

PROGRESSIVE RESISTANCE EXERCISE IN THE FUNCTIONAL RESTORATION OF THE PERINEAL MUSCLES

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INTENSIVE investigations and experiences of World War II, the recent studies of physiologists, and research in infantile paralysis have greatly changed the methods of conserving and restoring skeletal muscle function. This knowledge has not been applied to genital relaxation to appreciable extent.

A restudy of the problems of the lax perineum in relation to modern concepts of muscle-cell regeneration and function reveals that birth-canal musculature is especially responsive to an improved method of conserving and restoring function.

The process of childbearing, although ordinarily considered a normal physiologic function, is invariably attended by a certain amount of injury to the tissues of the uterus, cervix, vagina, and perineum. In the majority of women, healing takes place rapidly and the structures are quickly restored to a state which makes a repetition of the process possible. Never, however, do the organs resume their original integrity of form and function.

Modern advances in obstetrics have led to a great reduction in the loss of life associated with childbearing. Infection, hemorrhage, and toxemia, the three principal causes of death in the parturient woman, claim fewer lives every year, and toward the accomplishment of this end obstetric research has been largely directed.

It is not enough, however, merely to keep a woman alive; it is important to preserve for her the function of her reproductive system and to prevent injury so far as possible, in order that the involved organs may again approximate a normal state. Although some injury is inevitable, the manner in which labor and delivery are conducted and the way in which the patient is cared for in the postpartum state will in large measure determine the extent and permanency of that injury.

Mechanism of Injury

The delivery of a child is possible because the uterine and abdominal muscles can exert a force great enough to overcome the resistance of the birth canal. An object approximately 10 cm. in diameter is gradually pushed through the cervix, which has an initial opening of only a few millimeters, and through the vagina, with its lumen of only a few centimeters. Changes take place during the course of pregnancy which prepare these structures for the dilatation which is necessary before the child can be delivered. The tissues become progressively softer and more elastic, and, by the end of pregnancy, the cervix is usually so altered that it becomes completely effaced and dilated and permits the passage of the infant without undue strain.

The muscles of the perineum are less adequately prepared, and when the presenting part of the infant is forced into the vagina and against the perineal

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muscles, less dilatation occurs. Instead, as the lumen of the vagina increases in diameter, the cells in those portions of the radially inserted muscles which lie nearest the vaginal orifice become separated from each other as a result of lateral stretching, while the interdigitating muscles which surround the vagina are often torn as a result of overelongation.

When any large object is forced against a diaphragm with a smaller opening, the greatest stress is at the margin of the orifice. The more peripheral areas are subject to much less strain, and it is the area immediately adjacent to the opening which becomes excessively stretched or torn. This is true of the perineum during childbirth. It is in close proximity to the vagina that the most severe injuries occur. Only after the medial tissues have given way do the peripheral zones become involved.

As the perimeter of the birth canal expands during delivery and approaches the fixed rim of the pelvis, the musculofascial tissues situated radially between the vagina and the rim of the pelvis would become shortened and relaxed if the expanding movement were entirely linear. If the tissues remained in the original plane, the medial fibers of the radially inserted muscles would be pulled apart and separated, but the muscles would never be subjected to excessive longitudinal tension.

To illustrate this process, one may picture the pelvis as a hoop 12 cm. in diameter; attached to it by means of rubber bands 5 cm. long is a small centrally placed hoop 2 cm. in diameter, which represents the undilated vagina. The rubber bands hold the two hoops in one plane. If, now, the diameter of the inner hoop is increased to 10 cm. to correspond to the dilatation necessary to permit passage of the child's head and the two are still held on the same plane, the rubber bands are each 4 cm. longer than necessary to keep the two hoops attached. It is thus evident that the inner hoop may move from the plane of the outer hoop 4.89 cm. without tension. Only when the perineum is forced outward more than the amount permitted by the elasticity of the tissues will injury be inflicted, and it is at approximately this point that an episiotomy is often performed in order to increase the diameter of the vaginal outlet and prevent further downward pull on the musculofascial tissues.

