STRENGTH TRAINING AND AEROBIC EXERCISE

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Brief Review

Strength Training and Aerobic Exercise: Comparison and Contrast

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Abstract. Knuttgen, H.G. Strength training and aerobic exercise: comparison and contrast. *J. Strength Cond. Res. 21(3): 973–978. 2007.*—Most exercise programs for conditioning and rehabilitation are oriented to strength development, aerobic (cardiovascular) fitness, or a combination of the 2. Because the 2 types of exercise are located at the opposite extremes of a muscular power continuum, the design of a program must be highly specific with regard to the exercise to be undertaken, as well as the intensity, duration, and frequency, in order to attain optimal results. Strength exercise programs involve weight training or the use of high-resistance machines with exercise that is limited to a few repetitions (generally less than 20) before exhaustion. Aerobic exercise involves exercise performed for extended periods (e.g., 10–40 minutes) with large muscle activity involving hundreds of consecutive repetitions that challenge the delivery of oxygen to the active muscles. The chronic physiological adaptations and the variables in program design are highly specific to the type of exercise performed.

Key Words. force, power, intensity, cardiovascular

Introduction

The performance of exercise, whether it be for activities of daily living, labor, conditioning, or sport, involves both mechanical power and metabolic power. Mechanical power can also be described as external power. It is manifested by the actual biomechanical performance of walking, running, throwing, kicking, jumping, lifting, rowing, cycling, etc. Metabolic power is the internal power generated in the skeletal muscle cells by anaerobic and aerobic mechanisms that produce the forces necessary to carry out these activities (3).

The immediate source of energy and power for any and all muscular activity is the high-energy phosphate compound adenosine triphosphate (ATP). For continued muscle cell activity, the resynthesis of ATP must be accomplished by anaerobic metabolism, aerobic metabolism, or a combination of the 2.

Intensity of Exertion

Any form of exercise can be assessed and characterized by its mechanical and metabolic power requirements, with each expressed in the international unit of measurement for power, the watt (Table 1). Although neither the trainer nor the person who is exercising may think in terms of wattage, the knowledge of where the particular activity falls on a scale of power provides an excellent basis for prescribing and describing the form of exercise and the intensity. In Figure 1, metabolic power is plotted against mechanical power, and the 3 sources of energy for ATP resynthesis are indicated: aerobic metabolism, anaerobic glycolysis, and the high-energy phosphates ATP and creatine phosphate (CP) themselves. When ATP becomes depleted, all exercise terminates.

Low-intensity activity, such as slow paces for walking, swimming, rowing, cycling, and cross-country skiing, would be supported metabolically for ATP resynthesis by the aerobic metabolism of both fat and carbohydrate. The higher the intensity, the higher would be the relative contribution of carbohydrate. As the intensity of such activities is increased, the aerobic metabolism (as assessed by oxygen uptake, $\dot{V}O_2$) becomes greater and approaches maximal aerobic power, identified as $\dot{V}O_2max$. When a certain high level of aerobic metabolism is attained, the anaerobic metabolism of carbohydrate (anaerobic glycolysis) begins to make a contribution. This is evidenced by the increase of lactic acid over resting values in the exercising muscles and, subsequently, in the blood.

There is a very wide range of competitive sport activities supported principally by anaerobic glycolysis but this sort of activity is rarely performed in the conditioning room, training room, or fitness center. When such exercise is performed to the point of exhaustion, it would last for approximately 50 to 300 seconds. When the power demand becomes extremely high, a person's muscle cells turn to ATP and CP. This is the range of exercise intensity at which strength conditioning is performed. Adenosine triphosphate breakdown always constitutes the final biochemical step in power production but, in the case of the highest levels of power production, stored ATP and CP provide all of the energy and they are reconstituted via aerobic metabolism after the exercise is terminated.

