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T H E S I S

Physiological Effect of Exercise

by

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When speaking of the effect of exercise to the human body, a new meaning is given to the word "exercise". The occasional morning walk or ride, a day's ramble in the woods, or a gymnasium lesson taken once or twice a month, is not what is meant by exercise, but something, whatever it may be, that is done again and again, perhaps for pleasure only, but with the additional idea of perfecting ourselves in practice.

It is only when the muscular movements are repeated and practiced that they may rightly be called exercise and it is then alone, that any benefit can be derived from them.

If it is the wish to make an impression upon the brain the process has to be repeated again and again until the brain has become accustomed to it; just so is the effect on movements of the body, the physical impression lightly made at one time, repeated at short intervals will at last become a habit of the body.

The agents in movement are the muscles, these form the fleshy mass surrounding the different parts of the body.

When a muscle is caused to contract there is a large increase of the muscular changes going on within, the chemical change is source of energy which appears as external work. The main features are: first, during contraction the reaction of the muscle changes from neutral, to slightly alkaline, to acid.

A large increase in amount of oxygen taken up by corpuscles of blood and a still greater increase in amount of carbon dioxide given off by them.

The muscles perform the movements but they have nothing whatever to do with bringing them about.

The force of the muscle may be likened to the latent energy of gunpowder which cannot explode without a spark.

A muscle to act must have a stimulus--the most common of these is the will. However, any mechanical, physical or chemical action on the muscle may act as a stimulus.

So we may say that the will is a stimulus, but it would not be correct to say that the will is the source of the motor force; nor is this force produced from the nerves, spinal cord, or brain, but the production of heat by the body from its own materials is the source of the motor force.

We know from personal experience that movements can be made more effective and more accurate when the muscles have become warm. From this fact we get the phrase "warming up", the meaning of which is known to all but understood to a few.

Nature has a method of her own that is characteristic and very noticeable in some animals. In the case of anger, the movements made, such as the drawing back of the hips of the dog to show the teeth that are going to bite, or the lashing of the tail back and forth in the case of the lion, all tend to raise the temperature of the body to a degree at which the muscles act most vigorously. However, although heat may be indispensable to muscular contraction, it may also act as a hindrance if the temperature be raised too much.

The muscles of man and mammalia become incapable of contraction at 45 degrees C.

An animal is constantly producing heat, and if it were not always constantly losing heat, its temperature would rise to beyond endurance. As the temperature of a warm-blooded animal must be

maintained within narrow limits, it is apparent that there must be some means of regulating the production and elimination of heat to adjust the body to external conditions. This is accomplished in man in part by the natural physiological process, and partly by shelter, clothing, heat or refrigeration.

We have spoken of the heat produced by the body, but we did not explain how this heat may be produced.

The combustion taking place in the body differs from the term "combustion" as used in Chemistry. In Chemistry it is applied to the combination of two or more bodies with each other, accompanied by the production of heat and light. The change going on within us does not produce light; on the contrary it resembles more that of fermentation. For example, the changes of the body resemble those taking place in a damp haystack, rather than the phenomenon we observe in a burning fire.

The food, the reserve material, and the essential tissues of the body are the sources from which the external and internal work of the body draw the elements of which the chemical combinations give rise to the expenditure of heat.

The chemical and thermal changes referred to as accompanying muscular activity are going on all the time. When the muscle appears to be at rest it is never-the-less subject to a certain contraction or muscular toneness, the extent of which varies with conditions and individuals. This toneness results in the production of heat, only when muscles are applied to the performance of outside work. The energy is only to a certain extent realized in the muscles, the remainder appearing as heat. If the muscle is stimulated and not permitted to do outside work, that is motion; all the energy will

appear as heat, an example of this would be in standing.

It has been found by experiment that only one-third of the available energy of food; that is, energy in excess of that required for its digestion and assimilation, can be obtained as work, the remainder being transformed into heat at the same time.

There is a very close relationship between the quantity of work performed and the carbonic acid produced. Muscular work increases the quantity of carbonic acid in the blood, and the excess of this gas leads to an increase of the respiratory need.

