings be rightly brought into play.

Another method of holding the arm is by securing fixity of the shoulder-blade directly.

Lastly, the head is held by putting the chin and the occiput into two shelves, between which the capital weight is balanced and distributed. The security and simplicity of this plan is excellent, whether the shelves are slung from above or stayed from below. Cursory thought might evolve the idea that this cephalic hold was the most vital one of those requisitioned for

spinal orthopragms, and that, as the head is at one extreme of the spine and the pelvis at the other, all that would be necessary would be to grasp these two ends and straighten the intermediate column, as a piece of string is straightened by tension. Such a fallacy would rest on a popular impression that to "straighten the spine" must necessarily mean to bring it into a straight line, a point already fully explained to be neither possible, practicable, nor desirable, seeing that the perfect spine is by nature curved. It would further show an oversight of the fact that the body is an erected structure, each segment, like the stone stairs in a turret, resting on its inferior, and that, therefore, tension on the spine, either by traction or capital suspension, will not tend to restore segments that have become misplaced—a fact that will presently be buttressed by the arguments on which it reposes.

This exhaustively brings to a conclusion the holds available for spinal orthopragms, and in so doing completes the answer to the first term of the problematic question proposed in the initial paragraph of the chapter. It will be seen, therefore, that if the body be drawn on paper there can be shaded in the areas on which hold can be obtained, while the blank unlined remainder offers none whatever. This can be done further, so that the darker linings indicate the more valid and securer holds. Such a map, so to say, serves as a guide to grasp, as a geological one does to strata, and offers a rough-and-ready visual means for analysing any spinal orthopragm, with a view to dis-

criminate between necessity and superfluity, and to convey a clear understanding of the meaning of such an orthopragm. The entire body can be, and is in the mind of a connoiseur, mapped out after the same fashion.

One steps next within the bounds of the other term of this chapter's problem, namely, what forms of orthopragm are appropriate to the varied types of spinal curvature. The answer to this embodies the very extract of all that has gone before. Whatever materials might bear on it have been gathered, brought together, and balanced, that their full gravity could be realised, and these materials have been reduced down to the present point. The evidence, so to speak, has been taken, the principles determined, the matter summed up, the law laid down. It is to the practical putting in force of such law that one now turns.

In the second chapter there is a classification of the kinds and types of spinal curvature. From that chapter into this shall be moved the varied classes, in due and seried order, till their entire number is passed. Intrinsic curvature shall lead the way, first the osseo-ligamentous division, the musculo-nervous following; then shall succeed the extrinsic class, the remaining ones, with the secondary symptoms, bringing up the rear. As these thus go under review their mechanical equipment can be deliberated on.

Intrinsic Curvature.

The body was shown divisible into the spine, its base, and its burden. In the origin of pure intrinsic curvature these latter two are wholly natural and unaffected. If, as deformity progresses, they suffer apparent alteration, it is as a result, not as a cause. The legs are their right length, the triplet of arches they form with the feet are true, the pivots on which the pelvis is swung are level, and the joints and motor powers of the nether limbs are perfect. As a consequence, none of these matters call for mechanical interference. Everthing with both base and burden is good; there is nothing to make good. It is the spine alone that lacks the correctness, and in which the element of evil lies. To it, therefore, the reformatory mechanism must be adapted. In extrinsic curvature the conditions are considerably reversed. With this preamble one may proceed to the criticism of the divisions of intrinsic curvature.

Osseo-ligamentous Curvature.

The osseo-ligamentous division includes two mechanical stages, that of the duration of the morbid changes, and that of subsequent restituence, should the form or function of the spine have been impaired.

The first stage witnesses the progress of the morbid inflammatory processes whose course and effects have been already described. It lasts from the time these commence till the healing work is completed. The spine is being sapped at some point by a softening and malignant disease, which wastes its substance and un-

dermines its strength. Against this enemy nature struggles, and with a power proportionate to her constitutional energy. She strives to oust him from the system, to clean away the mess and débris he makes, and to fill the breach he burrows. Physic can of course fortify her efforts in this direction (but how or in what degree is foreign to the matter of these pages). Nature, however, has imposed on her a further task, namely, of attaining the circumstances of undisturbed quietude, which is a *sine quâ non* for her constitutional operations, and this for obvious reasons she cannot herself do. It must therefore be done for her. To explain: the affected parts of the spine must be kept motionless, to relieve them from the grating and grinding of the burden they naturally are competent to bear, but which now, broken down by disease, they can no longer sustain. The spine, schemed for motion, must now keep still; to keep itself still it is unable, and there is no other bodily mechanism which can do this duty for it. Its rigid muscular attempts towards this end fail in their object. For it is in the pitiful position of a famished man, who to earn the few pence necessary for keeping body and soul together must go to his work, but who cannot work because he is worn down and weakened out by starvation. The spine, to gain repose, must ease itself of its burden, and being overburdened it cannot do this. It seeks for rest, but can of itself find none; its rest must therefore be given it.

The orthopragm that shall render this rest must be a *passive* one. There is no call for active power. Its duty is not to cause permanent changes, but, on the

contrary, to check even the least temporary ones. It must also be as broadly as possible diffuse in its hold on the spine, for although only a small portion, one or two segments, perhaps, of the spine may be diseased, it is insufficient, even were it possible, to hold these segments alone. For the movements of the spine are undulatory, its changes are made as waves, just as a child flicks waves along its skipping-rope. If, then, the injured part only was held and the waves of motion were allowed to progress up to it, they would be abruptly checked with a jolt, and their power distributed as a vibratory jar over such part, and an effect produced as identically injurious to it as tapping it constantly with a hammer. Mass motion would simply be changed into vibratory molecular motion. Now, neither of these is in harmony with real repose, hence, not only must the injured part be held, but also the other parts of the spine. Next, this entirety of hold will give rest not only to the bony portions of the spine, but will ease its muscles of their duties, and so relieve the diseased segments of a multiplicity of pulls there are naturally upon them. The orthopragm must also bear the weight of the burden that the injured parts are wont to carry in health, but which no longer they can competently do, and must transfer it to the pelvis, thus affording relief from depression as well as quietude. Lastly, all these desiderata must be carried out without in any way interfering with vital functions, such as respiration, or even with that accessory to health, exercise. The spine must rest, but the patient must walk and take the air if needed.

Now, a splint was defined as a passive orthopragm with the greatest generality and spread of hold, having for its object the quiescence of the part to which it is adapted, and resisting by its own intrinsic immobility the instability of the part it protects. This will precisely answer the requisitions just detailed. The splint employed shall by its generality include all the spinal holds; it shall afford quiescence to a lengthy range of the column about the diseased part, whose burden it shall also bear, and by its intrinsic immobility transfer to the pelvis; it shall not interfere with vital functions; and the patient shall walk.

The needed magnitude of the splint depends on the part of the spine attacked, whether the disease lies in the neck or below that region. As the splint in the former case is but an extension of that in the latter, the simpler form may be taken first.

Deferring, then, for the moment the consideration of the manner of applying such a splint, as well as of the exact material best suited to its construction, there shall be dwelt on at present solely and separately its shape, its dimensions, and its proper points of intimacy with the body, in order that one may critically discriminate between what is essential and what is superfluous. Now, to do this two imaginary points shall be conceded which, if infantile in idea, at all events permit the points arrived at to be taken in sequential simplicity, and in no way affect their truth.

It shall be supposed, then, firstly, that there has been found a man without the faintest objection to

being made the vile body of experiment; and secondly, that, magician-wise, any wish with respect to that said man has but to be fathered by a verbal order to be instantaneously executed. The first postulate cedes the amplest conditions for experiment, the second, like a conjurer's trick, is intended to expose only results and not the ways and means. Now, this hypothetical man shall be, with the exception of his supernatural stoicism, in all points identical with his fellow-creatures. He is, therefore, as liable as they to be attacked by osseo-ligamentous disease. It will be legitimate, then, to suppose that he is shortly about to become a victim to it, and it must be legally understood that the experiments now to be made on him are with a view only to affording him the best means of withstanding its consequences when it comes. This being clear, one can proceed to try splints of various shape till the perfect one is hit upon. This model man, then, is unclothed and desired to assume his most upright and manly position. He is observed to be, as mankind in general, shaped like an hour-glass, broad at the shoulders, broad at the hips, but constricted at the waist, towards which the upper and lower swells of the body evenly taper. It seems obvious, then, that if his body be encased in a firm shell so shaped, the upper swell of the body will repose in the upper bell of the shell as comfortably as an egg in its cup, while the whole will rest on the lower swell of the body (*i. e.* the hips) as firmly as a hat on a head. Under the guidance of this light a verbal order is given that a rigid jacket shall encase the

body from the armpits down to the groins, an order by hypothesis instantaneously executed. As instantaneously the unfortunate man is found to be struggling in the agonies of suffocation. For it chanced that at the instant the splint caught him, his breath had ebbed to its lowest level prior to the fresh flow of the new breath being taken; with this ebb the chest had contracted to its smallest ordinary limit, to which it now becomes held, and breathing is impossible. This dilemma is of course terminated by a verbal counter-order for the removal of the shell, and the man is once again free.

Now, the said man, being wholly indifferent to any comfort of his own, is charmed to undergo a second or other experiments. This time, however, to guard against any repetition of the previous mishap, he is desired, while reassuming the erect position, to take his deepest breath and fill to the fullest his lungs with air. The moment these are complete a verbal order, as before, is given, and the man again encased. The effect is now wholly different. The splint affords no discomfort, and if examined by its sound on tapping (percussion) is found to fit closely to the body through all its area except opposite the ranges of respiratory movement, that is, over the front and sides of the chest. In these regions the surface of the body, during ordinary breathing, could not come in contact with the splint, provided this latter remains unshifted. For the splint was applied at the moment of deepest breath and greatest amplitude of the chest. Ordinary breath gives less amplitude; therefore, while in the

former instance it was tight on the chest, in the latter it is loose. Technically, the tidal size is less than the complementary. There is, then, a large area over which the splint does not touch the body at all. This area, in point of value of hold on the body, is useless. A verbal order is, therefore, unhesitatingly given for its removal, and a great gap or hole in the splint instantly appears. Now, were this hole but a small one, the body would be secure against all chance of slipping through it out of the splint, and this would be a *raison de plus* for the superfluity and removal of that portion of the splint.

