The purpose of this study was to determine the effects of power weight training and conventional weight training on forced vital capacity and forced expiratory volume in one second in college males. Sixteen college males were employed as the two experimental groups: seven subjects for a power weight training experimental group and nine subjects for a conventional weight training experimental group. Seven college males served as a control group for the study. Core exercises for the power weight training experimental group included the squat, the bench press, and a mini-weight circuit; whereas the conventional weight training experimental group performed general weight training. The subjects trained two days per week for a total of eight weeks. Selected pulmonary function measurements were administered prior to and at the end of the training period. The data
collected were statistically analyzed using a paired t-test and one-way analysis of covariance (ANCOVA). The .05 level of significance was selected for retaining or rejecting the null hypotheses (p < .05). The results of the training program indicated a minimal increase in the selected pulmonary function values, and no differences were found between the two training protocols. The results support the general belief that weight training is not an effective means of improving pulmonary function. However, based upon a lack of published experiments on the relationship between respiratory accessory muscles, pulmonary functions, and exercise, further study is recommended.
The Effects of Power Weight Training and Conventional Weight Training on Pulmonary Function

by

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THE EFFECTS OF POWER WEIGHT TRAINING AND
CONVENTIONAL WEIGHT TRAINING ON
PULMONARY FUNCTION

I. Introduction

Introduction

The ability of the human body to accomplish a variety of physical tasks is determined by its physiological capacities. Lung function constitutes a physiological system which is of major importance in determining the limits of human physical capacity. The primary duties of the lungs are to supply oxygen under pressure to the venous blood and to remove the excess carbon dioxide ($CO_2$) being produced by muscular activity. Consequently, lung capacity is one of the most important limiting factors in determining human physiological capacity, or what is more popularly known as "physical fitness."

Weight training has been described as an organized strength-fitness program of exercises in which the trainees use weights, barbells, dumbbells, and machines to increase individual strength (Chui, 1950). Recently, strength training has become an important physical fitness activity for many types of athletes and non-athletes due to its effect
upon body structures and functions. Hoffman (1939) recommended weight lifting as an effective means of physical training to develop visceral functions and skeletal and muscular structures. He believed that weight training produced a high level of physical conditioning in a minimum amount of time.

An understanding of the underlying scientific principles of exercise and training is critical for a successful weight training program. The physiological mechanisms of the human body are specific, therefore training programs must be designed with an emphasis on particular goals. Weight training, insofar as it is a resistance exercise which may be combined with a progressive overload principle, can produce appropriate resistance levels for specific tasks (DeLorme & Walkins, 1948).

However, exercise physiologists have long believed that rhythmic exercise, such as running and the other endurance activities, produces more favorable effects for circulorespiratory function than does weight training. A lack of improvement in aerobic power in response to weight training has been observed, even when such non-rhythmic exercises have involved sustained high levels of heart rate (Allen, Byrd, & Smith, 1976). More recent investigations involving weight training, including circuit weight training, have shown that non-rhythmic exercises which use small muscle groups can improve the circulorespiratory function (Gettman, Ayres, Pollock, & Jackson, 1978; Gettman & Hagan, 1981).
Darden (1973) went even further, insisting that high-intensity, variable-resistance strength training can be an essential component in producing a substantial increase in aerobic power.

Furthermore, circulorespiratory function measurements of high-caliber weightlifters have been reported to be above those of non-athletes (Fahey, Akka, & Rolph, 1975; Saltin & Astrand, 1967). Moreover, Stone, Carter, Smith, and Ward (1979a; 1979b) assumed that the weight training program performed by Olympic-style weight lifters contributed to their superior aerobic power.

Maximal oxygen uptake (\(V_02\) max) has been considered an essential part of physical fitness, and many investigations have studied the oxygen-carrying and delivery systems of the human body. The pulmonary system has received comparatively less research attention. Studies examining the effect of physical training on the lung volume of non-athletes indicate that training has little effect. However, selected pulmonary function measurements of athletes have been reported to be larger than those of non-athletes (Stuart & Collings, 1959).

Lung volume, measured as forced vital capacity (FVC) or forced expiratory volume (in one second, FEV\(_1\)), has been regarded in the past as an important parameter of physical fitness because of the close relationship between vital capacity and \(V_02\) max. It has been reported that a linear relationship exists when \(V_02\) max is compared to vital capacity
in individuals between the ages of 7 and 30 years (Astrand, 1952). Lyons and Tanner (1962) believed that this occurs because vital capacity is related to body size and age. More recently, Berger (1982) has stated that vital capacity and \( \text{VO}_2 \max \) are related to body size. However, a review of the literature concerning the relationship between pulmonary function and maximal oxygen uptake indicates that there are wide differences of opinion concerning this issue (see Chapter II, Review of Literature).

In the past, in attempts to find the best means of improving pulmonary function, investigators have concentrated on subjects who have trained by running or bicycling. Although weight training has been known to contribute to the acquisition of strength, power, and endurance, specific experimental evidence was not available concerning the effect of weight training on pulmonary function. In the absence of such information, the purpose of this study was to determine the effects of weight training on selected pulmonary function measurements.

**Statement of the Problem**

The purpose of this study was to measure the effects of an eight-week power weight training program and a conventional weight training program on forced vital capacity (FVC) and forced expiratory volume in one second (FEV\(_1\)) in college-aged male weightlifters. The study was structured
to determine possible changes in pulmonary function follow-

Hypotheses

The null hypotheses tested in this study were:

Hypothesis one: Pulmonary function, as expressed by

FVC and FEV₁, will not be modified by an eight-
week power weight training program or conventional
weight training program by college-aged males.