Power Continuum

The power continuum of physical performance begins just above the level of the metabolic power necessary to maintain life (traditionally referred to as the basal metabolic rate). The metabolic power required for various intensities of physical performance can be presented on the continuum from this resting condition up to and including the expression of maximal power. Maximal power may be manifested in such sport activities as jumping, throwing, and Olympic weightlifting. Plotting various activities on a power continuum from 0 to 100% (Figure 2) permits a vivid comparison and a basis for analyzing the physiological requirements and possible contributions to what is generally termed *physical fitness.*

Physical Fitness

The concept of physical fitness can be considered from 2 related perspectives. The first is as a general state of good health with sufficient capacities to carry out the various physical challenges presented by the activities of daily living (e.g., walking, climbing, lifting). This would involve a combination of both aerobic fitness and the strengths to perform various body movements. For certain patients undergoing rehabilitation, this could include activities as

TABLE 1. Basic definitions for exercise assessment.

Exercise: Any and all physical activity resulting from forces generated by active skeletal muscles, including occupational activities, activities of daily living, recreational activities, conditioning programs, and competitive sports

Power

Mechanical power: The rate at which work is performed in exercise

Metabolic power: The rate at which energy is released in the muscles in order to produce the movements involved in exercise and sport

**As the metabolic power of the active muscles regularly exceeds the mechanical power at a ratio of 4–5:1, the remaining metabolic power appears as heat and must be dissipated to the environment to prevent hyperthermia

Strength: The maximal force or torque a muscle or muscle group can generate at a specified or determined velocity

basic as rising from a chair, walking a short distance, or opening food containers.

The second conceptualization involves a special set of functional capacities to meet the increased physiological demands presented by special circumstances in life: running, swimming, bicycling, or rowing a significant distance; sprinting while performing these same activities; lifting very heavy objects on the job; or engaging in competitive sports. Because each of these activities involves a unique set of physiological requirements, it should be obvious that fitness for one does not necessarily result in fitness for the others. Drawing examples from the world of sport, the Olympic gold medal winners in the sports and events of the 100-meter run, the 100-meter swim, the marathon, weightlifting, tennis, table tennis, and the high jump are each superbly physical fit for their particular sport, but none is physically fit to perform well in the other 6 events.

COMPARISON OF STRENGTH AND AEROBIC ACTIVITIES

Exercise can consist of the activity of small muscle groups, such as those involved in elbow flexion, or it could involve large groups, such as in leg cycling. If a person engages in either strength exercise or aerobic exercise with the same muscle groups involved, the respective performances would be located at the opposite extremities of the power continuum, strength exercise vs. aerobic exercise. In both situations, opposing forces (commonly referred to as *resistance*) could be provided to limit the number of repetitions of the movement before exhaustion to between 1 and 10 (as in strength exercise) or to permit 200 or more repetitions for predominantly aerobic exercise. As an extreme example, running a marathon involves more than 10,000 step repetitions.

Because it has been stipulated above that it is the same musculature that is functioning for the 2 ranges of intensity, in 1 example for elbow flexion and in the other for leg cycling, the question can be addressed as to what is different for the 2 intensities in each form of exercise. For the sake of simple and straightforward discussion, let us consider motor unit recruitment, muscle cell metabolism, circulation, and the chronic adaptations of the body tissues and systems to specific conditioning programs.

Motor Unit Recruitment

Skeletal muscle cells are organized into motor units, and each unit is controlled by a single motor (efferent) neuron with its cell body located in the gray matter of the spinal cord. Each motor neuron's single axon emerges as a part of a motor nerve trunk and continues all the way to the particular skeletal muscle fibers it innervates. The muscle fibers of a single motor unit are homogeneous and are classified as being type I (slow twitch, oxidative), type IIa (fast twitch, oxidative/glycolytic), or type IIx (fast twitch,

