Free Weight Equipment for the Development of Athletic strength and power—Part I

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The choice of equipment to be used for strength and power training is of great importance. A strength coach deals with athletes who must exhibit precise coordinated movements with varying degrees of speed and controlled or explosive strength in their competitive events.

One of the immediately obvious advantages of free weight exercises over machine exercises is the ability to perform free standing total body lifts which require the maintenance of balance and coordination of many major muscle groups during execution of the lifting movement. Exercises such as the squat, power clean or snatch, standing overhead press and jerk are among many common examples.

The term "total body" when applied to an exercise implies the involvement of multiple joints (eg. ankle, knee, hip, intervertebral, shoulder) and their controlling muscle groups during the movement. This is the way the body works in athletic events. Consider the multiple joint and muscle group actions during a block or tackle in football, shot put or javelin throw, long or high jump, sprint on the track or soccer field, jump shot or rebound in basketball, floor exercise or vault in gymnastics, golf swing, baseball bat swing, tennis swing, etc. Think of the coordinated efforts required of muscles in the leg, hip, torso and arm for these typical sport activities. In which athletic event does the athlete perform while strapped into a seat, lying on a bench or otherwise supported while one or two joints and muscle groups work?

Free standing total body lifts result in the training of one's neuromuscular system, not one or two joints in isolation, and the result is excellent transfer to the neuromuscular demands of athletic competition. The reason for this derives from an important principle in exercise physiology called "specificity of training" (see, for example, reference 3). It simply states that the body adapts to the specific demands made upon it. This principle agrees with other physiological theories of adaptation, such as that developed by Selye (15).

There have been arguments presented by Jones (10) that strength training must either be exactly specific or not specific at all to the event to be contested. As an example to support his contention he relates the difficulty in maintaining shooting accuracy when changing from one long time used rifle to a new one. However, this example really supports the specificity concept. If someone had hunted with a bow and arrows for years and then switched to a rifle it would take a longer time to develop consistant marksmanship with the rifle than if they merely changed from one rifle to another. So it is also with the transfer of strength and power developed with free standing total body free weight exercises to free standing total body competitive events.

It takes some careful thought to properly blend strength training with technique and other components of an athlete's overall program during a training cycle to achieve maximal results (see, for example, reference 8). However, the transfer of strength and power will be easier and more beneficial if the strength program is based on free weight multi-joint exercises. It is unfortunate that the results of a few short-term, limited scope motor learning studies have been misinterpreted and extrapolated inaccurately to be used as evidence for complete specificity in exercise.

There is another very important reason why total specificity of exercise is unacceptable. It is the need for variability in exercise if progress is to be made over long periods of time. We know, for example, that a 1500 meter runner does much more in their yearly training than just run 1500 meter races as fast as they can. A weightlifter does much more during the training cycles than attempt maximal weights in the competitive lifts. Football players do much more in preseason practice than just play football games. Such a course of action for these or any athletes would rapidly lead to stagnation, overtraining and decreased performance.

We know from practical experience that runners train at distances above and below their competitive distance and at various paces (in addition to other exercises). Weightlifters do most of their training lifts with 75% to 85% of maximum and frequently do partial lifts with various hand spacings and initial bar heights. Football players practice components of the game, do conditioning drills, lift weights, etc. Shot putters throw 15 and 18 pound shots as well as the 16, they run sprints and do power cleans.

These examples are meant to emphasize the fact that training for any sport involves exercises with varying degrees of specificity to the competitive event. This variability of training methods is of paramount importance for continued improvement, especially for the advanced athlete. The neuromuscular similarities of the major free weight exercises to the neuromuscular demands of athletic movements make transfer of strength easy while permitting ease of varying the strength exercises.

Objective measurements have shown that olympic style lifters produce greater power outputs than are found in any other human activity (6, 7). (NOTE: The distinction between strength and power and the value of the quick olympic lifting type of movements in an athlete's program were recently discussed in Volume 3, number 5 of this Journal (18).

Russian weightlifters are by far the world leaders in their sport. The writings of their top coaches consistently stress the importance of variability in training. (NOTE: Two recent papers summarize and reference many of their key concepts (references 2 and 21.) In addition to the empirical knowledge of need for variability, as examplified by the Russian literature, there is a physiological basis for its importance as indicated in Selye's

"General Adaptation Syndrome" (see references 8 and 15). Another advantage of free weights involves the ease by which variability may be injected into a strength and power program. One may, for example, squat with various foot spacings or to different depths, or do high pulls with various hand spacings and/or from various initial bar heights (using boxes or small platforms). The variety of ways to execute a given free weight exercise, and the variety of exercises possible with free weights are almost limitless. A far cry from the monotonous few exercises possible with even a complete set of any machine company's products.

