# PHYSICAL EXERCISES

AND THEIR

## BENEFICIAL INFLUENCE.

A SHORT SYNOPSIS OF THE

# German System of Gymnastics,

FOR

TEACHERS OF GYMNASTICS AND ALL FRIENDS OF PHYSICAL CULTURE,

BY

F. A. SCHMIDT, M. D.,

With Two Large Plates.

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TRANSLATED FROM THE GERMAN BY

A. B. C. BIEWEND,

St. Louis, Mo., 1894.

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Published by the Executive Committee

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NORTH AMERICAN GYMNASTIC UNION.

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# INTRODUCTORY.

"The exercises of the body are nearly as endless and innumerable as those of the mind; but it would be folly to learn everything or to attempt all possible exercises."—J. C. F. GUTSMUTHS, *Gymnastic Handbook for the Sons of the Fatherland.*

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In regulating and classifying a system of bodily exercises, one may follow different plans. All physical exercise is accomplished by motions of the body. But the question naturally arises: What is the object of bodily exercises? It is to change the position of our own body or parts thereof, or the position of other bodies; in other words, to master and control the weight of our own body or some foreign weight. This is done instinctively by every one, from childhood up, in standing, walking, running, jumping, climbing, throwing, lifting, carrying, pulling, etc. Hence the most natural kind of gymnastics are those that define the essentiality of the primitive motions of the body, and practice them in such a manner as to cultivate and strengthen the whole body and the separate members thereof. The gymnastics of the Greeks were founded on this basis; and while we are constantly singing the praises of the Greek gymnastics, yet we always fail to profit by their example. Gutsmuths built upon this method at the time when gymnastic art was revived in Germany, and Jaeger founded his gymnastic school on this same natural and immovable basis.

Spiess took a different course. To him the human body was, to a certain extent, an automatic machine, consisting of head, trunk and limbs, capable of executing an endless number of motions. In this manner he made of gymnastic art a system of forms of motion, which cannot possibly be surveyed. In this chaos the natural, primitive motions of the body are reduced to a single form and are lost sight of in the endless and foolish changes and artistic abstract forms. To what, for instance, has this method of gymnastics reduced walking and running?

Spiess says: Gymnastic art does not deal with the anatomical-physiological formation and mechanism of the human body, nor yet with the laws of the mind and the conditions under which it manifests itself in physical actions, but accepts both as an established fact, for the reason that it develops the free exercise of the body outwardly only. It is sufficient to observe in a general way the relations of the trunk, the head, the legs and the arms to each other; to observe that the trunk is capable of bending and stretching itself in every direction; to observe how the legs, the arms and the head are exercised mainly through the trunk; how the arms and legs in their turn again are separate, membered parts, linked by joints and endowed with the power of turning, bending and stretching the main joints, while the minor joints they can bend and stretch only; how the hands and feet are capable of many more complicated motions.

This is simply making a fundamental principle out of an outward form. Verily a fertile principle for the creation of an immense number of exercises in a variety of forms, which were, later on, classified in accordance with the physical abilities of the pupils of different ages. No attempt is made to sift this superabundance of exercise-matter, according to its actual merits or worth.

With this I do not mean the merits which every gymnastic exercise possesses in developing particularly this or that muscle. The human body is not merely composed of bones and muscles conjointly linked to each other; the gymnasium is no orthopedic institute; gymnastic art is not the mere art of developing the muscles. It would be ridiculous and foolish to demand that gymnastic exercises shall exercise every one of the 316 muscles of the body.

In muscle-exercise, from a gymnastic point of view, intended to develop and cultivate the body, very different points must be considered; first of which is the participation of the *nervous system, the action of the will.* There are mechanical actions of the muscle that require very little bodily, but a very great amount of brain and nerve, exertion, and *vice versa.*

But here we must consider not only how strong the action of the will is, but also *what kind* it is, and how far it is capable of controlling the limbs in executing complicated exercises.

And it makes a great difference whether, in performing complicated exercises, a longer time to think is given, or whether the mind has been trained to execute *at once* any unexpected command; for force and *finesse* of the innervation are not the sole object of the exercise, *quickness* of execution must be considered as well.

It is simply ridiculous to assert that the object of gymnastics is the superiority of the mind over the body, or to attempt to teach gymnastics rationally as long as we do not clearly understand these important points of view. Every action of the muscles is, moreover, closely linked with the important organic functions, of the *breathing*, the *circulation of the blood* and the *molecular changes.* But each one in a very different way. Certain exercises are intended to strengthen and develop certain vital organs, as the heart and the lungs; other exercises, while of great benefit generally, have no direct influence on these organs, and others again may be, under circumstances, wholly detrimental to them, especially to the action of the heart.

We know that in "gymnastic handbooks for the gymnasium and at home" a certain creed is taught and strictly adhered to: "Gymnastic exercises effect a harmonious development of the body, the skeleton and the muscles; they stimulate the breathing and the circulation of the blood; they improve the health and the nervous system, produce appetite, sound sleep," etc.

But these are simply phrases. Not to every gymnastic art, be it ever so well conducted, can all these beneficial results be ascribed. There is a vast difference between the various exercises as to their "mental and physical influence," and these influences must be closely studied before a schedule of exercises can be successfully arranged.

The different ages of life, as we all know, demand different mental and physical exercises. With the child it is of vital importance to stimulate the great organic functions, as the circulation of the blood, the breathing and the molecular changes. The proper development and invigoration of these organs will lay the foundation for bodily strength and endurance through life, and help make a good gymnast out of the grown-up child. Later, during the period of development, when the skeleton becomes firmer, special muscle-exercises and the attainment of skill are advisable; the growing man is anxious to test his will-power in daring feats that require strength, agility and skill. In the prime of manhood the human body is endowed with the greatest amount of endurance and strength, but is not so agile and skillful as in younger years. After that age, when the activities of the heart and lungs decrease, man loses the power of performing feats that require great physical strength, and the exercises ought to be regulated from a dietetic point of view. It would be radically wrong to prescribe the same gymnastic exercises for all ages, whether calisthenics, tactics or exercises on the apparatus, classified and graded only after a certain manner. To this must be added that not only the different periods of development, but other circumstances must be considered. I will here but mention the influence which sedentary habits at home and in the school have upon the youthful body. Neither must the teacher of gymnastics, in arranging his exercises, forget to consider whether his pupils have been for hours under a mental strain, or whether they are mentally fresh; nor yet must he forget to consider the different avocations and life surroundings of men.

From all this we learn that a knowledge of the physiological character and value of the exercises is indispensable to the teacher of gymnastics.

If one is entrusted with prescribing important influential corporeal measures—and many gymnastic exercises are such—for the youth, he must certainly be able to define the kind and extent of the corporeal influence of these measures. Hollow phrases are of no avail here.

In the appended plates we try to show briefly and plainly the value of the different exercises and to classify them from this important point of view. We deem it necessary, however, to go into details first.

# I.

## THE DIFFERENT KINDS OF BODILY EXERCISES AND THEIR VALUE.

In regard to form and effect we distinguish between two great groups of motions, to-wit: *Exercises that require strength and skill* and exercises that require *quickness and endurance.*

### EXTERNAL FORM OF MOTION.

In the exercises of the first group we have mainly a positive, independent, simple or a compound form of motion following the resting position, which attains the height of the desired mechanical exercise more or less rapidly and then again relapses to a resting position of the muscles. No matter how many different motions may follow a compound or complicated motion, the whole, as such, will always remain an independent exercise—a single achievement that has a beginning, a crowning point and an end, and which is no longer the same exercise as soon as it is interrupted at any point.

In all exercises of quickness and endurance we have an *endless* group of *rhythmically repeated* motions, the succession of which may be interrupted at any time without causing the exercise as such to lose its character. Running will always be running, whether we cover 10 or 1,000 yards.

In the first named exercises the number of motions is of an endless variety; in the latter we have mainly a few well-known kinds of motion, although in all of them various exercising changes in the starting position, in regard to the manner of execution, the number of exercises and the rapid succession of the same are possible.

According to the degree of such modifications, motions of quickness may, in various ways, suffer in regard to their value as an exercise and lose their distinct character, thus resembling rather the exercises of strength and skill. Easy exercises of this class, on the other hand, if often and rhythmically repeated may closely resemble exercises of quickness.

Lastly, there are combinations of both kinds of exercises; for in all exercises of quickness it is possible to permit the unemployed members of the body to perform, in a modified way, certain exercises of strength and skill. These are, in brief, the great characteristic differences between these two groups in regard to external form. Of much greater importance is the difference in regard to their physiological effect.

In all exercises of strength and skill we find a distinct form of muscle work, which is of longer or shorter duration in the exercises of strength, be they very extensive *general* exercises of strength, or be they performed by the exertion of a smaller, or even the smallest, part of the muscles only. All achievements of a high order requiring great strength and exertion naturally cause instant fatigue of the muscles, and thus terminate the exercise, although the fatigue will soon disappear.

A temporary mechanical highest achievement on the part of a greater or smaller number of muscles is therefore a characteristic of the exercises of strength. We find the deciding point of view not in the extent of the mechanical achievement, but in its proportion to the ability of execution of those muscles which are exercised in the performance thereof.

Exercises of strength may require more or less skill, so much so that the limits of the two kinds of exercises meet. In cases of doubt we would have to decide whether it be an exercise of strength or skill according to which is most required in performing the exercise.

In exercises of mere skill the participating muscles are required to perform very little work in proportion to what they are capable of performing, and no muscle is ever required to do more than it can easily perform. These exercises, on the other hand, may change to exercises of strength if they are often and successively repeated. For in this case those muscles which are mostly exerted, gradually tire out; they then become reanimated, but are less capable of exertion, so much so that what is an easy exercise to the fresh muscles requires an utmost effort on part of the muscles which are tired out. The simplest calisthenic exercise, will, if frequently repeated, become a real exercise of strength.

Another circumstance, of which we will say more later on, renders it difficult to decide between exercises of strength and skill, and that is the amount of practice the performer has had. One who has had practice has learned to estimate with some certainty the amount of strength required for each exercise, and therefore uses the smallest amount of strength needed. One who has had no practice and who is awkward, is uncertain in his estimation. He therefore, to go sure, uses *too* much strength—in many cases again as much as necessary. His muscles unnecessarily contract convulsively and he is "stiff;" thus, an exercise of mere skill, becomes to him one that requires great strength and exertion. He who has had practice saves strength.

With the exercises of *quickness* all this is different. It lies in the nature of the thing, that the separate motions, which, when often repeated, compose an exercise of quickness, dare not require the *highest exertion* of the single muscles, for if they did, the muscles would soon relax and thus the exercise would terminate naturally, as we have seen above of the exercises of strength.

And yet in exercises of quickness more work may be done in shorter time than in exercises of strength. If, for instance, a man

weighing 75 kilograms ascends four flights of stairs, each six meters high, in one or two minutes, this is an exertion of $75 \times 24 = 1{,}700$ kilogram-meters; or the same (to look upon it as an exercise of strength), as if this man had in one or two minutes lifted 50 kilograms 17 times 2 meters high. The best trained athlete could not accomplish this enormous feat more than once a day, while any one who lives on the second floor, or still higher, climbs this number of stairs several times a day without thinking of being exhausted.

If, however, in exercises of quickness such gigantic work can be performed without causing a relaxation of the muscles, there must be some reasons for it, and they are as follows:

*Firstly.* In all exercises of quickness the work required to be done is distributed over a complex of the largest and most powerful muscles, especially over those of the legs, which alone comprise one-half of the whole muscle-power of the human body.

All exercises of strength and skill require a *concentrated* work of the muscles, while with the exercises of quickness it is a *distributed* work of the muscles that is required.

In exercises of strength the amount of *immediate* mechanical exertion required from the muscles is much greater proportionally, while in exercises of quickness and endurance the *aggregate* of the work done is much greater.

*Secondly.* We must consider that in exercises of quickness and endurance the working muscles are not continually contracted, but are constantly changing from a state of exertion to one of relaxation. This circumstance greatly aids the circulation of the blood through the working muscles, and thus guards against the immoderate accumulation of waste-matter in the working muscles. This waste-matter is continually removed by a more rapid circulation of the blood. How greatly the general circulation of the blood is aided by exercises of quickness we will discuss more minutely later on.