But the respiratory hole, on the contrary, is a very large one, so large, indeed, that unless means are taken for its prevention the body will inevitably fall through it, and the spine and back will droop away from the splint behind, and be deprived of all stay and hold whatever. To obviate this a verbal order is given that the gap shall be filled up with elastic material, whose elasticity shall be so forcible that it will hold the body strongly back in the splint and against the spinal holds, and yet lenient enough to in no way bar respiration. That these conditions are not incompatible can be practically proved by any one who lies prone on his chest in bed or on the floor; the chest supports, in this position, the weight of the portion of the body over it, or, in other words, there is a weighty pressure on the chest, and yet breath is taken with ease enough. Lastly, had the splint remained in its rigid intactness, and had there been no gap cut out nor any elastic replacement, then the body would have

slipped forwards across the interspace that was left for breath's sake between it and the splint, and would have dropped against the latter in front, while the man's back would have, of course, fallen away from the splint behind, and have become deprived of much support. Percussion would then show a hollow over the spine, not over the chest. To sum up, therefore, there must be no respiratory hollow, but respiratory elastic; the circlet round the body must be rigid over the hold points, resilient over the mobile points.

What in this matter applies to the chest applies with equal force to the hard and soft parts of the abdomen. The fleshy and flaccid parts of its walls afford no hold of any stability, and their size is subject to constant digestive variations, although these are without the regularity, and not within the even limits, of the thoracic alternations. There are, further, in the one sex large respiratory movements of the abdomen. If, then, the shell is carried rigidly across the abdomen then an interspace to accommodate these variations must be left, and if an interspace, then the rigid area of the shell over it is useless. A verbal order is, therefore, passed that the shell over the soft parts of the abdomen be replaced by elastic material of suitable resilience. This executed, it is found that the gap made is not so great nor comprehensive as that over the chest, nor is there for this reason, as well as on account of the utter uselessness of the soft parts of the abdomen in the matter of hold, the same necessity for very forcible elasticity. The bony elements of the abdominal wall which underlie the "cinc-

tural" hold (as previously detailed) can give ample security without there being reason to make any call on less substantial parts; indeed, if any further call has to be made to increase the firmness of the cinctural hold, it is on the legs the demand will be made.

Now, the shell having been, as regards its circuit round the body, made comfortable as well as conformable to the vital requirements of the man, the lines of its upper and lower edge must next be determined. It was originally ordered on from the top of the arms to the top of the thighs, but must not in any way through its over extent up or down deprive the man of free use of these limbs. He must be able to walk naturally, able to sit easily. To determine the nether limits he is directed to attempt to sit down, and should this be impossible, an order is given for the removal in front of all that may prevent his thighs coming to right angles with his body, for in sitting this angle is assumed.

Behind and on the sides, on the other hand, the shell may be permitted to reach almost to the seat of the chair on which he sits. The further in these directions it stretches the firmer it catches. The upper limits in front over the chest will be at the level of the armpits; behind over the back the same level is the lowest admissible. (It may here be parenthetically observed that in the event of disease being presumed to occur in the neck, then the shell would be carried up to cradle the head and neck, forming for the former a kind of night cap, for the latter a trough, a prolongation of the splint which would give

the most perfect attainable state of quiescence to the neck, both in walking and sleeping, and which would satisfy the principles already laid down, keeping the neck immovable, and relieving it of the weight of the head. In ordinary cases this prolongation is unneeded.) Under the armpits the shell shall be trimmed and rounded, so as to, on the one hand, free the folds of the armpits from cutting and galling, and at the same time, on the other hand, be kept sufficiently high to allow these said folds to get an easy cling over the rounded edges. This gives a completeness to the brachial hold. For the shoulder-blades are fairly secured by the fitting of the shell, and can stand, so secured, as the fixed points from which muscles between them and the spine can act, and this fixity of the shoulder is strongly amplified by the cling the folds of the armpit take over the edge of the shell.

Orders to these effects having been given and executed, the hypothetical man stands in a splint, whose shape and extent have been, as it were, experimentally determined, but which will, nevertheless, be found to precisely answer the requirements theory exacts. It embodies in the fullest respect the pelvic, spinal, costal, and brachial holds, and had it been built up piece by piece with this definite view it could not have more perfectly fulfilled it. It is true that the hypothetical man has been presumed to be a hale and healthy fellow, but the logic of the construction, dimensions, and aims of the splint is in no way impaired when applied to an invalided person, or one even actually suffering from osseo-ligamentous disease.

Leaving these points behind, and dismissing the hypothesis which acted as their foil, one comes next to the material of the splint, and later on to its mode of application. It was ordinarily admitted as a material axiom that for the firm parts of a spinal splint there was nothing like leather. Leather can be sopped and softened to any state of pliancy, can be bent and blocked to any shape, can be dried and dressed to almost any degree of firmness and hardness. It is light, it is porous, it is not harsh, and when clothing the body has no deleterious influence. The most popular and practical affirmation of these facts lies in the perpetual and entire use of leather for boots, certain orthopragms which make good the deficient durability of the sole of the civilised foot. Now, the old way of conforming a sheet of leather to the shape of the body and converting it into an appropriate splint, was to wet it till perfectly soft, to place it on the part to be fitted, to mould it by stretching or slitting to the person, and finally to bandage it *in situ* and permit it to dry and harden on the body of the patient during twenty-four hours. This fashion is nearly obsolete. It was dirty, disagreeable, and made no provision for permanently securing any desired position of the splint or part splinted.

The more cleanly, comfortable, and ordinary mode now in practice is to take a speedy primary mould of the person's back and shape, and using this primary mould as the matrix wherein to make an inverse casting, to employ the latter as a block on which a leathern replica of the primary mould can be formed.

There are two good ways of quickly and durably taking the primary mould—by gutta percha or by plaster.

The gutta percha employed is in sheets three sixteenths or a quarter of an inch thick. All kinds are not suitable for the purpose, nor is price a criterion in the matter. That manufactured for shoemaking purposes is usually the best. When cold it should be fairly supple, but not soft, and should neither scale nor crack when rolled. Immersed in very hot water it should be rather inclined to float than sink, should become perfectly pliant, but not sticky nor pappy, it should be capable of the amplest forcible stretching, but have sufficient coherence to bar spontaneous stretching under the strain of its own weight, and to permit it to retain its dimensions under handling. Finally, when withdrawn from the hot water it should set speedily and firmly at the ordinary temperature of the air, thereby fixing whatever form it may have at the time of setting.

To make a mould, accurate even to the hairs, with such material is simple. The measurements of the part to be moulded are taken, or even by noviciates a brown-paper pattern is cut, as the apparent shapes of the bodily surfaces are at first very misguiding. In cutting the gutta percha to these indications there must be borne in mind that it has a grain, across which it stretches with greater ease than in any other direction. The body next being placed in position the piece of gutta percha is floated quickly to and fro in a basin of hot water, till it is equably extremely pliant throughout,

is lightly lifted from the liquid, and, as far as may be, dropped on the part under modelling, and those portions of it which stand away are stretched and patted home into the closest intimacy with the skin. Three minutes' quietude and lapse of time completes the operation, which in summer time is expedited by placing a cold wet towel over the gutta percha while setting. The objections against the use of gutta percha are common ones. It is expensive, and not being manufactured with a precise view to the above use, is difficult to be obtained good.

The second plan of taking a primary mould has neither of these drawbacks. It is this:—A piece of common stiff muslin is cut of sufficient size to roughly cover the part; this is wrung through water till it is sticky, the gum which previously stiffened it conferring on it this new property; the patient is placed in position, the muslin thrown over the part, and dabbed home in a manner similar to that employed while using the gutta percha. The stickiness of its dressing causes the muslin to adhere to the skin, and it falls into little folds, which permit an accurate fit to be made, and take up, owing to the thinness of the material, no objectionable bulk. A cream of plaster of Paris, mixed at the commencement of the operation, is now on the verge of setting, and is smeared lightly over the muslin till a coating half an inch thick is formed. A few minutes later the whole is hard, and this so-formed shell is removed with a facility dependent on the fact that the muslin intermediated between the skin and the plaster. Having a muslin basis the shell

may crack, but can barely break. A common kind of cotton vest can be substituted for the muslin, and retains, of course, its closeness to the skin by its own elastic embrace.

Now, there comes next for consideration the question of what is the right position in which the patient should dispose himself or should be disposed while the primary mould is being taken. In the instance of the hypothetical man, he was desired to draw himself up into his most manly and upright position, and having full power to do so unaided, there was no difficulty in obedience. On the other hand, the very opposite instance can be imagined of a person whose spine was at some spot so softened by osseo-ligamentous disease that the weight that spot had to bear in walking was very near its breaking weight, and there was such imminent danger of fracture that the person could not stand at all, much less draw himself up. In the former instance the spine is fully competent, in the latter wholly the reverse. In the former case the patient can dispose himself, in the latter he depends on aid entirely for disposition. Now, between these two extremes there is of course a series of degrees of spinal competency to bring the body into the most erect position, through which, as disease and pain increases, competency diminishes and proportionate aid has to be rendered to attain the disposition aimed at. This fact has always been fully recognised and met. When the patient had not as yet lost full power of assuming a correct position, as in the very early stages of the disease, then he was desired unaided to do

so during the taking of the primary mould. As disease advanced, and this spinal self-assumption became less easy, he aided himself by his arms, having a chair placed on either side of him, between which he balanced himself, or in the case of children the nurse aided the child, holding it beneath the arms. In graver and later stages the patient was placed prone on the sofa, and relieved of all effort at erect disposition, and when the pelvis had been reposed in a correct plane the mould was taken.

