Dynamic Variable Resistance and the Universal System

By Frank Smith, Universal Gym Equipment, Inc.

Editor's Note: The NSCA believes that the strength coach should be aware of the various modes (types) of resistance methods and equipment on the market. Each has its own unique features that set it apart from the competition.

We have invited numerous equipment companies to "toot their own horn" and explain how their product's training mode achieves a training effect. This series of articles will help you judge the modes of conditioning and hopefully allow you to make your future purchases based on your strength and conditioning needs.

We would like to extend an open invitation to any equipment company that would wish to contribute to this series.

Back in 1957, barbells and dumbbells were the "state of the art" in weight training. Supplemental weight training programs for athletics were few and far between and usually quite limited in scope. The value of weight training in improving athletic performance and aiding the prevention of injuries was not yet fully recognized.

Harold Zinkin, a registered physical therapist and National AAU Weight Lifting Champion, was one of the first to realize that an entirely new conditioning system was needed—one that would condition every major muscle group and develop an athlete's strength, power, muscular endurance, flexibility and cardiovascular/cardiopulmonary efficiency. He applied his knowledge and experience in physical therapy and biomechanics to the design of the first Universal machine. It provided five different stations for individual exercising or circuit weight training. For motivational purposes, the machine's design allowed the user to see the weights moving up and down. This first prototype eventually was to become a full 16-station machine.

One of the first prominent coaches to recognize the potential of the Universal machine was Chuck Coker, a U.S. Decathlon Team Coach and coach of 23 Olympic track and field medal winners. Coker promoted the machine and its benefits throughout the country at coaching clinics, physical education conventions and school demonstrations. The Universal multi-system machine caught on fast because, unlike any equipment in existence at the time, it could condition a large number of athletes in less time and more effectively.

Today, Universal is a recognized leader in the fitness industry. Universal single and multi-station equipment has been selected by the U.S. Olympic Training Committee for its training centers: the original U.S. Olympic Training Center in Squaw Valley, California; the 1980 Winter Olympic Training Center in Lake Placid; and now the permanent U.S. Olympic Training Center in Colorado Springs. Chuck Coker is still on Universal's professional staff, along with George Oott, former Director of the U.S. Marine Corps Fitness Academy.

Highlights of the Major Developments

On-going inquiry and biomechanical research has led Universal to continually update and refine the body of knowledge that went into the development of Universal machines and the Universal system of exercise. These have been some of the major steps:

1. Universal developed the Dynamic Variable Resistance (DVR) feature (Figs. 1 and 2) which changed the machine's resistance to coincide with the body's changing leverage during the lifting stroke. DVR, through the lever and the cam systems, enables Universal machines to maintain a relatively con-
Figure 2. The Universal DVR cam system is used on the Leg Curl, Arm Curl, Vertical Chest and Leg Extension machines. While DVR increases resistance to coincide with the improving mechanical advantage of the muscles in all other Universal machines, the Leg Curl machine decreases the resistance toward the end of the exercise movement to coincide with the muscles' decreased leverage.

Figure 3. Universal’s DVR varies resistance to ensure maximum muscular effort throughout the range of movement. From the starting position through the mid-range of bench press movement, only a slight variation in the resistance occurs; from the mid-range through the powerful lock-out position, the resistance becomes significantly greater. Result: The development of maximum strength throughout the entire range of the movement.

Computerized biomechanical analysis was used to determine the muscular force curves produced during a bench press. This scientific research revealed the true muscular exertions as they occurred from start to finish. Notice Universal’s vast improvement in conditioning effectiveness through the use of Dynamic Variable Resistance.

Iowa Biomechanics Lab under the direction of Dr. James Hay and Professor James Andrews. One study in particular was undertaken to determine whether the demand placed on muscles by a Universal Arm Curl machine is consistent with the capacity of the working muscles to exert force through the same range of motion.

A mathematical model was developed to determine how the variable intersegmental force and moment resultant which act at the elbow joint during the arm curl exercise (Fig. 4) vary with time during a specific activity. The relevant forces were identified for the forearms plus hands segment, the rotating machine arm plus adjustable pad segment, the variable radius pulley, the smaller pulley and the moving weight stack (Fig. 5).

The experiment was recorded with a 16 mm motion picture camera and evaluated with the aid of a Vanguard Motion Analyzer linked on-line to an analog to digital conversion system. Four computer programs were used to obtain the required information.