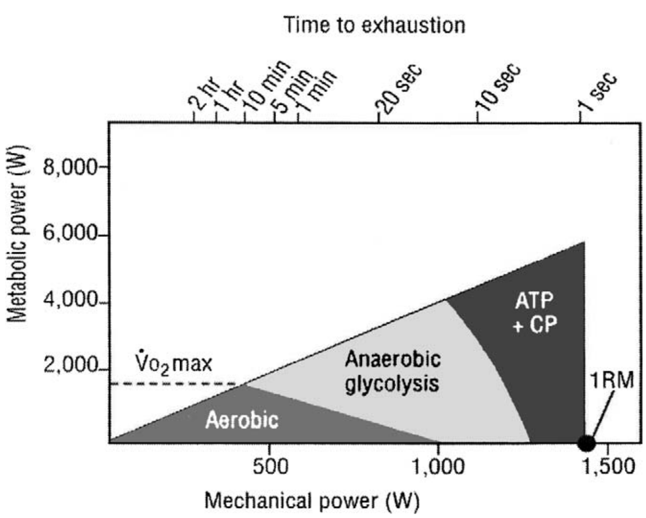

FIGURE 1. The relationship of metabolic power (watts) produced in skeletal muscle to the mechanical power (watts) of the activity utilizing a healthy male adult subject on an ergometer for which the velocity of movement is maintained as constant. The sources of the metabolic power are indicated as aerobic, anaerobic glycolysis, and the high-energy phosphates. Exercise time to exhaustion is presented on the upper coordinate.

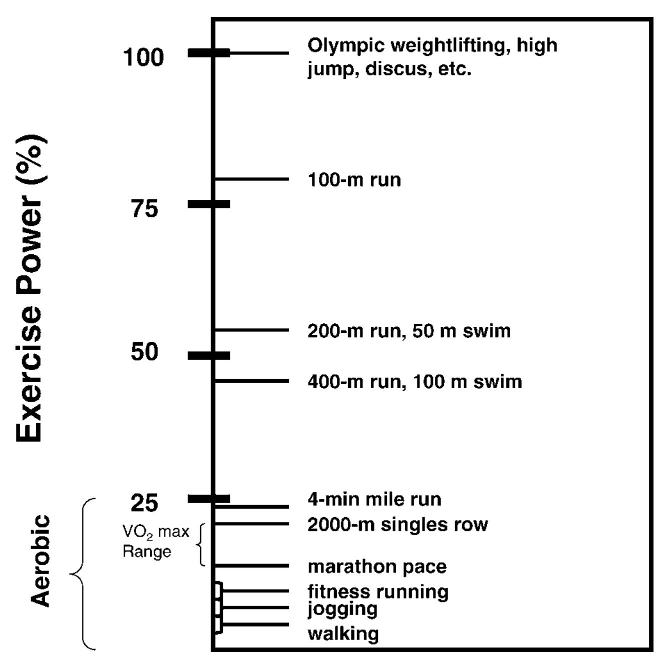

FIGURE 2. The percentage of a person's maximal power that is expended during various sport activities.

TABLE 2. Motor neurons and skeletal muscle fibers.

Motor neuron: A nerve cell with its cell body being located in the anterior horn of gray matter in the spinal cord with an axon connecting it with the skeletal muscle fibers (cells) it innervates
Motor unit: A motor neuron together with the skeletal muscle fibers it innervates, the fibers of each unit being homogeneous as type I, type IIa, or type IIx
Muscle fibers (cells)
Type I: Slow twitch, highly oxidative, limited anaerobic power capability
Type IIa: Fast twitch, modest capabilities for both aerobic and anaerobic power capabilities
Type IIx: Fast twitch, high force production and anaerobic power, limited aerobic power capability

glycolytic) (Table 2). The neuron cell bodies of type I motor units are relatively small, and the neuron cell bodies of type II motor units are relatively large when compared with each other.