*Thirdly* The difference in the work of the nerves in exercises of quickness and those of strength and skill is of great importance. In the latter not only the muscles, but also the nervous organs of motion, the cells of the nerves and the nerves themselves frequently perform a great deal of labor, and, like the muscles, occasionally succumb to the checking influence of fatigue. In all exercises of quickness the work of the nerves is of small account. The slightest impulse of the will and nerves is often sufficient to bring about a motion of quickness, and why this is thus, we shall show further on.

To recapitulate: The work of the muscles in all exercises of strength and skill is rather of a *qualitative* nature, while in all exercises of quickness and endurance it is more of a *quantitative* kind. In the former the *distinct* work of *certain* muscles is predominant; in the latter the co-operation of the greatest possible number of muscles predominates.

### PARTICIPATION IN AND KIND OF WORK OF THE NERVES.

We will now consider the distinctive characteristics in regard to the work of the nerves. Every involuntary contraction of the muscles is caused by a nervous irritation. The more the muscle is to be con-

tracted and the greater the mechanical work required from it, without regard to its burden, the more energetic the irritation of the nerves must be. An utmost exertion of the muscle necessitates also the utmost exertion of the relative nervous organs. The one as well as the other are subject to the influence of fatigue. From which it follows that all exercises of strength, just because their essentiality lies in the greatest exertion of a smaller or larger number of muscles, must also necessitate the highest energy of the respective cells of the brain and of the important nerves of motion.

Closely linked with this energy of the nerves, and this will-power is another activity of the nerves, namely, the *co-ordination*, and this in a much higher degree the more complicated a motion is and the more it is like a motion of skill.

We will shortly explain its nature. Even the very simplest motion includes the participation of a great many muscles. First of all, of course—and laboring hardest—are those muscles which immediately cause the particular characteristic main motion, as in bending a limb, the respective bending-muscles; or in stretching, the stretching muscles.

Then there are other muscles that co-operate with these, although in a contrary sense, namely the "antagonists." By a more or less slight contraction they indicate to the desired motion its desired measure, its required limits. Thus the motion of the bending muscles, for instance, is moderated and confined to its limit, by a slight extension of the corresponding stretching muscles and *vice versa*. This is similar to guiding a horse in a desired direction, which it is impossible to do if we pull at one rein only; for thus we either turn the neck of the animal too much or too little, most probably too much. Only after the horseman takes both reins in his hand, and by gently pulling this or that one, will he be enabled to turn the horse's head exactly in the desired direction. It is precisely the same thing with the motion of the muscles, which is to have a clearly indicated limit.

Then again a number of skeleton muscles co-operate, which fix those parts of the movable skeleton from which the moving muscles rise to the trunk of the vertebral column; for a muscle can only produce an effect from a fixed point upon a point that adheres to the bone to be moved. The *holding* muscles, especially those around the neck, shoulders, spine and pelvis, are also in activity, and they, by their contraction, keep up the equilibrium of the body, which is disturbed and deranged at every motion. A single example: Raising the arms sideward upward. In this instance the triangular armlifter (deltoid muscle) is the muscle which really executes the motion, and is the one by far most burdened. The adductor of the arm (the large pectoral and the broad back muscle), which work in an opposite direction, effect, by a slight contraction, that the desired motion stops at the designated point, namely, the horizontal position. The muscles around the arm and hand are slightly contracted. They thus, in reality, mutually counteract their effect, but at the same time they bring about that the arm and the hand, stretched out as a unit, are raised and held in an upward position. Now, the real moving muscle, the deltoid

muscle, rises to a great extent in the shoulder-blade. The shoulder-blade is a free, movable, three-cornered bone, which is linked to other bones at one angle only, while on all other sides it adheres merely to the muscles. The contraction of the deltoid muscle would therefore not really lift the arm hanging heavily down, but would rather bring the movable shoulder-blade towards the arm out of its position—draw it outward and forward—if the holding muscles did not, by corresponding contraction support the shoulder-blade, and thus make it possible for the working muscle to move, from this one positive starting point at the shoulder, the outstretched arm, like a one-armed lever, in the desired direction. But the holding muscles of the shoulder-blade rise mostly in the vertebral column, which is movable in all its links and is balanced like a staff on the pelvis. As soon as there is a one-sided contraction, they disturb the equilibrium of the vertebral column and cause an inflection of the same. It is therefore necessary that the muscles on both sides of the vertebral column contract, to equalize this inflection and to prevent the trunk from bending over toward the side on which the muscles work. In short, we have, with apparently so simple a motion even, the combined work of a great number of muscles, each of which has more or less work to do.

While the main working muscle does heavy work, all the other muscles, both moderating and supporting, have their more or less heavy work to do.

In this motion the brain is therefore called upon to furnish to a whole number of muscles the necessary incitation to motion, by means of the nerves of motion; and this incitation to motion must at the same time be so diversified by various graduations, as to allow the motion to be carried out in a strictly designated form and limit, in faultless attitude, and without interruption of the equilibrium.

In the above example a simple form of motion was considered; in complicated motions the mechanical relations can hardly be classified or surveyed. In many motions, too, not only the free action of the moving, moderating and supporting muscles, but other mechanical forces must be considered; among these, in the first place, *gravity*—for instance, the lowering, by its own weight, of a limb that has been raised; the effect of gravity on the body during all exercises of supporting and hanging—and also *elasticity*—effective, for instance, when exhaling. Certain activities of the muscles are thereby at different times more or less burdened and sometimes even rendered superfluous. A mechanical analysis of every exercise is an impossible and useless undertaking. The deciding point is the character of the exercise as a whole, the kind of activity of the organs which are chiefly employed.

And thus we find that the more complicated a motion, the more difficult is its co-ordination. For this a special achievement, not exactly of the muscles that obey the command, but of the central organ of the nerves, which must, at the given moment, furnish to a great number of muscles, as a general irritation, a certain number of irritations of motions, each one carefully weighed as to its strength. The possibility of this process during each motion could hardly be imagined, if our

involuntary motion-centers in the brain and spine did not possess the faculty to "*mechanize*" this complicated process for every form of motion as soon as the motion has once been successfully performed and repeatedly practiced. That is: The image of an oft-repeated motion impresses itself so firmly upon the central organs of the nerves, that the mere resolution of the will to perform a known exercise suffices to bring about spontaneously, as it were, all necessary irritations of motion, in their various degrees. This faculty of our will organ makes it possible that a positive control of the co-ordinate activity of the will-organ *may be acquired*, and that the primitive principles of all possible motions may be thoroughly mastered. *The better known a motion, the less necessary is a conscious co-ordinating activity.* The action of the will is then limited by the degree of the required mechanical exercise of strength in proportion to the executing or moving muscles. But it is different in all *unknown, new* forms of motion, or when changes in known motions are made. Here the nervous system lacks the image impressed upon its mind, which must be created by experiments; new combinations of muscles must be sought and discovered. The co-ordinating work of the will goes hand-in-hand with the strength-giving work of the will.

Now, it is a known fact that it is a difficult matter to discern just how much force should be used in attempting an unknown motion, especially as regards the supporting muscles, and therefore the will, to make sure, applies too much force.

For the *supporting muscles* are the very ones that are *unnecessarily contracted and taxed*, and while they mutually counteract their influence, they have a tendency to make the limbs stiff and gawky. Through this uncertainty in the co-ordination, other muscles, which bear no relation whatever to the desired motion, are brought into requisition; whence we get the accompanying motions, which must be suppressed by special influence of the will. Taking all in all, a person who has had no practice, when required to co-ordinate an unknown motion, will naturally make much greater efforts of both the muscles and the nerves than one who has had practice. For as soon as a motion has been learned, or at least partly learned, and the performer thereof has become *familiar* with the co-ordination of the motion, or at least the main parts thereof—in short, if the motion has become more or less "mechanized"—it is performed with the least possible amount of exertion. It is easily performed, no unnecessary over-taxation and contraction of muscles lame the joints which the moving muscles are to move, thereby rendering their work more difficult. *It is performed as it ought* to be; there are no unnecessary, useless motions of disinterested muscles. Thus the co-ordinating will finds the correct solution of the proposed problem of motion, and this correct solution is at the same time the one that requires the least amount of strength, and which as to its outward form is, from a gymnastic point, also the *most beautiful*.

We begin to cultivate the co-ordinating activity from the very beginning of our existence. The small child gropes along in an uncertain way when it wishes to reach a desired object, and only after many attempts does it succeed. Gradually, however, it becomes familiar with this oft-repeated, co-ordinating motion until at last it has thor-

oughly mastered it. The child has gradually learned to get hold of an object placed within its reach, if it wishes to do so, and has learned to do this safely and quickly, and without any waste of energy whatever. In a similar manner, after many wearisome attempts, the child learns to walk, run, jump, etc.; in short, it brings a number of well-known forms of motion, with which the co-ordinating action of the will is familiar, to school with it, and on this foundation the gymnastic school bases its work.

Our German gymnastics, as far as calisthenics and exercises on the apparatus are concerned—*i. e.*, in localized exercises of strength and skill—are in reality a *school of co-ordination;* they are principally gymnastics of the nerves and secondly gymnastics of the muscles. It is impossible to imagine a broader cultivation of co-ordination as to form than that which Spiess' system of gymnastics offers. In this respect it is unsurpassed. New problems of co-ordination are continually given the pupil. From an educational point of view it is positively necessary to so connect the problems of co-ordination that each succeeding one is a slightly increased modification of its predecessor. The will must not be compelled to suddenly face an entirely unknown combination of muscle-contractions; it should, on the contrary, be acquainted and even familiar with a part or the principles of the exercises which are to be mastered; so that it is only necessary to co-ordinate anew the modifications and additions to the exercise. The formal school of motions, therefore, impresses upon our central nervous system numberless forms of motion, and enables it, whenever necessary, to repeat them safely and often, either as motions with which it is familiar, or even as such that have become "mechanized" without any new display of co-ordinating activity. But here we must call attention to a restriction which the formal school of motion really imposes upon itself in regard to the co-ordination of motions. For the kind of co-ordination which is most capable of cultivation, namely the co-ordination of those muscle-districts which are *closely situated to each other*, is *not* cultivated in the gymnasium. Manual training, vocal culture, mimicry, etc., must be looked after outside of the gymnasium. Gymnastics deal rather with the co-ordination of the motions of larger and *more remote* muscle-districts of the skeleton. The more subtle possibilities of motion of certain parts of the body, such as the joints of the hands, the cartilage and bands of the larynx, receive no attention here. Spiess' system of gymnastics is therefore not adapted to all possible motions of the body, but to the *coarser* possibilities of motion.

This is not intended as a reproach of defect, for the special kinds of muscle-activity are beyond the sphere of gymnastics, in the customary sense of the word.

We have seen above that the instruction in exercises of skill and strength aims really at nothing else than to attempt all possible muscle combinations (with the cited limitations, of course) and to impress their image, so to speak, on the central nervous system. The person who has had practice possesses a number of forms of motion, which he can easily make use of whenever necessary. Now, the abstract forms of motion, especially those on the apparatus, are such as are rarely made

use of in common life. To master them would be useless if we did not know that a general participation of the will increases the faculty of co-ordination, even for unknown motions; that is, it not only gives a foundation to our acquired skill, but it also assists the brain to immediately find the right way and means for any new form of motions—in a word, to master them would be useless if they did not materially aid us in *getting a full control over* the body. How far acquired or natural talents come into consideration here, how much exercises of skill, systematically practiced, may do toward accomplishing this end, even with persons who are naturally gawky and awkward, is a question not easily decided. As regards the coarser motions it might be answered in the affirmative, but for the special motions of circumscribed muscle-districts it is different. At least all proof is wanting that the formal gymnastic exercises of the coarser limbs do also contribute to the easier co-ordination of the finer motions; for instance, those of the hand. It is an open question, therefore, whether the formal cultivaton of gymnastic skill exercises any influence on the easier attainment of special skill; in other words, whether it influences the controlling of the body by the mind. But our exercises of skill and strength do not exhaust all sides of nerve-gymnastics in yet another respect. For it makes a great difference in the co-ordination of motions whether a certain time is given for consideration before executing the motion, or if one is compelled to *co-ordinate quickly* or *suddenly*. A well co-ordinated motion, just like every act of thinking, requires time for deliberation. Slow motions only may be co-ordinated while being executed, quick motions must be co-ordinated beforehand. We frequently meet with emergencies in every-day life where we are called upon to suddenly execute unexpected and, in most cases, unknown motions. This is always done at the expense of accurate co-ordination—*i. e.*, such sudden motions are never done properly. With them we care not a whit whether they are *properly executed*, nor yet *how* they are executed; as *long as they fulfill their purpose* we are satisfied. I avoid a stone which comes flying in my direction without caring in the least *how* I avoid it. A ball-player tries to catch the ball in the air, regardless of any motions he may make with his arms, all he cares about is to catch it, and if he misses it, he will not pause to "left about face" in the proper way, but tries to run after the ball as quickly as possible, *without even thinking of his style of running*.