The results of the study indicated that the Universal Arm Curl machine did provide a variable resistance which was consistent in its general form with the capacity of the muscles involved when the lift was performed at a fast speed (Fig. 6). The study also showed that the barbell was decidedly inferior to the machine in terms of matching the resistance to the capacity of the muscles.

Universal is continuing its research and development efforts to assure that its equipment is biomechanically correct. In addition, Universal has the largest library on resistive training in the world today. Its existence is due to the efforts of Dr. John Atha, well-known exercise scientist at Loughborough University of Technology in England, and the biomechanics staff at the University (Continued, page 16)

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Figure 5. Free-body diagrams used in computations to determine how joint resultants vary with time during a specific activity (A) Forearms-plus-hands segment, (B) Rotating machine arm-plus-adjustable pad segment, (C) Variable radius pulley, (D) Smaller pulley, (E) Moving weight stack.

Figure 6. A comparison of three force curves. Curve generated by 64 college men during a study to determine the maximum forces capable of being exerted by the elbow flexors. Force curves produced during bicep curl executed at fast speeds with barbell and Universal Arm Curl machine (90% of four-repetition maximum).

(From page 15) of Iowa who spent 18 months researching 10,000 studies on resistive training from around the world.

General Principles of the Universal Conditioning System

Along with its pioneering inventions, Universal also developed a conditioning system that has been used by thousands of schools, colleges, professional teams and health clubs.

The Universal Conditioning System is based on the following principles:

1. Balanced, Total Body Conditioning

George Allen, former coach of the Washington Redskins and Los Angeles Rams, once said, "We should not be interested in developing Olympic weight lifters. We should be interested in developing the best possible football players." Consequently, Allen made sure his players developed under a balanced, total body conditioning program involving all the major muscle groups. This resulted in distributed strength and increased power, endurance and flexibility.

The importance of this approach to training cannot be overstressed. Muscular imbalance, when certain muscle groups or muscles within a muscle group are overtrained and others undertrained, can impair athletic performance and may lead to injury. Most muscle injuries occur to the antagonistic muscles, either because they have not been stretched or warmed-up properly, or because they do not have the strength to match that of the agonist muscles. All major muscle groups must be in good condition or the athlete is inviting trouble.

2. Training Fast to Be Fast and Powerful

Since a majority of athletic movements are explosive in nature, it is essential that athletes train as they will perform, employing relatively fast, intense repetitions and coordinated multiple joint actions. Universal recommends that athletes concentrate on making their muscles contract explosively throughout the entire range of motion no matter how heavy the resistance.

In sports, power is associated with quickness and explosiveness of movement. The formula for power can be expressed in various ways. Here are two examples:

\[ \text{Power} = \text{Force (Strength)} \times \text{Velocity (Speed)} \]

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OR

Power = Force x Distance Traveled / Time

In practical terms, power can be thought of as the ability to use strength in coordinated high velocity movements (power movements), and it can spell the difference between success or failure in athletics. Therefore, speed of execution during strength training becomes a key factor in the development of maximum power during athletic performance.

The relationship between power and speed has been noted by several researchers in recent articles published by The Physician and Sportsmedicine.

A recent study by George Davies of the University of Wisconsin at La Crosse, suggests that muscles trained at high speeds increase the power they generate at both high and low speed movements. However, carryover (to high speed movements) does not occur when muscles are trained at slow speeds. Muscles trained at high speeds will also contract faster to protect the joint in case of a contract blow than muscles trained at low speeds.

Preliminary research on swimmers by R. L. Sharp and D. L. Costill indicated that whenever a subject showed an improvement in power, there was a concomitant improvement in sprint speed.

Training for maximum power may become the generally accepted method of training in the future. J. E. Councilman anticipates that, in the next five or ten years, athletes will do more power training than strength training. At Universal, we have always advocated training for maximum power.

3. Year Round Training

Optimum training requires that specific goals are met at specific times of the competitive season. Universal developed the Antagonistic Muscle Circuit for off-season training, the Super Circuit for pre-season and the Peripheral Heart Action Circuit for in-season.

Off-Season Conditioning

A high strength development program should be conducted during the off-season when possible muscle soreness won't affect competitive performance. The Universal Antagonistic Muscle Circuit involves this training approach:

Heavy Resistance (70-80% of maximum one-time lift capacity for average persons, 50-70% for trained athletes).

AND

Low Number of Repetitions (7) at a relatively fast, intense exercise pace at each station with almost no pause between the Agonist and Antagonist stations (5 seconds). When 7 repetitions at each station can be maintained for 5 circuits, weights can be increased.

