

system. These impulses activate muscles, and muscles move bony levers in orderly fashion according to the mechanical laws of leverage. Our object should be to know more of the fundamental principles upon which these operations are based, so that we may facilitate freedom and economy of effort and motion—think straighter and throw a straighter ball.

## CHANGING PATTERNS OF POSTURE

The ability to improve a pattern of support and movement for the reduction of mechanical stresses comes, not through the development of bulk and power in individual muscles, but from the study and appreciation of the human body as a weight-bearing and weight-moving structure. Kinesthesia, the feeling of movement and of weight, is the important source of our information. Through it we are able to bring about a better balancing of parts, and thus coordination of the whole. Our real interest then is a knowledge of mechanics, aiming to establish mechanical freedom and organic unity.

By securing balance at all weight-bearing and weight-transferring points in the structure, we equalize the pull on the antagonizing muscles under passive conditions, and thus release a greater amount of energy for their use in action. Why hold the bony parts of our body when we can let them hang or sit? In movement, they must alternately depart from center and return, if coordination is to take place.

When "doing exercises" under instruction we are apt to think that we move or direct the moving of muscles. What actually happens is that we get a picture from the teacher's words or his movements, and the appropriate action takes place within our own bodies to reproduce this picture. The result is successful in proportion to our power of interpretation and amount of experience, but most of all perhaps to the *desire to do*. In any case, the final response is automatic and not the result of any consciously directed movement of particular muscles. It is the result of a combination of reflexes, no one of which can be selected as in itself "causing" the movement, or pattern of movement. As Starling has pointed out:

"We have no objective phenomenal experience of our muscles. All that we are aware of and can judge of by our other senses is the movement as a whole, and our sensation of movement is therefore referred to the whole movement and not to the individual muscles."\*

#### POSTURAL REFLEXES

Underlying all activity of the whole body, as in locomotion or in the various athletic skills, are the postural reflexes, by which man gets his bearings and keeps them. These are the reflexes that attend constantly to the important task of adjusting his weights along the upright of the spine, and maintain the spine itself in its supporting curves. Even the eyes are secondary in this process. They are constantly adjusting themselves as the messages come in from the labyrinth registering the positions of the head in relation to the earth.

The dog or the cat can balance itself with far greater ease than man, because at any given time three of his four feet can be on the ground at once and thus establish a plane. Even man finds that on steep or uneven ground he can progress better by using a stick for a third leg, to get a plane for balance. The tripod, because of its third leg, can be set down anywhere, on the most uneven surface, and thus makes surveying possible in the roughest territory.

#### CONDITIONED REFLEXES IN POSTURE

Posture attitudes of an animal are unconscious, while man's are largely determined by preconceived notions as to how he ought to look. The automatic character of response to a notion of what is desirable in posture is evidenced by the behavior of the average adult upon hearing the words: "Stand up straight." The chest is thrust out, the head and chin drawn stiffly back and up, in the effort to look "tall and straight." Actually the spine may become more curved than before, though in another direction. The height may thus be shortened, while the whole structure is handicapped both for general support and for move-

\* Principles of Human Physiology, by Ernest H. Starling, 1912.

ment, as the spinal curves are thrown out of relation to the vertical axis.

This familiar response is determined by our conditioned reflexes. That is, the sensory-motor chain of reactions in our nerves and muscles has been gradually modified through association of ideas derived, not from mechanical or physical considerations of what balance means or how a really straight back looks, but from moral, that is, social concepts.

The words "straighten up" imply traits of integrity and self-reliance. We try therefore to look like someone brave and strong, and the soldier on parade, preferably the leader, is usually taken as the pattern, reinforced by suggestions from picture, story and song. For long years, the only "official" bearing was that of the soldier. The conventional command for it was descriptive: "Shoulders back, chests up, chins in, toes out!" Now these, and especially the requirement of pointing the toes outward, are no longer stressed even in military circles and are not found in gymnasium directions, but the average adult still responds through his conditioned reflexes to these old social and group suggestions. To most persons a word is all that is necessary to produce a characteristic pose: the symbol of a strong supporting character is a "stiff backbone"; the person who can take punishment without whining "takes it on the chin." The old adage, "Don't carry your wishbone where your backbone ought to be," reflects the moral suasion of a past age—good morals, perhaps, but bad anatomy.

Conditioning the reflexes, thus establishing fixed muscular patterns follows the imposition of these mechanically false ideas. But the system would react with equal ease to the right mechanical idea, and it is a fortunate circumstance that the structure adjusts itself to varying inner as well as outer stimuli, because we can alter the position by altering the stimulus. That is, we can substitute for the artificial or morally perfect position, the mechanically perfect, or naturally balanced position. To do this we must make use of the kinesthetic sensations coming to the central nervous system from every bone and joint,

every ligament and muscle, just as surely as and more constantly than the peripheral sensations of touch, sight or sound.