Variations in anatomic relations may be responsible for differences in the tension to which the muscles in any quadrant are exposed. Short anterior muscles may be subjected to excessive tension, leading to injury of the anterior vaginal wall. Posterior muscles are more commonly overextended by the descending head and are more commonly injured. Excessive tension in a quadrant of one diameter will cause relaxation of muscles in both quadrants of the opposite diameter. For this reason lateral muscles are rarely injured.

Other muscles and fascias which are intimately concerned with the support of the pelvic structures and which must become dilated to permit the passage of the infant are the sphincters which surround the anus and vagina. Curtis and his associates¹ have shown that strands of muscles which are predominantly for support blend with and insert themselves by interdigitation into the intrinsic musculature of the lower third of the vagina as well as that of the urethra and anus. Gorsch² has emphasized that "the deep muscular strata, which consist of the levator ani together with its fascia, are more or less closely interrelated with the perineal sphincters. By supporting and fixing the pelvic diaphragm the levators synergize and coordinate the activity of the sphincters." According to Hill and van Del,³ "the levator ani muscle acts as a powerful sphincter, since it surrounds the vagina like a loop," and Bureh⁴ has made the statement that "relaxation of the vaginal outlet is caused by a lack of tone of the levator ani muscle."

The muscle tissue in the immediate proximity of the vaginal canal is in the area of greatest tension stress during labor. This sphincteric zone is most elastic

and resilient and is capable of undergoing a greater change than any other part of the perineum. Muscles in this area are injured to some extent in every pregnancy but in most instances show amazing recuperative powers.

When muscles and fascias are subjected to excessive tension during childbirth, two types of injury may result: (1) actual laceration and separation of the muscles and fascias and (2) separation of individual muscle cells from the motor nerves by which they are innervated. The latter injury is probably universal, owing to the great elasticity of muscle cells and the relatively lesser tensions which nerve fibers can withstand.

With the birth of the baby, the force which has been applied to the perineum suddenly ceases. The muscles and fascias of the peripheral zone, which have been subjected to proportionately less tension stress than those of the medial zone, contract, to cause reduction in the circumference, shape, and form of the vagina. In this position they serve as supportive splints for the medial muscles and fascias, which were the site of the most concentrated tension stress. Contraction occurs gradually, for a state of tension is never conducive to rapid healing, and only after some time does the vagina approximate its former size and the perineum approach its original competency.

The forces which lead to the dilatation of the birth canal and the consequent stretching and tearing of muscle and nerve fibers vary in their nature and in their effect on the perineal structures. The relative size of the fetal head and the bony pelvis, the position the head assumes in the pelvis, the character of the uterine contractions, the length of time during which force is exerted and the state of the perineal muscles, all play a part in determining the extent to which the perineum will be injured. In a young woman with resilient, elastic muscles, if the head is in an occipitoanterior position, the uterine contractions are normal, and an episiotomy has been done to prevent overdistention of the perineum, permanent injury is minimized.

In any region where tissues become overstretched, even though lacerations of muscles or fascias are not visible, nerve injury is inevitable. Every muscle cell is supplied with a motor end-plate, attached to one of the many filaments making up the terminal portion of a motor nerve. Since muscle cells are capable of greater extension than nerve fibers, they may stretch to such an extent that the motor end-plates are torn from the nerves of which they were a part. Never are all such connections severed. Some muscle cells will retain their innervation and be capable of acting as splints or crutches for their injured neighbors. The amount of permanent muscle relaxation will depend in large measure on the proportionate numbers of intact and disrupted nerve-muscle units and the number which are reconstructed.

Mechanism of Reconstruction

It is not enough, therefore, to approximate the margins of lacerated muscles and fascias and suture them in place. Such a procedure will ordinarily lead to a restoration of the gross form of the perineal structures but will not in itself bring about a return to normal function. In some way, re-innervation of muscle cells must be accomplished and the injured muscle cells must again be educated to function.

The situation most favorable for a return of function is a demand for use. Fischer⁵ stated that in general an inactive injured muscle will lose almost 80 per cent of its weight, while an active injured muscle will lose only 20 per cent. Injured perineal muscle cells are in an ideal situation for maintenance of size through activity. The interspersed intact muscle cells are ordinarily sufficiently

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numerous to permit some contraction, and when these muscles are actively exercised, the injured muscle cells are put to work at the same time. The incentive for reinnervation, regeneration, and re-education is the need for function of the muscle as a whole.