The condition of normal respiration is the presence in the lungs of atmospheric air and of venous blood, in order that the inspired air may give up its oxygen to the blood, and that the blood man rid itself in exchange of its carbonic acid. We can readily see from this that anything that would hinder the circulation of blood in the pulmonary capillaries or to the free entrance of air into the pulmonary air cells, will render the respiratory act incomplete.

Every time that the rhythm of respiration is disturbed we have the condition called "breathlessness" resulting. This effect upon the lungs may be caused either mentally or physically; the form spoken of here will be that caused from violent exercise.

The heart and lungs are very closely related functionally, and where the normal condition of one is disturbed we usually find the other one affected.

One of the best effects of exercise is to increase the frequency of the heart beat, thus quickening the blood-current. The blood-current is also increased because of the need felt for the aeration of the blood in which carbonic acid has increased in quantity during work. For a short time after violent exercise there is

an equilibrium established between the amount of blood that passes through the lungs and the amount of air that enters them; the respiration has become fuller and deeper, much more active but not insufficient. But soon the heart, although the heat is increasing, does not give the blood so powerful an impulse as under ordinary circumstances and the blood pressure in the arteries falls and the current is slowed. The lungs become overloaded with blood, leaving no room for the inspired air. Thus, the carbon dioxide accumulates in the blood, the respirations are no longer quickened, but stop half finished, interrupted by periods of stoppage called "breathlessness".

There is a certain analogy between the process of breathlessness and that of stiffness. These two forms of fatigue are due to the accumulation in the blood of certain products of dissimilation.

We have already stated that the accumulation of carbon dioxide in the blood causes breathlessness, and after careful study of stiffness we might come to the conclusion that it is caused by the accumulation in the blood of the products of its own activity.

Stiffness only occurs after exercise in certain special circumstances, such as when a person is out of practice in the exercise he is performing. Under these conditions there are products of dissimilation which are not formed during the usual amount of exercise taken by the individual. When muscles are used waste products are not allowed to accumulate and thus stiffness does not follow.

Stiffness is unknown to men who lead a life of continual muscular activity, and they are not easily affected by overwork. Through daily exercise the muscles become harder and more elastic, and are more ready to resist shocks and strains and also more fitted to protect the sensitive parts of the body from external violence. A well-trained foot-ball player no longer feels the blows of his opponent,

his flesh has become so hard that it is not injured by the blow.

Exercise does not merely harden the skin and muscles, but it also consolidates all the organs of work.

Careful investigation has determined that the bones themselves become adapted, by an increase in size and density, to the more energetic work of the muscles attached to them. The bones of horses which have done violent work in a circus for some years have been weighed and compared with those of horses of the same build which have spent their lives quietly at grass; the skeletons of the circus horses were much heavier, their bones harder and firmer. The same thing holds true of men given to athletic sports.

Under the influence of insufficient exercise certain materials, which should be used up each day by work, accumulate in the body. It is necessary for the perfect balance of nutrition that the reserve materials should be used up as fast as they are found. When they are not regularly destroyed and by their accumulation tend to hinder the working of the organs, we feel ourselves impelled to bring our muscles into action, with the unconscious object of burning these materials in the work, and the need of exercise is produced.

Insufficient exercise not only leads to the accumulation of certain useless materials within the system, but it also induces the diminution of the materials necessary to the balance of health, and thus leads to impoverishment of the constitution.

The air cells of the lungs brought into play by active respiration expand and push outward in all directions: the thorax expands, the ribs are raised, and the chest assumes a convex shape. It is easy to understand how respiration must be facilitated by this increase in the size of the thorax. A much larger volume of air is

introduced into the lungs, the elimination of waste products takes place over a much larger field, thus breathlessness during exercise diminishes.

If insufficient exercise be taken respiration introduces too small a supply of oxygen into the system and the vital combustions languish.

One of the most important points to bear in mind in all exercise is that their difficulty diminishes in proportion as they are practiced. There is less fatigue in exercises which are diligently practiced because of a more intelligent use of the muscles. The work which a man can perform does not only depend on the real strength of his muscles, but also on his knowledge of the way in which to use them.

Thus it is that the well-trained athlete can do more work, because he has perfect control over his muscles, than the stronger man who does not know how to use his limbs.