#### PSYCHOLOGICAL REACTIONS AND POSTURE

The organic, or proprioceptive sensations, usually unconscious, are most significant in all movements involved in reflex action, and therefore in the process of learning or of habituation in practically all skills.

Postural reflexes have more widespread significance than is generally realized, since they enter into and modify other physical processes, such as breathing and the circulation, and may even affect mental activity. William James, in his "Principles of Psychology," pointed out that bodily postures definitely influence the emotions.\* Certainly the reverse is also true, and the peculiarities of posture associated with mental diseases and abnormalities of various types have long been observed.

Laboratory experiments have shown distinct differences in the ability to make sensory discriminations according to bodily position. For example, pitch is best determined in the vertical posture, which is also favorable for testing the strength of grip and the accuracy of tapping; while the tactile sense and the visual and auditory memory appear to be best in the horizontal position. Many scholars have reported that they were able to do their best intellectual work while lying down.

These facts may explain the instinctive choice of the standing position for certain activities, even where the conditions of space do not demand it, as in the case of a musician, who must constantly adapt to the pitch of others, like the tap-drummer or castanet player, in an orchestra; or where delicacy and precision as well as strength are required as in fine surgery, mechanical drafting or machine-tending. Lying down, however, may best serve the person sizing up a situation in mental review, or planning for some future activity, where passive receptivity to ideas is needed rather than alert preparedness for immediate response to an outside stimulus.

William H. Burnham, the noted educator, remarked that

\* The Principles of Psychology, by William James.

"conditioned reflexes of the utmost significance to physical and mental health may be developed in connection with posture."\*

#### WHY STANDING STILL IS HARD WORK

The reflexes induced by the effort to stand still have been compared to the activities in a signal and switching station of a great railway, where half a hundred possible wrecks must be averted simultaneously. In our bodies there is a continuous tendency for gravity and inertia to unbalance the various units of weight and a continuous counter-effort to keep them balanced. The signaling between the various parts of the body and the cerebellar switching station is like that in the dispatching office, only far more complicated. Save in the artificial surroundings of the old-fashioned classroom or the Army, we have actually little occasion to stand still more than momentarily. But consider what happens when we "stop, look and listen" at cross-streets and the speedy dispatching that must be done through our various nerve centers to prepare arms, legs, spine and head to act together in a sudden backward jump that may be necessary to meet a threatening situation. When the wild creature stands still it is generally in some similarly critical situation, in which the impending choice for flight or attack leaves no time for deliberation; all must be "set to go" in any direction. This means a fine balance, as close to unbalance as can be, so that the slightest impetus will release the appropriate chain of motions.

Walking, as we all know, is easier and less fatiguing than standing, since the process of losing our balance and quickly recovering it causes less strain than the effort to keep our very flexible, delicately poised mechanism in one position. In standing there are actually many more small movements of more small parts cooperating. We must, moreover, impose our wills upon our bodies, since the attempt to stand still is not "natural" and must be directed consciously. This is more fatiguing than any movement that follows an unlearned pattern. Muscles

\* Posture as a Condition of Efficient Brain Activity, an essay by William H. Burnham, American Posture League.

can be held in one position or continuously contracted only for short periods without fatigue; and the pattern of muscle action is that of alternate contraction and relaxation, which may be exhibited either by the whole group of muscle fibers making up what we call "a muscle" or by separate bundles responding within it.

Motion allows for rhythmic alternation and variation in the use of muscle fibers, and gives time for the individual bundles to rest, that is, to resume their simplest state of elementary tone. However, when standing, if the three bulks of weight—head, chest and pelvis—are held in alignment at their own spinal levels and balanced at their bony joinings, the muscles do not have to work nearly so hard to keep them there as when they are held out of alignment. Gravity itself is harnessed when we keep our weights balanced. By cultivating our sensitivity to kinesthetic impressions we can learn how the various parts feel when they are balanced, and by frequent reference to this consciousness we reduce strains and stresses within the structure.

#### MUSCLES, MOTION AND REST

The nature of muscle action with its alternate contraction and relaxation may be best exemplified by the heart beat. Cannon states that the heart, during twenty-four hours, works nine hours and rests fifteen; such are the proportionate periods of contraction and relaxation in systole and diastole which enable it to keep going for a lifetime. The alternate rhythm is especially marked in the heart because of the presence of two types of muscle tissue, the striped, which is like that in the skeletal muscles, and the unstriped, like that in the intestinal canal and in the walls of the blood vessels. Unstriped muscle is characterized by a tendency to continuous and rhythmic contraction and relaxation.