Hypothesis two: No differences exist between a power
weight training group and a conventional weight
training group in developing pulmonary function.

Assumptions

This study was based on the following assumptions:

1. All subjects represent their respective age groups.
2. FVC and FEV₁ are representative of selected pul-
monary function characteristics.
3. All subjects exerted maximum effort during weight
training sessions.
4. All subjects exerted maximum effort during pul-
monary function testing sessions.
5. All tests used in this study were reliable and
valid.
**Definition of Terms**

**Power Weight Training (Power Lifting):** A method of high-intensity training which utilizes large muscle groups (i.e. use of the bench press and the squat).

**Conventional Weight Training:** Weight training, utilizing many weightlifting exercises and incorporating low-intensity and high-volume resistance.

**Forced Vital Capacity (FVC):** The maximal amount of air that can be exhaled from the lungs by forceful effort after a maximal inspiration.

**Forced Expiratory Volume in One Second (FEV₁):** The maximal amount of air that can be forcefully exhaled in one second after maximum inspiration.

**Oxygen Uptake:** The amount of oxygen absorbed through the lungs and transported by the blood to bodily organs and tissues. Maximal oxygen uptake (VO₂ max) is the greatest amount of oxygen which the individual is capable of utilizing; it is measured during the performance of physical activity. The VO₂ max is often expressed in milliliters of O₂ per kilogram of body weight per unit of time (ml/kg/min), allowing comparison of maximal oxygen uptake between individuals of different body weights.

**Strength:** The ability of a muscle or a muscle group to produce force in a maximum exertion.
Set: A series of repetitions without a rest for a specific exercise. A set may be continuously repeated any predetermined number of times.

Repetitions: The number of times a dynamic contraction is repeated in a specific exercise set. One repetition maximum (1-RM) is the greatest load a muscle is able to contract against for one repetition. The maximum load a muscle can contract against for two repetitions is 2-RM, etc.

Station: An area where a specific exercise is performed.

Limitations

The following limitations were recognized in the study:

1. The subjects were tested at various times of the day because of their personal schedules.

2. The training period for the power weight training was limited to eight weeks: two weeks for the muscular endurance phase; two weeks for the strength phase; and four weeks for the power phase.

3. The subjects of the experimental groups were Caucasian volunteers who were enrolled either in a power weight training class or a beginning weight training class.

4. The motivation of subjects to perform to maximum capacity during testing or training could not be controlled.
5. The subjects' normal daily physical activities, diets, and sleeping habits could not be controlled.

**Delimitations**

The delimitations of the study were:

1. The subjects of the experimental groups consisted of 16 college-aged male volunteers with varying degrees of weight training experience.

2. The training program's core exercises for the power weight training group were the bench press and the squat.

3. The subjects of the beginning weight training class used a conventional weight training program.

4. The training session was limited to two one-hour training periods per week for eight weeks.

5. Pulmonary function testing was conducted during the pre-conditioning period and upon conclusion of the training period.

6. The control group was a selected group of volunteers, none of whom actively participated in any regular and rigorous exercise program.
II. Review of Literature

Introduction

Weight training has long been considered a method of developing specific qualities, such as strength and muscular endurance. Recent research has indicated that some form of weight training may have positive circulorespiratory effects. Byrd and Barton (1973) demonstrated that weight training utilizing the interval training method will suppress heart rate to levels comparable to those achieved in an endurance training program. Knuttgen, Nordesjo, Ollander, and Saltin (1973) suggested that the lack of circulorespiratory development in the traditional weight training investigation might be explained by the duration and intensity of training. They added that the lack of circulorespiratory development is partially explained by the use of exercise tests which do not accurately measure circulorespiratory effects.

Accordingly, in keeping with recent efforts to develop aerobic power through weight training, recent investigations have been directed at measuring the effect of weight training on the development of circulorespiratory endurance (Darden, 1973). Wilmore et al. (1978) found that positive
changes occurred in the circulorespiratory functions after an intense circuit weight training program.

Continuous physical training has generally been believed to promote development pulmonary function beyond the natural rate of increase in developing adolescents. Based on studies comparing the value of the pulmonary function of athletes and non-athletes at various age levels, the athletes showed larger than predicted lung volumes. Shapiro, Johnston, Dameron, and Patterson (1964) assumed that the increased total lung volume was accounted for by early physical conditioning. Additional studies indicated that training had a minimal effect on the vital capacity (VC) of post-adolescents. However, other researchers have reported that mature, young swimmers and old sedentary people were possible exceptions (Brynteson & Sinning, 1973; Swenson & Zanner, 1967).

Astrand (1952) noted that there was a significant relationship between VC and VO₂ max when analyzed in normally active subjects. In a more recent study by Raven (1977), however, no positive correlation was found between FVC and VO₂ max for distance runners. Consequently, a controversy still exists over whether or not pulmonary functions have a relationship to VO₂ max.

This chapter will cover in greater detail the available information concerning the relation between physical training, the circulorespiratory functions, and the respiratory
muscles. For convenience, the literature is divided into four major categories: 1) Respiratory muscle function; 2) Physical training and pulmonary function; 3) Pulmonary function and aerobic power; and 4) Weight training and aerobic power.

