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An Investigation of the Effect of Isometric Contraction Exercises on the Development of Strength

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AN INVESTIGATION OF THE EFFECT OF ISOMETRIC CONTRACTION EXERCISES ON THE DEVELOPMENT OF STRENGTH

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CHAPTER I

THE PROBLEM AND DEFINITIONS OF TERMS

I. THE PROBLEM

It was the purpose of this study to investigate the pros and cons of a new-and-old form of exercise called isometric contraction and to determine its place in the realm of athletics and physical fitness.

Through research the paper will attempt to reach a conclusion as to the predicted success of isometric contraction upon strength, a component of physical fitness. It will attempt to show the advantages and disadvantages of isometric contraction as a means of attaining, maintaining, and improving strength.

II. DEFINITIONS OF TERMS

Isometric contraction. This refers to the physical phenomena resulting when a contracting muscle is unable to move a load and retains its original length. There is internal pushing and pulling but no general bodily movement (21:74; 16:104; 10:13). The term "isometric contraction" is derived from the fact that during this type of contraction there is no change in the length of the muscle.

Hence, isometric; iso--same; metric--length. Although no work is done, near maximum effort is expended.

Isotonic contraction. When the resistance offered by the load is less than the tension developed, the muscle shortens and performs mechanical work (21:75; 16:105; 10:14). This is the type of contraction upon which all of our past accepted methods of strength training were based. The principal difference between isometric and isotonic contraction is that in the latter the muscle fibers shorten and tension remains the same, while in isometric contraction the length of the muscle fibers remains the same. The other major difference is that isotonic contraction performs mechanical work; that is, it actually moves something. Although isometric contraction develops tension, it performs no mechanical work; all the expended energy appears as heat (16:80).

Strength. A review of the extensive literature concerning strength and its development reveals no adequate definition of strength. The difficulty in defining strength arises from differences in connotation. To some, strength means the ability to exert one maximum exertion against resistance. Others approach strength from the ability of the muscle to exert repetitious effort until it becomes fatigued (2:37).

As far as this study is concerned, strength will refer to the ability to produce tension.

Physical fitness. The term physical fitness has been used frequently and sometimes rather loosely. Physical fitness and a state of health are not necessarily synonymous. Health can be a rather passive state of being free from disease; physical fitness is a dynamic, on-going process (8:19).

The best definition of physical fitness the author can put together is that physical fitness is the development and maintenance of a sound physique and of soundly functioning organs, to the end that the individual fully realizes not only his capacity for physical activity but also for mental accomplishments unhampered by physical drains or by a body lacking in physical strength and vitality. Physical fitness is not merely muscular development. It is a happy mixture of the best possible bodily health plus the physical condition to perform everyday tasks effectively and meet emergencies as they arise.

All individuals have some degree of physical fitness, which varies considerably in different people and in the same individual at different times. It is more than "not being sick" or "merely being well." An individual is considered physically fit when his capacity for performance and endurance in physical activity is great (16:116).

The elements of physical fitness are strength, endurance, flexibility, neuromuscular control, ability to relax, and organic fitness (16:117; 2:93). The definition of strength has previously been given. Strength is an essential for speed. Weak muscles can neither develop speed nor resist fatigue. Endurance, the capacity for protracted work, is a measure of the ability to stave off fatigue. The ability to resist fatigue depends not so much on the muscles as on the efficiency of the cardiovascular-respiratory system to supply the muscles with adequate circulation. Flexibility, the range of movement of the muscles and joints, is partly determined by the individual anatomical variations at the joints. The range of movement may be limited by the length of the ligaments and their attachments. However, these limitations may be overcome to some extent by repeated use of the muscles at specific joints. Increasing the range of movement makes for agility and skill. Neuromuscular control is the ability to coordinate the movements of the limbs and trunk in performing body movements. The ease and efficiency with which these muscle movements are carried out depend upon the control exercised by the nervous system over the muscular system. Good body control is the result of economical use of the muscles. Although muscular tone is a requisite for efficient performance, relaxation is essential to prevent chronic fatigue and for

continued performance. With increased physical fitness the reciprocal innervation of the antagonistic muscles increases. This inhibition of the antagonistic muscles is absolutely necessary for efficient performance.

The final element to be considered is organic fitness. The development of the circulatory, respiratory, digestive, heat regulatory, and other organic systems depends upon vigorous activity. To be physically fit a body must be free of physical defects and strains which drain the human mechanism.

CHAPTER II

HISTORY AND LIMITATIONS

I. HISTORY

Even though muscle training has been practiced with remarkable success for centuries, one may be surprised to discover that even now there is no complete agreement as to the best method for muscle training. The usually accepted idea has been that one has to give all he has in order to get more.