Such practice in sudden motions of quickness, the practice of *quickness of innervation*, is a part of nerve gymnastics, not only worthy of consideration, but it is of the greatest importance. The qualities to be cultivated thereby are *presence of mind* and *readiness to act*.

In the formal school of motion where exercises of skill and strength are executed on command, or where pupils try to repeat what the class-leader has shown them, and during which ample time is given for co-ordinating deliberation, this side of the cultivation of the nerves of motion does not come into consideration. But this defect is made good mainly by the exercises of alertness, of which we shall speak later on.

In reviewing our remarks we find that in regard to the nervous system all exercises of strength and skill lay claim to a double activity: 1. The *strength-giving* activity of the will, mainly in exercises of strength. 2. The *co-ordinating* activity of the will, which is extensively practiced and cultivated by the exercises of skill in German gymnastics.

We must now consider the activity of the nerves in *exercises of quickness and endurance.* We have seen that they consist mainly of an endless number of motions rhythmically repeated, limited in regard to their form to a few generally well-known kinds of motion. We have also seen that motions of quickness do not require an utmost effort of any single muscle. With them the invigorating activity of the will, the straining of the nerves, falls away; neither do they necessitate any special co-ordinating activity, since we have to deal with well-known motions only—and if any new motion of quickness is to be learned, the co-ordination of the constantly repeated fundamental motion is quickly learned, quickly mechanized. The activity of the nerves or of the will in exercises of quickness and endurance is finally reduced to such a minimum that these motions follow the slightest impulse of the will so mechanically that all these motions are designated as *half-automatic.*

It is a well-known fact that in the living body muscle-motions take place *automatically*, without any participation of the will. These are the activities of the heart muscle and of the breathing muscles. The latter activity only is occasionally and under certain conditions subject to the influence of the will. Both activities are characterized on the one hand by their rhythmical succession, and on the other hand by so moderate a force that fatigue is out of the question. But here we must remark that the power of action of both the heart and the breathing muscles is far greater than that of the arbitrarily-moved muscles of the skeleton. They are much less subject to the laws of fatigue, and the reason for this we find in the fact that their functions are performed *without the participation of the easily fatigued organs of the will.* A large part of these qualities may be transferred to such kinds of motion which are performed and repeated in an even, rhythmical succession, and which do not necessitate or require any strenuous effort on part of the participating muscles. They are very similar, both as to execution and qualities, to the automatic motions, and become half-automatic. A slight checking of the will ends the motion. The motion proper, however, does not need the continued impulse of the will from the brain, but is kept up by the nerve-centers of the spine, working involuntarily. From which we explain the fact, that the amount of mechanical effort in an exercise of quickness or endurance is often much greater than is the case in mere exercises of strength or skill. Hence the characteristics of motions of quickness and endurance are that they *necessitate the least activity imaginable of both the nerves and the will, in comparison to their mechanical work.* They act as a *restorative* on the nerves. This is of special importance to those who after straining, mental labor wish to take bodily exercise. The professional man instinctively seeks recreation in a walk, while our youths find theirs after school hours in games and unrestricted play of all kinds.

Of course, motions of quickness and endurance may, under certain conditions, require a special activity of the will.

In the first place they require an *invigorating* activity of the will whenever exercises of quickness and endurance are made supreme efforts.

Whenever we try to cover a certain distance in the shortest possible time, or *vice versa*, to cover the greatest possible distance in a given time, as, for instance, in running-, rowing-, bicycle-races and the like, a similar energy of the will as in great exercises of strength is required.

Exercises of endurance, too—running, marching, rowing, etc.—will, even in a moderate form, if continued too long, finally fatigue the muscles. The muscles are less easily excited and a stronger, more strenuous activity of the will is needed to overcome a general feeling of tiredness and to continue the motion.

The *co-ordinating* activity of the will also makes itself felt. In the first place, when new exercises of quickness are to be learned. Rowing and cycling, for instance, must be learned and practiced so long until they, like walking and running, become half-automatic. The person practicing must become familiar with the co-ordination in balancing, that is, in the co-ordination of the supporting muscles.

Secondly we may wish to perfect a half-mechanized and half-automatic motion of quickness. Marching and walking exercises differ widely from common walking; with frequent practice our every-day walking may become a half-automatic habit, and the advantages derived from gymnastic practice are clearly apparent in our everyday walking.

Of the special activity of the brain, which may be united with motions of quickness *in tactics*, we will speak later on.

Thus far we have succeeded in establishing for exercises of strength and skill, as well as for exercises of quickness and endurance, essential differences in regard to the participation of the nervous system. Briefly said: The former have a burdening and exercising, the latter a soothing effect upon the nervous system.

### ACTIVITY OF THE LUNGS, THE HEART AND THE CIRCULATION OF THE BLOOD.

Similar essential differences exist between these large groups of exercises in regard to animating the vegitative organic activities, to-wit, *the breathing and the circulation of the blood.*

In every active muscle the blood-vessels become enlarged, a greater flow of blood and greater molecular changes take place. The active muscle secretes a much greater amount of carbonic acid and consumes much more oxygen.

The carbonic acid forming in the active muscle is absorbed by the blood and secreted through the lungs; the muscle is supplied with the necessary oxygen by the vehicles of oxygen, the red blood-corpuscles.

When the muscles are actively employed the lung is forced to secrete more carbonic acid and to take up more oxygen; the heart must, furthermore, cause the blood to circulate quicker, so that more red blood-corpuscles, more vehicles of oxygen, pass through the working

muscles. *The quantity of carbonic acid* to be secreted is what chiefly causes the *increased automatic activity of the lungs* in muscle-motions, while the *greater demand for oxygen* increases *the automatic action of the heart.*

This increased action has, of course, its limits. The lungs, which, in a state of rest, breathe with but a small part of their breathing surface, work with their entire breathing surface as soon as the chest is expanded, and the change of gas becomes the greater the oftener we breathe in the same space of time. Thus the breathing capacity of the lungs, while the muscles are actively employed, may be twelve, fifteen and even twenty times greater than when they are in a state of rest.

It is similar with the heart. The heart, too, increases its activity in a double manner, it causes a greater circulation of the blood by increasing its contractions in a given time to the highest limit (from 70 to 80 beats of the pulse to 180–200 per minute), and by pressing a greater quantity of blood into the arteries at every contraction. Thus the activity of the heart may be increased six to eight fold.

But there is a difference here between the action of the lungs and that of the heart in regard to a light activity of the muscles. While the surface of breathing is increased at every greater secretion of carbonic acid, however slight, and vast differences manifest themselves, even in standing, slow walking and moderately fast walking, the heart need not circulate more blood in *minor* muscle-work.

For, as a rule, only a part—about one-half of the oxygen—which adheres loosely to the red blood-corpuscles that circulate in our veins, is consumed while the organs of the body are in a state of rest. If a slight motion in the active muscles necessitates a greater amount of oxygen this is simply supplied — in accordance with the law of saving as much strength as possible — from the existing surplus; and only when this surplus is insufficient is the heart called upon to circulate more oxidized blood.

From this we draw the conclusion that easy motions have little or no influence on the activity of the heart.

Then again there is a vast difference according to the composition of the blood in the person performing the exercise. With healthy individuals the blood abounds in red blood-corpuscles. With them therefore the blood contains more oxygen, and the surplus thereof for muscle-work is greater. With them the extra work of the heart will not *so soon* come into requisition.

With anæmic persons the very opposite is the case, for if a person has thin blood or suffers from chlorosis, this is not caused by a lack of blood, but from the fact that the blood is deficient in the vehicles of oxygen, the red blood-corpuscles. With such persons even the easier activities of the muscles require an increased action of the heart, and the greater the work of the muscles, the sooner will the action of the heart reach its highest possible limit. And as soon as this is the case a continuation of the motion is out of the question. On account of this difficulty in supplying a sufficient amount of oxygen, persons with thin blood are more or less unfit for all physical exercises requiring much exertion.

Another thing to be considered is the quantity of water contained in the blood. The blood may be thicker or thinner or contain more

water, and yet the total sum of red blood-corpuscles will be the same. Now, if the heart, in either case, presses an equal amount of blood into the veins (60 ccm.) at every contraction, it is evident that this quantity of blood is *richer* in the vehicles of oxygen; the red blood-corpuscles, with persons whose blood is *thick* than with those who have very *thin* blood.

This circumstance has been practically taken advantage of long ago in training man and beast for great physical efforts. The nourishment taken while training is rich in albumen, for such food tends to make the blood richer in albumen—*i. e.*, richer in red blood-corpuscles; persons training are forbidden the liberal use of liquids and must frequently undergo a sweating process, in order to make the blood thicker and richer. All of which enables the heart to endure better and hold out longer in all exercises requiring strenuous efforts.

For the heart, as well as the lungs, may be overworked, and when the limit is reached fatigue sets in, the organs refuse to perform their functions, the motion that has been begun cannot be continued. Against this the strongest will is helpless.

Here the question arises, Are we to consider this influence of physical exercise on the activity of the lungs and heart simply as "something given," to use Spiess' expression—to look upon it as an established fact, or have we before us results of exercises which must be more closely followed out? Results which will have a decisive effect on the formation of gymnastical material?

To answer this question we must in the first place call the reader's attention to the fact that the aims and end in view of gymnastic exercises is the full development of the youthful body and the attainment of its full capacity for bodily exercise. Let us call it "the rule of the mind over the body."

But a mere formal development will by no means answer the purpose; an *organic* foundation is necessary. The best developed *capacity* for exercises and motions is worthless if weak lungs or a poorly developed heart limit the *possibilities* of motion to a minimum, and it is foolish to assert that as little as the school is required to furnish nourishment for the body so little is it its duty to develop the lungs and the heart. For this development is inseparable from the kind and amount of physical exercise; while physical culture on the other hand (which certainly does not aim at outward skill only), when it has reached a degree of perfection, is dependent upon the extent of this same development.

In addition to this we find that in our maturing years especially, the growth and development of these two organs are of the very greatest importance to the general development of the body. Outwardly this may be seen from the fact that no organ of the body shows such porportinate growth in the years from 12 to 18 as the lungs and the heart. And if these organs do not receive the proper attention it necessarily follows that the general development and the power of resistance of the body will, throughout life, be imperfect. What is neglected in these years can never be made good later, and first of all we must call attention to the very important part the heart plays during our maturing years.

With children in whom the molecular changes are greatest, and in whom we notice readily how fast they grow, the heart is small as compared to the width of the arteries. But when we have reached the age of maturity and have ceased to grow, the very reverse of this appears. To express this in figures, we find, according to Beneke's statement, that with children the volume of the heart is to the diameter of the arteries as 25 to 20; before reaching the years of maturity as 140 to 50, and after full maturity as 290 to 61. During this period the volume of the heart is increased twelvefold, while the diameter of the arteries is increased only threefold. The heart of a child, counting the length of the body at 100 cm., has a volume of 40 to 50 cm. while the heart of a matured person, taking the same bodily length, has a volume of 190 cm. The beginning of the development, as well as its completion, therefore undoubtedly seems to be greatly dependent upon this very development of the heart, and the increased pressure of the blood in the circulation, caused by the proportionate narrowing of the arteries.

From all of which it appears that it would be foolish to deny the necessity of frequent exercise of the lungs and the heart.

But which is the most important form of exercise for these two organs? We answer: *Every kind of exercise that will increase their activity.* In the same manner as work exercises the muscles, so does it exercise the lungs and the heart; with this difference, however, that of the latter we speak of *increased* action; since the heart and the lungs are to a certain extent in constant activity.