The practice of exercise brings individuals of the most opposite constitutions to the same type. This is because exercise produces in the system two absolutely different effects: it increases the process of assimilation, and it accelerates the process of dissimilation which leads to the destruction of certain materials.

Exercise contributes in many ways to the perfection of vital processes. It directly accelerates the circulation of the blood, hastening the passage of material from the venous to the arterial side; increases the functional activities of the liver and intestional canal; promotes absorption of digested fluids; improves digestion by its effects on the quality and distribution of the blood, and by regulating the demand for and supply of food; promotes the nutrition of all portions of the body, and overcomes the action of gravitation

which would cause stagnation of the blood and other fluids and consequent congestion and inflammation in various organs.

When stricken down by disease the child whose organs have been well developed by skillful training will be able to throw off the products of disease, or even to resist the attack altogether, while the child whose physical education has been entirely neglected, who has been allowed to sit bent up in the school room, has to succumb to disease.

Having treated of the effects of exercise to the body as a whole, it would perhaps be well to say a few words in regard to the changes taking place in the brain during physical activity.

One of the functions of muscular exercise is to purify the blood and promote its circulation. The brain, on account of its structure, is capable of receiving a large amount of blood, but cannot, of itself, dispose of the extra amount, and it is here that the muscles of the other parts of the body come to its aid.

The blood leaves the brain in response to a legitimate demand for its use in any part of the body. All brain workers should observe this fact and take vigorous exercise after extreme mental efforts. We have two effects of physical exercise on the brain: that of purifying, and that of regulating its blood supply. There is still another and that is, that the exercise of the muscles of a particular part of the body will stimulate the growth and functional power of that part of the brain that is functionally associated with it.

Now, taking up some of the exercises helpful to different parts of the body, and those that can be taken without apparatus, we will speak first of the exercises to develop the chest. By these exercis-

es we should strive to bring into action those portions of the lungs that have not been used to their fullest extent. To encourage this, breathing exercises are useful. One is as follows: lie on the floor, or flat on a couch, extend the arms upward over the head, take in as much breath as possible while counting twelve, hold it while counting five, then slowly and gently expel.

Another breathing exercise which has good effects upon the muscles of the sides of the waist: raise the arms slowly from the sides sideways above the head, palms up, inhale, lower arms forward in front of the chest and down while exhaling.

Almost all movements that exercise the arm freely will aid in chest development, because the muscles that cover the chest extend over to the inside of the upper arm, and so whem we move the arms we are at the same time exercising the chest muscles.

Rotation of the arms backward, one at a time, and then both together, is an excellent exercise for the development of chest, shoulders and arms.

Another exercise for broadening shoulders and strengthening chest muscles may be taken with dumb-bells. With a dumb-bell in each hand raise arms sideways shoulder high, palms up, flex the fore-arm, bringing the hand to the shoulder, with emphasis on this last movement. As an exercise for back of the arm the emphasis may be put on the outward fling of the arm.

Round or stooping shoulders, and the back of the arms, may be strengthened by the following exercise: place hands and elbows in front of the chest at right angles to the body, close fingers and force arms backward vigorously, keeping elbows shoulder high. The exercise should be repeated a number of times, the hands returning

each time to position in front of face.

The spine is one of the more important parts of the body that need exercise. All movements that bend the body backward against resistance, forward, or from side to side, develop, to a greater or less degree, the spinal muscles. The "chopping" movement with dumb-bells, and the exercise imitating that of swimming, brings into play the muscles of the spinal column.

Exercises are taken for strengthening the muscles of the abdomen, and also for reducing the undue deposit of fat in this region. The abdominal muscles are used in bending, stooping, raising from recumbent positions, and many other movements.

A purely abdominal exercise is taken lying on the floor, the feet held down under a piece of furniture. The body is raised, without the aid of the arms, to a sitting position. In this the muscles of the abdomen do all the work.

The best hour for all exercise is before breakfast. This is possible for the vigorous persons, only; for the more delicate, two hours after breakfast would be a very profitable time.

Under the influence of exercise a person is physically transformed, and to sum up the changes taking place in his system, in a few words, we may say that all parts of the organism capable of favoring the performance of work have been developed, and all the materials which could be a cause of hindrance in the performance of movements have been diminished in quantity and tend to disappear.