In the disposition of the body by these modes no attempt is made by traction or otherwise to reduce the deformity. Whatever changes of form have been permitted to take place (and it is a matter of permission, for taking in time they can ordinarily be entirely avoided), these are viewed as unalterable at this stage. What is wanted is rest, an end not gained by active interference. The aim of the splint is to remove simply the onus of burden and the percussions of the spine's undulations, not to substitute traction in their place. Having prevented pressure on the sore it would be rashness to pull or push it constantly about; it would be to escape one extreme and to rush into the opposite. It is the mean that is requisite, the mean of passive rest. When healing is complete then partial obliteration of deformity by restituence, or comparative obliteration through growth, may be looked for; but to discuss this now would be to trench on the matter of the second stage.

From and to the primary mould thus obtained the leathern and elastic splint is made. The leathern

portion, left stout in the lines of more cogent strain, is stiff enough to bar bending, and further offers an excellent basis, if needed, to which to connect holds on the limbs accessory to the bodily ones already described. The whole splint is light, not harsh, shocks neither the functions nor sensibility of the skin, and being removable at will, admits of cleanliness, a matter on which most English people are scrupulous.

Now, this form of splint does, and ever has done, its duty rightly, provided always, in the case of growing persons, it be reblocked at least once every three months. Failure to see the necessity for this periodical repetition has not unfrequently impaired its efficiency. What was self-evident in the case of a boot was not realised in the case of a splint. The fact of growth was stamped out of sight, under a false impression conceived of the mercenary interests of the mechanical adviser.

Summing up, then: the principles which underlie the construction of the splint for osseo-ligamentous disease find verbal embodiment in the statement ensuing. That the spinal column is perfectly sound except at the points attacked by the disease, but that the spine, in consequence of the attack, is incapable of reposing itself in the circumstances adapted to allow nature to heal the sore. That the requisite circumstances, apart from constitutional ones, are removal of the burden from the weak and sore points, and prevention of the undulatory percussions, which would strike these points with each and every move-

ment of the spine. That these circumstances are best attained by the application of a splint of composite constitution and certain form, which shall gain the fullest grasp over the holds available. That the position in which the body should be disposed to receive this splint is that of upright ease, wherein the sore place is neither pressed upon nor pulled upon. Lastly, that any effectual attempt by traction to obliterate deformity that may have arisen is false in principle, seeing that, if the sore be pulled on, it is hindered from healing; and that if the sore point be sufficiently soft to yield to traction, then such traction endangers fracture; and if, on the other hand, the sore point is sufficiently firm to withstand the traction, then traction is superfluous and worse than useless.

This last point has lately been strongly denied, and it will be wise to dwell next on the why and wherefore of the denial, as well as the practical form it has taken.

Three years since a method was transported from America for attempting to reduce, among other forms of spinal curvature, the angularity of the curvature of osseo-ligamentous disease while the disease was still in progress, under the conviction that a sufferer hung by the head and arms could be brought into a state of suspended relief, and could be fixed so by rigidly shelling the person in plaster-of-Paris cement, certain loose allowances being made for breathing and digestion.

For this plan a superiority over all other modes ever in vogue was ably and strenuously claimed. It

was asserted not even to be particularly good for any special stage of a special kind of curvature, but, on the contrary, to equally and thoroughly do for every stage of every kind of curvature. It might, at first and cursory sight, have appeared that the operation was complicated, and there would be some difficulty in inducing people to go and be hung. Such was not the case, extreme simplicity being one of the principal elements on which its success depended. The whole execution had the further merit of celerity. The professional and personal attainments of its transatlantic originator secured it the most cordial reception in this country, and through his kindly courtesy demonstrations were held in the various metropolitan and provincial hospitals, at which England had the advantage of becoming able to learn at first hand the precise minutiæ of the method. It subsequently had the amplest and most universal trial in both public and private practice. What was the result of these trials to patients has been fully since expressed in most of the medical periodicals. The plan of this treatment was laid out as follows :—The body of the patient, having been previously stripped, was clothed with a tightly-fitting jersey, between which and the skin were placed, over the regions of the chest and stomach, a series of pads, whose objects were to enlarge *pro tempore* the corpulence of the jersey. Having been so clad, his arms and chin and skull were received into proper loops, by whose means the entire body was raised till the spine was in a state of greater or less tension in proportion as the body was hanging

more or less wholly by the head and arms, this being also the precise proportion in which the spine suffered the traction occasioned by the weight of the lower part of the body. While thus suspended, bandages soaked with moist plaster of Paris were lightly wound round the person and over the jersey, within an area identical with that previously described as being correct (in the instance of the hypothetical man), till a layer of the requisite thickness was obtained. The jacket so constituted speedily set hard. The patient was then lowered and freed from the suspending gear, the pads, previously interposed between the jersey and the skin, were removed, and the edges of the jacket smoothed and trimmed from irregularities which might chafe the body of the wearer, who was subsequently dismissed to carry this irremovable case-hardening for weeks or months till the next application was deemed necessary, during the whole of which period the parts of the body covered remained entirely unwashed.

The rational consideration of these proceedings falls under two critical heads: first, what circumstantial alterations for the better the body makes if suspended; and next, how far the plaster splint can maintain such alterations, even if they are proved beneficial. Now, had the suspensory gear been merely used to attain what has previously been described as the correct position, the operation would be neither particularly punishing nor particularly new. But the avowed aim of the method was not this; it went beyond, and its distinct object was to submit the spine to traction.

Its purpose was not to relieve solely the weak point of the wearisome burden that pressed on it, but to exchange this burden for the onerous and pendant weight of the body below; not to simply ease the spine of its efforts as a column, but to strain its capacity as a chain.

The actual application of this splint took from ten to twenty minutes, during the whole of which time the subject of the operation was in a state of trying suspense. The opening proceeding had a grim likeness to capital punishment, which, if only a seeming one, shocked, at all events, the nervous sensibilities of an invalid. Suspended by the arms, the skull, and the chin, the sufferer underwent a severe brachial, occipital, and mental strain, mental in the amplest sense of the word. The circulation in the arms being impeded, they passed through the disagreeable stages of the sensation known as "pins and needles," and subsequently became cold and blue, and lost their feeling entirely. The muscles of the entire body, braced and knit at first into an involuntary effort to control the discomforts of being hung, were after a minute or two fatigued and rendered powerless, and the patient relapsed into a state of pendant and distressing helplessness. Retching and vomiting not unfrequently supervened, the sufferer sometimes fainted before the completion of the splint, and there are on record one or more instances in which fatal results have followed. It is true that a light person suffered less than a heavy one, but this fact can barely be esteemed an ameliorative argument; to adduce it is to use the soothing

sophistry of an executioner. Such an ordeal is therefore a matter of gravity, which it would be wise even for a strong and healthy man to weigh well prior to submitting to it; with much greater reason should it be cautiously and carefully balanced before being undergone by a nervous, impressionable, or delicate invalid.

Still, as all things are by comparison, and as a lesser evil is ever acceptable to secure the refusal of a greater, there would be no valid grounds for either stigmatising or avoiding suspension, could it be shown indispensable to the exigencies of treatment. This, however, is not the case, and for the following reason :—The changes the body undergoes when hung by the head and arms are made easily obvious by experiment. The shoulder-blades rise up from their natural position, and do so in proportion to the share the arms are given in the allotment of the body's weight between them and the head. If the arms alone are entrusted with the weight of the body, the shoulder-blades will rise from three to five inches, and although the rise is less when the head takes a portion of the duty, still it is invariably a material one. The ribs rise as the shoulder-blades do, and the chest enlarges, so that it is much larger during ordinary breathing when the person is suspended than when not so, although the amount of breath in both cases may be identical. The bellows, so to say, may puff equal volumes of air in both instances, but are more widely open in the one case than in the other.

Next, the influence of suspension on the spine is

determined by viewing its conversion from a column into a chain, from a state of mutual repose of its segments on each other through their facets to a condition of mutual dependence by their ligaments. As a column the spine has its segments resting one above the other, moving under the guidance of their opposed facets and restricted by the tether of their uniting ligaments. As a column the spine is used in every-day life, and as a column its lapses into deformity alter it. All this has been fully explained, and there is no reason, therefore, for affirming that these lapses into an unnatural condition can be reverted otherwise than by treating the spine as a column. Traction does not tend to restore natural curves to the spine, the make of both facets and ligaments do not accord with this; the former would be separated, the latter stretched. Together they will evenly order the muscle-made motions of the column, but they will fail to naturally regulate the changes resulting on traction. And if this lack of tractile regulation exists with the uninjured portions of the spine, there is much less ground for reversionary regularity at the spots where the mechanism is thrown entirely out of gear by disease.