It has been demonstrated that the action of these organs is naturally increased as soon as greater efforts are expected from them. This is always the case when muscle-work requires the inhaling of more oxygen and the exhaling of more carbonic acid. The more this becomes necessary the greater must the activity of the lungs and the heart be. Hence it is the quantity, the amount of muscle-work done, which *defines* the amount of extra work of the heart and lungs. And at first it seems to make no difference whether the muscle-work, which causes the increased action of the heart and lungs is done by one or more muscles. For a positive, mechanical effort of strength of so and so many kilogram-metres, the consumption of a corresponding amount of oxygen and the formation of a corresponding amount of carbonic acid is necessary. Every muscle may be strained to the utmost but no farther. And when, as here, it is mainly the work of *many muscles* to increase the action of the heart and the lungs to the highest possible limit, this work must not be assigned to a few, limited muscle-districts; for else these muscles will be exhausted and will refuse to perform their functions before the intended influence on the lungs and heart manifests itself. But if the work be distributed over many large muscles, in such a manner as to require no one muscle to be strained to the utmost, and yet make the mechanical effort of strength and with it the molecular changes as great as possible, the activity of the lungs and the heart is increased to the highest possible degree, without fatiguing the muscles before attaining the desired result.

We have shown above that in exercises of *quickness and endurance* the aggregate amount of distributed muscle-work is greatest. For

these exercises mainly increase the action of the lungs and heart, and fatigue and exhaust these organs quicker than other exercises. Above all, these exercises do not only gradually increase the extra activity of these organs for a mere short moment—for exercises of strength do this, too, in a certain measure—but this increased activity is of a certain duration, gradually approaching the highest possible limit.

There is a vast difference, however, as to the kind of exercises of quickness and as to the manner *how they are executed.* In the first place, exercises of quickness and duration differ widely from each other in *the mechanical* amount *of strength* required. Ascending a mountain or a flight of stairs, or swimming or rowing against the stream, requires harder work on the part of the muscles than walking, running, cycling, etc.

In the last named exercises it makes a big difference whether one foot is constantly on the ground, as in walking, marching, or whether the whole body is raised and is suspended in the free air for a moment, as in running, hopping, jumping, etc.

Then, again, it makes all the difference in the world *how quick* a motion in exercises of quickness and endurance is to be repeated. Hence we establish the following differences in these exercises:

### I.—EXERCISES OF QUICKNESS IN A STRICTER SENSE OF THE WORD.

These are exercises where we try to cover the largest possible space in a given time, or to cover a certain distance in the shortest possible time. We all know that the action of the lungs and the heart can be increased to a certain limit. Beyond this limit these organs refuse to perform their functions; breathlessness and exhaustion set in, and the exercise must stop then and there. If, however, the exercise is not continued until a complete exhaustion sets in, a few minutes rest will give new strength to the lungs and the heart, and thus enable us to continue the exercise.

The typical forms for motions of quickness for exerting the lungs and the heart to the very utmost are running races, rowing races, swimming races and bicycle races. The trained prize-runner knows just how fast he dare run without tiring out his lungs and heart. The longer the distance to be run the more saving must he be of his powers of heart and lungs, the more must he moderate his running, if he wishes to reach the goal. While in a race, a good runner may run 200 m. in a certain time, he cannot cover 400 m. at the same pace; he will need more than double the time it takes him to run the 200 m. The results at races prove this beyond the question of a doubt. According to Victor Silberer the best records of the world, made on English-American sporting fields by professional runners, are as follows:

For $\frac{1}{8}$ English mile=200 m., 22$\frac{1}{5}$ seconds.
For $\frac{1}{4}$ English mile=402 m., 48$\frac{2}{5}$ seconds.
For $\frac{1}{2}$ English mile=804 m., 113$\frac{1}{5}$ seconds.
For 1 English mile=1,609 m., 256 $\frac{1}{5}$ seconds.

Nor must we forget that the participants in these races had been training for months for just this distance. With non-professional runners, with pupils and gymnasts, these differences are much greater.

The same can be said of rowing races, swimming races and bicycle races.

Of course, each of these exercises requires the greatest possible exertion, and in this respect the exercises of quickness, when they require every nerve and muscle to be strained to the utmost, are similar to the exercises of strength which require an utmost effort.

It is different, however, with the second form: *The exercises of quickness in a wider sense of the word*, during which the action of the heart and lungs is at certain times increased to the highest degree, but where we do not try to cover the greatest possible distance in the shortest possible time. Neither do these exercises require the fullest exertion of the energies of the mind, for they follow half-automatically. This is especially true of those exercises of quickness generally practiced on our play-grounds, first of which running might be mentioned. As a rule, these exercises are interrupted or greatly moderated as soon as the *first* signs of fatigue of the heart or the lungs make themselves felt. The instructor cannot so well notice this with each single member of the class as the individual practicing himself notices it, and for this reason the weak beginner especially will find those exercises of quickness best suited to and most profitable to him in which he himself has it in hand to moderate his exertions, or to stop with the exercise, when he begins to get out of breath or to feel a strong palpitation of the heart; and this is the case in *all games of motion*. These games furnish ample opportunity for quick motions, thus bringing about the full activity of the heart and lungs, without any danger of overexertion, since it rests with the player himself how much or how little he wishes to exert himself. Special, individual characteristics and temperament will naturally make a great difference here, too.

Lastly, the exercises of quickness can be so moderated, as to require no *increased* action of the heart and the lungs; the long-continued motion keeps the activity of these organs at a certain point, thus establishing a *permanent equilibrium between what is required and what is performed*. The motion of quickness then becomes a motion of endurance. Here, too, we have an utmost effort based on the duration of the exercise, which ends with the complete exhaustion of all bodily organs and not, as in exercises of strength, with the exhaustion of the muscles and nerves alone, or, as in exercises of quickness, with the exhaustion of the heart and the lungs only. This feeling of a *general exhaustion* is caused by the accumulation of waste-matter in the blood, an accumulation, which naturally follows any work which had to be performed, by continuing an exercise, until exhaustion sets in. In mere exercises of strength we cannot even attempt to do the amount of labor that is done, for instance, while ascending a high mountain, if continued until we are completely exhausted; not even when the former require us to strain to the utmost every nerve and muscle, while we take it comparatively easy in ascending the mountain.

Arduous labor and strenuous efforts are by no means the same.

An exhaustion caused by continuing to the utmost an exercise of duration, is one that lasts twenty-four hours and longer. The muscle of the heart as well as the nerves of the heart are under the influence

of large products of tissue-wastes circulating in the blood. The action of the heart becomes feeble; the pulse is weak and rapid; yes, death even has been caused by overexhaustion from marching too long and too rapidly. The breathing is weak, the warmth of the body sometimes reaches the fever-point; the appetite we ought to have after such a feat is wanting, and in spite of a feeling of tiredness and weakness we pass a sleepless night. The next day we feel as though every bone in our body were broken.

In the urine precipitates are perceivable, consisting chiefly of lithiates, the poisonous products of excessive muscle-work. Not until the third day do we regain our usual health and freshness.

It goes without saying that it cannot be the aim of healthful gymnastics to indulge in the practice of exercises of endurance, continued to such an extent as to cause complete exhaustion. This may happen while on dangerous journeys, or in war during forced marches, or may be practicable while training, as a special test of what can be accomplished in walking, running, rowing, cycling, swimming, etc. On our play-grounds and while on excursions, while climbing mountains, etc., this degree of exhaustion is to be avoided—*i. e.*, the exercises of endurance must be interrupted *before* the exhaustion becomes too great. Greatest possible efforts in motions of endurance are hardly desirable in physical culture. But for all this, the exercises of endurance, even in a mild form, have a decided and important influence on the action of the lungs and the heart. It has been shown to be an essential characteristic of the exercises of endurance in their action on the heart and the lungs, that, while they produce an increased activity of these organs (and in some exercises of endurance this increased activity is very great), they do not require any supreme efforts and do not cause complete exhaustion, but keep the activity of both the heart and the lungs at a certain point as long as the exercise lasts. If I climb a hill very fast I shall soon have to stop to recover my breath—*i. e.*, to allow the overtaxed lungs to recuperate. If I walk a little *slower* I can climb a much greater distance without stopping, and if I go still slower I may continue to climb a hill for hours, without getting out of breath; provided, of course, that the grade is not too steep, for the heart and the lungs in this case are in a continued, equal state of increased activity. The lungs work for hours with their whole surface expanded in every direction, in a manner such as I can at best keep up for a few minutes only when I try to expand my lungs. Such general, even action of the lungs as in this kind of exercises of endurance can never be approached even by any other kind of arbitrary exercises; not by mere arbitrary breathing exercises, not by combining breathing exercises with calisthenics, least of all by calisthenics with or without weights. These last named exercises will certainly strengthen the muscles around the chest and the shoulders, which muscles may sometimes in breathing-efforts or shortage of breath be employed as auxiliaries in breathing, but they do not strengthen the real breathing muscles, the muscles of the diaphragm and the intercostal muscles. Gymnastics for the chest and shoulder muscles are of great advantage to weaklings, whose chest, from a weakness of the muscles, droops and who are round-shouldered.

The result of strengthening the pectoral—shoulder—and dorsal muscles is a permanent extension of the ribs and entire breast, whereby the hold of breathing muscles on the ribs is made materially easier, and a freer breathing through the ribs is made possible.

But these are special cases, the gymnastic treatment of which belongs to the physician and to parlor gymnastics rather than to the teacher of gymnastics. The special breathing exercises of the orthopedic institutes do not come within the pale of general educational gymnastics; for them the exercises of quickness and endurance are and always will be the preferable form of heart and lung exercises.

The different exercises of quickness and endurance, however, as has been remarked before, have a smaller or greater beneficial influence on the heart and lungs, for the reason that different exercises require greater or smaller mechanical efforts. This is especially true of moderate and easy efforts in regard to quickness and endurance.

The fullest breathing continued at the same *rate* for a longer period and which causes the highest possible action of the heart with special advantages to the circulation of the blood—of which we will speak more minutely later on—is made possible in slowly climbing a mountain, in swimming and in slow running. We all know that in rowing, especially in fast rowing, the work of the arm-, pectoral- and shoulder-muscles impedes free breathing by enlisting the thorax in supporting these muscles. This may be prevented to a certain extent if we exhale every time we pull the oars back so that the act of inspiration and expiration follows rhythmically with the motions of rowing. In rowing one-quarter of the time is spent on the pulling of the oars and three-quarters on the pause during which the oar is put back to its original position; and in order to use up the whole strength of the arm-, pectoral- and the shoulder-muscles, the rower holds his breath and his chest becomes fixed while drawing in his oars—*i. e.*, there is a short moment of extra exertion, a characteristic, as will be learned later on, of all exercises of strength. Rowing is therefore very often not a *mere* exercise of quickness, but has, to a certain extent, the character of an exercise of strength. This is especially true of fast rowing. But from these facts it follows that rowing taxes and strains the breathing-powers more than any other exercise of quickness—*i. e.*, exercises them in the highest degree.

In walking, a strong action of the heart and lungs is produced only when a person walks very rapidly or when going "double-quick." The half-automatic walk of most people is slow, and for this reason a stronger, lasting action of the will is necessary for keeping up a very rapid pace of walking. Forced marches, climbing of mountains and runs of endurance certainly have the exercising influence on the heart and the lungs, but they lack the nerve-restoring qualities which are characteristic of the half-automatic exercises of quickness. The natural consequence of this is, that very fast walking strains the nerves in a similar manner as the exercises of strength do, and tires a person out much quicker than the climbing of mountains or the runs of endurance. Another special circumstance of the very greatest importance in all exercises of quickness and endurance and of great influence on the action

of the heart, must now be mentioned, namely the *facilitation* of the *circulation* of the blood by special auxiliaries. These auxiliaries are (1) the *breathing*, and (2) *the rhythmical liberal muscle-exercise.*

The circulation of the blood is affected by the differences of pressure caused by the contraction of the heart in the net of the arterial system. The pressure of blood in the aorta, proceeding from the left ventricle of the heart, is about 2 m. (160-170 mm. quicksilver), but it gradually decreases in the veins and becomes negative in the venæ cavæ.

Normal breathing exercises a double beneficial influence on the circulation of the blood and the activity of the heart. During *inspiration* the negative pressure in the lungs causes the blood to be drawn from the superior vena cava near the heart, and the filling of the auricles is greatly facilitated. But during *expiration* the walls of the chest are drawn in, causing an increased pressure in the lungs and in the heart, thus facilitating the emptying of the ventricles of the heart into the arteries. A similar facilitation of the small circulation to that of the larger circulation is thus created in the lungs themselves.

Thus we see that those exercises, during which the action of the heart is increased without impeding the fullest breathing, will also effectively facilitate the circulation of the blood and the action of the heart.