**Respiratory Muscle Function**

The primary function of respiratory muscles is to overcome pulmonary tissue, chest wall, and airway resistance. Airway resistance is determined by the magnitude of the interaction between the flowing gas molecules of an inspiration, the length of the airway, and the diameter of the airway radius. Because the effects of these factors are minimal, however, airway size and resistance are normally affected by other factors. While expansion of the lungs decreases airway resistance, expiration increases airway resistance. Airway size is also regulated by the parasympathetic neurons; the force from the chest wall, lungs, and accessory muscles provides energy, which is stored in the elastic structures and expended during the periods of expiration.

The diaphragm and external intercostal muscles are believed to be the primary muscles employed during quiet breathing. The movement of these muscles causes the ribs and sternum to move upwards, creating an additional increase of the anteroposterior and lateral diameters of the chest cavity. Campbell, Agostoni, and Davis (1970) reported that
the diaphragm contributes two-thirds of the tidal volume in sitting and standing positions and three-thirds in the spine position. Although expiration is a passive phase during quiet breathing, during exercise expiration is not passive: it is aided by contractions of the expiratory muscle, making it an active process. The internal intercostal and rectus abdominis muscles are responsible for increasing intrapleural pressure during expiration. When exercising, the large lung volume of inspired air is aided by contraction of two other inspiratory muscles: the scalene and sternocleidomastoid muscles. The extensor muscles of the back and neck, the trapezius, and the pectoral muscles are also believed to facilitate inspiratory breathing during vigorous exercise. In a structural assessment of respiratory muscles, there is a question of whether respiratory muscles adapt to training in a pattern similar to skeletal muscles.

Leith and Bradley (1976) examined respiratory mechanics before and after a five-week training program focusing on the ventilatory muscles. The study consisted of three groups of four subjects: control, strength training, and endurance training groups. The strength training group tried maximum static inspiratory and expiratory maneuvers at 20% intervals over the vital capacity volume for 30 minutes per day, 5 days per week. The endurance training group repeated normocarbic hyperpnea to exhaustion, 3 to 5 times per day. The study concluded that static contractions resulted
in increased respiratory muscle strength and that deep breathing improves endurance when it is done at high rates.

In an effort to determine the effect of diaphragmatic breathing exercises, Marrick and Axen (1981) evaluated three indices of inspiratory muscle functions in 20 healthy young adults before and after a six-week program of diaphragmatic breathing exercises. The subjects performed 30 maximal voluntary diaphragmatic contractions in the supine position, with a moderate to heavy weight three times per week. The results failed to prove the effectiveness of isotonic exercise on inspiratory capacity, peak inspiratory flow rate, and maximal pressure. However, it was concluded that the inspiratory muscles adapted to training in view of the fact that subjects each increased to the maximal weight they found tolerable.

Physical Training and Pulmonary Function

Athletes and physically active persons have greater lung volume than sedentary persons, and physical training has been the primary reason for improvement of pulmonary function. In a comparative study by Stuart and Collings (1959), the vital capacity (VC), maximum breathing capacity, and maximal voluntary ventilation (MVV)/vital capacity (VC) measurements of 20 athletes and 20 non-athletes were investigated to determine what influence physical training had upon pulmonary function. The investigators reported that the athletes had significantly larger vital capacities than
the non-athletes, while no significant differences were found in other measurements.

Shapiro et al. (1964) analyzed pressure-volume-flow relationships during maximum effort expirations and inspirations in 27 studies on 7 nonsmoking athletes, 5 nonsmoking non-athletes, and 7 non-athletic smokers. It was shown that the mean vital capacity, maximum breathing capacity, and airflow of the athletes were greater than those of other subjects during the first half of the forced inspiration.

A study by McKay, Braund, Chalmers, and Williams (1983) subjected 10 males and 15 females to lung function tests in order to determine pulmonary efficiency. The mean values for VC and FEV₁ were significantly greater in the male swimmers than in the females. They had a higher mean VC than the mean vital capacity predicted from Cournand's nomogram using age and height as indices.

Generally, physical training has been believed to develop the pulmonary functions in developing adolescents by producing a long trunk and a broad chest (Shephard, 1978). It has also been believed that physical training for adolescents would not affect vital capacity, with the possible exception of young swimmers and adult men. To test this hypothesis, Ekblom (1969) subjected 13 young males, all age 11, to 6 months of physical training. The subjects were divided into experimental and control groups. The former exercised at two submaximal workloads: at rates of 300 and
450 kpm/min for 6 minutes on a Krogh bicycle ergometer. After 15 minutes of rest, exhaustive exercises were performed for 3 to 5 minutes on a motor-driven treadmill. A significant increase in vital capacity was observed following the training.

Engstrom, Eriksson, Karlberg, Saltin, and Thoren (1971) investigated the development of lung volume in female swimmers, 9 to 13 years old, in a longitudinal study. It was indicated that the group which trained for one year or more had a mean vital capacity greater than normal.

However, controversies about the effects of endurance training on pre-adolescents have persisted. It has been assumed that training in this age group fails to increase pulmonary functions beyond the development caused by bodily growth. The lung function was studied over a three-year period in children in swim training by Andrew, Becklake, Guleria, and Bates (1972). Resting lung volumes, expiratory flow rates, and diffusing capacity during exercise were measured each year. Results were compared with the results of a control group which had undergone no specific athletic training program. The data showed that physical training between the ages of 8 and 18 affects lung function as well as the physical growth rate.