In the course of embryologic development, contractile muscle tissue is formed earlier than the nerves which supply it, and consequently muscle cells become secondarily innervated.⁶ This ability of a nerve fiber to establish a connection with a muscle cell is carried over into adult life, and a muscle cell which has lost its innervation may become reinnervated under favorable circumstances. Van Harreveld,⁷ Billig and van Harreveld,⁸ Arey⁹ and others have shown that striated muscle fibers atrophy when they lose their nerve supply but are capable of restoration when reinnervated. A single nerve fiber is capable of growing and of multiplying its branches many times, so that it may eventually supply a greater number of muscle cells than it did originally. To no group of muscles in the human body are the general principles of muscle-cell regeneration more applicable than to those injured in childbirth.

The need for some method by which perineal muscles may be preserved and developed has long been recognized. Hippocrates tried oil injections, hot douches and salves, and Soranus (A.D. 110) attempted support with the hand. Medical literature of the past century reveals that many obstetricians and gynecologists have felt that exercise or some other conservative means of reconstruction is indicated and should be of value during the childbearing age, but records of their efforts have been more or less relegated to the footnotes of gynecologic history. Exercises such as the assumption of the knee-chest position, walking on all fours, leg raising and early postpartum activity are valuable in aiding the uterus to resume its normal position and in improving the tone of the abdominal muscles. They do little, however, to affect the state of the perineum, and for its muscles special exercises are necessary.

Specific Exercise

In the current literature there is little mention of exercises to promote the restoration of perineal function, and it would seem that no satisfactory exercise has been found. One of the few references to exercise is that of Scott and Van Wyck,¹⁰ who described a procedure in which the patient contracts the gluteal muscles, at the same time drawing in the rectum as though to check the passage of feces through the lower bowel. Personal communications from many physicians indicate that it is a fairly common practice to instruct the patient to draw in the perineal region repeatedly.

One report of interest is that of Van Skolkvik,¹¹ who observed unusually firm perineae among a tribe of natives in South Africa. He found that it was the duty of the midwife, who was usually the mother or mother-in-law, to see that the young mother recovered perineal strength after childbirth. Exercise by contraction of vaginal muscles on distended fingers was begun several days after birth and was continued periodically for several weeks, until the desired result was obtained.

Past observations of obstetricians and gynecologists in relation to regeneration of muscle function are in accord with the conclusions reached concerning such regeneration through investigations conducted during World War II. Prior to the war, the accepted treatment of injured muscles was prolonged rest and passive exercise. It has been found, however, that heat, whirling water, expert massage, electrical stimulation and haphazard general activity have their place, though they have rarely made an injured muscle strong or prevented

flabbiness, atrophy, or loss of function. With excessively long periods of passive immobilization, muscle reflexes become so impaired that actual paralysis is often simulated.

During the recent war, according to a war summary,¹² it was found that "loss of coordination is easier to prevent than to restore." "In the preservation or restoration of muscular function, nothing is more fundamental than the frequent repetition of correctly guided exercises" instituted by the patient's own efforts. "Exercise must be carried out against progressively increasing resistance, since muscles increase in strength in direct proportion to the demands placed upon them."

It would seem from the accumulated evidence that perineal exercises are especially important for two purposes: (1) to promote a return of normal muscle function in the immediate postpartum period and (2) to restore muscle function in women still in the childbearing age who, because of muscle-cell injury incurred at a more distant time, suffer relaxation of the pelvic musculature.

For the past fifteen years I have experimented with various means of exercising the perineal muscles. Any active exercise must be directed primarily toward drawing in the perineum. Only the exceptional woman, however, will continue the exercise long enough to produce results on mere instruction to do this. Many women, in addition, have no "awareness of function" and, unless provided with some way of knowing whether or not they are being successful, soon become discouraged or are unwilling to make even an initial attempt at exercise.

It seemed advisable, consequently, to devise some method by which the patient might see the results of her activity and be encouraged to continue her efforts—to give her an actual incentive to increase the contractile power of her perineal muscles and vaginal sphincters.