The second auxiliary power in the circulation of the blood is the *motion of the muscles.* A greater amount of blood flows to the active muscle; the active muscle also presses on the lax walls of the surrounding veins, and aids in circulating the blood in them more rapidly. This influence on the circulation of the blood is all the greater when a larger number of muscles is actively employed, and it will be the more energetic and of longer duration the more regularly and rhythmically the contractions and relaxations of the active muscles succeed each other. These two qualities: (1) A great amount of work on the part of a large number of muscles; first of all, in the legs, with their large vein-trunks, where, even in a state of rest, the weight of the blood *per se* makes its retarding influence on the circulation felt, and (2) constant rhythmical succession of contraction and relaxation of the active muscles, constitute the characteristics of exercises of quickness and endurance. Liberal physical exercise, however, influences the circulation in other respects, too, namely, by anatomical relations, which exist between the location of some of the large arteries and the ligaments and fasciæ in certain parts of the body. Thus we find the large *crural vein* in the groin under the Poupart-ligament, which extends from the illium to the pubic bone. If the thigh is turned sharply to the outside and stretched backwards, this fascia expands greatly and presses the large vein underlying it together. If the thigh is turned inward and is bent, the fascia relaxes, draws the upper side of the vein, which is connected with the fascia and the surrounding network, upward, and thus enlarges the vessel. If these motions of the thigh are alternately repeated, the great crural vein also expands and contracts alternately—*i. e.*, the blood of the veins is pumped towards the heart—and the circulation of the blood is greatly facilitated at this point; for the valves of the veins allow the blood in the veins to flow but in one direction.

Now, the motions of the leg in climbing a hill, in running, in rowing (on a sliding seat), in swimming, are such that necessitate a rhythmical, strong, bending and stretching of the thigh, whereby the auxiliary mechanism of the circulation in the veins is rhythmically effected. A similar mechanism for the veins of the arms and the neck, but of much less interest in regard to physical culture, is found in the neck over the collar-bone.

This mechanism in the groin, however, is effective only, as has been remarked before, in extensive motions of the thigh. In the same way extensive motions of the thigh only (as muscle-motions) manifest their influence on the circulation of the blood in the large blood-vessels of the lower limbs. While standing, as everybody knows, the hydrostatical pressure, caused by the blood's own weight in the veins, manifests itself, by causing the dependent veins *above* the heart (of the head, arms and chest) to empty more *easily* and the veins *below* the heart, especially those of the legs, to empty more slowly. Consequently, if a person stands for a long time, the veins of the lower part of the body are full of blood and the circulation is slower. People who are compelled to stand much and take but little exercise frequently suffer from permanent dilatation of the veins (varicose veins) in the legs, or in the veins of the rectum (hemorrhoids).

If exercises of endurance are executed *very slowly* or with only *an insignificant amount of exertion*, their stimulating effect on the circulation of the blood in the veins finally becomes so small that the opposite influence *of the gravity of the blood* in the veins is *not overcome*. All the less so, because these smallest and slowest exercises of endurance necessitate a very small amount of muscle-work, and consequently only a very slight animation of the breathing ; and thus the promotion of the circulation by deep and full breathing is lost. The characteristics of this form of exercises of endurance, which has no effect on the lungs, the heart, or the circulation of the blood, are short-stepped walking, either in the form of a comfortable promenade, or in form of a short-stepped, noiseless walk, which unfortunately has found its way into our playgrounds and gymnastic halls during the practice of tactics.

This style of walking keeps the legs overfilled with blood and causes them to get *heavy*, for the reason that the auxiliaries of the circulation cannot be kept in a corresponding state of activity. While the circulation ought to be promoted, stagnation sets in, the waste matters are not secreted and an exercise requiring really so little work soon produces a feeling of tiredness.

While the robust traveler, who takes vigorous, brisk steps, retains his vigor and freshness, the slowly sauntering promenader soon requires rest; and yet the former does ten times more muscle-work than the latter. It is therefore an essential part of educational gymnastics to animate and to encourage a brisk, vigorous walk, which gradually becomes half-automatic, even in our common, everyday walk, and to strenuously oppose all short-stepped, affected tripping—in gymnastics for girls as well as in all other gymnastics.

And here we will merely hint at the value of a brisk, vigorous walk, the characteristic of a self-confident, ready resoluteness in the formation of character.

In once again looking briefly over our remarks, we find that it has been shown what great influence the exercises of quickness and endurance have on the action of the heart and lungs. With the heart, besides its *own increased activity, the promotion of the circulation of the blood*, which follows a *deep, full breathing*, and the *rhythmical liberal exercise* of large muscle-districts, especially those of the lower limbs, is especially noticeable.

It has further been shown that exercises of quickness, when performed, in a *narrower sense*, as *supreme efforts*, increase the action of the heart and lungs to such an extent that these organs momentarily refuse to perform their functions, although a short rest quickly restores them; while exercises of quickness, in a *wider sense*, are continued only until the first signs of fatigue of the heart and the lungs manifest themselves, and are then voluntarily moderated or ended, thus avoiding a disturbance of the equilibrium between what is required to be done and what is really done.

It makes a vast difference in exercises of duration whether a *supreme effort as to endurance* is to be made, whether an exercise to be performed which always ends with a feeling of general exhaustion (especially of the heart), or whether a medium exercise of endurance is to be gone through, which necessitates an extraordinary increased activity of the heart and lungs, or, lastly, whether so light an exercise of endurance as to have no influence at all on these organs, and ever impedes rather than promotes the circulation of the blood is to be performed.

Now comes the question: What influence have the *exercises of strength and skill on the action* of the lungs and the heart. It is self-evident that every motion of the muscles naturally increases the activity of the heart and the lungs in a measure corresponding with the amount of muscle-work performed, which latter again corresponds with a positive increase of oxygen inhaled and of carbonic acid exhaled. It is only when a motion is so insignificant as to permit the oxygen necessary for its execution to be taken from the *reserve surplus* of oxygen in the blood, that an increased action of the heart is not necessary. This may be said of a great number of *lighter* exercises of skill. In connection with this, however, it must not be forgotten, as has been shown above, that in all these exercises the quality of the blood of the persons performing the same is of great importance.

It is different, however, when an easy exercise is often *repeated in quick succession*, for in this case the muscle-work, insignificant in itself, is rapidly increased by repetition, and a similar influence on the lungs and heart as in easy exercises of quickness manifests itself. Thus calisthenic exercises, for instance, when performed in rapid succession, will quickly increase the extent of breathing, especially when they include motions of the legs and the trunk.

It goes without saying that a larger amount of oxygen is inhaled and more carbonic acid exhaled, and that at the same time the action of the heart and lungs is increased, whenever a real exercise of strength is performed, and it is at first perfectly immaterial whether the exercises require the exertion of single muscles in particular, or if the work is evenly divided between a larger number of muscles. After an exercise on the horizontal or parallel bars, which requires

strength, a heavier breathing is noticeable; but after a few minutes rest the breathing resumes its former regularity. In this instance a more localized exercise of strength came into consideration. In a *high* or *long jump* with preceding start, we have a divided effort, a high mechanical effort—to throw the whole weight of the body a considerable height or distance. During such exercises, as is but natural, the breathing and the beating of the heart is greatly increased and this increased action of the lungs and the heart slowly returns to its normal state. During class-exercises, when the members perform successively a number of high and long jumps, the breathing and the action of the heart are continued in a moderately increased degree, the same as in strong exercises of endurance, and shortly after each jump an increased action, which afterwards decreases, is experienced. Continued jumping exercises therefore have a similar influence on the organs of breathing as the exercises of endurance and light exercises of quickness.

A very particular procedure, however, which demands closer attention is noticeable in all *exercises of strength*, both difficult and easy, whenever it becomes necessary *to strain to the utmost* one or more muscles, especially those of the arm and shoulder. This procedure is the physiological act of *exertion*.

To understand this involuntary reflex-action, one must remember that the whole frame of our body is made up of articulated bones; further that a muscle, which is to work to best advantage from its origin on the movable epiphysis—*i. e.*, to bring the epiphysis as a movable point near to the origin as a fixed point—cannot do this if the origin, which is in itself a movable point, is not held fast to the trunk by special muscle-effort. The trunk, however, reposes on the pelvis, and must therefore be held by the muscles of the pelvis, and the legs, etc. Thus a little motion of one part of the body, which, however, requires the fullest aid from the nearest interested muscle (thus making an effort out of the motion), continues to extend its circle, until the whole muscular system is more or less drawn into action.

Let us take an example from life. A drawer of a desk, which is usually opened so easily that an effort of the muscles is not even noticed, happens to be out of order. The usual gentle pull does not open it, even when repeated a little more energetically. But it *must* open—we begin to lose our temper, we hold our breath, we close our mouth firmly, our forehead is wrinkled with frowns, we place our legs firmly on the floor and we pull with all our might. The exertion causes the blood to rush to our head, the veins on our forehead swell, and great drops of perspiration fall from our brow. There!—at last the ban is broken, the obstacle has been overcome and the drawer is open. A deep sigh of satisfaction, a few heavy, quick-drawn breaths, a short, loud beating of the heart—and everything is once again as before.

This was no great exertion; and all this is repeated in a higher degree whenever a particular strenuous effort is made; as in lifting a cwt.-load, in propping a heavy dumb-bell, etc.

But notwithstanding all this, in the present case it is of the greatest importance that the chest became fixed, on account of its effect on the activity of the heart, the lungs and the circulation of the blood.

A whole number of powerful muscles rise in the walls of the chest, of which we will only mention the great pectoral muscle and the sterno-clytoid muscle, which assists in supporting the arm and the shoulder-blade in strenuous exertions of the arm-muscles. To enable them to do this, the chest, which is usually in continued motion from breathing, must be held in such a position by the ribs as to give the muscle a perfectly firm starting point.

This is done by closing the epiglottis after a deep inspiration—the mouth, too, as a rule, is convulsively closed—thus pressing tightly together the air in the lungs (which cannot escape) by a forced motion of expiration—violent contraction of the abdominal muscles and the posterior seratus muscle. By this strong compression of the walls of the breast, causing the diaphragm to be pushed upward by the abdominal muscles, *a violent pressure* in the pectoral cavity is produced.

This, in the first place, effects in a greater degree what, as we have seen before, accompanies every act of expiration. The ventricles of the heart *empty faster* and more *completely* than usually; especially the left ventricle and the great arteries. As the *coronary* vein, which gives nourishment to the heart, rises directly over the crescent-shaped valve of the great main artery, the *heart-muscles* will be without the *necessary increase of oxygen from fresh artery blood just when the effort has reached the highest point* and the increase of oxygen is most needed. On the other hand, the emptying of the great arteries and the refilling of the auricles is made difficult. The *blood* in the *arterial system* is dammed up. The superficial arteries on the neck, the forehead and temples are greatly swelled, and the head and neck are very red. As soon, however, as the effort is over everything wears a different aspect. The air in the breast, overburdened with oxygen and tightly compressed until now, escapes with an audible sigh, and the blood which has been dammed up in the veins, rushes violently into the auricles, causing an immoderate expansion of the same and of the thin-walled right ventricle with its weaker muscles.

Thus we see that numerous disturbances in breathing, in the circulation of the blood and in the activities of the heart are connected with every act of exertion.

These disturbances will be all the greater the longer the act of exertion (which almost always is of a few seconds' duration only) lasts; the more intense it is, and the more muscular work it requires.

Now, which exercises require the act of exertion? As a rule, all general exercises of strength do, especially in propping heavy weights and in wrestling. A great number of localized exercises of strength, those at the apparatus especially, also require it. Of these we may make special mention of the exercises on the parallel and horizontal bars, and of these again the exercises of the muscles that flex the arms and the knees?