Imagining, then, that the patient is suspended, that he is breathing, that the chest and stomach pads are in position, that the chest is above its ordinary size, that the shoulders are risen, and that the spine suffers traction. The splint is as quickly as possible formed by lightly rolling the bandages round the body, and takes the larger size of the chest as that rises and falls with breath. The splint sets, the patient is

lowered, the head and arms are freed, and the pads removed. Now, this splint, of course, is divided by the waist into its upper and lower bells, a division convenient for its analysis. The lower bell, resting on the swell of the pelvis, very perfectly comprises the "cinctural" hold, and affords a very stable base for the rest of the splint. It is true the pelvis itself tilts a little down during suspension, and returns again on that ceasing; but this change is slight, and makes no practical defect to the steadiness of the grip. With the upper bell of the splint it is different. The removal of the pads, as well as the resumption by the chest of its natural and smaller capacity, cause the splint to be loose, and the wedge-shaped shoulder-blades, descending, drive themselves between the back of the splint and the body, and, thrusting the body forwards through the splint, deprives the spine of the intimate support that this method professes to afford, and terminates all possibility of spinal traction, which the splint is especially supposed to continue after the cessation of suspension. These facts can be easily established by percussion, and by this further proof, that if the splint be sawn down the front with evenness, and the patient be removed, he can easily be replaced without suspension, the splint closing with accuracy along the line of section. All that is necessary to effect this is to so raise the arms, without exercising force, that the folds of the armpits may be brought well over the upper edge of the splint. This section of the splint was deprecated entirely as being fundamentally opposed to the ideal principle of the

novel method, namely, that the entire splint kept up a state of things of which suspension was the originator, and which the cut splint was presumed to be incapable of perpetuating. Hence, it was laid down as a law that the splint should be unremoved till lapse of time rendered a successor desirable. The length of this lapse had no defined limits given to it. It might be through breaking of the splint, for were it made strong enough to effectually resist fracture its weight was very great; and, on the other hand, were it kept reasonably light, then its material power was inadequate. Next, lack of cleanliness constituted a barrier against a lengthy continuance of such an irremovable garment as the plaster jacket. The fatty and acrid perspirations of the skin are ordinarily prevented from noticeably accumulating by washing and changing of linen. These last become impossibilities when the splint was worn, and this state of uncleanliness, for the first few days disagreeable, was next offensive, and finally disgusting. The skin became clogged with its own excretions and lost its functional activity; this compelled sluggishness, reacting deleteriously on the general health. The jacket absorbed the discharges of the skin; these decomposed, and produced a condition of filthiness which was contrary to all common sentiments of cleanliness, and still more so to the present scientific view of the propriety of cleanliness, even to antiseptic degrees. Each rise and fall of the chest in breathing whiffed out a volume of foul air from between the splint and the body, most objectionable alike to the wearer and to those near.

Now, the splint, although only fitting roundly to the shape, was very harsh; had it fitted with accurate absoluteness into the recesses of the form it would have been intolerable. The stretching of the jersey over the body prevented this, however. Still, wherever there chanced to be forcible contact between the body and the splint there was the greatest liability, nay more, likelihood of abrasion. The splint was as harsh as mortar, being, indeed, made of a kind of mortar; the uneasiness of mortar against the skin is easily estimable. Further, as the splint afforded constrained concealment of the parts it surrounded, all irritations, excoriations, or abscesses, were perforce hidden from view, and rendered inaccessible to treatment. The method, it is true, made certain perforating provisions for dressing abscesses already existing and examined, but there was no possibility for either examining or dressing those that subsequently arose. In short, the entire surface of the skin covered by the jacket, in addition to having to go unwashed, had also to go unwatched.

There were, however, two very obvious and very great advantages presented by the method on its introduction. Firstly, the cost of the application of such a jacket was, after the original outlay for the apparatus, most economical. Although the suspensive gear was expensive, yet the actual materials for the splint were covered by a very few shillings. This economy could not fail to be of importance to the needy and to large public institutions dealing with the poorer classes. Secondly, as the gear and materials were very portable,

and as the process was presumably, after a little experience, practicable by any qualified person, there would cease to be the necessity for an invalid to even leave the house, much less to undertake a journey to town, or to a specialist who made such matters his particular study.

To these two great advantages, coupled with the faith with which the benefits of the system were accepted, the plan owed its wide and immediate spread, and by this spread the test of experiment was applied, and faith in the principle of the method first shaken, then shattered, and ultimately lost altogether.

At first, however, the principle was granted, and it was only modifications, whose aim was to alleviate the most glaring objections to its practice, that were sought; but these modifications may be reckoned as the practical outspeaking of the deficiencies of the process. Two points began to be especially studied, namely, how to relieve the distress occasioned by suspension, and how to avoid the disgust and discomfort excited by the ceaseless wearing of the jacket.

With the first view inventions were introduced which, by systems of pulleys or otherwise, allowed a discriminating allotment of the shares of the body's weight borne by the head and arms respectively to be made; more weight could be thrown on the arms and less on the head. Next, it appeared that the amount of suspension could be diminished without difference in results, the same being attained by permitting the patient to stand and be merely drawn into an erect position. Finally, it was discovered that it made no

material difference to very invalided patients if the splint was applied in the prone position. And so, as the practice improved, the principle fell through.

Meanwhile a similar lapse took place in the other view, for, going on the other tack, some experimentalists rendered the plaster jacket capable of removal and replacement by sawing it down the front and adding lacing pieces, whereby the jacket could be closed as are stays. Later was introduced a novel material for the jacket, whose use would both shorten the suspension and admit of the diurnal or periodical removal of the jacket. This new material was a felting impregnated with a spirituous solution of resins, which was as firm as vulcanite at the ordinary temperature, but, like it, softened by heat. At 180° F. it became very soft and mobile, and could be, when so soft, moulded to the form to a considerable extent, although not with perfect accuracy, seeing that it was incapable of stretching. Jackets were constructed of this felting as nearly to the shape of the body as previous measurements would allow, they were left open down the front, where a lacing or straps were placed for closure when *in sitû*. The patient was prepared as before described for suspension, the jacket was put in an oven and heated till soft, and when this happened the patient was quickly suspended and the jacket clapped on, buckled, and rubbed to the form. Within two minutes it had set and the operation was completed. If there chanced to be any particularly delicate points on the body under cover of this splint, the fact that the resinous stiffening could be dissolved out of the felt,

which then became quite soft, yielded the power of avoiding excoriations. This new material, in fact, was calculated to give the suspension system the very amplest, the very freest opportunities for practical demonstration. The splints so formed carried so many advantages—the rapidity of their adjustment, the brevity of suspension, the facility of their removal and replacement, the possibility of their being softened at desirable points; all these and other desiderata for efficiently displacing the principle of suspension. They laboured, however, under one great disadvantage. It was this:—Just as they came to light the principle on which they depended was beginning to be occulted. The patients had been weighed in the balance, and the principle was found wanting.

In fine, the pith of the American introduction after all the bark has been gone through is this:—The suspensory gear, if used only to bring the patient into his erect position, is convenient, not novel; continuous traction on the spine is inadmissible; and further, it is unattainable by this process of jacketing. As a consequence suspension is a needless act of supererogation. The actual splint itself has the merit of extreme economy, but the demerits of uncleanliness, weight, and harshness, qualities of a kind to debar its use among the well to do. The rich, therefore, barely benefit by the introduction of plaster as the material of a spinal splint so much as the needy do, and so it must be esteemed that the great advantage and value of that introduction is that it is a poor one, or more correctly, a pauper one.

In conclusion: the first stage of osseo-ligamentous disease requires passive treatment, and this is afforded in the fullest degree by a splint. The extent and limits of such a splint are those found in the instance of the hypothetical man. The construction should, if possible, be compound, part rigid, part elastic. The best material for such a splint in respect of lightness, comfort, and cleanliness, is leather. The most economical material is plaster of Paris, and if employed should be so without the exaggerated proceedings till lately associated with its use for gaining suspensive traction, the principles of such proceedings being entirely fallacious.

Two other points must be noticed before dismissing the subject. No splint alone can overcome or remedy the tendency which strongly exists, of some sufferers under osseo-ligamentous disease, to lean persistently to one side or the other. When such an inclination is the case, accessory holds have to be taken on the legs to obtain a check to the evil, and while the plaster splint is wholly incompatible with any such accessory mechanism, the leathern one, on the other hand, readily admits of its attachment.

The second point is this:—Although a splint offers the greatest possible breadth of hold and secures the amplest immunity from motion, still there are cases in which there is no real necessity for such completeness, and then a light steel orthopragm, comprising the rudimentary essentials of the splint, is all that is needed. As, however, this particular orthopragm is very similar to the one next to be described, the two shall be considered under one.

The second stage of osseo-ligamentous disease is a restituent one. Active disease has ceased, but its immediate effects remain, which in their turn become the causes of further changes in the spine; and the management of these further changes constitutes the treatment of the second stage of osseo-ligamentous disease.

Now, the immediate effects of the active disease are these:—A certain number of the spinal segments, having lost substance, have changed their shape, and with this change of shape have altered the planes of the surfaces by which they rest the one on the other. Such an alteration of surface throws the whole of the spinal column out of natural gear, and provokes further restituent alterations, whose object is to bring it back into a more facile condition of subjection to the gravital law.

Imagining, for example, that three contiguous segments have been affected by active disease, that they have become softened, and compressed more or less one on the other, and that these three have been, by the disappearance of the disease and by nature's cure, fused together into one piece, then, in lieu of the three natural segments, which were harmonious to all their fellows, there would be in the course of the spine a novel element, which is out of harmony with its natural undulatory movements. Now, if the three segments instanced fused together merely, and did not change their shape in so doing, then, although three segments had become one, still the top surfaces of the uppermost segment and the bottom surfaces of

the lowermost segment would have their planes unchanged, and stand in the same average relation to each other as they did before fusion. In such a case there would be no deformity, only a certain joltiness of action at the part and a lack of power and pliancy to make certain movements which were previously possible. But such fusion without deformity is rare, and almost invariably the top and bottom surfaces do alter their relation; and it is this alteration that puts the spinal column out of gear, and starts restituent changes.

And, although one has arbitrarily taken three segments in instance, the same reasoning applies to more or fewer. Were one segment solely to be affected and changed in shape, then its surfaces above and below would alter in plane, and the same provocation to restituence be given.