The principle of restoring the function of a segregated group of muscles with a specific aid, method, or program of re-education is well established through constant use in the fields of orthopedics, neuromuscular and plastic surgery, physical medicine and rehabilitation. Important specifications common to accepted methods of restoring function of injured skeletal muscles are means of segregation, guidance, and progression.

An early method studied was Fränkel's¹³ (1895) re-education program for locomotor ataxia. Methods recently developed for rehabilitation of the war injured and for establishment of awareness of function in patients with infantile paralysis gave valuable help in this study. The most recent developments in this highly important field are by Huddelston and Golseth¹⁴ and by Billig,¹⁵ who have devised a method of registering muscle action potentials on a loudspeaker, so that the patient hears increased sound when he is pulling more accurately with the muscle being trained for improved function.

The special sense which ordinarily activates the genital muscles is the tactile sense, which obviously cannot be utilized in training, on account of its hypersensitivity and exhaustibility. Sight is the most highly developed special sense for the guidance of skeletal muscle action, and in the restoration of perineal muscle function the response to sight sense guidance is instantaneous, with immediate understanding of the *modus operandi* by the patient.

The Perineometer

A pneumatic apparatus (Fig. 1) has been devised specifically for the exercise of birth canal muscles, with measurement of each muscular contraction visible to the patient. A chart (Fig. 2) is provided to keep a record of the accomplishment of each exercise period and serve as a progress guide for both patient and physician. The apparatus consists of a simple, balanced-resistance

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pneumatic vaginal chamber operating at atmospheric pressure and connected by means of rubber tubing with a manometer calibrated from 0 to 100 mm. of mercury. In construction, the vaginal chamber is an anode-processed rubber cot of specified consistency, lightly stretched over a rigid slender core with a flange at each end. An air vent in the core connects the pneumatic chamber with the tubing and manometer. The base of the chamber is fitted with a round, semirigid rubber shield 8 cm. in diameter, which limits placement in the vagina

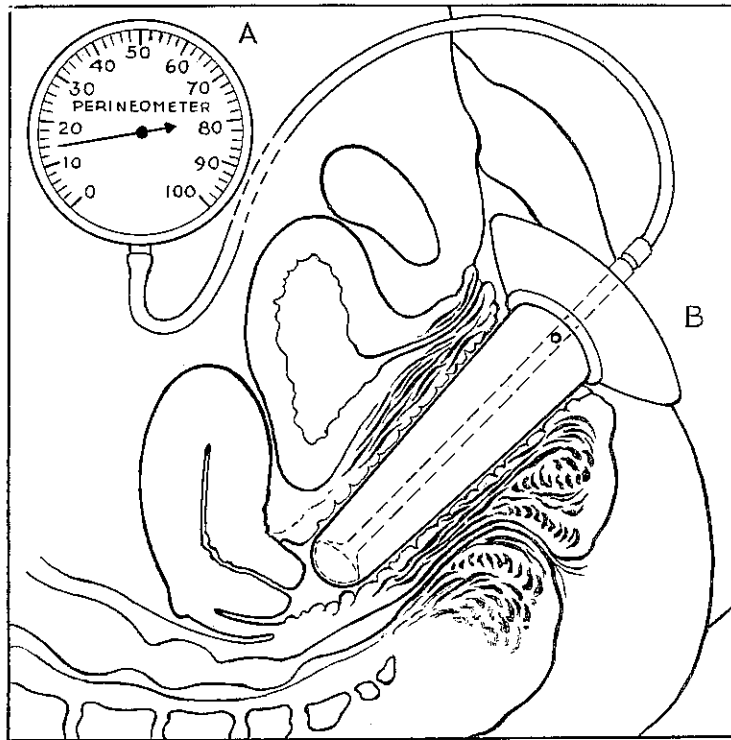


Fig. 1.—Diagram showing the Perineometer during Progressive Resistance Exercises of Lax Perineal Musculature. A. The manometer measures the force of perineal muscle contractions from 0 to 100 mm. of mercury during increasing resistance exercises. Visual guidance helps to establish awareness of function and coordination, and renders further exercise possible. The tubing is long enough to permit the patient to hold the manometer for observation. B. The pneumatic vaginal chamber receives the muscular contractions for conversion to sight sense perception. Conformity of the chamber to anatomic structure (length, 8 cm., diameter, 2 cm.) permits reconstructive exercise radially of anterior and posterior vaginal musculature and visceral extensions of the levator ani muscle.