Practice and natural talent cut a great figure in all exercises of strength and skill. It has been shown above that the less skillful person, who has but little practice, is very much inclined to contract immoderately the supporting co-ordinating muscles, no matter what the exercises may be, and all the more so if the exercise be new to him. In

the same way he is inclined to hold his breath, and to make a strenuous effort even when the exercise is an easy one. This effort, however, is a reflex act, which may be suppressed whenever an utmost effort is not positively required. The teacher of gymnastics, by constant, energetic interference, trains the new beginner not to get into the habit of making such hard work of every exercise, thus making the exercises much simpler and easier. It is of vital importance to keep up a regular, even breathing during all exercises of strength and skill. For great exertion does under all circumstances cause a disturbance in the breathing and the circulation of the blood. Violent exertion, if frequently repeated, may have lasting, injurious effects, especially on the heart; these may not appear immediately, and sometimes do not appear until after the lapse of years. A want of arterial, oxidized blood, in the muscle of the heart just at the moment when the effort is greatest, the overburdening of the right ventricle, which is less capable of resistance, immediately after the exertion, if frequently or, worse yet, regularly repeated, must necessarily have lasting, injurious effects on the heart. Degeneration of the muscular system of the heart, and enlargement of the heart, combined with a corresponding disturbance in the circulation of the blood, will positively result, even though it may take years before all this begins to manifest itself. Failing health, so often noticed in persons who have taken excessive physical exercise, may in most cases be traced to this source. Nor is the possibility of a dilatation of the lungs by immoderate expiration excluded. Of special import is this to a person whose heart is already affected. Ailments, like scarlet fever, diphtheria, articular rheumatism, contracted or inherited syphilis, etc., frequently leave behind them injurious effects, without the patient being, for many years, conscious thereof. For such people exercises of strength, requiring great efforts, are positively dangerous; for it is greatly to be feared that the organ, already weakened, will very soon become entirely unfit for exertion, and that permanent disturbances will make themselves felt.

But be this as it will, let the consequences of frequent momentary efforts be ever so slight, the fact remains that exercises of strength and skill, requiring great efforts, are of *no practical value in developing the activities of the heart and the lungs and the circulation of the blood, on account of their disturbing influence on the action of these organs.* If we add to this that exercises of this kind, not requiring special efforts, demand but a slight increase in the activities of these organs, we must draw the conclusion that exercises of strength and skill are *not* the proper means for producing the necessary activity and development of the heart, the lungs and the circulation.

The development of the heart and the lungs is as necessary for a harmonious physical education as is the development of the muscular system and the controlling of the same by the nervous system. Mere gymnastics, as calisthenics, tactics and exercises on the apparatus, without due attention to exercises of quickness and endurance, can never do justice to one important branch of physical culture, namely, the influencing of the activities of the breathing and the circulation, and can never attain a harmonious development of the body.

NFLUENCE ON THE MOLECULAR CHANGES AND THE NOURISHMENT.

A short discussion on the influence of the above-mentioned exercises on the molecular changes and the nourishment may follow here.

The muscle is a machine of strength. It performs mechanical work by contraction and shortening. This labor, the generation of strength during the activity of the muscle, is based on the transmutation of elasticities to living strength, produced by a chemical process, in which all the groups of chemical muscle-matter participate. For this process, which we will not go into details upon, but simply designate as oxidation, the muscle needs, as has been shown above, a corresponding increase of oxygen, the amount of which corresponds with the amount of mechanical labor performed; to perform one kilogram-meter of work the muscle needs one-third to one-fifth ccm. of oxygen. Larger quantities of oxygen are transmitted to the muscle when the increased activity of the heart circulates more blood, and increases the circulation of the blood; and, secondly, when the blood-vessels in the active muscle are enlarged and contain a greater quantity of blood.

Thus a much greater number of vehicles of oxygen (red blood-corpuscles) pass through the active muscle, in order to deposit there the required increased amount of oxygen.

This process in the active muscle produces an increase of warmth; this is equalized to a certain extent by an increased evaporation from the skin (perspiration), as well as by heavier and deeper breathing, and then, too, a number of oxidations take place. Of these we have already mentioned carbonic acid, which escapes in vast quantities during exhalation after any muscle-work. Mention has also been made of other products of decomposition of muscle-work, namely, the tissue-wastes. This influence makes itself felt, on the one hand, in the tired muscle itself, as the waste-matters diminish the irritability of the muscle and have a laming influence on the same. On the other hand, it may happen that when the muscles perform a great amount of work, that the product of tissue-waste in the blood accumulates, and thus has an effect of a general nature, a kind of self-poisoning, on the organism, the result of which is fever heat, a feeling of dejectedness and debility, loss of appetite and sleeplessness for hours, etc. (See above: General exhaustion after excessive exercises of endurance.)

Thus every muscle-work means an influence on the molecular changes, which influence manifests itself by the consumption of a larger amount of oxygen and an increased exchange of muscle-matter and an increased secretion of carbonic acid. The molecular changes, however, are not confined to the working-muscle only. On the contrary, the increased breathing and rapid circulation of the blood, caused by the work of the muscle, effect an increase in the total change of matter. The muscle, too, does not only consume the matter contained in its cellular tissues, but when strained to the utmost it is supplied with other material for the molecular changes, during its activity, by the greater amount of blood flowing through it. The body is possessed of certain reserved matter in its cellar tissues for this purpose, the first of which is the fat.

The animation of the molecular changes, however, is equivalent to the animation of the nutrition (Ernährung), for the matters consumed during activity are restored by rest and recreation. This restoration is so complete with the muscle that the former full strength not only returns, but the same is greatly increased. The muscle, when frequently used and exercised, grows stronger and larger, for the exercise furthers its development. In a similar manner muscle-work influences greatly the growth and the general development by increasing the molecular changes in all cellular tissues of the body, provided that the work of the muscle does not require such strenuous efforts as to consume larger quantities of reserve matter. While this may be desirable where there is a superabundance of reserve matter, as, for instance, with grown people who are too fat, so undesirable is it where these reserve matters are to serve other purposes, and are to be utilized in building up the system, as is the case with the growing child and youth. For these the amount of muscle-exercise, if it is to be beneficial, must have narrower limits than is the case with adults.

Let us consider the different important kinds of exercises from this point of view.

In all exercises of strength, the work which is localized in certain muscle-districts comes into consideration. Whenever strenuous general exercises of strength are required, strong oxidations, corresponding with the amount of work done, take place in the muscles, which are strained to the utmost; oxidations which exhaust the muscles' supply of strength—*i. e.*, its momentarily oxidizable matter—and which affect the reserve matters of the body, as fat, for instance, and consume them. *Strenuous exercises of strength* have a *degenerating* effect on the molecular changes. With the *exercises of quickness* it is different, for here the great amount of work is distributed over large muscle-districts, and no muscle need be strained to the utmost. Active oxidation and molecular changes take place in the body, but in no case do they cause exhaustion. Of the exercises of quickness it may therefore be said, that they promote and animate the molecular changes, without leaving any depressing effects. The same may be said of the *moderate exercises of endurance:* a few hours' walk, a short row, or leisurely climbing a hill.

All these have a wholesome effect on the molecular changes and the nourishment.

But not so with immoderately extended exercises of endurance, for they exhaust in a similar manner as do the exercises of strength, with this difference, however, that with the latter the exhaustion is more localized, while exhausting exercises of endurance are detrimental to the whole organism, poisoning it, so to speak, by the immoderate amount of waste-matter circulating in the blood, which condition is generally overcome in one or two days.

*In exercises of skill and localized exercises of strength;* the muscle-work is less and the molecular changes are correspondingly smaller. The work of the muscle is increased and has a more general influence only when the exercises are so arranged that all the muscle-districts in the body are brought into requisition as much as possible. Later on we will discuss the special points in regard to promoting the molecular

changes for the growing child and youth on the one hand, and the mature man on the other, and will show why the kinds of exercises for the different ages should be essentially different.

*The exercises of attention.* Closely linked with the two great groups of physical exercises here discussed—the exercises of strength and skill, on the one hand, and the exercises of quickness and endurance, on the other—are two special kinds of exercises, which do not differ from them in general character, but in a certain direction only, namely, in regard to brain and nerve-gymnastics.

The exercises of attention (tactics, etc.), can hardly be said to possess any decided practical value in physical culture, or to have any influence on the activities of the great organs, unless they are—and these are exceptions—such exercises as vigorous marching, hopping or dancing. Otherwise the measured, short-stepped walk in tactics is of *absolutely no benefit* to the activities of the heart and lungs and the molecular changes. And exercises of this kind, if continued for a longer time (sometimes more than one-quarter of the whole time allotted to gymnastics is given to tactics), are positively detrimental to the circulation of the blood, because they retard the same; for the facilitation of the circulation—produced by deep breathing and vigorous exercises, especially the exercise of the legs—is lost here, causing a stagnation in the circulation of the blood in the lower limbs. The arteries of the legs are overfilled because the influence of the blood's own weight is not correspondingly equalized by the auxiliaries of the circulation, and because the conditions are wanting, which at other times cause an increased action of the heart. The result of which is that a slow walk or tedious standing produces a tired feeling in the legs, a feeling of laziness, while a real physiological exhaustion, such as is experienced after muscular work, is out of the question. One organ only is taxed more than usually, and is strained, namely, the brain.

Class-tactics, with their "dress your lines, right-face, left-about face," etc., demand uninterrupted attention; and constant attention is to the mind what exertion is for the muscle. If tactics are to be perfect it is necessary that the few constantly repeated motions, such as forming lines, right-face, left-face, etc., be promptly and exactly executed on command of execution—preceded of course by the command of warning—*i. e.*, they must be just as promptly as correctly "co-ordinated." Hence, tactics in this respect are a sort of *co-ordination exercises*, consisting of the instantly well co-ordinated execution of a few constantly-repeated familiar and mechanical motions on command of execution, while the command of warning, however, gives time for co-ordinating deliberation.

This kind of co-ordinating exercises, especially as conducted on the military campus, is called: *Drill.*

No one, however, will deny that class-tactics, where each member is but a part of the whole, and which nevertheless require the strictest attention and the correct motions from every member in the class, if the whole performance is not to suffer or to be spoiled, are of a peculiar value from an educational point of view in promoting physical culture.

But their value in regard to physical exercise amounts to very little, indeed, and is limited to such exercises of co-ordination known as preparatory to the drill.

For children *in school*, who are compelled to exert their mental faculties in school, these exercises prove but a further burdening of the brain, and during gymnastics, which follow upon several hours of hard mental labor in the school-room, when the pupils are more or less mentally exhausted, the exercises of attention will easily lead to an unhealthy overtaxing of the brain and the nerves.

*Exercises of alertness.* An entirely different co-ordination of the activity of the will is developed by the exercises of alertness. To these belong wrestling, fencing, and above all, the more intricate games of running and ball-games. Of these exercises wrestling may be counted with the number of general exercises of strength, while fencing belongs rather to the class of localized exercises of strength and skill, and the games are pre-eminently exercises of quickness. The characteristic points, however, of these exercises in regard to co-ordinating the activity of the will are as follows.

1, The motions do not follow on the command of the teacher, nor yet on the instruction and example of the preceptor, but on *the impulse of the moment*, whenever sudden and unexpected emergencies during a wrestling or fencing match or during the course of a game require them.

2. The necessary motions need not be executed in perfect, correct, co-ordinating form; the end in view is to *gain positively a certain point.* (What we are after here is to watch closely and follow up quickly any advantage our opponent or chance may give us, or to render his attacks on us ineffective; and during a game of ball the main points in question are to make your base, to avoid being hit by the ball or being overrun by your opponent, to hit the ball safely, no matter how swiftly the pitcher twirls it, to catch a batted or thrown ball, etc., etc.)

3. Sizing up the situation, resolve and execution must follow in lightning succession.

In gymnastics, where the command of warning precedes the command of execution, time is given to deliberate, to *co-ordinate beforehand*, in class-gymnastics the members of the class are given ample time to think over the exercises which they have been shown, and they can also, if the execution be slow, *co-ordinate while performing* the exercise; thus in educational gymnastics ample opportunity for deliberative co-ordination is given, but a readiness to meet any emergency, no matter how unexpected, is required and to gain a certain point by the quickest possible motion; in a word, to co-ordinate suddenly.

Every well-regulated motion requires a certain time for deliberation; the excitement of the will transferred to the nervous system requires a certain, measurable time to reach the muscle which is to be moved; the muscle after being excited to activity by the nerves, needs a short time for preparation before contracting. This space of time, needed for every deliberate motion, from the time when the will is excited to action until the muscle contracts—generally lasting a fraction of a second—must be shortened when one is expected to act as quick

as lightning. This is effected by a certain mental strain, which increases the irritability of the whole nervous and muscular system. This mental strain and increased excitement is experienced by the runner of a race who waits for the signal for starting, ready to start like "a ball shot from a cannon" on the given signal. In fencing and wrestling this strain continues throughout the whole combat; the consequence of which is, that such exercises, when continued for a long time, are followed by a prolonged, unusual exhaustion of the nervous system, not to mention the strain upon the muscles. In games, however, it is different, for here such a strain and readiness to act is required at certain periods of the game only, thus giving a continued change between exertion and recreation while an undue strain and exhaustion of the nerves, is entirely avoided. Hence games are particularly suited for forming a person's whole character and for acquiring a readiness to act in cases of emergency and for developing presence of mind; all the more so, because the finer games, as compared (especially with fencing), involve a much greater variety of accidents and unforeseen, unexpected emergencies

In this variety of possibilities of confronting the player with all manner of conditions lies the essential value of the different games; the more intricate a game is, the greater its variations, the more practice does it afford. These qualities especially give such games as foot-ball, cricket, base-ball, etc., the foremost place in this kind of nerve-gymnastics, and in acquiring and developing a readiness to act.