It was explained, that so long as the contiguous surfaces of the spinal segments were natural and regular, then the restituent efforts constantly at work (presuming them healthy) were expended in keeping the spine in its natural form. It was pointed out that, for every shape of the segments, there was an ideal form towards which the spine constantly tended. It was shown that the natural form of the spine was the ideal one of the naturally-shaped segments. And it is equally true that, whenever the shapes and surfaces of the segments get altered by osseo-ligamentous disease, there is immediately an ideal and unnatural form, or, more correctly, deformity, to which the spine tends by restituence to conform. But, as the osseo-

ligamentous disease is generally quick, and as the restituent changes are in comparison slow, being brought about by accommodative and not diseased absorptions, so it usually happens that the active disease is finished and healed before restituence is fairly started; and it occurs as a consequence that one finds when the active disease is cured (and the first stage terminated) one has to face another problem, namely, what effect the restituent changes will produce, if carried out, whether deleterious or otherwise. So that the orthopragmatic treatment of the second stage resolves itself into the question of the government of this restituence.

And with different cases different government is needed. It may be necessary to encourage it, to control it, to retard it, or even at certain points of the spine to check it altogether. For the dangers of ungoverned restituence are sometimes grave, sometimes slight, these depending on the position and amount of the provoking deformity. That is to say, the more marked and pronounced the alteration of the planes above referred to the more also will the new restituent ideal differ from the natural spine, and the more urgent will be the tendency of the spine to conform to that ideal. And if this tendency be very urgent, and be left ungoverned, then the strain on some portions of the spine, either on the lately diseased part or on some other part, will be so great as to cause inflammation at the point, or to re-excite acute osseo-ligamentous disease. On the other hand, if the spine, in undergoing large and ungoverned restituent changes, actually escapes injury

to itself, it will, nevertheless, in changing, cause results of great gravity to the rest of the body, which becomes so misshaped as to impair the vital functions of the organs in the spinal, thoracic, and abdominal cavities, and as a consequence the train of symptoms, which have been styled secondary, are induced.

Now, the policy of the government of restituence in such cases is pillared on these two principles. First, to conserve, as far as possible, the shapes of the three vital cavities of the body, so as to preserve freely intact the powers of the nervous, thoracic, and abdominal systems (metaphorical, King and two Houses of the community corporate). Second, to liberally support the spine and direct the changes that take place, that they may be gentle, not abrupt; that they may be guided, not wantonly the reverse. And, although in these two principles the stress seems to be laid on function and not on form, on bodily ease and not on bodily elegance, yet the twain in this instance go hand-in-hand. The one gained, the other follows. The world looks mostly after form, the physiologist chiefly after function. The right government of restituence satisfies both. One stone kills the two birds; one style of treatment grants the two desiderata.

And with this policy of government, as with all policies, it would be possible to lay down exact laws. An astute mathematician, after careful study of the motions and motor powers, of the facets and muscles, of the spine, could accurately predict that when, after the first stage of osseo-ligamentous disease, certain alterations of planes of the facets have ensued, then

such and such restituent changes would infallibly occur, and such and such forces be requisite for right control. But the intimate mathematics of the spine are very complicated, and further, these changes of plane are not with accuracy to be gauged in the living body, hence the rougher results of experience in many cases have to act as the guide in lieu of the inapplicable refinements of the laws of science. But the whole treatment, whatever its keynote may be, must harmonise with the two principles aforesaid. The orthopragm, to execute these designs, must be active, and this constitutes a clean distinction between the two stages of osseo-ligamentous disease. In the first stage the object of the passive orthopragm was to bear to the fullest degree the burden of the spine, and to check as absolutely as possible all motions in the spine itself. In this second stage, on the contrary, the undulations of the spine are to be encouraged, and encouraged under right government, while the spine itself must be gradually educated to receive its burden again. And this education must not be abrupt but gentle. As a well-known classical athlete brought himself to great bodily perfection and strength by daily carrying a calf, and by thus gradually increasing his power as the calf increased in bulk, till at last the calf became a full-grown bull, and the athlete became fully strong enough to carry it as he had when it was a calf, so the spine must be gradually educated to take up its burden again, and to carry it unassisted.

The construction of the orthopragm is in keeping with these considerations. Its form is as follows:—

The base-hold is taken by a light metal band encircling the pelvis at the line previously laid down as being aptest, and to admit of its being so placed the band is made to spring or to hinge open. It is held in position by a webbing or fabric moulded to the shape of the cinctural hold, and laced to cling over the swell of the hips. This is usually sufficient to ensure its stability, but if needed, some other of the pelvic holds can be requisitioned. So held, the band becomes practically part and parcel of the pelvis, and from it the agents of the orthopragm arise.

First, to co-operate with the spine in bearing its burden, there arise from the base-band two light thin steel upright rods, reaching along and fitting the sides of the body from hips to armpits, and terminating in two semicirclets which receive the arms at the armpits. To these semicirclets the folds of the armpit cling, and use them as *points d'appui*, from which the intervening muscles can sling through the medium of the ribs the weight of the upper parts of the body as already described. Under this arrangement there are two ways by which the spine's burden can be transmitted to the pelvis. As in a house having two staircases people can pass down both equally, or down one more than the other, or down one only, so the bodily weight can be made to pass down to the pelvis evenly through both spine and the crutched uprights, or to use either more or less according to desire. While the spine is rickety and weak, and under reparation, the uprights can be amply used, and such use gradually lessened with the need for it.

It has been critically objected by an opponent of this plan that there are two drawbacks to which these crutched uprights are open. It was said that they threw the shoulders injuriously up, and that the nerves and vessels of the arm were compressed by them. This criticism is both philippic and erroneous. The shoulders are thrown neither materially nor injuriously up; they are not dragged upon. On the contrary, the folds of the armpit cling to the crutches, and the muscles act from these fixed points in the same tonic and reflex way as they ordinarily do through the body; they are neither over-strained nor fatigued. Nor are the vessels and nerves impinged on by rightly shaped crutches, but pass freely between the folds of the pit into the arm without any interference.

It must be distinctly understood, however, that these crutched uprights have the intention only of relieving the spine of its weight, not of otherwise acting on it. Almost all bathers are aware that a huge stone can be with facility moved about in water, which taken thence and brought into the air becomes manually difficult even to stir. While the water buoys the stone it can be moved and controlled with ease; and so it is that while the crutched uprights buoy up the burden of the spine restituence can be more readily governed. This scheme for buoying by means of base-band and crutched uprights is tolerably antique, and has stood unvaried the tests of time and criticism.

The same has not been the case with the governing agents to which one next comes. With these, on the

contrary, the ingenuity of the mechanician has ever been under tax to devise new forms of government. The result has been the production of many very charming and very complicated pieces of mechanism, which have almost invariably suffered from this drawback, that they have not been made in keeping with any distinctly defined principles, and whose efficiency was simply vaunted in the vague dictum that they "gave great support" to the spine. And, as a further result of this lack of definition, a newly-invented orthopragm, if introduced into notice by its inventor in a noisy and business-like manner, has usually been indiscriminately and fashionably applied to all and every stage of curvature, no distinctions being made. And by this indiscrimination the orthopragm, good perhaps in certain cases, has signally failed in others, has lost its reputation, become esteemed unreliable, and been ousted from the popular and professional fancy by the next new invention.

Now, the governors of restituence shall not be complicated, cumbrous, nor haphazard. Their aims and duties having been clearly laid down, they shall perform them simply. They must possess power to govern, and also the means of varying their power with tact; that is, the governing agent must act to the fullest on the spine, and at the same time must be capable of alteration as the case progresses. The agent best able to satisfy these conditions is constructed as follows. To the orthopragmatic parts, already described, namely, base-band and crutched uprights, there are added two spring-metal bands, which pass from the

base-band, to which they are fixed, up along the back of the patient, overlying the two tracks on each side of the spine, which have been described under spinal holds as affording the aptest purchase for direct action on the spine. These two spring bands are connected above by light and rigid wires with the back of the crutches of the crutched uprights ; and they are, when so arranged, obviously fixed at their either end. Through their course the bands are fitted and moulded flatly and evenly to the body along the tracks aforesaid, being left soft originally for that purpose. They are then tempered, and at the same time so set that, while still closely fitting the form, they exercise at any desirable spots any desirable pressure and control; for it was shown previously, in discussing springs, that such fitting force is easily practicable. The power and amount of control thus gained is regulated by the exigencies of the case, and the government needed. It will be seen that these spring bands, rising as they do from the back of the base-band, rise practically from the back of the bony pelvis, for the base-band and pelvis are practically one. The spine and the spring bands, rising in intimate relation from the same base as a common footing, have secured to them also a community of action, becoming, as far as practicable, united in movements. As the spine undulates, so the spring bands do; and yet the latter ever at certain points and parts retains its influence over the former.

With respect to the amount of power exercised by these spring bands, it is easy for them to be made with any gravity or levity of spring, or indeed rigid and

without any spring at all. In the latter case, the bands being rigid, would be consequently passive; and, when so, would constitute the orthopragm alluded to in the terminal paragraph of the matter devoted to the first stage of osseo-ligamentous disease, and referred to as being the one to be used where the splint orthopragm was unneeded, either through the slightness of the disease or through circumstances rendering the comprehensive hold of a splint undesirable. Now, this passive frame-like orthopragm forms, as it were, the connecting link in leaving the splint, and in passing to the active orthopragms. From it the transition is easy, by graduating and varying the back bands in springiness, activity, and force, from the early times of the second stage down to the later times, when the necessity for government is diminishing and ceasing; so that the spine, at first under absolute control, passes gradually to partial, and thence to none at all. And as the processes of nature are transitional, and not by jumps and jerks, so should her auxiliaries tally with her on this point.