and permits pivoting into position. The length (8 cm.) and diameter (2 cm.) of the vaginal chamber are in conformity with anatomic structures, especially with regard to the anterior and posterior musculature of the vaginal wall. In operation, any pressure from 0 to 100 mm. of mercury exerted on the pneumatic vaginal chamber is immediately registered by the dial of the manometer. The patient is instructed to insert the pneumatic chamber into the vaginal cavity so that the rubber disk rests against the perineum. She is then told to attempt to contract the muscles of the vagina while watching the dial on the gage.

Patients vary greatly in their ability to contract the vaginal muscles. Many, especially those with marked relaxation of the pelvic floor, are unable to register even a few millimeters of pressure on their initial attempts. Gradually, after

practice, and as the muscles become stronger through exercise, the pressure which can be exerted increases and frequently reaches 60 to 80 or more millimeters of mercury.

Since the instrument measures the degree of contraction of the perineal muscles, it has been called the "Perineometer." It is a simple pneumatic apparatus which functions only to show that muscular contraction is taking place and to measure the contraction. Its only action is to provide a medium between muscle action and sight. There is no provision to stimulate muscle contraction, nor does it provide for passive exercise in any way. The apparatus was constructed with the view that any pulsating or massaging action would defeat its purpose and would prove detrimental, harmful, and useless, and that, in the preservation or restoration of perineal muscular function, nothing is more fundamental than exercise instituted by the patient's own efforts.

Clinical Application

The initial test with the apparatus requires less than five minutes and is made in the course of physical examination. The patient is instructed to exercise twenty minutes three times daily and to record both the periods and the omissions of exercise on her chart. The period over which it is necessary to carry out this procedure varies principally in relation to the state of the perineum at the time exercises are commenced and to the diligence of the patient. Initial presence or absence of awareness of function and coordination also is an important factor. An occasional patient may experience great difficulty in gaining awareness of function.

Restoration of tone and function to lax or atrophied perineal muscles requires from twenty to forty hours of progressive resistance exercise, spread over twenty to sixty days. As a rule, young patients progress more rapidly than older ones, but one woman of 58 increased her contractile strength from 10 to 100 mm. of mercury without undue effort in thirty days. The period required for maximum results varies also according to the purpose for which Perineometer exercise is prescribed, whether to restore tone and function in the immediate postpartum period, to improve early cystocele or rectocele during the child-bearing years, to improve the vaginal muscles so that a contraceptive diaphragm may be retained,¹⁶ or to relieve urinary stress incontinence. When satisfactory results are not achieved in a reasonable period, the patient may be exercising abdominal gluteal, or other extraneous muscles to affect dial readings. Backache or abdominal distress also suggest that the wrong muscles are being used. The patient who complains of fatigue probably is exerting greater effort than is necessary. For these reasons the patient should be seen at least once a week, so that her efforts may be properly directed.

While the patient is exercising regularly, she is encouraged to attempt to increase the pressure 1 to 2 mm. of mercury daily and to keep a record of the maximum contraction of which she is capable at each exercise period. For this purpose the graphic chart has been prepared, to enable her to record the pressures registered on the dial. The actual record kept by one patient is shown in Fig. 2. With minor variations any woman with reasonable diligence may duplicate the record shown.

The types of contractions of which this patient was capable as she continued with her exercises and evidenced progressive restoration of function are shown in Figs. 3, 4, 5, and 6. While the period necessary for maximum restoration of function by exercise may vary, it is possible to discern three or four phases of development. The record chosen for illustration shows four phases rather evenly distributed over four weeks. The first phase, the period required to establish

awareness of function and coordination, may be absent or brief or require as long as eight days. The second phase is a transitional phase. The third phase, or period of regeneration, is recognized grossly by the gradual increase of resistance registered. It is during this phase that a change in symptoms, such as relief of urinary incontinence, occurs. The phase of restoration is recognized by a leveling out of the resistance which the muscular contractions are able to overcome, usually above 60 mm. of mercury pressure. A leveling out at less than 40 mm. is an indication that the lower vaginal muscles have been active and that with continuation of exercise the muscles in a higher plane will show evidence of regeneration. To meet the latter contingency, one specification of the pneumatic vaginal chamber is that it shall be compressible but not expansible. If compression of one segment were to cause ballooning of another segment of the chamber, it would be possible for strong muscles to undergo development at the expense of weaker muscles.