A tremendous interest in strength and the ways to attain it started in 1945 when Delorme proposed a system of heavy resistance exercise in physical medicine and rehabilitation, pointing out that skeletal muscles possessed such qualities as power, endurance, speed, and coordination, and that a different type of exercise was needed to develop the desired quality in any particular muscle. He described a system of heavy resistance and low repetitive exercises to build up power and volume in muscles, as contrasted to light resistance and high repetitive exercises to develop endurance in the muscles (41:23).

In this manner the "overload principle" was developed. The amount of tension a muscle must exert to overcome a resistance is the

key to muscular development. A muscle which contracts against a resistance that demands exertion increases in strength. The degree of the increase depends on the amount of resistance. If the muscle is strengthened enough to overcome the resistance easily, then that resistance is no longer exerting the muscle and there is little if any gain in strength. In order for the muscle to make further gains, the amount of resistance must be increased. This is known as the overload principle.

Probably man has been interested in his strength and its development from the beginning of his existence. The fact that persistent use of muscles causes their enlargement and a correlated increase in their strength has been known ever since there were boys.

Overload can be produced in several different ways; its results vary with the kinds of activity performed. The four most common ways in which overload can be accomplished are to (1) gradually increase the speed of performance in a progressive manner; (2) gradually increase the total load; (3) progressively increase the total time that a given position can be held; and, (4) with a constant resistance, progressively increase the total number of performances.

Basically, three methods or systems are currently in use for the development of strength. The first and most widely used of

these is DeLorme's progressive resistance exercise. This system consists of determining the maximum resistance which can be overcome for ten repetitions. The second method, infrequently used, was first described by Zinovieff of England. That system is known as the Oxford technique. In this exercise program, maximal resistance is introduced at the onset of exercise and then reduced systematically until the onset of fatigue. As can be seen, it is essentially the reverse of the procedures of DeLorme (2:141). The third and more recently described procedure, developed by Hettinger and Muller of Germany (13:15), is called isometric contraction. Isometric contraction, neither new nor revolutionary, has only recently been applied to a wide variety of sports.

American athletes have been raised with the belief that hard work is the only way to success. Our ideas are based on the seemingly erroneous foundation that anything which affects the human body can have a positive effect only if accomplished with sweat and pain and much self-discipline. Athletes have been taught to suffer, and any system that makes it easy seems wrong.

Only in the past twenty years has much research been done on strength and methods to acquire it. DeLorme postulated his overload principle in 1945, and Hettinger and Muller published their findings

on the development of strength through the use of isometric contractions in 1953.

It took many years for the idea of weight training, or the overload principle, to make headway in this country. It will take time for the isometric contraction theory to be accepted and given its rightful place in the realm of physical fitness.

II. LIMITATIONS

This system does little for the heart and lungs. It is mostly a system for increasing strength, and, as stated earlier, strength is only one aspect of physical fitness.

CHAPTER III

SURVEY OF THE LITERATURE

I. EXPERIMENTAL

Increased interest in the type and intensity of exercise which produces greater strength gains has resulted from the investigation of Muller and Hettinger (13:18). With regard to the effect of isometric contractions, they reported that a static contraction equal to 1/3 maximal strength held 6 seconds once per day caused muscle growth. When held at 1/2 to 2/3 maximal strength for 6 seconds once per day, the muscle grew as rapidly as possible. Furthermore, one practice period per day in which the tension was held for 6 seconds resulted in as much increase in strength as longer periods and more frequent practices.

In 1955, after further research, Hettinger stated that muscles increase in strength at the same rate whether 2/3 maximal contraction is held for 10 seconds once a day or a muscle contracts as briefly as possible to 2/3 its maximal strength 12 times at 2 second intervals once a day (20:31). This means that the intensity of contraction is the adequate stimulus. There is no need to hold the contraction

in order to promote increase in strength.

Darous and Salter investigated the response of muscles to repeated isometric and isotonic contractions. Two groups of six subjects were trained with static (or isometric) and dynamic (or isotonic) contractions for a period of six days. At the end of the training period, the results suggested carrying the experiment on for a longer length of time. Six subjects continued until twenty to twenty-eight sessions had been completed. Both types of training resulted in an increase in strength, although the effects of isometric contraction training were not immediately apparent (1:325).