Next, with respect to the ability to vary the government progressively and with tact. The temper, ordinarily given to these spring-back bands, is of a kind that, while it resists speedy alteration under the diffused antagonism of the spine and body, will yet yield immediately to the wresting of the "wrenches;" and it is imperative, rightly, that the wearer of the orthopragm should periodically see the orthopractician, in order that the back bands, which do gradually yield, should be reset by the wrenches. The springs and

the spine are in opposition, both yield gradually to the other in their own way; the spring is periodically reset to its work, and the spine, having no such aid, is forced to follow the dictates of its governor. The virtue of the back bands is grounded, Antæus-like, on the new strength they receive when the wrenches touch them; and it follows that the mere buying, applying, and wearing the orthopragm, without submitting it to this mechanical readjustment, is insufficient, and that the orthopragm is not faulty for failing for want of it. The wires of a piano are springs, and pianos drop gradually out of tune and their wires require periodical readjustment, without which the music becomes unmusical, but the piano is not therefore faulty. The simile applies precisely to the springs of the orthopragm.

To keep the orthopragm rightly and comfortably in position certain lacing pieces are added. These together form a stay, so that the entire apparatus comes to constitute a stay with the metal-work let in as the bones in stays ordinarily are, and fits the body in a similar way.

As time progresses, in ordinary cases, the spine, under the double influence of its own restituence and the orthopragmatic government, takes a novel form, which, if not its original and natural one, is, at all events, more desirable and safe than the one it would ungoverned have assumed, and to admit of this the facets of its segments accommodatively alter. The body, at first strongly subservient to the orthopragm, now again becomes fit to be on its own uninterfered with

responsibility, and it is the orthopragm in its turn which becomes more and more subservient till its use can be altogether dispensed with.

If the spine, after finally assuming its last and novel form, still displays a weakness in doing its duties, then the buoying of its burden is continued by means of crutched uprights of the lightest kind, which are fastened to ordinary stays and which are made secure at their lower end by bridging the hips, instead of arising from any base-band, as in the previous orthopragm. This aid is usually required with women alone, and then only as a rule for a brief period, and it forms the ultimate step in the transition from the splinted acme of restraint on the one hand to absolute freedom on the other, a transition which in most cases is perfectly and rationally indicated. But there is a minority of cases in which this simple transitional treatment by back bands is not rightly indicated, cases in which it is rather necessary to give the spine a very forcible maintenance at some particular spot in its course, and to leave the rest of the spine untouched to restitute round this governed spot. On this said spot the grip is taken by either a single plate over the entire breadth of the spine, or by a doubled plate of which each half lies on the tracks at each side of the spine. The plate is connected with the base-band by a rigid rod, at the lower end of which there is a rack and pinion, through whose medium the plate is pressed home to the spine with requisite power, and variations at will are made. And there are instances in which this more forcible government has to be life-long,

instances in which the original change during the first stage has, from presumable inattention, become so great as to render it imperative for life's safety to curb at some point the restituence of the second stage, and in which it is practically impossible to bring the segments, even in long lapse of time, ever to accommodate themselves to a form that would be secure without extraneous government. In such instances, if the government be removed, secondary symptoms at once begin to declare themselves with such violence that is is rendered obvious that continuance of health is synonymous with continuance of government. Such cases are luckily rare.

Finally, although in describing the application of the principles that underlie the treatment of this second stage of osseo-ligamentous curvature, reference has been borne rather to the back than to the head and neck. Still the same transitional method holds good in both cases. It was mentioned earlier that the splint used in the first stage could be carried up to cradle the back of the neck and head; the progression from this restrictive cradling to perfect freedom is facile. When in lieu of the splint the orthopragm, consisting of base-band, uprights, and back bands, is substituted, then these said back bands are extended along the neck upwards, and terminate in a shelf for the back of the skull. A further connection is made from this shelf to the chin, so as to complete the capital holds. By these means both the head is borne to the relief of the cervical spine, and the cervical spine itself is placed within the bonds of government

by the back bands. But this arrangement entirely precludes the rotatory movements of the head whereby the head is turned in looking from side to side. And as this rotatory movement is performed through the medium of a joint at the extreme upper end of the spine, and as further, this movement is permissible without in any way implicating movement of the segments below, so as time progresses this rotatory motion is given. And in one of two ways; the axis whereby it is accorded being either at the base of the skull, or over the top of the skull. If the former, then an extension of the transitional orthopragm is carried by means of a rod to the base of the skull, where there is a rotatory axis on which turns horizontally a shelved circlet in which rest the chin and the back of the skull, and as the circlet turns so does the supported head. If the latter, then the prolongation passes as a rod right over the top of the skull, where a cross-bar is sustained by it rotating on an axis identical in line with that on which the head rotates, and from the cross-bar the chin and base of the skull are slung. The former method is the neatest and least ostensible, the latter has the merit of having its axis in the true line with the real axis of the head. These matters are, however, rather minutiæ in application of the principles, alterable by circumstances, and not of such importance as the principles themselves.

In conclusion, it will be observed that osseo-ligamentous (or more popularly "angular") curvature has been taken as being antero-posterior, that is, distinctly to and fro, without lateral deviation. It is

rarely otherwise, but should it be so, its exigencies would be met by the laws presently to be laid down for lateral curvatures in general.

Musculo-nervous Curvature.

In previously defining the courses of musculo-nervous curvature a distinction was drawn in the first instance between two kinds, the one due to general debility and lack of tone throughout the musculo-nervous system, and the other due to no general cause but to some special accidental or diseased injury or lesion affecting some portion only of the musculo-nervous system. The former kind, being most common, calls therefore for careful review, while the latter, being rare, can be deferred for briefer and later consideration.

The general and atonic kind of musculo-nervous curvature was further itself shown divisible into four distinct stages, each of which will now be taken in due succession, and will be seen to require different ortho-pragmatic treatment. It will be remembered that the limits of these four stages run as follows :—The first is coincident with the period of sluggish debility which exists before the spine permanently loses its natural curves, but during which the habit is contracted of at times stooping (to use the popular expression), and there is a failure after the slightest fatigue to keep the body rightly braced up in its erect position. The second stage commences when the temporary failing of the first stage becomes a permanent one, the natural curves having been completely lost, and the stooping

having become constantly confirmed. The first and second stage thus run without distinct line of demarcation confluently into each other. What commences as a temporary condition is consummated as a permanent one. The third stage originates with a tendency of the spinal segments to become displaced on each other in a lateral and rotatory manner, and comprises, as this tendency is yielded to, the consequent distortion of the ribs and shoulders, with the initiation of the secondary restituent lateral curve in the loins. The fourth, and final stage, is contemporaneous with the advent of accommodative absorption of the spinal segments. This clinches the impossibility of reversion to the natural. The lapse from the unnatural through the first three stages can be reverted to the natural; but, after the setting in of the fourth reversion becomes practically impossible. Briefly, up to a certain point the curvature is curable, beyond that point ameliorative prevention (to us a euphemism) is to be sought, complete cure being rarely possible. Now, it must be distinctly premised and understood that whatever orthopragm is to be used in reverting the deformity and in bringing the body back to its natural condition, must be *active* in its exertion. A passive orthopragm, as a splint, would be useless for such intent. And next, as the lapse into deformity is due to muscular incompetency, so the active agents of the orthopragm which is to remedy this incompetency and remove its effects must be elastic in character, and sufficient in force to counterbalance the lost muscular power, and to put the weakened muscles in

a position to effect by exercise their own restoration to tone. The law on this matter has already been laid down and explained (Chap. III). This premised, one may proceed to the consideration of each stage *per se*.

The first stage is the doorway to deformity. During it, deformity has not arisen. The musculo-nervous elements are losing the disciplined subservience they owe to their proper governors—the gravital and voluntary stimuli, and are beginning to disobey them, a disobedience which, in the second stage, reaches rank mutiny. The stooping or curve-change is not yet permanent, only showing itself at first when the sufferer is fatigued, and even then being alterable by the will. Hence it has been viewed as and styled a habit. When the patient is spoken to, he can still bring himself into proper position, only to continue so entails a fatigue beyond the power of present muscular endurance.

In this early stage mechanical aid is not required. The malady is arising as a habit from debility of health, and can be broken as a habit with re-establishment of health; for the will, which retains its full power with greater persistence than the gravital stimulus, can still act as tutor towards the feeble muscles. First, the constitutional ebb into weakness must be stopped, the tonic decline must be checked, and the tone of the body brought by fresh air and physic to par. This is a simple medicinal point, and without the pale of these pages.

The breaking of the habit, on the contrary, is me-

chanical, although needing no mechanical aid. The enfeebled muscles, while undergoing the medicinal tonic invigoration, require to be carefully exercised in order to reach their pristine state of strength. This exercise should be of the regular character of a drill, and should aim both at strengthening the back muscles generally and also at encouraging the act of upright balance, and so restoring the power to permanently re-establish it. Writers on gymnastics have devised many series of figures for performance with this view, but the simple setting-up drills in use among soldiery are perhaps the best, and are to be learned from any drill-sergeant. These done gently at first, and with increased vigour as time progresses, bring the muscles into the desired strengthened condition. But, probably, the best exercise to attain the double end of spinal use and balance is riding, and more especially that taught in the military schools. For when a man is mounted his pelvis rests on the saddle. Every movement of the horse compels a corresponding spinal movement, in order that the balance and the seat may be kept. Meanwhile, the military instructor insists on the head and chest being kept up, the shoulders being held back, and the small of the loins being well knit in; and the rider is ever reminded of the least lapse from these positions. These he keeps, too, under varying conditions of gravity as the horse moves, and thus, not merely holds himself erect, but balances himself also. At first, of course, these exercises must be gentle and of short duration; gradually they can be extended as the

muscles acquire more vigour. This riding is easily and economically obtained at all places where there are cavalry barracks, it being the custom, through the courtesy of the colonels, to permit the school to be used during leisure hours for such instruction. The advantage of this balancing mode of exercise is not only based on theory, but has practical proof. In countries where riding is a part of the ordinary and early education of all classes, this kind of curvature is unknown, and the same applies to parts of the world where pitchers or other burdens are carried habitually on the head. In short, balancing occupation yields an influence towards immunity from this curvature, and, even in the nursery, a swing or a rocking-horse, trivial as it may sound, serves to establish the uprightness of the childish figure. When this uprightness is becoming lost "as a habit," that is, when the will is still potent, although the gravital stimulus is becoming impotent, then, after proper medicinal tonic remedies, exercise of the back on this balancing principle is best suited to break the habit and restore uprightness.