While progressive resistance exercise with the aid of the Perineometer is useful whenever it is desirable to strengthen perineal muscles, work now being done in relieving urinary stress incontinence furnishes an excellent example of the efficacy of the method. To date (May 20, 1948), the condition has been relieved in 64 cases. Insufficient time has elapsed to justify a statistical report on this series, but the patient longest under observation has remained dry for fourteen months.¹⁷ Some of the women treated had worn pads continuously for as long as eleven years; others had undergone one to three plastic operations, without relief. There have been no failures when the condition was due primarily to relaxation or atrophy of the anterior vaginal muscles and the patient had at least partial control at times.

The method has been used also to improve tone of muscles and texture of tissues in the presence of anal incontinence, and apparently facilitated repair. A patient with rudimentary vagina and congenital absence of the uterus was instructed to use the "Perineometer" after plastic procedures to enlarge the vagina, and increased sphincter action from 0 to 40 mm. contractile strength.

Summary

The passage of the fetal head through the vagina during delivery is invariably attended by muscle injury. Excessive tension sever motor end-plates attached to muscle cells from the terminal nerve filaments to which they

Fig. 3.—Muscular Contractions (I) taken from Phase of Initial Efforts to Contract Lax Perineal Muscles. Oscillations are slight and irregularly spaced. Although an attempt was made to contract muscles at regular intervals, only an occasional oscillation occurred. This is interpreted as being the result of absence of awareness of function or lack of coordination resulting from the detachment of muscle cells from nerve fibrils. This phase of efforts to gain coordination varies greatly, approximately 60 per cent of patients requiring only one or two exercise periods, while 40 per cent require up to eight days, depending on previous function.

Fig. 4.—Muscular Contractions (II) taken from Phase of Awareness of Function and Coordination. Oscillations have become more regularly spaced, indicating a recovery of awareness of function and a prompt response to effort. Variation in the height of the oscillations indicates that ability to control the degree of effort has not yet developed.

Fig. 5.—Muscular Contractions (III) taken from Phase of Regeneration. Oscillations are regularly spaced and are of almost equal height. This is interpreted as an indication of prompt response and an adequate control of effort. Increasing numbers of muscle cells are being reinnervated and are undergoing regeneration. The fact that muscular contractions are overcoming resistance at a single level, in this instance 40 mm. of mercury, indicates that the full strength of the muscles is being exerted and registered. Subsequent increases of resistance as shown in Fig. 6 are interpreted as the result of continued muscle regeneration and hypertrophy.

Fig. 6.—Muscular Contractions (IV) taken from Phase of Restoration. Oscillations regularly reach 80 mm. of mercury and the crest of each is rounded and prolonged. Marked increase in strength and in control of effort is revealed. Contraction is accompanied by less fatigue, and reserve strength exists. Palpable muscles are found to be firmer, thicker, and broader than before the institution of exercise. Evidence of improved function exists.

Note: Further effects of progressive resistance exercise on sphincteric and supportive muscle groups may be studied by tracing the course of linear force from anatomic point of action to fixed point of origin.

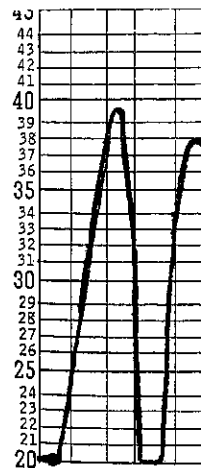
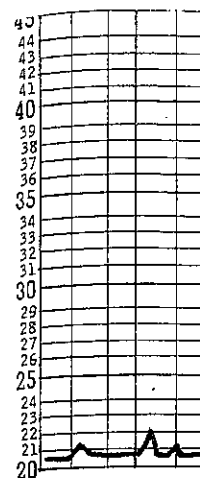