Striped muscle tissue also partakes somewhat of this tendency. As muscles work in pairs, actors and antagonizers, when one set contracts the opposing set relaxes, allowing it to be stretched. Through the agency of the proprioceptive mechanism, the tension in this set produces in the muscles a tendency to contract,

thus initiating the next movement. That is, in extending the whole leg from the body, all muscles about the thigh joint take part. As those in the front of the leg contract, the ones in the

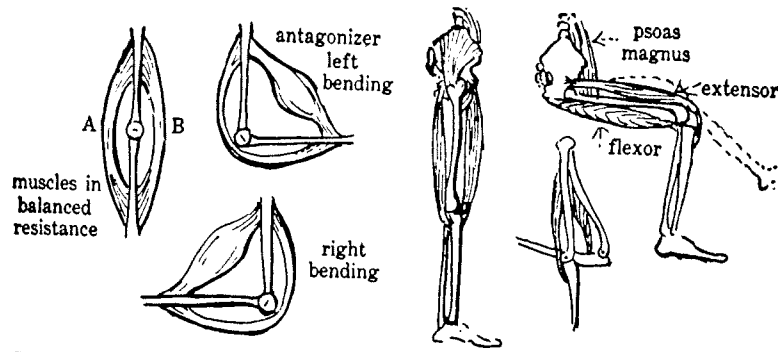


FIG. 7. Antagonizers. As a muscle on one side of a bone contracts, its opposing muscle stretches.

back relax and thus can be stretched; otherwise the leg would not move. There would be instead a tug of war between the two sets of muscles. When the hamstrings contract, the leg bends backward and as this happens, the quadriceps muscles relax and are stretched in turn, with the result of producing in them a tendency to contract, reversing the movement again. And so this alternation continues, in all activities such as walking, riding, running, bicycling or climbing.

The accompanying diagram shows schematically the action of the two sets of muscles about a joint, the bones being represented by two rods, with muscles attached to both sides.

The timing system controlling this alternation in muscular movements lies in the proprioceptive mechanism. The action of the legs is facilitated by the timing of the alternate contraction and relaxation of muscles. This timing is perfected by repetition and practice, until an intricate series of timing reflexes is built up for each type of movement involved in establishing new skills.

The motions of the various parts of the body used in standing or walking involve many pairs of muscles which move the

spinal segments, so that the weights of head, trunk and pelvis are balanced upon the jointed column, and these combined weights are transferred through the legs to the ground. Muscles should not be called upon to hold special parts away from center in response to notional concepts. The muscle task is to move the bones, balance them at their spinal contacts along the axis of the spine, and transfer their weights as directly as possible to the base. Holding them in any preconceived position results in strain. The only way to avoid this is by keeping the joints properly aligned and the muscles as free as possible to move the bones and transfer or alter their direction of movement. Such result can be reached only through an understanding of balance and weight-thrust at the joints. A knowledge of mechanics is essential. We need not worry about appearance, because the balanced posture is bound to be beautiful. Indeed, when we analyze our impressions of posture, we find that it is the carriage showing poise and quiet strength which attracts us, while the strained attitude, with local rigidities, communicates to us a sense of discomfort.

On the other hand, a subjective impression of "comfort" in a particular position cannot be safely identified with mechanical balance. From long habit one may become accustomed to a wrong position even though it creates stresses throughout the mechanism. Because of nervous adjustments that have been made in establishing it, it may feel comfortable, especially if we complacently regard it as proper. Any readjustment, even to a balanced position, may produce at first the discomfort attendant upon change. Thus, a person who has been holding his chest high, in response to some notion of duty or brave front, feels when first told to disregard his chest in accordance with better mechanical adjustment, that he is losing some of his moral force by so doing. This is plainly a reflex which will require reconditioning or a process of re-education to change. After the body weights have been shifted from positions where they were held by muscle power to positions where they are balanced at their bony joinings and sit or hang in line with their supports, new reflexes (powerful enough to displace the old



ones) must be smoothly established so that the new position is maintained with the least sense of effort. Then effective responses to these new sensations and better coordinated action will bring about new habits, or new patterns of posture, which in time will feel comfortable.

#### BODY MECHANICS AND STRUCTURAL HYGIENE

Throughout the entire bodily structure run two forces: the one is mechanical, operating on all parts of the body in the same way that it acts on any similar combination of weights, levers and supports; the other is the living force exerted by the neuromuscular mechanism. In our dynamic organism, correlation is accomplished in two interrelated ways: by mechanical changes through direct transmission of pressure or tension, and by organic changes through the excitation of living tissue. The effect of the neuromuscular force is to move bones about, while the effect of the mechanical force is to move them in accordance with the principles of natural balance. In the absence of the neuromuscular connections, the spine would collapse in response to purely mechanical force. This happens in paralysis. However, the adjustment of our bodily mechanism to the forces about it must follow the same principles that govern other structures with the same mechanical problems. There is no valid reason for believing otherwise. To secure conscious control of balance in the bony structure of the human body we must begin with an understanding of its mechanical design and then trust to the long-established automatic machinery of the neuromuscular system to make the necessary space-time adjustments. But this automatic process is interfered with whenever we attempt to force into a new position any particular part without reference to the pattern of the whole.