Even experienced bodybuilding coaches and gym operators have expressed the advantages of free weight exercises in general over machine exercises (see, for example, reference 19). It is interesting to note that the vast majority of those who emphasize machines in a strength program have little or no competitive experience in strength or power oriented sports and have not spent countless hours in the weight room striving for the improvements so critical to these types of competition.

Generally, the machine advocate has a financial interest in a machine company or a gym featuring machines of one type or another. Some academically well trained individuals, such as medical doctors or physiologists, will support a given training concept based on theoretical concepts but they have little or no practical experience or evidence to support advantages of the concept. Claims made in advertising and articles are often exaggerated or untrue and cannot be supported by objective, independently obtained data.

On the other hand, people who advocate the emphasis of free weight exercises in an athlete's strength and power program generally have nothing to sell. They are experienced athletes, former athletes and/or coaches who through practical experience and education have learned what will produce the best results. Before discussing some additional advantages of free weights over machines it is worthwhile to credit a few of these individuals whose insight resulted in early cautions against excesive training with weight machines.

In the first (1969) and second (1976) edition of his extensively used text (reference 12) Dr. Pat O'Shea of Oregon State University cautions against overuse of "guided apparatus work" since it "hinders development of neuromuscular coordination and the antagonistic and assistance muscles" (compare with comments from Dr. O'Donoghue's text (13) in "Rehabilitation" below). He recommends only supplemental use of machine exercises in a strength and power program. Professor O'Shea was a competitive weightlifter for many years, a strength coach and weight training instructor, and researcher in strength physiology. Recently, at 50 years of age, he squatted with over 500 pounds while weighing under 200 pounds.

Bill Starr has devoted an entire chapter of his popular text (reference 17, 1976) to comparing free weights with machines. He covers many topics including safety, expense, clean-up and maintenance. His conclusions are straight forward—you get stronger faster with free weights and the strength transfer to sports is better than with machines. Bill was for many years a competitive olympic and power lifter, once setting a world record in the deadlift. Later he was a successful strength coach for the Baltimore Colts (1970) and University of Hawaii.

Thus far arguments have been presented for the superiority of free weight training based on the multi-joint, multi-muscle group nature of total body free weight exercises and the resulting neuromuscular specificity and transferability to sport activities. The ability to easily add variation to the strength program (most important for the advanced trainee, see references 2 and 21) was another important point. The following are but a few of many additional considerations which favor the emphasis of free weight exercises in the strength and power programs of athletes.

(1) **Acceleration:** Lifting free weights is not isotonic exercise as commonly stated. Isotonic means constant tension and this is never the case in lifting free weights. The reasons are many (such as length-tension and force-velocity constraints on muscle, and leverage changes which will be discussed by Dr. Stone in the next issue of this Journal) but acceleration or changing bar velocity is a major factor. As one lifts a barbell they exert a force (F) which overcomes the downward pull of gravity (weight of the barbell, W) and accelerates (a) the mass (m) of the barbell. These factors are related by a fundamental equation of engineering (Newton's second law of motion): $F - W = ma$, so that $F - W = ma$. The athlete's exerted force does not equal the bar weight but is dependent on the acceleration term "ma". While passing through strong leverage positions an athlete can exert a larger force on the bar and it accommodates this effort perfectly by accelerating at a greater rate. This perfect accommodation is perhaps the greatest advantage of free weights when coupled with reasonable total body full range joint movement exercises: rep after rep, as fatigue develops the athlete can always make the maximum possible effort and the barbell accommodates it by the appropriate acceleration.

Acceleration is a key factor in sport movements such as jumping, throwing and striking. Isokinetic (constant velocity) machines by definition prevent acceleration. In a recently published four way discussion of strength training for swimming (16) one panel member properly defined isokinetic exercise as stated above and shortly thereafter stated that there was acceleration initially with higher machine speed settings. This is true, indicating that at the very important high movement speeds isokinetic devices are isokinetic for only part of the movement range. However, they offer no resistance during this initial acceleration period. Fortunately another member of the panel pointed out that free weights do not have such limitations. Isokinetic proponents often cite a published study (14) to support their sales claims. One should note, however, that this paper (14) has been criticized for questionable experimental design (9) and one of its authors has publicly requested that his name be disassociated from the paper due to data analysis errors (20).