Vaccaro and Clarke (1978) observed cardiorespiratory alterations in a group of previously untrained 9 to 11 year old children, following 7 months of swimming training. Subjects consisted of 15 members of a competitive swim team.
Measurements on VC, FEV₁, and MVV were executed on three separate days, both before and after the training period. The results indicated that the mean changes in each measurement were not greater than what would have been predicted.

Reuschlein, Reddan, Burpee, Gee, and Rankin (1968) subjected eight freshmen university candidates who had no recent, rigorous physical training to a program which included distance running, weight training, general calisthenics, and specific training in rowing. At the end of the study, the authors concluded that there was no significant difference in pulmonary function as the result of rigorous physical training.

Brown, Harrower, and Deeter (1972) investigated 12 girls between the ages of 8 and 13 to determine the effects of cross-country running on aerobic power. Training periods were held four or five days a week and lasted from one to two hours, based on the age and maturity of the subjects. Training schedules generally called for progressive running over gradually increasing distances. After six weeks of training, the subjects competed every Saturday for eight weeks. No significant lung function changes were found after three months of training.

Brynteson and Sinning (1973) tested 21 subjects to determine the effects of differing weekly exercise exposures on retention of cardiovascular fitness. The subjects participated in five weeks of bicycle ergometer conditioning exercises, designed to increase the heart rate to 80% of its
maximum. They were divided into four experimental groups. Each group performed four separate workouts at the same work intensity for five more weeks. The investigators concluded that there was no significant pulmonary function increase as the result of training.

The studies cited above indicate that no effect of physical training on the lung function is observed after maturity is achieved, but that swimming possibly has an effect upon lung function.

An early study by Carey, Schaefer, and Alvis (1956) reported that a significant difference in lung volume existed between 16 instructors at the Escaping Training Tank, who had directed in-the-water instruction for an average period of one and a half years, and 16 adult males from the Medical Research Laboratory. The lung volumes of the tank instructors were markedly larger than those of the laboratory personnel. Following these tests, a longitudinal study was performed on a group of 20 tank instructors for a period of one year. The study revealed a significant increase in total lung capacity, vital capacity, inspiratory reserve, and tidal volume for the subjects.

Bachman and Horvath (1968) investigated pulmonary function changes as a result of differing types of physical training, assigning 29 males to 3 groups: a control group of 9, a swimming group of 12, and a group of 8 wrestlers. With the exception of the control group, the subjects underwent four months of standard athletic conditioning. Signif-
Significant changes in lung volume were found only in the swimming group, and no significant alterations of pulmonary function occurred in the other two groups. They concluded that training in a swimming program reduced the residual volume, functional residual capacity, and inspiratory rate level and caused the pulmonary volume to change.

Older males, between the ages of 52 and 87, were tested by deVries (1970) to determine their response to rigorous exercise training. Six men underwent calisthenics, jogging, and either stretching exercises or swimming programs for approximately one year. Significant increases in VC (19.6%) were found to result from the program. It was concluded that older, sedentary males respond to physical training at a greater rate than had been thought and that training effectiveness at an old age is not related to the amount of previous training in youth.

Wilmore, Roche, Girandola, Katch, and Katch (1970) studied the physiological effect of a ten-week jogging program. Subjects were divided into 2 groups, one of which exercised 12 minutes per day, 3 days per week, while the other group trained 24 minutes per day, 3 days per week. After 10 weeks of training, both groups demonstrated significant increases in VC. A decrease in residual lung volume was observed in the group which trained 12 minutes per day, whereas the group which trained 24 minutes per day showed a decrease in maximal tidal volume.
Pulmonary Function and Aerobic Power

Maximal oxygen uptake (VO₂ max) and pulmonary functions have been described as important characteristics of endurance athletes. Many investigations have been undertaken for the purpose of developing the best training programs for the development of oxygen transport and delivery systems within athletes. However, little agreement has been obtained concerning the relationship between pulmonary function characteristics and VO₂ max. In 1952 Astrand suggested that there was a significant relationship between vital capacity and VO₂ max when analyzed in normally active subjects, but that a number of comprehensive studies had failed to reach agreement on this point. In a subsequent study, Astrand (1960) examined the FEV₁ of 44 healthy females, aged 20 to 65. The subjects were tested in a seated position, and a correlation of 0.08 was found between FEV₁ and the maximal oxygen uptake. It was reported that there was little correlation between vital capacity and their oxygen uptake capacity and maximum ventilation among healthy adults.

Ishiko (1967) investigated the relationship between maximal oxygen uptake and pulmonary function characteristics. Track and field athletes and oarsmen who were candidates for the Tokyo Olympic Games were Ishiko's subjects, and testing showed that no significant correlation existed between oxygen uptake and pulmonary function characteristics.
Sinning and Adrian (1968) employed 7 members of a women's collegiate basketball team and a control group of 8 non-active females to study the effects of a season of basketball on selected cardiorespiratory characteristics. Subjects underwent 25 organized practices and 7 games over a 66 day period. The results revealed a significant change in only maximal VO$_2$ for the basketball team group, an increase from 34.4 to 38.8 ml/kg per min. No pulmonary function characteristics showed concomitant improvement.