Accompanying this size difference, the cell bodies of type I neurons have a lower threshold of excitation. The larger the demand is for power, the larger will be the wave of excitation coming down the spinal cord, and this will determine the order of recruitment of the motor units of the 3 muscle fiber types (Figure 3). A wave of excitation of small magnitude originating in the brain's motor cortex and passing down the spinal cord to the motor neurons serving a particular muscle group will stimulate type I motor neurons but not those of type II. If the need for force and power development becomes greater, increasing numbers of type I motor units will be recruited by increasingly larger waves of excitation passing from the brain and down the spinal cord. Eventually, all of the type I motor units will become involved in the exercise, and the need for oxygen to support aerobic metabolism will reach a maximum ($\dot{V}O_2$max).

At approximately 20% of maximal force and power production, the wave of excitation becomes sufficiently strong to exceed the thresholds of excitation of certain of the type II motor neurons, and increasing numbers of the type IIa motor units become involved. Evidence of the participation of the type II muscle fibers is provided by the appearance in muscle and blood of lactic acid, an end product in anaerobic glycolysis. As the exercise intensity is increased and there is need for increased metabolic power, larger waves of excitation pass down the spinal cord, the threshold of excitation of larger motor neurons are exceeded, and increasingly greater numbers of type IIx motor units become involved.

To stimulate a muscle to develop maximal force (i.e., strength), the largest possible wave of excitation must be developed in the motor cortex, pass down the spinal cord, and activate all of the motor neurons serving the muscle. All of the motor units of the 3 types will be recruited. All of the skeletal muscle cells will generate force.

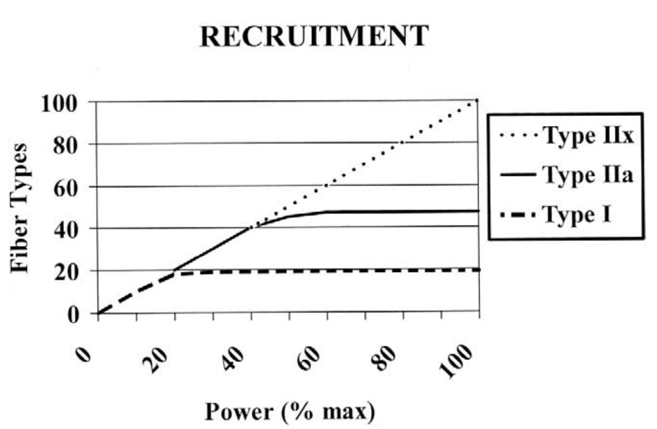

FIGURE 3. Skeletal muscle fiber type recruitment as a function of percentage of maximal power. Maximal power would be as in the performance of a 1RM strength effort.

Muscle Cell Metabolism

For the highest production of muscular power, ATP and CP, as stored in the muscle cells, account for virtually all of the energy expenditure in the active muscles. The highest intensity exercise, as involved in Olympic weightlifting, high jumping, discus throwing, and baseball pitching, involves only ATP and CP breakdown for the necessary energy and power. The force generation and resultant activity is too short to involve additional metabolism. After the performance of each action, ATP and CP are returned to resting levels from their metabolic "end products" of adenosine diphosphate, adenosine monophosphate, creatine, and organic phosphate by means of the aerobic metabolism of carbohydrates and fats in the mitochondria (3).

In high-intensity exercise that can be continued for longer periods (e.g., 10–60 seconds before exhaustion), anaerobic glycolysis of glucose and stored muscle glycogen accounts for a large portion of the energy necessary for the power production. The longer the period of exercise within the 10- to 60-second range, the greater is the proportion obtained from anaerobic glycolysis, as evidenced by the increasing amounts of lactic acid found in the exercising muscle and, subsequently, in the blood. Recovery and the return to resting ATP and CP concentrations, as well as the removal of lactic acid, are again accomplished by means of the aerobic metabolism of carbohydrates and fats.

As the exercise intensity is reduced and the periods of exercise extended, aerobic metabolism, especially in the type I motor units, assumes responsibility for the power production. This actually occurs by default as the smaller waves of neural excitation in the spinal cord become less and less able to recruit type II motor units. Aerobic metabolism of carbohydrates and fats in the mitochondria provides the energy for resynthesis of ATP and CP, and the exercise can be continued. When the exercise intensity is reduced to marathon running pace (approximately 75–85% of $\dot{V}O_2$max), all of the power production is dependent upon the aerobic metabolism of the muscle cells involved.