But if the will itself has fallen into impotence, if, when the patient is told to hold himself uprightly, he cannot do so beyond a few instants, if the stooping, which was formerly a temporary habit, has become a permanent and uncontrollable practice, then the second stage is entered on. The muscles can no longer, when called on, bring the chest up, the shoulders back, and the small of the loins in; they only weaken and fatigue themselves in their effort to do so, and they must be orthopragmatically aided just into the

position to accomplish a share of this task which shall be within their scope, and by doing which they shall gradually become stronger and stronger, till they are competent in time to perform their entire duties unaided.

The orthopragm to do this has the following constitution :—The base-hold is taken on the pelvis by a thin metal band, encircling it in the proper line, passing round from the sacrum to the pubic bone and back again to the sacrum. At the pubic bone there is a softly-padded enlargement of the band, which enlargement rests on the pubic bone and gives the circlet a certain stability. The circlet is actually maintained in position by its own tightness on the pelvis, it being tightened to a degree consistent with stability, and not inconsistent with comfort. This mode of hold is amply sufficient in this instance, and there is no necessity to employ the cinctural nor any of the auxillary holds, there being no weight from above to be borne by the circlet. Next, starting from the base-circlet behind, there arise two metal slips, which pass up the tracks along the side of the spine and reach as high as the top of the back, where they join each other in an arch. There springs from each of these back bands, at the level of the armpits, a spring-wire horizontal branch, which passes straight across the back to the armpit of its own side, through the armpit, and under the arm, and which curls round to appear in front and terminate in a plate, pressing against the top of the shoulder and holding this latter back. These are termed arm-pieces. Lastly, the orthopragm is completed by an elastic belt, which, surrounds

the lower abdomen and is fastened to the back bands in the loins, thus holding the back bands closely to the spine and supporting the abdominal walls.

The use and intention of the entire orthopragm is to give the aid lately mentioned. In doing this the back bands play the principal part, the remaining portions being rather subordinate and holding the back band to the spine. The latter are the holds, the former the agents. It is true the holds have subsidiary intents of their own—the arm-pieces help the muscles to hold the shoulders back, the belt aids the muscles of the abdominal walls, and the pelvic circlet can be at pleasure modified to control uterine malpositions. These uses are, however, secondary somewhat to that of keeping the back bands in apposition to the spine. The back bands and the spine are thus as nearly as can be one, and the spine being deficient in certain muscular power the spring back bands are set to supply by their force the deficit, and the spinal muscles are aided to aid themselves, as explained. The whole orthopragm is at sword temper, supple, and pliant. As the body bends it bends. It fits with such closeness as to be undetected by sight, and even by casual touch, for its hard parts coming in the position of hard parts of the body its presence is unsuspected.

Now, the virtue of this orthopragm lies in the fact that it aids the spinal muscles, and places them within governance of the gravital stimulus, and acts also as a reminder to the will. It does not force. The old orthopragms used to truss back the shoulders and practically splint the spine into shape, and this plan

was fallacious and erroneous. The same error was committed when a brace was worn for round shoulders. The brace tied back the shoulders, and did not train their muscles to do so themselves.

The strength of this orthopragm is varied, of course, with the amount of deficient power it has to supply. It is used, when very lightly made, even in the first stage of this musculo-nervous curvature; it becomes the drill-master, for being a constant reminder to the will, it drills. It is frequently used now by the weaker sex as a mere preventive against fatigue or back-ache, more especially where the duties of their station or of their profession put a more than ordinary strain on the muscles of the back. Not a few eminent actresses have habitually used it, the less to be fatigued by the constant necessity they have to maintain an upright figure; and for a similar purpose it is beneficial to those who, riding for long afternoons in their open carriages, sit uprightly with their back unsupported. In these cases the orthopragm is used rather for weaknesses, but by quoting them is shown the extension of which the elastic principle is capable.

Now, this orthopragm is flexile with the body, particularly in the antero-posterior direction. The deformity in this second stage takes place all in one single direction, the antero-posterior. The lapse of the body into the next stage introduces an entirely new mechanical element, and has to be met in a distinctly different orthopragmatic manner.

The third stage comprises the period during which the segments of the spine become displaced on each

other in a lateral and rotatory manner. The whole deformity of this stage follows from that simple fact. The ribs follow the segments, the shoulders follow the ribs, and the secondary restituent curve follows the disturbed distribution of weight that springs from the primary curve. In the previous stage the spine bowed in one single plane of direction, and the centre of gravity of the mass of the body altered also in this plane, in which, likewise, both restituence takes place and orthopragmatic reversion has to be directed. The force employed for this latter purpose was consequently single, simple, and direct, in that plane. In the third stage it is quite otherwise. The trunk yields simultaneously in a spiral and lateral direction. The reversionary orthopragmatic force must, therefore, be spiral and lateral and in similar due combination. The expression was used a few lines since, "the trunk yields," and advisedly so; for if the attention is pinned, as it were, too strictly to the spine, one is apt to lose sight of the fact that the other contemporary changes, of ribs, shoulders, and loins, are coincidentally going on. It is, therefore, wise to embrace all the changes in one glance or thought. The trunk, then, be it said, is moving spirally and laterally, the spine being the stalk of its movement, and it is the trunk as a mass that has to be replaced.

Now, in a massive replacement of this kind it behoves one not only to see that the force employed be properly directed, but also to take every means to lighten the labour. A man, for example, might be unable to move a heavy table which, if put on castors, a child could

wheel about with facility. This lessening of friction, in lessening the labour, lessens also the amount of force needed. And (returning to the trunk) the less force employed the better, so long as it is adequate, for the bodily tissues are not very tolerant of violence. And this point is the more to be insisted on, seeing that the force to be made use of in this third stage is spiral. Every one knows the difference in the difficulty of pushing a chair straight across a room, and of pushing it round a table. As a consequence the orthopragm should have a distinct provision for easing the labour of the active agent.

Lastly, with respect to the hold that can be obtained to spirally move the trunk. The only holds the spine itself offers have been shown to be the two tracks in its rear, holds useless from a lateral, and of feeble use from a rotatory, point of view. What the spine refuses the ribs, on the contrary, are able to grant. First, as to rotation. The ribs were shown to be as handspikes on the spine; they were shown being part and parcel of the spine to rotate with the spine during the third stage, the ribs of the one side backwards, the ribs of the other side forwards; they were shown to be incapable for respiratory reasons to offer any hold in front over the chest, but to be amply capable behind in the back. These data yield the fact that the spine can be re-rotated through the medium of the ribs, but that this re-rotation can only be made on the one side, namely, that side on which the ribs have themselves rotated backwards. Still, it is obvious this capacity is sufficient for the purpose, seeing that a

windlass is turned whether half or all the handspikes be used.

Next, as to the lateral lapse of the spine. It was shown that the ribs could be used as a means of indirect lateral pressure on the spine, and that when the spine curved laterally they spread, fanwise, on the side of the convex curve, a spreading which disappears again if the curve of the spine can be eliminated; and it is a fact that force can be so distributed to the ribs as to revert the lateral curve and to restore the ribs to their proper parallel position.

Finally, it chances that the same identical ribs are the ones to be acted on both for rotation and for lateral lapse; hence it will be found that the active agent of the orthopragm for this third stage shall be a single spring force acting on certain ribs in such a spiral and lateral direction as shall ensure all the reversions aimed at.

The orthopragm itself is of the following construction :—The base or pelvic hold is taken by the same plan as that used in the second stage of osseo-ligamentous curvature, namely, by a thin metal pelvic band conjoined to a webbing cinctural one. From the sides of the pelvic band arise similar lateral uprights, and for the same purpose, to float the weight of the trunk. It is precisely this floating which places the trunk under more facile and exact control of the active agent, lessening the labours of the latter. The active agent itself is a coiled spring. It arises on the one side from the front of the steel pelvic band, and therefore indirectly from the bony pelvis itself; it passes round

the back of the body to the prominent ribs of the other side, and it terminates in a plate which overlies these ribs and distributes its force to them in a combined spiral, lateral, and elevating manner; spiral to re-rotate the spinal segments, lateral to laterally revert them, and elevating to close the fan-like spread and restore the parallelism of the lower ribs. To be more exact by an instance: the spine has rotated (as it usually does) so that the right ribs have moved backwards. To those of the said ribs which lie below the shoulder-blade a spring-steel frame is closely fitted so as to be capable of diffusing pressure on it to the underlying bones. The coiled spring to give such pressure commences at the pelvic band in front of the left hip (just below the anterior iliac spines), and passes round and up the body to the centre of the plate on the right ribs. When the orthopragm is *in sitú* on the body, the spring fits with almost close accuracy, and its powerful force is comfortably exerted in directing the ribs in the directions already mentioned. When the orthopragm is off the body the spring coils up in accordance with the set given it prior to tempering.

Now, this coiled spring constitutes the only true and rational means by which the trunk can be replaced round the axis of the spine, nor is there any other plan by which the required and combined directions can be gained.

This coiled spring has been described as being used in conjunction with base-band and lateral uprights. This is ordinarily so, but in the case of girls, where the third stage is almost incipient, and where the spring

required is but light, it is practicable to merely fit the coil to their stays, one end of it clipping the hip as a truss spring, and the other terminating in the proper rib plate.

This concludes the orthopragmatic guidance of the third stage. Up to this point the lapse of the spine is, if caught and taken, curable. As, however, the lapse occurs by stages so the reversion has to be made through stages. Thus, a patient in the third stage wears the orthopragm for that stage till the rotato-lateral element of lapse has been eliminated, and then takes to the orthopragm of the second stage, finally completing the cure by the healthy exercises of the first stage.