Salter followed this study with another designed to compare the effects of training by repeated sessions of isometric contractions with the effect of comparable "doses" of exercise by isotonic contractions. Supination of the hand was the exercise performed over a period of four weeks, four days per week, by twelve male and eight female subjects between the ages of seventeen and forty-eight years. Isometric contractions consisted of a gradually increasing force until maximum was reached over a period of about four seconds. Isotonic contractions likewise lasted for four seconds, during which time the subject lifted a load equivalent to approximately 75 per cent of maximum isometric strength. The load was returned to rest position at the end of four seconds. In addition to the two types of contractions, the length of the

daily exercise session was varied so that some subjects completed the required thirty contractions in two minutes while others exercised for fifteen minutes. Salter reports that all training procedures resulted in an improvement in muscle strength but no significant differences were found between the methods used (19:109).

Lorbach compared the relative effectiveness (for the production of strength and muscle girth) of two types of training, namely, short periods of isometric contractions and a customary weight training program. As a result of the training program extending over a period of twelve weeks, both groups gained significantly in strength and muscle girth and, except for knee flexion, both methods were equally effective in causing strength and girth gains. Isometric contraction resulted in a significantly greater amount of strength in knee flexion than did the customary weight training program (11:1).

Rodgers reports on his comparative study of the effects of two methods of weight training, one based on isotonic contractions and the other on isometric contractions. The two groups, consisting of ten and nine subjects, respectively, trained over a period of six weeks. Both groups gained in strength, but the difference between the gains for the two groups was not statistically significant (17:1).

Wolbers and Sills administered four tests to two groups, each

consisting of ten students from the State University of Iowa. The experimental group trained isometrically by performing nine selected exercises in which one static contraction was held for six seconds. The second group, a control group, continued everyday living processes. The experimental group made greater gains by the end of the eight-week period than the control group in all of the four tests which included back lift, leg lift, combined grips, and Sargent jump (24:446).

In connection with an investigation designed to study the effects of various frequencies of training programs upon the muscles, Mathews and Krause report on the additional problem of studying the effectiveness of isotonic and isometric contractions in terms of strength changes. Four exercise frequency programs were established with fifteen subjects assigned to each, one group exercising twice weekly and the other three, three times, four times, and five times, respectively. Each subject in the isometric unit held for six seconds three maximum isometric contractions (12:1). Conclusions were that the five day a week exercise program was as beneficial in terms of strength gains as were the three times a week workout. Furthermore, the isometric type contractions resulted in greater strength gains than did the isotonic type in terms of the exercises used in this study (12:12).

II. USES

Athletics. Strength is the key to success in modern athletics. Such a statement may sound extreme, but it is true. A great deal can and should be done to make an athlete stronger. Any athlete can improve his strength and with it his over-all performance.

Isometric contraction is becoming more popular all the time as a conditioner and as a preventative. It has genuine value in any sport, particularly in cutting down on muscle and joint injuries. Many schools and professional teams of the various sports in the United States are now aware of the true value of isometric contractions.

Louisiana State University was the first major team in the United States to use isometric contraction extensively in its conditioning programs. Notre Dame, Army, U. C. L. A., etc., are just a few of the major football teams now making full use of isometric contraction (18:36; 22:27). These teams using isometric contraction show a very low incidence of injury during the season. The trainer of Notre Dame's Fighting Irish gives full credit to isometric contraction for the low number of injuries recorded by the football team (22:29).

Forerunners of isometric contraction in the field of professional athletics has been the San Francisco 49'ers football team and the Pittsburgh Pirates' baseball team (18:37).

The Pittsburgh Pirates hired Jay Bender, professor of physical education at Southern Illinois University, to correct and prevent injuries. In 1960, at the request of the Pittsburgh organization, Bender began to establish his program among the Pirate players, and at season's end, the Pittsburgh management secretly credited him with helping the team win its first World Championship in 35 years (23:42).

The members of the San Francisco football team aren't allowed to talk about their conditioning program, under threat of a $500 fine (18:38). But, again, the San Francisco 49'ers show a very low amount of injury.

Another strong booster, Bob Hoffman, the United States Olympic weightlifting coach, says that isometric contraction is the greatest thing the world's ever seen (18:39). He uses isometric contractions in the work-outs he prescribes for the members of the weightlifting teams. Many of the athletes he has trained have shown tremendous results and improvements through their use.

Lou Riecke lifted weights for 14 years without success. In November of 1960 he stopped weight training and began a set of isometric contraction exercises, pushing and pulling against an immovable bar for a mere 15 minutes a day, including rest periods.

At the end of six months, he was able to press 300 pounds, 45 more than his previous high. He could snatch 305 pounds instead of 265 pounds and clean-and-jerk 375 pounds instead of 315 pounds. In June, 1961, Riecke, at the age of 34, earned a berth on the five-man United States Olympic weightlifting team which competed against Russia.