In a recent study, Palatsi, Niemela, and Takkunen (1980) compared pulmonary function to the relationship between the forced vital capacity and maximal oxygen uptake of well-trained runners performing speed or endurance training. The subjects included 21 male runners (9 sprinters and 12 endurance runners), with 12 sedentary males as a control group. The FEV$_1$ was determined with a water spirometer, and oxygen uptake was measured while subjects performed on an electrically braked bicycle ergometer. The results revealed that the FVC of the sprinters was higher than that of the endurance runners (p < .05). No other differences between any of the test group participants were found for the pulmonary values. The average VO$_2$ max was higher for the endurance runners than for the sprinters, although no significant differences were shown between the sprinters and the control group. The FVC of the sprinters was related to VO$_2$ max, but no significant correlation was noted for the endurance runners.
The literature concerning the relationship between pulmonary function and VO$_2$ max shows that wide differences exist. Astrand et al. (1963) sought to determine the effects of competitive swimming training on female swimmers 12 to 16 years of age. Initial testing revealed that the average lung volumes of the subjects were above those of other girls of the same size and age. Following the training, Astrand found that vital capacity and FEV$_1$ were significantly related to VO$_2$ max. Holmgren (1967) studied the relationships between VO$_2$ max and selected ventilatory measurements, employing 10 conditioned young males and 10 conditioned young females as subjects. It was observed that there was a correlation between the maximal oxygen uptake of the subjects and their VC and FEV$_1$ measurements.

**Weight Training and Aerobic Power**

Determining the actual circulorespiratory effect of weight training has been a major concern to investigators. Evidence to support positive effects or non-effects is inconclusive and equivocal. However, recent trends have suggested that the primary differences are associated with the type of weight training undergone, and a number of studies have been published regarding changes in aerobic power as a consequence of specific types of weight training.

Nagle and Irwin (1960) sought an indication of improved circulorespiratory responses by weight training groups following training. In a eight-week training program, one
weight training group used a system of low-repetition and high-resistance exercises, while the other weight training group used a system of high-repetition and low-resistance exercises. Though there was an indication of change in circulorespiratory responses, statistical treatment of the data showed no significant differences between the two groups.

In another study concerning the effects of anabolic steroid, Fahey and Brown (1973) reported that there were no significant differences in aerobic power after a nine-week training program. Twenty-eight male college students underwent power weight training three times per week. The training program consisted of a few sets and repetitions which emphasized the maximum resistance.

More recently, Hickson, Rosenkoetter, and Brown (1980) sought to determine if heavy-resistance training resulted in aerobic power and whether there was a relationship between aerobic power and strength. The subjects were nine men who performed an exercise program designed to develop the strength of the quadriceps muscle. The exercise consisted of weight training 5 days a week for 10 weeks. Following the training, a small increase in VO2 max was observed, but no significant differences were observed when expressed in ml/min. The results of the study suggested that increases in strength might be capable of increasing endurance capacity without an accompanying increase of VO2 max.

These studies have supported the concept that non-circuit weight training is not beneficial to developing the
circulorespiratory system. The conventional weight training programs have been too intermittent and have emphasized the use of heavy weights with repetitions, along with long rest intervals. In 1976 Allen et al. concluded that this traditional type of training program does not develop the circulorespiratory functions. Comparative studies, however, have reported that the $\text{VO}_2\text{ max}$ of weight lifters is above that of non-athletes.

Fahey, Akka, and Rolph (1975) examined the maximal oxygen uptake of 30 exceptional athletes who had trained extensively with weights. The $\text{VO}_2\text{ max}$ was determined on a bicycle ergometer by the open circuit method. The weight lifters in this study showed higher mean $\text{VO}_2\text{ max}$ values than did a group of sedentary individuals in an earlier test by Buskirk and Taylor (1957).

Recently, Stone, Wilson, Blessing, and Rozenek (1983) reported on the circulorespiratory responses to Olympic-style weight training by nine males over an eight-week period. The subjects exercised with the training program used by various weight-lifting teams in Europe and the United States. At the end of this period of Olympic-style weight lifting, a small but significant increase in $\text{VO}_2\text{ max}$ was determined.

Circuit weight training is another mode of exercise to develop circulorespiratory function and muscular strength. Circuit weight training is characterized by multiple repetitions and multiple sets of exercises, with submaximal weight
resistance and limited rest periods. Milesis et al. (1976) and Gettman et al. (1976) have both reported significant improvements in cardiorespiratory function.

Peterson (1975) examined the effects of high-intensity strength training. Thirty-two football players were employed as subjects, each of whom performed a 10-exercise routine with exercise time averaging between 28 and 37 minutes. Cardiovascular changes were evaluated by measuring multiple physiological parameters. It was concluded that circuit weight training significantly improved the cardiovascular condition of the subjects.

Wilmore et al. (1978) performed a study to determine the physiological consequences related to weight training. Twelve college women and 16 college men exercised in a 10-week circuit weight training program, consisting of 10 stations performed on a Universal Gym, 3 circuits per day, 3 days per week. The subjects exercised at 40 to 55 percent of maximum strength, executing as many repetitions as possible in 30 seconds, while resting between stations for 15 second. The male subjects showed improvement in treadmill time to the exhaustion phase following the circuit weight training program. For the female subjects, significant changes in VO$_2$ max, maximum expiratory volume, and treadmill time to exhaustion were observed.