Circulation

Such circulatory factors as muscle tissue capillarization, blood volume, blood composition, and cardiac output are irrelevant for the highest intensities of exercise. Performing Olympic weightlifting, high jumping, discuss throwing, and baseball pitching, as well as running to first base, carrying the ball on a short running play in football, or sprinting the 100-meter dash, do not depend at all on the delivery of oxygen and substrate to the muscles or on the removal of CO_2. These functions occur immediately after the activity during the recovery period.

When the exercise intensity is decreased sufficiently for the power to depend principally on anaerobic glycolysis, the circulatory factors become increasingly important with regard to the removal of CO_2 and lactic acid (e.g., in the range of 35–50% of maximal power). Decreasing the exercise intensity so as to eventually emphasize aerobic metabolism for the provision of power during extended periods of exercise brings increasing demands for circulatory system delivery of O_2 to the active muscle cells and removal of CO_2.

In the range of 30 to 35% of maximal power, exercise can be continued for approximately 4 to 10 minutes, and measurements of respiratory exchange indicate a peak delivery of O_2 for the particular exercise involved (cycling, running, rowing, cross-country skiing, or activities involving smaller muscle groups). In this range of exercise, peak oxygen uptake (or maximal aerobic power) is attained. It is then of extreme importance that the person have optimal values for cardiac output, blood volume, hematocrit, and muscle tissue capillarization. This is the reason the terms *aerobic fitness* and *cardiovascular fitness* are often used interchangeably.

The lower the exercise intensity is in terms of maximal aerobic power, the longer it can be maintained. This can involve many minutes or, if low enough, some hours. It will take a person who runs a complete marathon between 2 and 5 hours.

Tissue and System Adaptation

When a person adheres to a program of exercise for 2 or more days per week, possible adaptations can occur on cell, tissue, organ, and system levels. The extent of these anatomical and physiological changes would be mainly dependent upon the initial level of the person's fitness, the genetic potentials of the individual for improvement, the exercises selected, the intensity of the exercise, the duration of the exercise periods, and the frequency of the workouts. Because this article concentrates on 2 areas, strength exercise (2, 4, 5) and aerobic exercise (6), the following discussion will focus on adaptations to these 2 types of exercise for the purposes of comparison and contrast.

Strength Exercise. Strength exercise is performed at very high intensities that limit the number of movements (e.g., lifts) to 20 or fewer (2, 4, 5). The principal adaptations after some weeks of a strength program occur in the type II muscle fibers that will increase in size (cross-sectional area). Eventually, the increases in size for a large number of such fibers will result in a noticeable increase in the cross-sectional size of the muscle (muscle hypertrophy).

A standard strength program can be expected to result in no observable changes in cardiac function or in blood volume and composition. One interesting observation has been that, with no increase in the numbers of capillaries in a strength-conditioned muscle, the increases in size of the type II muscle fibers result in the muscle capillaries being moved apart, a situation that has been described as a capillary dilution.

Physiologically, all of this makes good sense. The need of a person for an increased capacity for force development in muscles can only be accomplished by larger muscles. A strength activity, be it turning a doorknob by a patient or the shot putting by an athlete, involves only a few seconds of effort and, therefore, has no relation to the functioning of the circulatory system. Although strength performance is affected by certain mental/psychological factors involved in the recruitment of motor units, the adaptation to a strength program can be briefly stated: an increase in the size (cross-sectional area) of type II muscle fibers in the exercised muscles.