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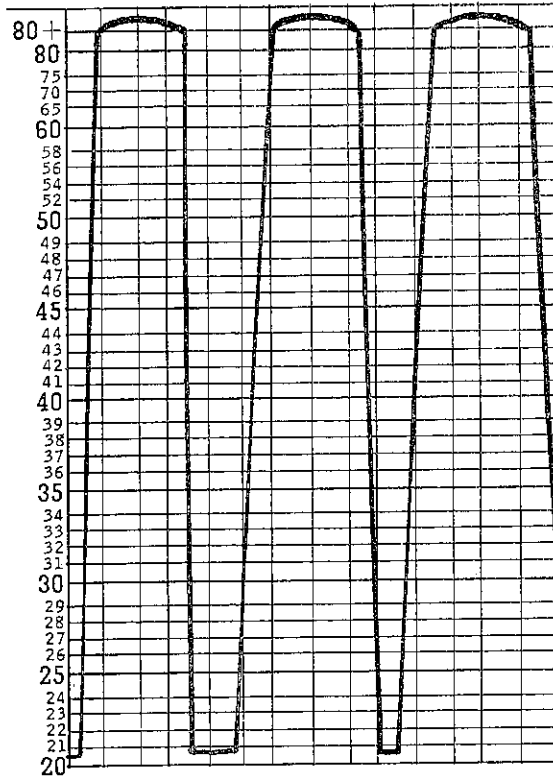
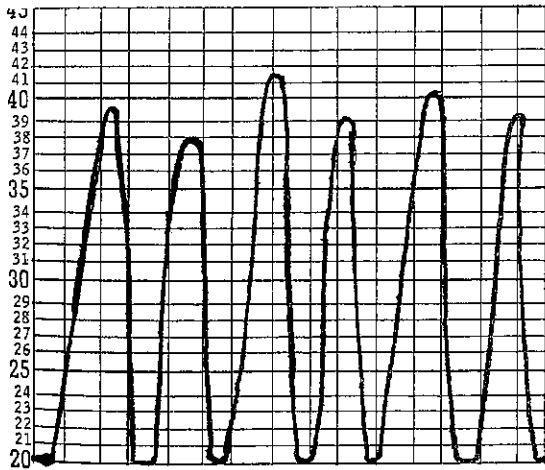
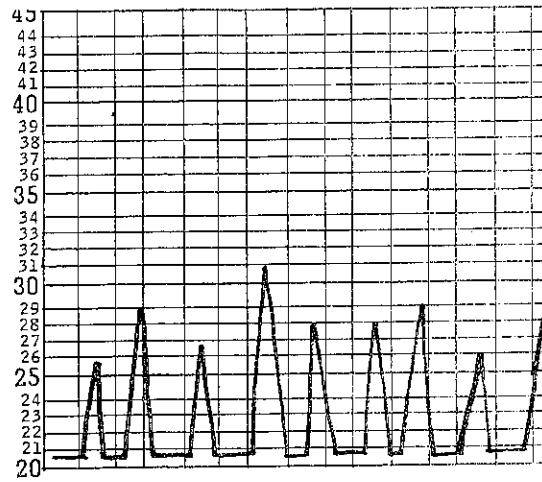


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are normally connected. This partial loss of innervation is in large measure responsible for the relaxation of perineal muscles so commonly observed after childbirth.

Experience has shown that a demand for use is the most important factor in restoring the functional capacity of any skeletal muscle. Active exercise will aid in the reinnervation of injured muscle cells and will bring about a return of normal contractility.

The shorter the time elapsing between muscle injury due to childbirth or a surgical procedure and the beginning of exercise, the less will be the amount of tissue atrophy and the shorter will be the time necessary to re-establish normal function.

Exercise with the Perineometer is useful in restoring function and tone in the immediate postpartum period, improving early cystocele and rectocele during the childbearing years, improving the vaginal muscles so that a contraceptive diaphragm may be retained, and relieving urinary stress incontinence.

Surgical procedures for the correction of vaginal, urethral, and rectal incompetence may be facilitated by preoperative and postoperative exercise which improves the texture, tone, and function of perineal muscles.

The "Perineometer," an instrument devised to register muscle contraction, is of great value as a visual aid in guiding the patient during the course of her exercises and in encouraging her to continue until the desired result is attained.

The method of exercise described suggests a new approach to the studies of perineal physiology as related to physics.

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