Gettman, Culter, and Strathman (1980) compared the effects of isotonic circuit training with isokinetic circuit training on physiological changes. Aerobic power (VO$_2$ max)
was measured prior to and following 20-week programs of isoto-
tonic and isokinetic circuit training by two groups of sub-
jects. After testing was administered, training took place 
3 days weekly over a 20-week period. Subjects were randomly 
assigned to either of the two groups. Subjects in the 
isokinetic program exercised at a slow speed of movement, 
while the isotonic training group exercised at approximately 
the same speed of movement on Nautilus equipment. During 
workout sessions the subjects performed two exercise cir-
cuits with 12 repetitions per exercise. The subjects in the 
isotonic group worked at 50% of maximum lifting capacity 
throughout the training program. The results indicated that 
both groups had significant increases in VO2 max and (7 and 
8% increases, respectively, for the isotonic and isokinetic 
groups).

Based upon the review of related investigations, im-
provement of aerobic capacity depends on the intensity, vol-
ume, and frequency of the training protocols. The subject's 
age and prior training status also affect improvement. The 
performance of multiple repetitions and sets, using submaxi-
mal weight resistance, is believed to be a critical factor 
in improving aerobic power. At the present time, of all the 
weight training programs, circuit weight training is the one 
most often prescribed for the improvement of aerobic capac-
ity.
III. Methodology

Introduction

The purpose of this study was to examine the effect of a power weight training program and a conventional weight training program on forced vital capacity (FVC) and forced expiratory volume in one second (FEV₁). A comparison was also made to determine what effective differences existed between the two training protocols in selected pulmonary function characteristics. This study was conducted at Oregon State University, Corvallis, Oregon, during Winter term, 1986. The testing of the subjects was done in the Exercise Science Instructional Laboratory of the Department of Physical Education. The weight training room was the site of the training portion of the study. This chapter will delineate the procedure used in subject selection and information concerning training methods, testing procedures, instrumentation, and statistical analysis.

Subjects

The subjects utilized in this study were 23 healthy college male students of Oregon State University. The population pool consisted primarily of male students enrolled in physical education activity classes, who were recruited dur-
ing the first week of Winter term, 1986. The subjects were divided into two experimental groups and a control group. Nine subjects enrolled in the beginning weight training class exercised with the conventional weight training program. Seven subjects enrolled in a power weight training class exercised with the power weight training program. Seven subjects enrolled in a beginning bowling class did not participate in any weight training activities and acted as the control group. Limited experience with weight training was required for both experimental groups in this study. Ages in the groups ranged from 18 to 23 years with a mean age of 20.39 years. The mean height was 179.78 cm, and the mean weight was 78.89 kg (see Table 1). The mean ages of the power weight training and conventional weight training groups, respectively, were 20.42 and 20.00 years; the mean heights were 180.94 and 181.09 cm; and mean weights were 87.65 and 77.49 kg.

Table 1. Physical Characteristics of Subjects (N=23).

<table>
<thead>
<tr>
<th>Age (yrs)</th>
<th>Ht (cm)</th>
<th>Wt (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>20.39</td>
<td>179.78</td>
</tr>
<tr>
<td>S.D.</td>
<td>1.58</td>
<td>4.77</td>
</tr>
<tr>
<td>Range</td>
<td>18-23</td>
<td>172.74-190.4</td>
</tr>
</tbody>
</table>

Details of this study were explained verbally and in writing to each subject prior to the signing of the Informed Consent Release (see Appendix E), which was obtained from
each subject volunteering for the study before the testing procedures were administered. This release explained the necessary procedures, possible risks, and termination privileges. Any subject who had previously engaged in vigorous weight training was rejected. The control group was requested to maintain their normal levels of activity during the eight-week experimental training period. The control group also agreed not to perform weight training or strenuous sports activities during this period. One subject from the power weight training group was dropped from the study because of personal problems.

Training Procedures

Power Weight Training Program

The power weight training program was composed of three phases: 1) the muscular endurance phase; 2) the strength phase; and 3) the power phase. All subjects participated in a two-week pre-conditioning program which preceded the eight-week experimental training period. During the two-week pre-conditioning period general weight training exercises were emphasized. Instructions were provided for correct techniques of power lifting (squat and bench press) as stated in the International Federation Rules governing the execution of power lifts.

Squat: The lifter assumes an upright position with the bar across his shoulder in a horizontal position, not more than one inch below the top of the deltoids, hands gripping
the bar, feet flat on the floor. From that position the lifter bends his knees and lowers his body until the tops of his thighs are parallel with the floor and then, without bouncing and with vigorous drive, ascends to the starting position.

Bench press: The lifter lays prone on the bench with the bar held at arm's length above the chest, with head and buttocks in contact with the bench and feet flat on the floor and chose to the bench. From the starting position, the bar is lowered to the chest, and then with a vigorous drive the bar is returned to the starting position. Throughout the lifting movement, head and buttocks remain in contact with the bench. No heaving or bouncing of the bar from the chest is permitted.

During the pre-conditioning period moderate loads were used, with from 8 to 12 repetitions for 3 sets. After the conclusion of the conditioning period, the subjects were instructed to measure their one-repetition maximum (1-RM) lift in the bench press and squat. The 1-RM served as the baseline for selecting initial workout weights and for the establishment of intensity level during the experimental weight training period. The experimental training period was conducted in three phases. During each phase of training, in addition to emphasis on the bench press and squat, the subjects underwent a mini-weight circuit, consisting of arm raises, leg extensions, leg curls, dumbbell presses, sit-ups, pull-ups, and dumbbell flies. All subjects com-
pleted two sets of the mini-weight circuit, the purpose of which was to stress the respiratory muscles through forceful breathing.