Exceptional performance in any one activity is not involved, nor emphasis upon a special set of muscles, but rather a cultivation of habits of thinking which secure the balance of the separate units of weight at their points of support. Contemplate the facts, and you will find your body responding with comfort in sitting, lying and standing, and with a new freedom

in activity. Economy of effort is a component of this new freedom. Functional design and the balance of forces in materials must be studied and applied to establish economy and to form a basis for structural hygiene.

Structural hygiene, then, may be defined as the application to the human body of the principle of organic development that *form follows function*. The prime mechanical function of the bony skeleton is to resist gravity and to support the weight of the body above the ground. Its form has developed for this purpose. The prime function of muscles is to move bony levers by furnishing power at appropriate points. They should be used for this purpose, and not to do the work assigned to the bones. This muscular action, directed by the nervous system, performs the patterns of time-space-movement.

As the organism becomes more elaborate or meets increasingly elaborate hazards, with new needs at new levels of consciousness and interest, it can make special adaptations of particular parts only by means of the old neuromuscular mechanism. The superimposed interests do not and cannot be made to supplant the old basic concern of survival amidst the contending forces of gravity and inertia. New functions do not replace the old, they are simply added to them.

The function of the skeleton is protective in its primary sense, even before it is supporting, and the supporting phases must not be allowed to interfere with the protective phases. When man lifted his body-weight from the ground in assuming the erect posture, the added handicaps of support through his narrow base were met by various devices for management as well as by structural change. These changes, however, have proved to be inadequate in themselves to solve the problem of easy balance under the new conditions. As a consequence, the functioning of the skeleton as a protective mechanism is often jeopardized by poor mechanical adjustment. Human intelligence must be applied to this problem.

If muscles are called upon to lift and to hold weights unnecessarily instead of to move bones in balanced relationship, such action violates their relation with the nervous system, as

the organic sensations then sent to it are not designed to induce the appropriate reflexes. The holding of parts in fixed and strained relations impedes circulation, and the resultant congestion of one part and the defrauding of another can work havoc throughout the system. Quite limited breathing may suffice for the exchange of oxygen and carbon dioxide in the lungs, as may be seen in cases where the lung capacity is greatly reduced by disease and yet life is maintained. But the failure to utilize to the full all the chain of muscles that normally take part in the mechanics of breathing, such as the deep-lying abdominal and pelvic groups, robs the body of one of the natural coordinating mechanisms by which, for example, lymphatic and venous circulation, liver action, and peristalsis are promoted.

"Posture" is incessant. Even in sleep, organic functions such as breathing and digestion are still continuing in their rhythms, and structural parts assume relationships to each other, varying in their freedom and tension according to the strains of the day's activities. Small strains and tensions then assume an importance quite incommensurate with their initial dimensions. The stimuli constantly transmitted to the nervous system from joints and muscles are cumulative in effect, and often persist and hold over in muscular patterns of fatigue, which may not be completely relieved by sleep.

If these fatigue signals continue, as they may when there has been over-long contraction without rest, even when individually imperceptible, their effect piles up until enough is collected to produce a reaction in the nervous system. This reaction may partake of the nature of "shock" and be violent and incalculable in its effect, since the neuromuscular system, in its effort to deal with unassimilable impressions, may engage many more side chains of reflexes than ordinarily would be necessary. The end-result may be extreme inaction or an explosive overflow of nervous energy, according to the nature of the stimulus, and of the reacting organism. In any case, the particular reaction to fatigue depends to a great extent upon the emotional balance of the individual.

The type of postural maladjustments which consume energy and fatigue us most are those connected with our daily activities as we sit at a desk or sewing table, at a typewriter or a microscope—activities employing small movements of the eyes and hands and necessitating many small decisions and judgments, and constant attention. Attention means tension, a readiness to move with no movement taking place, which spells fatigue, for the reasons we have reviewed. This is doubly the case when to attention we add worry as to the outcome of our work, or anxiety for the future. Even when the anxiety is quite apart from the work in question, or when we are not sitting at a small, constraining task, our emotional undercurrent will express itself in some postural pattern. Emotion constantly finds expression in bodily position; if not in the furrowed brow or set mouth, then in limited breathing, in tight-held neck muscles, or in the slumped body of discouragement and listlessness.

These are some of the more important, though elusive strains to which the body may be subjected, through violation of the principles of mechanical adjustment, in the primary function of supporting itself against gravity.

There are ways and means which we may consider of achieving and maintaining primary body balance between these two sets of forces—the living and the mechanical. If sometimes we seem to be insisting on the obvious, let us remember that the ideas which need the most clarifying are often those to which we say, "of course."