Aerobic Exercise. As has been discussed above, purely aerobic exercise is performed at approximately 20% or lower of maximal power and involves the recruitment of type I motor units exclusively. Possible increases in the size (cross-sectional area) of the type I muscle fibers will not result in increases in aerobic performance as much as increases in the oxidative metabolic capacities of these same fibers and the increased availability of oxygen to them. The oxidative metabolism of type I muscle fibers will be enhanced by increases in oxidative enzyme concentration, mitochondrial size and number, and myoglobin content. Oxygen delivery will be enhanced by increased capillarization for the type I muscle fibers, increases in cardiac stroke volume and minute volume, and increased oxygen carrying capacity of the blood. It is not surprising, then, that champion marathon runners demonstrate sparse musculature but high blood volume, high hematocrit, and high cardiac output.

Exercise Prescription

The formulation of a program of exercise should begin with an identification of the person's goals. Would the person benefit most from increases in strength, increases in aerobic power, or a combination of the 2? For such program planning, we are not considering the extensive range of power generated by anaerobic glycolysis that is vital to many athletes but is not addressed in the conditioning room, the training room, or the fitness center.

The important considerations that then follow are the selection of the activity, the identification of the intensity of effort (the power), the identification of the repetitions and/or time involvement for each exercise session, and the weekly program.

Strength Program

Weight training is the activity of choice for strength development. Increases in strength and maximal power of the muscles are brought about through exercise programs involving very high opposing force (also termed *resistance*). Exercise may be accomplished by utilizing free weights, exercise machines in which weights are incorporated, or exercise machines in which the opposing force (or resistance) is provided by other means (e.g., electronically).

The human body can perform an infinite number of strength exercises that involve the trunk, the head and neck, and the limbs. Therefore, it is necessary to identify the movements for which the muscles need to be strengthened and, then, utilize exercises that employ these movements. The basic movements consist of trunk flexion, trunk extension, and trunk rotation (right and left); neck flexion, extension, abduction (right and left); and rotation (left and right): shoulder and hip flexion, extension, frontal and transverse plane abduction and adduction, rotation; knee flexion and extension; elbow flexion and extension; and wrist and ankle movements. Unless the focus is on a limited number of joint movements, a typical strength training program can include 8 to 10 different exercises.

TABLE 3. The repetition maximum (RM) system.

R = a repetition of an exercise movement
Set = a series of repetitions
RM = the maximal number of repetitions possible at a given resistance
1RM = the weight with which one and only one repetition can be performed, often identified as the strength of the movement

The Repetition Maximum System

Strength training programs around the world are routinely based on a system of exercise as performed to a repetition maximum (RM) and presented more than 50 years ago by Thomas L. De Lorme, MD (1) (Table 3). Every time a person performs a particular exercise, this "set" is performed for the maximum number of repetitions possible (repetition maximum, or RM), and this number is recorded along with the mass lifted or the opposing force recorded on an exercise machine. These results can be recorded in table form, or the points can be plotted on graph paper to describe the curvilinear relationship (Figure 4). Such high opposing forces would limit the number of repetitions that can be performed to exhaustion in a single exercise set to 20 or fewer and, therefore, a set duration of less than 40 seconds. Exercise programs based on higher repetitions per set (e.g., 30–50 repetitions before exhaustion) develop local anaerobic endurance but are not conducive to optimal strength and maximal power development.

Repeated testing at increasingly higher opposing forces will eventually lead to the determination of a 1RM, a set in which the person can perform the movement only 1 time. In the RM system, the mass lifted or the opposing force recorded as the 1RM is accepted as the person's "strength" for the particular movement at the particular point in time in the training program.

The weekly and daily programs and the predicted RM for each set are then based on the curvilinear relationship between the mass lifted (or resistance provided) and the number of repetitions before exhaustion. This relationship is determined for each muscle group and each individual exercise. The exercise sets can then be identified as light, medium, and heavy as follows: light, 12–15 RM; medium, 7–10 RM; heavy, 3–5 RM.