Phase 1, the muscular endurance phase, lasted two weeks and was followed by progressive and resistive weight training in which the intensity of the workout was increased weekly. The subjects started at 70% of their 1-RM, performing five to seven repetitions in three sets, twice per week. The general workout schedule consisted of a five-minute warm-up, warm-up sets for the bench press and squat, training sets for the bench press and squat, and a mini-weight circuit.

Phase 2, the strength phase, lasted two weeks and was progressive, requiring the subjects to lift at 80% of their 1-RM. All subjects performed two sets of four to five repetitions.

Phase 3, the power phase, lasted four weeks and consisted of a split program of medium and heavy days. Heavy-day workouts consisted of three sets of two to three repetitions at 90% of 1-RM in the bench press and squat. Light-day workouts consisted of three sets of five to seven repetitions at 70% of 1-RM. The schedule of increased loads in the bench press and squat was modified to the individual's ability. A sample workout for each phase is listed in Appendix A.
**Conventional Weight Training Program**

Initially, the purposes of conventional weight training and the general procedures to be followed were explained. The subjects were acquainted with the weights, barbells, and dumbbells. The conventional weight training program consisted of three phases, all of which were completely supervised at all times, ensuring that each subject followed proper techniques.

Phase 1 lasted two weeks, during which all subjects did 15 to 20 repetitions of each set of each exercise at a starting load based on a percentage of individual body weight. A 30-second rest period followed each work interval. The exercises used in this phase are listed in Appendix B.

Phase 2 lasted two weeks, during which each subject performed 3 sets of 10 to 15 repetitions. Resistance was increased as soon as each subject could easily manage the prescribed number of repetitions. If the subject was not able to reach the minimum number of repetitions, resistance was adjusted until the prescribed number of repetitions could be performed. The exercises for this phase are listed in Appendix C.

Phase 3 lasted four weeks, consisting of low-intensity, high-repetition traditional weight training with such instruments as barbells, dumbbells, and machine training. The training protocol is indicated in Appendix D.
Instrumentation

Generally, the pulmonary function is characterized as forced vital capacity (FVC) and forced expiratory volume in one second ($\text{FEV}_1$). To test the hypotheses, FVC and $\text{FEV}_1$ values were measured immediately before and after the training period, using a Collins 13.5-liter spirometer with a function analyzer calibrated to measure volume (Warren E. Collins, Inc., Braintree, MA). Pulmonary function testing was initially done on two separate days at the Exercise Science Instructional Laboratory of the Department of Physical Education. Pulmonary function tests were carefully controlled to ensure the reliability and validity of the base value. The subjects were tested again following the eight weeks of experimental training to quantify changes in pulmonary function. The post-training value was compared with the base value. Data for the selected pulmonary function measurements consisted of the highest scores recorded in three trials during each measuring period.

Testing Procedures

Pulmonary Function Test

The subjects of both the experimental group and the control group were given a learning session in order to familiarize them with the use of the spirometer. The initial measurements were taken during the pre-conditioning period, following the learning session. The purpose of the learning
period was to reduce any possible learning effects. All pulmonary function values measured were converted to body temperature and pressure saturated (BTPS). The 13.5-liter Collins spirometer was used to measure the air volume expelled during dynamic ventilation.

The subjects were seated and wore nose clips to prevent the leaking of unmeasured air during testing (see Figure 1). Before the subjects executed the maximal blow, two or three practice breaths were allowed. Each subject was individually tested by instructing him to slowly inhale as deeply as possible and then exhale as quickly, forcefully, and as completely as possible. The test was repeated three times, with brief rest periods between each test. The highest scoring FVC tracing for each subject was analyzed in accordance with the methods of Kory, Collahan, Boren, and Syner (1961) and was recorded as that subject's FVC. The FEV\textsubscript{1} measurement was taken by tracing FVC over one second.
Figure 1. Pulmonary Function Testing
Statistical Analysis

The statistical analysis was processed by computer in the Computer laboratory of the College of Health and Physical Education. The pre-test and post-test mean differences of the power weight training group and the conventional weight training group were compared to the corresponding scores of the control group in order to examine the effects of training on selected pulmonary function characteristics. A paired t-test was used to determine if a significant difference existed between correlated mean scores obtained on the pre-test and the post-test. The results of the two training programs were also analyzed using a one-way analysis of covariance (ANCOVA). The 0.05 level of significance (p < .05) was selected for acceptance or rejection of the hypotheses formulated.
IV. Results and Discussion

Introduction

The effects of a power weight training program and a conventional weight training program on selected pulmonary function characteristics were investigated and analyzed statistically using paired t-test and one-way analysis of covariance (ANCOVA). The subjects were measured for forced vital capacity (FVC) and forced expiratory volume in one second (FEV$_1$) during the pre-conditioning period and at the conclusion of the study.

The null hypotheses of primary interest were that pulmonary function, as expressed by FVC and FEV$_1$, would not be modified by an eight-week power weight training program or a conventional weight training program, and that no difference would exist between the two groups in developing greater pulmonary functions.