## II.

## NEED OF EXERCISE AT THE DIFFERENT AGES OF LIFE.

In the preceding pages the different influences of the separate kinds of exercises on the main activities of the body have been shown.

In the following pages we will endeavor to determine which of these influences is the most beneficial at the different ages of life, and how the material of exercise should be most advantageously distributed. The special influence of school-life, as well as that of the different professions and avocations followed later in life, shall be briefly mentioned and we will distinguish practically between the following ages:

(1.) *The years of childhood* until beginning maturity; hence the years from the day of birth until the 14th year. During these years, a new era begins with school-life (generally in the 6th year). The years before going to school may be passed over in silence, for they hardly come into consideration here, and one cannot well speak of really educational physical exercise, in the common sense of the term, at so tender an age. The following school years, from 6 to 14, we divide practically into two parts.

(*a.*) The years from 6 to 9. In these three first years the child becomes, so to speak, mentally and physically, accustomed to school-life; while the growth, and the development of the skeleton, especially the bones of the head, is materially furthered; which may, among other things, be plainly seen, when the child gets its second teeth (generally in the 8th year).

(*b.*) The years from 9 to 14. The child grows larger and heavier; the bones grow stronger and the muscles can endure more and longer.

(2.) *The years of development* — the age of maturity, from the 14th to 20th year.

During these years we attain sexual maturity, and the growth of the body, as to height, almost reaches its limit.

But most noticeable above all is the rapid growth of the *lungs* and the *increase in the dimensions of the heart* during these years. The latter is the result of the fact that the size of the heart as compared to the transverse dimensions of the arteries, of the arterial system experiences essential changes in the years of maturity.

In the years of childhood the heart is comparatively small and the arteries wide. The action of the heart is more rapid, the pressure of the blood is less and the circulation of the blood is facilitated. Thus the process of molecular changes, comparatively so intensive, is effected more easily in the child's body than in later years, when the rapid growth requires an increase in the molecular changes.

At maturity, when a person is almost full-grown, these conditions change. The heart increases almost double in size, during these years,

while the growth of the arteries, as far as their width is concerned, arrives at a stand-still. The consequence of this is a stronger pressure of the blood, an increased demand on the activity of the heart. From the day of our birth until we are full-grown, the transverse dimensions of the arteries have increased but 3 fold, while the dimensions of the heart have increased 12 fold (Beneke).

During the years of development the total growth is as follows:

| | | |
|---|---|---|
| The height of the body averages | 1.18 fold. | Quetelet Key, |
| The weight of the body " | 1.42 fold. | Beneke. |
| The volume of the lungs, averages | 1.63 fold. | Beneke. |
| The volume of the heart, " | 1.92 fold. | Beneke. |

The size of the above organs increases, according to Beneke, on an average as follows:

| | | |
|---|---|---|
| In the years from 7–14 | the heart, annually | 5.6– 7.5 ccm. |
| | the lungs, " | 4.5– 5.0 ccm. |
| During the years of development | the heart, " | 1.9– 3.0 ccm. |
| | the lungs, " | 10.0–14.0 ccm. |

These facts show that the development of the lungs and the heart are, from a physiological point of view, the chief characteristics of the years of maturity.

(3.) *The years when the youth grows to full manhood* — from the 20th to 30th year.

In these years (from 23 to 25) we stop growing, and the skeleton assumes its final shape.

The ligaments of the joints have full sway of motion, our motions are easy and skillful, the muscles are strong, we enjoy life to the fullest extent and our daring and self-confidence is greater than ever.

(4.) The years of *full vigor of manhood* — from the 30th to 40th year. When the strengthening of the skeleton is completed and the muscles have been fully developed, physical strength has reached its zenith. At no time is the body in better condition to endure utmost efforts, whether in momentary exercises of strength or in exercises of longer duration. The ligaments of the joints grow stiffer and less inclined for graceful motions; strength has taken the place of skill, which latter is no longer capable of being increased.

(5.) The years of *overmaturity of manhood*—from the 40th to 60th year. After the 40th year, with some sooner, with others later, peculiar conditions in the vascular system manifest themselves, which effect particularly an increasing brittleness of the walls of the arteries, thus decreasing the power of action of the heart during exercises of strength, and more yet during exercises of quickness. The heart grows fagged and we get out of breath more quickly than in former years after any physical exertion, especially when, as is the case with most men, the accumulation of adipose tissue has become too great.

It has become more than ever necessary to observe a certain limit and a certain regularity in all physical exercises; and this is especially true of all exercises where a fair amount of strength or quickness may eventually be displayed; but when great exertion of this kind cannot well be endured without endangering the health.

It is not necessary here to consider old age.

And now let us, from this point of view, briefly fix the amount of exercise necessary for the different ages.

### THE FIRST SCHOOL YEARS.

The growing child needs above all things stimulation to growth, such as is effected by all motions tending to stimulate and quicken the circulation of the blood. This is to be effected by such motions in which a great number of muscles actively participate and not such where a few muscular districts in particular are burdened or even strained.

For it has been demonstrated that localized exercises of strength will soon exhaust the strength of the muscles—and of the weak, undeveloped muscle of the child this is doubly true—and recruit new strength from the reserve-matter in the tissues.

The growing child, however, needs these reserve-matters greatly for its growth and the further development of the body. Muscular exercise with the child has therefore not the same effect as with the grown person; it does not immediately strengthen and increase the size of the muscle, but interrupts the growth and the general development. Children that are taught gymnastic feats while they are still very young generally suffer for this in regard to general development and growth. This is a well-established fact.

The special influence of school-life must next be considered. Remaining in a sitting posture for hours, as the child is compelled to do from its 6th year, has a great influence, especially on the organs of breathing and the circulation of the blood, and hence on the formation of the blood. A sitting posture interferes with healthy breathing; the breathing while in a sitting posture is more of an abdominal breathing—*i. e.*, a breathing with the lower parts of the lungs only—while the important breathing with the breast, and especially the airing of the apex of the lungs, falls entirely away. The circulation, too, is deprived of important stimulations, namely, of the influences which, as has been shown above, are effected by deep breathing and liberal muscular exercise; hence the heart performs its functions under difficulties. Another detrimental influence on the formation of blood and the molecular changes are due to the bad air so often found in the school-room, especially when the rooms are too small or poorly ventilated or overcrowded. This is why so many school-children suffer from anæmia and chlorosis.

If all this be carefully considered and the special influences of the different kinds of exercises be closely weighed, we naturally come to the conclusion that the exercises most beneficial for children are those which promote their growth and general development, and which counter-effect the detrimental influences of the school-room; these exercises are those which exercise liberally the breathing and the circulations of the blood; or, in other words, *the exercises of quickness*.

Stationary calisthenics would lack the influence on the heart and the lungs; the same must be said of the exercises on the apparatus, even the easier ones, not to mention that a child, being as yet unskilled in these exercises, is very apt to overexert itself. The best way to

practice these exercises of quickness is undoubtedly in the form of *simple games of motion.* In the first place, because they combine pleasure with the greatest possible variety of exercise; and then again, because they, in opposition to exercises of quickness executed on demand, avoid a minimum as well as a maximum of exercise. A child which, during any game, has run until it is out of breath, will stop of its own accord and will allow itself to be caught. We have mentioned above the relations between the heart and the arteries as to circumference in the years of childhood and in later years, and this circumstance makes exercises of quickness particularly beneficial to the child; for it is simply impossible for a grown person to run so long a time at a stretch as a child sometimes does for hours in a game, for the pressure of the blood is entirely different from what it was in the days of his childhood. Another thing in favor of games as a means of exercise for children is the fact that the games afford the child the opportunity to exercise its own will and thus render the gymnastic lesson less of a mental training-lesson.

Due consideration for general health as well as special consideration for the breathing organs and the promotion of the formation of blood demand that this kind of physical exercise—*i. e.*, these *games*—be played out-doors whenever this is *at all possible;* for everybody knows that the influence of fresh air and sunshine, combined with liberal physical exercise, on the molecular changes, and the formation of the blood can never be replaced by even the cleanest and best ventilated of gymnasiums.

If occasionally bad weather,* continuous rain, insufferable heat or cold, compel us to seek shelter under cover, then let the children learn to form lines to march, to perform easy calisthenics, wand exercises, jumping exercises, etc., etc.

### THE SCHOOL YEARS, FROM THE NINTH TO THE FOURTEENTH YEAR.

During these years, too, the stimulation of the growth and the overcoming of the detrimental influences of sedentary work in school and at home are essential requirements of perfect health. The value of exercises of quickness is not diminished during these years, but the games vary more and begin not only to amuse and exercise, but to cultivate also alertness and agility. To foot-ball, which is of incalculable benefit, especially during the colder season, are added base ball, cricket, prisoners-base, cross-tag, etc., etc. Besides games, systematic exercises in running are practiced, especially the exercise in long distance running with a careful increase of the duration.

Other light exercises of endurance, too, such as short excursions that invigorate but do not tire, are highly beneficial. In the tenth year the child may safely, without any detriment to its health, begin to learn to swim, as long as the thing is not overdone. And how anxious is not the healthy boy in winter for a good, jolly skate. During regu-

*The number of days on which it is impossible to enjoy out-door exercise is not near so large as is generally believed. If the play-ground is so arranged as to dry quickly, some time may be spent usefully on the play-ground every day, when it does not rain incessantly, but at intervals only.

lar gymnastic lessons the main things of importance are the acquiring of a straight, graceful carriage, and of a nice, vigorous walk, which are taught in exercises of marching, running (as mentioned before) and jumping; while, at first, calisthenics with weights, such as light dumb-bells and iron wands, are practiced to develop skill.

In this line there is a superabundance of good material of exercise. Of the exercises on the apparatus, the easy exercises of skill are to be recommended, while all exercises which are more of the character of exercises of strength, and which require strenuous efforts are to be avoided. The real benefit of the exercises on the apparatus does certainly not begin until after the skeleton has become stronger, and the muscular system better enabled to endure exercise—*i. e.*, generally with the close of the twelfth year.

Gymnastic exercise in the form of walking, running and jumping is for this age undoubtedly the most important and most beneficial.

THE YEARS OF DEVELOPMENT, FROM THE FOURTEENTH TO THE TWENTIETH YEAR.

These years are of great importance in two respects: Firstly, on account of the great development of the heart and lungs, which are now growing at an enormous rate, and which require the necessary invigoration for their growth. And here, besides long distance running, quick running is beneficial; excursions even may partially be made in "double quick," but real exhaustion is even now to be avoided yet.

Then these years are best adapted to acquire the positive control of the muscular system by developing the skill. For this reason the manifold exercises on the apparatus are of great importance, as well as localized exercises of strength for the purpose of strengthening the muscular system, which is now ripe for exercises, but great exercise of strength, where strenuous efforts are unavoidable, must not be frequently attempted. Such exercises of strength as muscling heavy dumb-bells, etc., are to be avoided entirely. The out-door games, in order to be amusing and instructing at the same time, should be characteristically games of alertness. But at this age we must be careful to distinguish according to outer circumstances of life. For those whose chosen profession gives them frequent out-door exercise, as for instance the gardener, the farmer, etc., calisthenics and exercises on the apparatus for the development of agility, skill and will-power are mainly required. For the mechanic or artisan, the laborer, the merchant, who pass their week days in the work shop, factory or office, the exercises of endurance and quickness in the open air are of special benefit. If our social habits, especially the bad habit of seeking recreation in the saloon, are in conflict with this assertion, it nevertheless remains true. A change must be tried here. Gymnastic exercise in the gymnasium without the necessary exercise in the open air, in games, marching, running, etc., are decidedly insufficient to counterbalance or eradicate the baleful influence of the workshop and factory on the apprentice. The fact that in our country the greater half of artisans are the victims of consumption (the death-rate among the members of the sick fund in the City of Krefeld during the last years shows that 61 per cent. of the deaths were due to consumption), must necessarily give rise to serious

thought. No matter what other influences may be at work, the question of a correct health-promoting form of recreation by bodily exercise is of the greatest importance. There is no question about it that regular physical exercise aids in making the lungs healthier and stronger. This is not, however, done by exercise on the apparatus in closed, dusty gymnasiums, but by liberal exercise in the open air; nor can these exercises be encouraged enough.

