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Prescribing strengthening exercises for my patients: which equipment should I select?

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This paper examines various devices used in strength building exercise programs. These include free weights, pulley machines, variable resistance weight machines, isokinetic units and elastic tubing and banding. Advantages and disadvantages of each are discussed and examined from the view point of the health care provider and the suitability of each type of device for prescribed progressive resistance exercise programs for patients. In addition to such practical aspects such as cost and maintenance, biomechanical factors, types of contraction elicited, ease of patient instruction and proprioception benefits are also compared in order to assist the clinician in selecting the most appropriate equipment for each individual patient.
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KEY WORDS: exercise, exercise therapy, chiropractic.

Cet article examine différents appareils utilisés dans les programmes d'exercices de musculation. Parmi ces appareils, on compte les poids et haltères, les blocs de musculation composés de poulies, les blocs à résistance variable, les unités isocinétiques, les tubes et les bandes élastiques. Nous avons décrit puis analysé les avantages et les inconvénients de chaque accessoire du point de vue du professionnel de la santé et nous avons vérifié que chacun d'eux convenait au patient à qui nous avions prescrit un programme d'exercice visant à augmenter progressivement la résistance. Outre les aspects pratiques tels que le prix et l'entretien, nous avons également comparé les facteurs biomécaniques, les contractions provoquées, la facilité d'utilisation et les bénéfices au niveau de la proprioceptivité, afin d'aider le clinicien à choisir l'equipement le plus approprié pour chacun de ses patients.
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MOTS-CLÉS : exercice, traitement basé sur les exercices, chiropractie.

Progressive Resisted Exercise (PRE) is the term applied to the systematic increasing of the exercise load for the purpose of gaining muscle strength. While athletes have, for thousands of years, trained with weighted implements, one of the earliest references to progressive resisted exercise dates back to about 558 B.C. when, as legend states, the Olympian Milo "invented" progressive resisted exercise.[2,5] While training for the ancient Olympic games, Milo began to carry a calf. As the calf grew, so did Milo's strength until the calf became a full grown bull 4 years later, just prior to Milo's great success in the Olympic contests. As athletes are wont to do, Milo's colleagues "borrowed" his technique and began exercising with implements of increasing weight as they gained strength. The implements they used were the ancestors to our modern barbells and dumbbells.

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A frequently identified need of the patient and one of the aims of the practitioner is to increase the strength of the muscles or muscle group around the injury site, regionally, or perhaps in the whole body.[1] This need entails strengthening muscle tissue which has become weakened and atrophied due to disuse following injury, or may involve taking a patient with "normal" strength to a higher level. In either case, the principles to be applied are essentially the same; only the values may differ. While the strengthening program might begin with only isometric exercise, usually resisted exercise through a range of motion will become the mainstay of the program.

When, with appropriate frequency, intensity, duration and specificity, stress is applied to a muscle or group of muscles in the form of exercise loading, the body adapts to this increased mechanical load by making certain physiological adaptations.[2] Some of these adaptations result in increased muscle strength. As the exercise load is progressed, the strength of the muscle continues to increase. When the load is kept constant, there are almost no further strength gains.[3,4] If the load is diminished, the strength gains begin to regress and the muscle becomes weaker.

The purpose of this paper is to examine various types of strength training equipment as well as the benefits and disad-

vantages of each. This will be done from the view of the clinician who may be considering incorporating strengthening exercise equipment in his/her clinical setting. (Table 1)

Using free weights

When one exercises with free weights, the exercise is usually described as being isotonic. Isotonic exercise is a time proven and very effective way of gaining strength especially when it is part of a Progressive Resisted Exercise program. It is, however, limited by two important factors. As a joint is moved through its range it encounters various weak and strong points within the joint's biomechanical arc of movement. When exercising with free weights, we are limited in the amount of weight we can use and the limit is defined by the weakest points within the range. If one can move 50 pounds at about 90 degrees of elbow flexion but is 20% weaker in full extension, then one can only begin the exercise of resisted elbow flexion with a 40 pound weight. This would provide ample resistance for the early part of the range, but proportionately less stress would be applied to the muscle as the elbow moves towards its strongest arc of the range. With less stress applied, less adaptation occurs, that is, limited strength gain.