The Antagonistic Muscle Circuit involves exercising those muscle groups which work in direct opposition to each other (Agonist-Antagonist). For example, if exercising begins with a bicep exercise (arm curl), the athlete immediately follows with a triceps exercise (dipping); an abdominal exercise (sit-up) is followed with a back exercise (back hyperextension), and so on. With not more than 5 seconds between the Agonist and the Antagonist exercise stations, the athlete benefits from increased blood flow and greater neuromuscular chemical activity in that specific body area. That means intense neurological impulse energy and blood circulation needs are met instantly, greatly enhancing the strength development process.

Pre-Season Conditioning

Pre-season conditioning should build on the strength achieved during the off-season and concentrate on developing peak physical conditioning. Increased power and high aerobic and muscle endurance. Universal Super Circuit conditioning is recommended for this period and it involves this training approach:

Moderate Resistance (40-50% of maximum one-time lift capacity for average persons, 50-70% for trained athletes).

AND

High Number of Repetitions (15) at a relatively fast, intense exercise pace at each station with aerobic exercises between stations instead of short rest intervals. Working up to 8 consecutive circuits is recommended.

The Universal Super Circuit training system can be an invaluable tool in bringing about peak, total body conditioning for any competitive sport or leisure activity. Because it combines aerobic training with the benefits of circuit weight training, it may be the only supplemental conditioning required, allowing an athlete more time to spend on the skill development aspects of his or her sport.

The exercise sequence for the Super Circuit is identical to the Peripheral Heart Action Circuit (Figure 7) which involves alternating upper and lower body exercises.

After some initial stretching, a warm-up session on an exercise bike (or jogging, running in place or jumping rope) is used to raise the pulse rate to a target training level. The athlete performs the first exercise for a period of 30 seconds (normally about 15 repetitions).

At the end of 30 seconds (or 15 reps), the athlete immediately performs an aerobic exercise (running, exercise bike, rope jumping, etc.) for 30 seconds. At the end of 30 seconds, he or she proceeds immediately to the next exercise station without any rest interval. The entire Super Circuit is performed in this manner, alternating 30 seconds of aerobic exercise with 30 seconds of weight lifting exercise at each station. The object is to keep the heart rate at a continuously high working level. Breathing should be rhythmic, exhaling as the weight goes up, inhaling as the weight returns.

For additional strength development, weight resistance may be increased up to 70% of one-time lifting capacity. However, no matter how heavy the resistance, the athlete should concentrate on making the muscles contract intensively and explosively through the entire range of motion.

In-Season Conditioning

In-season conditioning should maintain the strength, power and endurance developed during the previous training periods without consuming vast amounts of time. A balanced, aerobic conditioning program, such as the Universal Peripheral Heart Action Circuit, involves this training approach:

Moderate Resistance (40-50% of maximum one-time lift capacity for average persons, 60-70% for trained athletes).

AND

High Number of Repetitions (12-15) at a relatively fast, intense exercise pace at each station with only a short pause between stations (15 seconds for advanced exercising, 20-30 seconds for average exercising). Working up to 3 consecutive circuits per workout is recommended to maintain the heart rate at a desired training level for at least 20-30 minutes.

This type of circuit involves alternating upper and lower body exercises (Fig. 7). The exercise sequence causes blood pooling back and forth between the ex-
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tremities. Consequently, the heart works harder, elevating the pulse rate and maintaining it at a target heart rate for greater cardiovascular/cardiorespiratory benefit.

Special Emphasis/Rehabilitation Conditioning

While the Universal Conditioning System emphasizes circuit weight training to bring the athlete to peak, total body physical condition, individualized, non-circuit conditioning may be necessary to address specific strength/endurance/flexibility needs, weaknesses or injury rehabilitation problems.

Because the Universal System emphasizes total body physical conditioning, it is recommended that special emphasis or rehabilitation conditioning be carried out in addition to an athlete’s regular circuit weight training program.

Summary

"Balanced, total body conditioning;" "functional strength, power, muscle endurance and flexibility;" and "cardiovascular/cardiorespiratory efficiency" are the watchwords of Universal's training philosophy. Muscle strength alone is not enough for optimal athletic performance. What is crucial for the athlete is the ability to use that strength in competitive situations and to "go the distance" successfully. High standards of health and physical fitness, as well as strength, are integral to Universal's conditioning programs.

*Super Circuit is a registered trademark of Universal Gym Equipment, Inc.

Figure 7. Single station room layout for the Super Circuit and the Peripheral Heart Action Circuit. The Indoor Joggers are used in the Super Circuit to maintain a high heart rate between exercise stations.