Variable resistance type machines, including some cam machines, restrict acceleration severely by increasing resistance [the W term in Newton's equation given above] through the movement range. The resulting velocity profile therefore deviates severely from what is common to athletic movement, that is, periods of high acceleration. Other cam devices permit so much momentum to be built up in the linkage mechanism during a movement that the movement must be done slowly or no resistance is felt near the end of the movement range. In fact, if done too fast these machines continue to move on their own for a short distance after the trainee has reached full joint extension or

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flexion. The manufacturers, of course, have created a totally unsupportable principle of always training slow (see discussion under "Counter Movement" below). For more discussion on these types of factors see reference (9).

(2) **Eccentric Movement:** When giving in to the weight, such as lowering the barbell in a squat or bench press, muscles undergo a lengthening or eccentric contraction as opposed to the normal shortening or concentric contraction. This is another type of valuable stimulus for the development of muscle strength. Studies reported in the Russian literature indicate that a combination of both types of muscle contraction is superior to either separately. Some types of machines, especially isokinetic devices, do not permit eccentric movements. With free weights and spotters one can do a variety of supramaximal eccentric movements (too heavy to reverse via concentric contraction). Those, however, must be done with caution and should be a very small fraction of the total training volume. The eccentric movements that occur with normal lifts, such as returning the barbell to the floor in a controlled manner after a power clean, are the preferable way to mix both types of contraction.

(3) **Counter Movement:** When muscles and connective tissue are forcefully and rapidly stretched elastic energy is stored and can be utilized in an immediately following concentric contraction. This energy recovery is very important in many sport movements, such as running, jumping and weightlifting, in terms of power output and efficiency (1, 5, 11). This counter movement effect is found in many free weight lifting movements, such as direction reversal in the squat (11), dip for jerking a barbell overhead (5), and shift of the knees and hips when executing a snatch, clean or pull using the "double knee bend" technique (4, 6). A "stretch reflex" facilitation of the concentric contraction may also occur. The speed and force of the stretch and lack of delay or unloading prior to the subsequent concentric contraction are critical factors. The requirements for efficient recovery of elastic energy are impossible with many machine exercises due to the absence of loaded counter movement (eg. isokinetic) or unloading at the end of counter movement (eg., weight stack impacts supports). The presence of counter movement effects in training is very important. Connective tissues are viscoelastic in nature. This means that they resist elongation (stretch) differently depending on the rate of loading. If never exposed to high and rapid loading in training one cannot expect these tissues to be conditioned to withstand them without high risk of injury when encountered in competition. High loads and rapid loading are the rule rather than exception in sport competition.

(4) **Rehabilitation:** Machines are generally considered of major value in rehabilitation exercises due to the controlled movements possible. However, this control limits the extent of rehabilitation. In Dr. O'Donoghue's widely used and highly respected text on Sports Medicine (13) it is stated, for example in the shoulder rehabilitation section, that free weights are superior to machines at the various stages in the rehabilitation process due to the multiple movement direction control required with a barbell, and the resulting involvement of many more of the smaller shoulder and shoulder girdle muscles. Thus, more complete conditioning of the total shoulder area is possible. Machines certainly have a place in selected rehabilitative situations, but implications of the above considerations to general conditioning and strengthening are obvious.

To conclude it should be noted that throughout this paper emphasis on free weight exercises has been recommended and reasons for doing so given. Dr. Stone of Auburn University will provide additional reasons and insights in the next issue of this Journal. Machine exercises can play a meaningful role in an overall strength and power program but still a minor one. The vast majority of world class strength and power athletes do more than 95% of their lifting volume with free weight exercises. The contribution of machines to improved strength programs for athletes has been small. In many cases the "machine influence" has hurt progress in strength training in the United States by making coaches and athletes think that the best way to train is the machine way. If this continues our athletes will be at a major disadvantage in international competition since foreign athletes from the world sport powers use the best means to train rather than the easiest or most novel way. The latest fad to appear in strength training is "computerized exercise machines". These have many of the faults already given for other machines, especially constrained movement patterns and very limited exercise choices, in addition to basing one's effort on a single force position or time measure for each subject in a given exercise. It is well known that such a measure will vary from day to day, change frequently during an exercise program, and vary due to fatigue during a single workout session and with repetition in a single set. What about variation of the load (ie., light, medium, and heavy training sessions)? Major advances in strength and power training will come from better educated athletes and strength coaches, better training programs with productive exercises, and not from money making gimmiks.

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