The second limitation of free weights is easily understood when we consider an exercise in which the free weight is moved through an arc as opposed to one in which the weights are moved in a straight line. Consider standing resisted shoulder flexion with a weight held in the hand. As the arm moves from the anatomical position to a position parallel to the floor it passes through a 90 degree arc. The arc is made up of vertical and horizontal segments or components. During the early part of the movement, the weight is moved more horizontally than vertically. During the latter part, the weight moves more vertically, or more directly against gravity. The exercise becomes more difficult as the weight moves through this part of the arc. This limits the weight used and once again may offer some degree of inefficiency in the exercise.[6,7]

This second "problem" with free weights was the first to be solved. Instead of holding the weights directly, athletes pulled on a handle attached to stacked weights by a chain or cable and crossing one or more pulleys. Now the weights would travel vertically against gravity throughout the full range of the exercise. "Weight Stack" exercise machines are now common place. The resistance is easily adjusted via a pin inserted at the appropriate level and the patient moves the weights with a handle, attached either by rigid lever or cable and pulley.

Variable resistance units

Another problem is overcoming the inherent weaknesses that may be found throughout a joint's range of motion. One of the first solutions to this was developed by Arthur Jones, in 1948.[7] Jones developed a simple exercise machine which had the capability of varied mechanical efficiency.[2] Basically, he modified the shape of the pulley wheel from circular to an asymmetrical shape. This resulted in a pulley or cam which, as it is rotated, changes its radius. The machine, therefore becomes more efficient as the body moved through an inefficient arc of the range and less efficient as the joint range became more biomechanically efficient. This "variable resistance" machine still employed the weight stack concept thereby allowing the weights to be moved vertically. The most commonly seen variable resistance units in use today are made by Nautilus.

From a superficial examination, it might seem that these variable resistance units would be the best to use for enhancing strength gain. As we have seen with free weights, though, there is also a down side to these machines. Most of these units have a limited range of adjustment for body size; those too short, or too tall may not fit into the unit. Also, unlike free weights, the plane on which the movement takes place is fixed which might be seen as a limitation given the multi-planar movements our patients need to do in their activities of daily life. The planes of free weight movements, on the other hand, can be infinitely modified in order to produce an exercise mimicking a specific movement, if this is desired.[5,7]

With many variable resistance exercise units, the user is strapped into the machine in a very secure and supported position. While this does help to isolate the specific muscle group to be exercised, it does not allow for as much muscular torso stabilization as free weight exercise.[5,8] Expense in terms of purchase, floor space, and maintenance may also make these machines less desirable. Unlike free weights, variable resistance exercise using stacked weights machines cannot easily be incorporated into a home program.[8]

On the other hand, these units can be often used by people who might be wearing casts, or who have had injuries which may preclude their use of free weights. Free weights can cause injury by being dropped and may not be as easy to use in terms of resistance adjustment. Free weights do have the advantage in terms of expense and their use is limited only by the clinician's imagination. Further to this, most work and activities of daily living tend to be primarily isotonic, that is, very similar to free weight exercise. Lifting, stair climbing, etc. all closely simulate the muscular work done in free weight exercise. Free weights may be more specific to our patients' normal activities. (Table 1)

Isokinetic exercise

Isokinetic exercise is also possible with some machines. With these units, the maximum speed of the movement is set and the machine generates resistance as the user reaches and tries to exceed this speed. The user can get a close to maximal contraction through a full range of motion. A unique feature of most of these types of machines is their elimination of the eccentric contractions in any movements. Following a concentric contraction the machine is reset, or returned to the starting position by a concentric contraction of the opposing muscles.[2] With free weights, pulleys or variable resistance units, the initial movement is concentric and then the same muscles contract eccentrically in order to control the speed of descent of the weights.