The fourth stage commences with the advent of accommodative absorption. It entirely lacks regularity. The facets of the spinal segments become changed and lose their planes, and this perdition once started is very unrestricted. In the meantime large restituent converse curves arise in the course of the spine. Orthopragmatic assistance resolves itself into checking these processes. The spine is relieved of its burden. Rightly applied forces are put in tension to control or revert the spinal lapse, reversion not being possible, as in the previous stages, by calling the facets into play, for this is no longer practicable, they having altered; but rather by establishing a government on restituence on the one hand, and attempting to get, on the other hand, a counter-accommodation from the segments, after the original provocation has been removed. Cases so guided can most usually be checked from further lapse,

and not unfrequently can be slowly and surely ameliorated. The orthopragms employed for this purpose uniformly consist of base-band and lateral uprights, similar to those employed in the previous stage. By the uprights the spine is relieved of much of its burden, a relief in itself alone enough sometimes to stop further evil progress of curvature, The agents employed vary much, but generally take the form of plates fitted to the bony parts which require staying, these plates being brought by racked rods into the required closeness of adjustment, and where the agent is intended to be merely prohibitive and not restorative it may be almost passive in its character.

It was previously stated that musculo-nervous curvature was due either to general musculo-nervous failure, or, on the contrary, to some special or partial peculiarity, as local spasm, lesion, or injury. When these latter states arise the curvature is treated on principles similar to those already laid down, and cure (that is, reversion of the deformity and restoration to the spine, not only of its natural form, but its natural power, in order that the use of the orthopragm may be discontinued) will depend on whether the provoking cause can be removed. If the provocation is continuous in its occurrence then the orthopragm must be also so in its use. If there is a persistent muscular tendency to detract the spine in an unnatural way, then the antagonistic orthopragmatic power must be persistent in its opposition. In this class of musculo-nervous curvature the orthopragmatic agents should be active, and the

construction of the orthopragms of which they form a part will depend on the proper attainment of holds whereby such agents can exert fit force and obtain right direction.

Extrinsic Curvature.

Extrinsic curvature is entirely restituent, and is provoked by some causes absolutely external to the spine itself. A number of these provocatives were categorically given, and found to be summed up as falling under either a disturbance of the spine's base, or a disturbance of the spine's burden, through some irregularity.

Treatment therefore resolves itself into two things: removal of the provoking irregularity and government of the restituence in a reversionary direction. This being so, it will be seen that of necessity there is very little to be said concerning it in this place. For the principles on which base or burden should be rectified when in error have been already given, how the truth of the axes and arches of the former must be restored, and how the distribution of the weight of the latter must be re-regulated. The practical means of so doing do not come within the scope of this portion of the work, but are reserved for future parts treating on the upper and lower limbs respectively. For instance, a club-foot may practically render the limb to which it belongs shorter than its fellow, and this shortening, in its turn, disturbing the truth of the pelvis, provoke restituent curvature in the spine. It is a fact that bears on spinal curvature that the truth of the pelvis must be restored, seeing that the pelvic error is the

irregularity which in this case provokes spinal deformity; but how this restoration is practically to be effected, how, in short, the club-foot is to be treated is foreign to spinal curvature, and belongs to the orthopraxy of the lower limb. And so with all the provoking causes of extrinsic curvature; the practical means of their removal have to be considered at length in their due place and not in this particular chapter.

Again, as regards the government of restituence, the same brevity suffices. The position and direction of the restituent curves will accord with the kind of the provoking irregularity. The agents to revert these curves must be active, while the orthopragms will conform to the necessities of the curvature, and will ordinarily be of a type similar to those previously described. This may sound vague as a statement, but as the precise course these extrinsic curvatures take cannot be actually laid down, so a precise description of the orthopragms applicable to them is equally impracticable, and if given would mostly constitute a catalogue of exceptional cases.

Complicated Curvatures.

Complicated curvatures arising when there is the coincidental occurrence of more than one of the provoking causes which have hitherto been entered into, require orthopragms in which this compound provocation is foreseen and provided for. The construction of such orthopragms becomes merely a matter of instrumental composition, whereby the elements of two mechanisms are harmoniously blended. The task

of so doing is usually simple, and offers no novel matter for consideration.

Secondary Symptoms.

There are certain functional disorders of the vital organs which accompany spinal curvature, and which yield to orthopragmatic treatment in a similar manner, the intimate connection between the two being the obvious reason of this fact. For as the spine lapses from its natural form so the guardian cases of the vital organs become changed, cramped, and straightened, and the organs themselves dislocated, compressed, and subsequently disordered. These disorders are mechanically amenable, and it is for this reason they have been reintroduced for consideration. For, although at first sight there may appear a disconnection between the spine and the vital organs, and it might be received with incredulity that (putting the point more widely) the wearing of a spinal appliance could restore to an organ, such, for example, as the uterus, the healthy tone from which it may have lapsed, still it will be seen after proper explanation that such is the case. And it will be wise to once more survey the vital organs in order to trace the line of this connection.

The brain is clearly protected from all direct injury by spinal curvature. The spinal cord also is but little liable to harm except when a curvature arises of so acute and angular a kind as to endanger actual constriction of the cord, and this is rarely the case. The spinal nerves, on the other hand, are more exposed to hurt, being dragged or pressed on by no very con-

siderable alterations of the spinal segments, and being excited to produce either neuralgic and painful sensations, or to create involuntary movements in the muscles to which they may be distributed. These nervous exhibitions are generally very speedily curable by the orthopragm which, tending to restore the segments, also removes the strain from the nerves involved.

There is another peculiar nervous state which, although not connected to curvature as a secondary symptom, nevertheless should not be overlooked at this point, being as it is amenable to orthopragmatic cure. Its evidences are known under the name of spinal irritation, and they can be either real or hysteric. If real, there is, without any actual deformity, great tenderness, sensitiveness, and aching of the spine and its immediate surroundings, and these are met by light orthopragmatic support which gives rest to, or rather relieves, the spine, and so gradually puts an end to the irritable condition. If hysteric, there may be presumed to be a mentally produced hyperæsthesia in the immediate region of the spine, an over-sensitiveness which is terminated by rest as well as by even pressure diffused over the adjoining parts, this being apparently due to the fact that a hyperæsthetic sensibility of such a kind can be obliterated by sending other impressions (of pressure in this case) along neighbouring nerve-ways, just as when a paining part is suddenly dipped into cold water the cutaneous nerves are occupied, and those which previously transmitted the pain fail for the time to have their impressions felt or attended to.

Finally, this hysteric spinal sensitiveness may be presumed to be purely imaginary, and in such cases the orthopragm may act as a mental rather than a bodily cure, faith being pinned to it by the patient who is subsequently cured. Be this as it may, this nervous irritability over the spine is not uncommon.

Next, passing to the chest: increase in its bulk is gained by elevation of the front of the ribs, decrease by falling of the front of the ribs, and by all their other movements such as rotatory, as well as by all unnatural changes in their shape. Diminution of the chest lessens the efficiency with which the heart and lungs do their duties, and there is as a result inadequate aeration and irregular circulation of the blood. All the changes of shape induced in the chest by spinal curvature provoke such diminution and such evil results, which latter, on the other hand, yield to the orthopragmatic appliances which revert the ribs and increase the openness of the chest; and so these secondary thoracic symptoms yield to orthopragmatic influences.

And the same again applies in respect to the organs in the abdomen. As the shape of the spine alters, as the natural curves are lost, so the organs along the intestinal canal trench on the room of each other, and, getting huddled as it were together, fail to act in a tonic and healthy way, a failure which is remedied by restoration of the spine through the proper orthopragms. And there is one organ in particular, the uterus, which, from its position below all the others, and from the fact that it lies trapped in the bony basin

of the pelvis, is particularly liable to functional disturbance by the lapse of the superimpendent organs upon it. And being very prone to mechanical dislocation, and further, these said dislocations painfully and functionally disturbing the health of a sufferer, uterine displacements are both very common in their occurrence and very noticeable in their effects. And in associating them with spinal curvature it must not be imagined that they are the late accompaniments of that deformity, on the contrary, they begin to arise in even the earliest stage of musculo-nervous disease. For even then, as the lumbar curve straightens, the pelvis greatly changes its position, forming a novel angle with respect to the perpendicular, and carrying with it into a new position the uterus. At the same time the bowing of the back permits the other organs (especially the intestines) to drop on to the uterus, which by its change is in a position wholly unfortified against the aggression ; and further, when the constitution is atonic, the actual tissues are ill disposed to resist interference. As a consequence the uterus and its adjuncts give way, become malposed or misplaced, pain and functional disturbance ensuing. There is a sense of dragging in the small of the back, and frequently pains of a bearing-down character in the abdomen.

Now, this state is a concomitant of spinal curvature. It also is common with women who, having no actual disposition to curvature, are nevertheless through weakness or fatigue prone to sit not erectly but with the lumbar curve straightened, and in short to assume

a position very analogous to that of the first stage of musculo-nervous curvature. And it is by a modification of the very orthopragm designed for this first stage that such cases are met and ameliorated, the orthopragm doing two things, namely, reconstituting the lumbar curve and supporting the abdominal walls. The effect of such orthopragmatic action is this. The pelvis, and with it the uterus, is restored to its natural angle or plane, and the back ceasing to be bowed, the organs which are swung by ligaments over the pelvis, are pulled by the tightening of these said ligaments as the body is erected, away from all chance of interference with the uterus, which, restored to its power of keeping a position necessary for the healthy discharge of its functions, takes at once advantage of the opportunity to resume its natural position and tone. The possibility of treating these uterine dislocations by external orthopragmatic aid is only lightly touched on here from its point of view in connection with spinal curvature. Many of the dislocative disorders of the uterus can be so met, but the subject is a large and lengthy one, and is reserved for consideration at full in a later forthcoming part of this work.

REFERENCES

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