Isometric contraction is really finding its place in track. Some of the major track teams using isometric contraction as an integral part of their training program are L. S. U., University of Southern California, Villanova University, New York University, and the Los Angeles Striders, to name a few (5:34; 18:42; 22:23).

Jim Elliott, track coach at Villanova University, is an avid supporter of isometric contraction (6:36). He advocates isometric contraction exercises for his entire track team. Frank Budd, the "world's fastest human," uses isometric contraction regularly as a part of his training routine.

Other outstanding members of the track and field world who use isometric contraction are Jay Sylvester, Gary Gubner, Jim Beatty, and Jim Webster, an 18 year old whom Jim Elliott says will be the greatest middle distance runner of all time (6:41).

Professor Gene Logan of the University of Southern California, where high jumper Bob Avant is a student, reckoned that the angle of

the knee of Avant's push-off leg was 135 degrees at the moment of takeoff and decided to strengthen his leg muscles at that precise angle. They, Bob Avant and Professor Logan, consider isometric contraction the most important factor in converting Avant from a 6-foot-8 high jumper into a seven-footer. It took two months (18:43).

Marty Broussard, trainer of Louisiana State University athletic teams, says he has even used it to improve his golf game. Holding a club in various positions against immovable objects and straining the muscles employed at those points, he has lengthened his drives 15 yards.

Dr. Jim Counsilman, swimming coach of Indiana University, advises isometric contraction as a part of the "dry land" training of his swimmers. Chet Jastremski, one of Dr. Counsilman's outstanding swimmers at Indiana, credits isometric contraction with his rapid rise in the swimming world (6:39).

Therapeutic. Muscular activity has been used for therapeutic purposes for centuries. The great emphasis upon the medical use of muscular activity came near the end of World War II, when a shortage of able-bodied soldiers existed. Increased demand for more man-power brought about pressures for less and less bed rest for these hospitalized men. Although it had been known for many years that early

ambulation offered many benefits, such as lessening the formation of adhesions and the prevention of deconditioning, with a few exceptions it was not until the urgency of World War II that early ambulation was actually practiced.

The application of weight lifting exercises to attain beneficial results was introduced into medical practice in 1945 by DeLorme. While assigned to a military hospital in Chicago, he noted that, following knee surgery, the quadriceps which became so weak, so soon, in so many, could be rapidly restored to full strength by increasing the resistance applied to exercising muscles. The method, which he called Progressive Resistance Exercise, was adopted more rapidly and widely than any proposal in this field except early ambulation (2:147).

Therapeutic exercise is described as "a movement prescribed and performed in proper form, and aimed at the development of a given muscle quality or qualities." A therapeutic exercise is prescribed with a specific purpose in mind, usually for a particular part of the body. On the other hand, exercises may be also called therapeutic which are aimed at general body conditioning, for example, following a period of bed rest.

Probably the most important contribution of isometric contraction to medical restoration is the prevention of atrophy through

muscular activity involving overload of muscle which brings about the development of muscular strength.

Often overlooked when considering the restorative values of muscular activity is prevention of the onset of muscular fatigue. For instance, those who have experienced bed rest even for short periods of time--say for two or three days--find a certain inability to return immediately to normal movement upon arising from the sick-bed. Even with this short a cessation of normal muscular activity, the fatiguing effects are often noted.

The first and probably most important consideration deals with the development of strength. At the present time, much study is being devoted to ways in which strength can be developed most rapidly, in the most efficient manner, and with the least demand being placed upon the patient. For example, when the exercise procedure in which isometric muscular contractions was introduced, studies were immediately undertaken to determine the relative effects of this technique as compared with isotonic or movement type of exercises. When the isometric contraction exercise procedures were introduced, movement exercises were in general accepted throughout the medical profession. As a result of comparative studies, investigators concluded that the isometric exercise is slightly better than isotonic for the development of strength (9:263).

CHAPTER IV

CONCLUSIONS

Isometric contraction will not help a non-dieter lose weight nor will it increase endurance or stamina. But one thing seems certain. Isometric contraction is the most economical method known to man, in terms of time and energy output, for developing muscular strength. Studies indicate that the time required for building muscular strength can be substantially reduced over that previously believed necessary.

The author feels that isometric contraction can improve all-around fitness, provided it is used with exercises such as running, which build up the cardio-vascular and respiratory systems.

Not a complete answer, isometric contraction must take its place among the more conventional forms of exercise, a valuable supplement but not a substitute. Isometric contraction practices should not be undertaken without the benefit of a trained supervisor. Like anything else, isometric contraction will do more harm than good if not done properly.

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