Table 1
Comparative Chart of Strength Exercise Equipment Features

Equipment / Feature	Free Weights	Pulley and Weight Stack Units	Variable Resistance Cam and Weight Stack Units	Isokinetic Units	Elastic Tubing and Banding
Expense	A/B	B	C	C	A
Safety	B	A	A	A	B/C
Ease of Use	A	A	A	A/B	B/C
Ease of Instruction	B	B	B	C	B/C
Effectiveness for Home Progress	A	C	C	C	A
Versatility	A	A	C	C	A
Simulation of ADL	A	A	C	C	B/C
Quantification of Work/Improvement	A	A	A	A	C
Provision of Proprioception and Balance Exercise	A	A/B	B/C	B/C	A
Accuracy of Resistance Adjustment	A	A	A	A	C

A = Excellent B = Good C = Fair

While concentric only resisted exercise may be desirable in some situations, it should not, in most cases, comprise the whole strengthening program. In addition, while relatively safe to use, these machines do require significant expenditure for purchase, floor space, maintenance and operation.

Exercise concerns with rubber tubes and bands

The prescription of strengthening exercises using elastic banding or tubing is also a common practice. As with the previously examined methods, elastic materials also have advantages and disadvantages. Elastic tubing/banding tends to be relatively inexpensive and as well as being highly portable. A patient can easily carry some tubing to use at home, at work, on vacation, etc. and these features may aid in compliance.[1] All body parts can be exercised with this method of resistance. Both the elastic banding and tubing are available in a variety of graded resistance levels and patients' programs can be progressed through a range of various diameters or colours, representing the force required to stretch the elastic. These features add to the versatility and variability of the elastic materials.

Some practitioners consider tubing and banding to be easy to use while others feel that there is too much adjustment necessary if more than one muscle group is to be exercised. It is true that in order to be effective, part of the elastic device must be fixed and the point of fixation must be adjusted in order to position the band correctly. This is sometimes accomplished by attachment to a wall, door or a piece of furniture. Fixation may also be done using another part of the body. However it is fixed, this attachment must be very secure to ensure the elastic does not slip while under tension and cause an injury. Additionally, the elastic must be frequently examined for tears, nicks or signs of excessive wear so that the chance of breakage under use is minimized.

Elastic tubing and bands may also require a significant time commitment in order to properly instruct the patient in its safe and effective use. The time required of the instructing practitioner increases with the number and complexity of the exercises prescribed.

Due to the increasing variability of resistance as the elastic material is stretched, it is difficult to apply effective stress to the muscle group throughout the full range of motion. At the beginning of the movement, there is little resistance while at the end there is much. To a large extent, this can be compensated for by teaching the patient to exercise in different positions which may pre-load the elastic or by having the patient try to do the same exercise with different resistance levels of elastic. All of this adds to the required instruction time as well as the complexity of the program. In addition, unlike weights or resistance training machines, elastic tubing/banding exercise is difficult to quantify. (Table 1) Some patients like to see that they are increasing their strength by seeing the weights they are using get progressively heavier.[8] Switching to a different colour level or diameter of elastic, even though it means more force must be applied by the patient, may not provide the same concrete reinforcement to the patient of his/her progress.

Summary

Undoubtedly there is no single best system or type of device for increasing muscle strength. A plethora of factors will always influence the practitioner's choice, but appropriate suitability for the patient's needs should always be paramount in the program prescription process. Some patients may prefer and have access to high tech exercise units, while others may be restricted to programs which can be done at home and at minimum cost. The health care provider must take all of this into account and remain open minded enough to construct strengthening programs regardless of the equipment available. When, however, the patient does have access to a selection of various exercise devices, then the practitioner should be able to select an exercise from this available menu to construct an appropriate and effective strengthening program.

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