In regard to the pupils of this age, attending the higher schools, the above established rules cover the exercises needed by them. But it is necessary that this mental training during gymnastics be different, according to the place which gymnastics occupy in the course of study. We know from the investigation by Prof. Angelo Mosso, in Turin, that several hours' mental work is prejudicial to the apparatus of motion. The nerves of motion, as well as the muscles, are less excitable, and their immediate power of action is diminished. For strenuous bodily efforts much stronger will-power becomes necessary than when the pupil is mentally fresh. A pupil who has undergone three or four hours of mental strain is not fit for gymnastic exercises that require exertion and will-power, nor can he endure them, without burdening still more his already tired brain. In such cases gymnastics should be of a recreative nature, and such exercises as half-automatic walking, running, and, above all, games of motion, etc., are in order. And as the important physical exercises, which are to develop exertion, will-power and skill, must not be missed, it is wrong to place gymnastics immediately after a number of brain-stretching lessons in the course of study, for if this is done, gymnastics will burden rather than invigorate the nervous system.

### THE YEARS FROM TWENTY TO THIRTY.

These are the years in which exercises of quickness and skill may be practiced with impunity, and in which daring and courage reach their zenith. During these years it does no particular harm if a certain form of exercise is passionately indulged in; whether one prefers the exercises on the apparatus, or rowing, or bicycling, etc. Not that we would for a moment advocate such one-sidedness; we simply state the fact that during these years, such preference of one form of exercise over the other is less detrimental to the health. Any excess will be followed by the punishment in its wake, be these excesses in the form of exercises of strength or endurance or skill.

The modern "sport" has done much to establish the custom of "training"—*i. e.*, of "getting into condition"—by living in accordance with certain rules as to sleeping, eating, drinking, smoking, etc., and while this may have its good sides, it is certainly of no practical common value. Nor is it always safe, from a hygienic point of view, to undergo a course of training, and for any one, whose organs, especially the heart, are not perfectly healthy, it is positively dangerous.

### THE YEARS FROM THIRTY TO FORTY.

In these years, when man is in the prime of life, man's achievements, as far as exercises of strength and endurance are concerned, reach their highest point; while, on the other hand, his skill grows less, or is at least no longer increased by practice. For even now, if there be any

inclination at all to corpulency, the fatty substances develop more easily, and for this reason the exercises of strength and endurance are most beneficial, because they diminish the reserve matter—*i. e.*, the adipose tissue—and oxidize the same.

But the hindering influences of the exercises of strength on the breathing and circulation of the blood, and their possible detriment to the general development and the action of the heart-muscles must not be lost sight of, and any excess of one-sided, heavy exercises of strength should be avoided as dangerous.

### THE YEARS OF FORTY TO SIXTY.

After the completion of the fortieth year man's physical powers gradually begin to diminish. The arteries grow more rigid, the action of the heart becomes weaker. The heavy accumulation of adipose tissue, which always begins in the mesentery of the intestines, together with the fat of the abdomen, impede the action of the diaphragm in breathing. The consequence is that whenever an exercise is attempted which requires an extra, sudden effort on the part of the activities of the heart or the breathing organs, these organs will refuse to perform their functions, and breathlessness results. From which reason the exercises of quickness especially should no longer be practiced at this age. The same may be said of the heavier exercises of strength, which are all now more dangerous than ever to the muscles of the heart. But the strength for exercises of endurance, vigorous walking and climbing of hills is frequently possessed in a remarkable degree by men of this age. All calisthenics and light exercises on the apparatus, which do not require any special skill or effort are very beneficial to men of this age, for retaining a certain degree of suppleness and elasticity. But such exercises, during which the head comes to hang downward and the legs upward—somersaults, handsprings, etc.—must be avoided.

Injuries to the joints, caused by knocking against the apparatus while exercising, especially in the knee or foot joints, are very apt to cause wearisome pains and stiffness in the joints.

When, therefore, the accumulation of fatty substances increases, and we grow older and stiffer, the exercises on the apparatus (and jumping) must be stopped, while the practice of calisthenic exercises will prove beneficial until old age.

These are, briefly stated, the principles to be observed in general for the different periods of life. It is self-understood, of course, that they hold good for a majority of people only, and that there may be many exceptional cases. The development of the body is not the same in all people, the one grows old sooner, the other later; vigorous, healthy natures retain their freshness and vigor for years after reaching the years when men are generally considered old, and, on the other hand, weaklings will remain poor weaklings always, even in the prime of life. Rational physical exercise at all times of life is of incalculable benefit to health, vigor and enjoyment of life, and cannot be overestimated nor replaced. Would that this idea might spread and impress itself on the minds of our people for the welfare and advancement of our glorious country.

Plate I.

# The Beneficial Influences of Physical Exercises

| KIND OF EXERCISE. | Character of the Exercises: General. | Character of the Exercises: SPECIAL. | THE DIFFERENT EXERCISES. | INFLUENCE ON: The Lungs. | The Heart. | The Circulation of the Blood. | The Molecular Changes and Food. | The Nervous System. | The Muscles. |
|---|---|---|---|---|---|---|---|---|---|
| I. General Exercises of Strength. | Separate independent act of motion. Endless variety of form possible. | **Straining a large** number of muscles **to the utmost,** combined with the **act of exertion.** | Wrestling, putting up weights, and dumb-bells. Putting the shot. | Increased straining activity, caused by the act of exertion. | | | **Weakening Effect.** Strong oxidation of reserve matters, especially of the fat. | **Strong Effort of the Will.** | **Straining a great number of muscles to the utmost,** until the muscles become momentarily exhausted. **Increase in the strength and dimensions of the muscle.** |
| | | | | Disturbance of rhythmical breathing, caused by the fixed position of the chest during forced expiration. | Emptiness of the arterial system and the heart during the exertion and inflation of the right ventricle after the same. | Disturbance in the right auricle, caused by the emptying of the great arteries; stagnation in the nervous system. | | | |
| II. Localized Exercises of Strength. | | Severe to **utmost** straining of a **few** muscles, minor action of numerous co-ordinately active muscles. Frequently combined with the **act of exertion;** especially with persons not drilled. | **Calisthenics:** Especially with weights, frequently repeated or combined with long holding. **Exercises on the Apparatus:** Especially exercises in the rest on the horizontal bar, parallel bars, ladder and rings. Throwing. Pole-vaulting. | Moderately increased activity. Disturbance during the act of exertion (as under I), but generally in a lesser degree. | | | **Moderate Incitation,** increased only with the greatest possible change of the muscles coming into requisition. | Moderate to strong effrt of the will, requiring **resoluteness and courage** for some exercises; especially: Exercising the co-ordinating activity in varios combinations of motions not generally metwith in every day life; hence: **Acquiring a Geneal Control of the Musles** for mastering positive **prscribed** problems of motion. Greater security in he co-ordination, finally also in new, unexpectedly required motions. The co-ordination of adjacent, special muscle districts is exceptec. Manual training, vocaltraining. | **Straining a small number of muscles to the utmost,** especially in the arms and shoulders, until exhausted; weak to moderate activity of a large number of muscles, especially around the chest, shoulder, back, arm. **Increase in strength of the muscle most exercised.** |
| III. Exercises of Skill. | | Exercise of the **co-ordinating brain** and **nerve activities.** Moderate to strong activity of single muscles; moderate and light activity of numerous co-ordinate muscles. With the **beginner** and **awkward person: Frequently** the **act of exertion; always: greater** activity of the **supporting co-ordinating muscles** than with the skillful or drilled person. | **Compound and Flourishing Calisthenics:** Balancing exercises (balance board, etc.) **Exercises on the Apparatus:** Especially the practice of the combined jump over and the exercises on the vaulting-buck and horse-vaulting over the horizontal and parallel bars, etc. Far and high jump over the rope. | Moderately increased activity. With persons who have had no practice: Frequent slight disturbances by the act of exertion (as under I). | | | | | Passing **moderate to weak activity of a large number of muscles,** especially those of the upper half of the body. |
| IV. Exercises of Quickness. | Rhythmical succession of constantly repeated motions that may be interrupted at any point without derogating from the character of the exercise. Limited circle of forms. | **Rhythmically repeated motions, distributed over a great number of muscles,** with the intention of moving forward quickly, (rowing-race, running-race, etc.), or as rapidly as possible, **straining the activities of the heart and the lungs to the utmost,** and causing a temporary exhaustion of these organs. | On even ground: Walking, Marching, Running, Quick Running, Time Running, Games of motion, Rope-jumping, Hopping, Dancing, Far and high jump with a run. Ascending: Climbing a hill, Climbing a ladder, Climbing a flight of stairs. In the water: Swimming, Rowing, with movable seat. Moving forward by means of special vehicles: Bicycling, Skating. Natural exercise: Sawing wood, Turning the wheel. Work with climbing apparatus: Mountaineer's equipment. | Rhythmically greatly increased activity. | | Strong acceleration and alleviation. When the lungs and heart are fatigued: Passing congestion of the lungs. | **Generally animating** by accelerated circulation and the great activity of many muscles. Weakening only when excessive exercise is indulged in. | When covering a cerain space in the shortest possible time: **Effort of the Will.** At all other times, half-automatic motions; hence the least strain on the brain; **recreative character in regard to brain and nerve activity.** | **Great Amount of Muscle Work,** but distributed over a large number of muscles in such a manner as to prevent localized exhaustion of single muscles, effecting however a certain degree of general tiredness. |
| | | | | Tasking the whole breathing surface, generally but partly backed. | Increased pulsation, increased volume of the pulse (the increased flow of blood with each contraction of the heart.) | | | | |
| | | | | When utmost efforts are made: Momentary exhaustion. | | | | | |
| | | | | Breathlessness. | Weak, intermittent pulse. | | | | |
| V. Exercises of Endurance. | | The same rhythmically repeated motions, their quick succession, however, **moderated to such an extent** that the **equilibrium** of the **different organic activities,** coming into requisition, is preserved, and that **the motion may be continued** for hours. | | Continued increased activity and Extra efforts without injurious effects. | | Continued Acceleration and Alleviation. | **Generally animating** when **continued too long.** Weakening to a high degree; (oxidation) and even exhaustion, lasting two or three days, accompanied by fever, loss of appetite and sleeplessness, caused by the accumulation of waste-matter. | Half-automatic character, recreative for the brain and nerves. Only when continued too long and when the nerves and muscles become so exhausted that their excitability is greatly diminished: Exertion of the will. | Only when the exercise is continued too long: Strong accumulation of waste-matter and diminishing of the excitability of the power to act. |
| | | | | | Only when continued **too long:** Fatigue of the heart and its nervous organs; feeble pulse for hours. | | | | |
| VI. Exercises of Attention. | | Class tactics, where the single member is but a part of the whole. Exerting the **attention,** and sometimes too, **the memory.** (In rhythmical motions). | Tactics. Rhythmical motions as in May-dance, etc. | Amounts to O | Amounts to O | In slow motions and when taking short steps, or while standing a long time, sluggishness of the lower extremities; (congestion of the veins). | Amounts to O | **Purely mental strain and attention;** in rhythmical motions the **memory** is taxed. Prompt co-ordination of a few unpracticed motions. (Turns, steps, etc.) | Amounts to O |
| VII. Exercises of Alertness. | | **Quickest mastering of unforeseen, suddenly necessary motions,** on the **impulse of the moment.** | Wrestling, Fencing, More intricate running and ball games. | Same effect as under I. | | | Weakening. | **Quickest sudden co-ordination** of motions not executed after a strictly prescribed form, **but executed, on the impulse of the moment, in such a manner as to positively gain a certain point.** Positive and quickest inervation possible only by **strained attention** and **increased irritability** of the nervous system. In a game of ball required at certain moments of the game only; recreation and exertion alternating. In **wrestling and fencing, required throughout the duration of the contest;** hence these, when of longer duration, cause **exhaustion of the nerves.** | In Wrestling: Utmost effort. (As under I). |
| | | | | Same effect as under II. | | | Inciting to weakening. | | In Fencing: Localized utmost effort. (As under II). |
| | | | | Same effect as under IV. | | | Generally animating. | | In Playing Ball: Great amount of muscular work, without localized fatigue. |

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