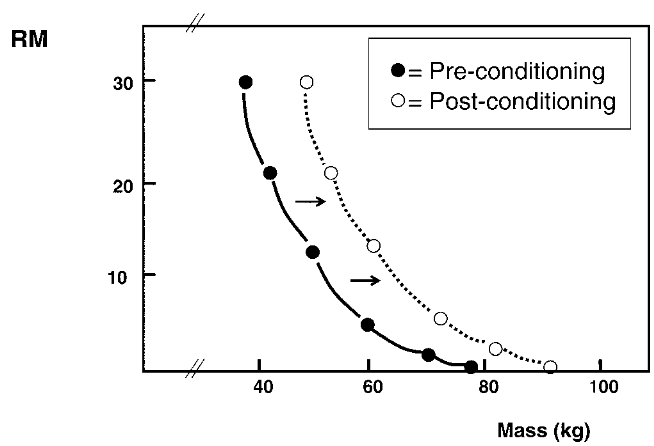

FIGURE 4. The maximum number of repetitions that a particular individual can perform lifting various masses in a specific exercise both before (●) and after (○) some weeks of strength training. The entire performance curve representing this relationship shifts to the right as the person gains in strength.

The terms light, medium, and heavy are relative terms for the exercise intensity in that the strength exercise performed in each of the 3 categories is both highly intense and highly stressful. The number of sets for a particular exercise and the intensity of each set as determined by the predicted RM for light, medium, and heavy are then prescribed for each muscle group as based on the objectives of the program and the progress of the individual (2, 4, 5). Varying the intensity among light, medium, and heavy ("variation") is employed as much for diversion and psychological reasons as for the desired physiological adaptations of the musculature. Typically, a person who is beginning a strength training program performs 1 set of each exercise in a particular exercise session and, after a few days or weeks, advances to 2 sets and, eventually, 3 sets. Typically, rest periods between sets last from 1 to 3 minutes for the light and medium ranges (longer for beginners) and 3 to 4 minutes for the heavy range. Ideally, strength training should take place at least 3 times a week, but the number of sessions and the time involved will vary according to the person's exercise schedule. There could certainly be advantages to a greater number of sessions per week.

The principal adaptation to strength exercise by a person's musculature is an increase in size (hypertrophy) of the type II (fast twitch) muscle cells. The total increase in size of the muscle then presents the possibility for the expression of greater force and power. As the person's strength for a particular movement increases, the number of repetitions before exhaustion (RM) increases and the prescribed resistance is increased so as to maintain the number of repetitions within the light, medium, and heavy ranges.

Aerobic Conditioning Program

Aerobic conditioning is often referred to as cardiovascular conditioning because, in addition to the changes in the aerobic metabolic capacities of certain muscle cells, there are major adaptations in circulating blood, muscle tissue capillarization, and the pumping power of the heart.

In addition to making a contribution to the body's ability to engage in a variety of physical activities of long duration, this type of exercise makes a highly valuable contribution to the prevention of heart disease and to rehabilitation from myocardial infarct. Because the rate of energy expenditure is high, aerobic exercise constitutes a valuable tool in body weight control.

The factors to be considered are again the activity, the intensity, the duration of individual bouts, and the weekly program. To bring about changes in the circulatory system, the activity must necessarily involve a large portion of the person's skeletal muscle. Therefore, the activity could be chosen from walking, jogging, running, cycling, swimming, rowing, cross-country skiing, or on an exercise machine where these activities are simulated.

The intensity should be sufficiently high to elicit a high percentage (e.g., 50–80%) of the person's peak aerobic power ($\dot{V}O_2max$) for the particular activity. It is highly unusual that a person could obtain laboratory test results for this aerobic power, and, therefore, alternative methods should be considered, using heart rate and/or perception of exertion. The heart rates for performance at these oxygen uptakes would be in the range of 130 to 160 $b{\cdot}min^{-1}$, although there is wide variation that requires adjustment for individual differences, especially as regards age. Although there are various systems for quantifying the person's perception of exertion, the simplest approach would be to advise the person to exercise at an intensity that is perceived as physiologically challenging but, yet, can be carried on continuously or semicontinuously for the duration of the exercise period. The total duration of the exercise period should be at least 20 minutes (for beginners) and, more commonly, between 30 and 50 minutes. The frequency should be minimally twice per week but, more commonly, 3 to 6 times per week.

Combining Strength Training and Aerobic Conditioning

For the person desiring improvements in both strength and aerobic fitness, the prescription of a program must first deal with the challenge of the availability of time for completion of the exercise sessions. Either the total time devoted on a particular day must be increased up to twofold to accommodate the 2 forms of exercise, or the number of exercise sessions per week must be increased to include an every-other-day approach to strength sessions and aerobic sessions. It must be remembered that aerobic exercise makes little or no contribution to strength gains, and the standard strength workout does not increase aerobic performance.

Participation in competitive sports can contribute both to strength development and to aerobic fitness, although the contribution is usually mainly to the latter. This frequently involves the sports of tennis, court handball, and squash, and, especially for younger adults, also includes basketball, volleyball, and soccer. Excluding putting, a golfer could take between 40 and 60 swings with the standard golf strokes for 18 holes, but the total effort makes little contribution to either strength or cardiovascular fitness. Walking the 18 holes could be of cardiovascular importance, but this would obviously be completely negated by use of a golf cart.

Sample Programs. The prescription of exercise is a highly individualized procedure that involves consideration of a person's initial level of fitness, the program objectives, the availability of time, and the access to exercise facilities and venues. Therefore, it is not possible to describe programs that would be suitable for all persons. Following certain general principles, however, it is possible to present 5 examples:

a. Strength for a beginner. Start with the determination of the relationship of the RM to mass lifted for each desired exercise (usually 8–10 separate exercises). Identify the 7 to 10 RM range and perform 1 to 2 sets of 6 to 12 exercises for minimally 2 sessions per week. Continue with each exercise varying sets among light (12–15 RM), medium (7–10 RM), and heavy (3–5 RM) intensity, performing 2 to 3 sets of each exercise. Increase to 3 to 5 sessions per week.
b. Strength for the advanced. Perform 3 sets of each exercise (usually 8–10 separate exercises) varying during both workouts and days among light (12–15 RM), medium (7–10 RM), and heavy (3–5 RM) intensities. Exercise at least 3 sessions per week, but increase the frequency according to the person's objectives.
c. Aerobic exercise for the beginner. Begin with large-muscle exercise (cycling, walking, jogging, rowing, etc.) at an intensity perceived as low to moderate or resulting in heart rates of 115 to 130 beats per minute for 15 to 25 minutes, perhaps breaking up the exercise with short periods of rest or lower intensity exercise. The minimum frequency of sessions is 2 per week. During succeeding weeks, gradually increase the intensity, duration, and/or frequency of sessions.
d. Aerobic exercise for the advanced. Engage in large-muscle exercise 3 to 5 times per week for periods of 30 to 50 minutes. Vary the intensity and duration of exercise on different days. Include Fartlek or "speed play" training in which speed is varied during a single training session.
e. Strength/aerobic fitness combination program for an experienced exerciser. Engage in each form of exercise on 2 to 3 occasions per week, e.g., Monday-Wednesday-Friday for aerobic exercise, Tuesday-Thursday for strength exercise, or vice versa.

Common misconceptions include the assumption that strength exercises improve cardiovascular fitness or the assumption that aerobic exercise improves strength. To paraphrase Rudyard Kipling, "East is East and West is West. The 2 exercise performances are at the opposite ends of the power continuum." Another misconception involves confusing R and RM in strength exercise. Simply performing 8 repetitions ($R = 8$) of a particular exercise that could have been performed for 30 or more repetitions is probably a waste of time with regard to strength development. Exercise must be performed to exhaustion or near exhaustion in the RM ranges as described above in order to develop strength.

CONCLUSION

There are great differences between exercise programs performed for strength gain vs. aerobic fitness gain. The prescription of exercise for either program demands precision with regard to the choice of activities, exercise intensity, exercise duration, and frequency of exercise sessions.

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