Paired t-tests were used within experimental and control groups on each of the variables (Dowine & Heath, 1974). One-way analysis of covariance was employed to determine the significant differences between the two training programs with the pre-test mean score as the covariate and post-test mean score as a dependent variable (Courtney, 1984). This
Results and Discussion

The means, standard deviations, standard errors, and the values of the t-statistics were computed (see Tables 2 and 3). The mean for FVC for the power weight training group increased from 5.70 liters in the pre-test to 5.84 liters in the post-test. There were minimal mean gains in the conventional weight training group, increasing from a pre-test mean of 5.38 to a post-test mean of 4.81 liters, and a post-test mean of 4.85 liters.

There was no increase in FEV₁ in the experimental groups, and a decrease of FEV₁ value was observed in the control group after the eight-week period. The difference between the pre-test mean and post-test mean value for each group was compared using the paired t-test. The results of these calculations showed that there were no significant differences between the mean values of the FVC or FEV₁ obtained in either the pre-test or the post-test.
### Table 2. T-Test Values for Pre-Test and Post-Test FVC.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>S.D.</th>
<th>S.E.M.</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-Test</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Training</td>
<td>5.70</td>
<td>.53</td>
<td>.02</td>
<td></td>
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<tr>
<td>Conventional Training</td>
<td>5.38</td>
<td>.81</td>
<td>.27</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>4.81</td>
<td>.84</td>
<td>.32</td>
<td></td>
</tr>
<tr>
<td><strong>Post-Test</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Training</td>
<td>5.84</td>
<td>.58</td>
<td>.22</td>
<td>-1.187</td>
</tr>
<tr>
<td>Conventional Training</td>
<td>5.39</td>
<td>.87</td>
<td>.29</td>
<td>-0.06</td>
</tr>
<tr>
<td>Control</td>
<td>4.85</td>
<td>.92</td>
<td>.35</td>
<td>-0.689</td>
</tr>
</tbody>
</table>

**Decision:** null hypothesis was retained.

### Table 3. T-Test Values for Pre-Test and Post-Test FEV₁.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>S.D.</th>
<th>S.E.M.</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-Test</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Training</td>
<td>4.8</td>
<td>.67</td>
<td>.25</td>
<td></td>
</tr>
<tr>
<td>Conventional Training</td>
<td>4.33</td>
<td>.8</td>
<td>.26</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>3.79</td>
<td>.67</td>
<td>.25</td>
<td></td>
</tr>
<tr>
<td><strong>Post-Test</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Training</td>
<td>4.8</td>
<td>.74</td>
<td>.28</td>
<td>-0.037</td>
</tr>
<tr>
<td>Conventional Training</td>
<td>4.33</td>
<td>.75</td>
<td>.25</td>
<td>.129</td>
</tr>
<tr>
<td>Control</td>
<td>3.69</td>
<td>.64</td>
<td>.24</td>
<td>.6</td>
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</tbody>
</table>

**Decision:** null hypothesis was retained.
A one-way analysis of covariance with the pre-test FVC mean score as the covariate at the 0.05 level of significance was used to determine the mean difference between the power weight training group and conventional weight training group after the eight-week training period. The F-ratio was calculated after treatment of the data by a one-way analysis of covariance. The calculated variance after the eight-week training period revealed that there was no difference between the two experimental groups (see Table 4).

A one-way analysis of covariance was also used to determine any significant differences of FEV\textsubscript{1} between the power weight training group and the conventional weight training group at the end of the training period. The obtained F-ratio indicated that no difference existed between the two groups (see Table 5).


<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>.062</td>
<td>1</td>
<td>.062</td>
<td>.84</td>
</tr>
<tr>
<td>Within</td>
<td>.963</td>
<td>13</td>
<td>.074</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>1.02</td>
<td>14</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Decision: null hypothesis was retained.
Table 5. Analysis of Covariance Between Power Weight Training Program and Conventional Weight Training Program on Forced Expiratory Volume In One Second.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
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<td>1</td>
<td>.0005</td>
<td>.04</td>
</tr>
<tr>
<td>Within</td>
<td>.158</td>
<td>13</td>
<td>.012</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>.159</td>
<td>14</td>
<td></td>
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</tr>
</tbody>
</table>

Decision: null hypothesis was retained.

The results of this study have provided material for discussion of the mean values for pulmonary function measurements and how these measurements are affected by training. When the pre-test mean and the post-test mean values were compared, it was found that the power weight training group, the conventional weight training group, and the control group showed a minimal increase in FVC and FEV₁. The values of the repeated measurements of FVC ranged from 6.68 to 3.66 liters. The mean of the repeated measures of FVC was 5.35 liters, when all subjects were considered as a single group. This mean value was lower than the predicted mean of 5.38 liters, calculated from the composite average age of 20.39 and height 179.78 cm of the mean and using the nomogram structured by Kory et al. (1961). There was only minimal change in the FVC as a result of training, and the values of FEV₁ were decreased in the conventional weight training group and control group. At the present time the
decreased values of FEV\(_1\) cannot be explained based upon any physiological theory.

The results support the general belief that strengthening respiratory accessory muscles is not related to increasing pulmonary function, even though Bachman and Horvach (1968) suggested that an increase in strength of intercostal musculature could be a factor in the increase of the inspiratory capacity, which in turn is related to increased vital capacity. Stuart and Collings (1959) and Maksud et al. (1971) suggested that the respiratory accessory muscles respond to physical training in the same way as other muscles, and that development of the respiratory musculature may be responsible for high values of selected pulmonary function measurements.

The evidence generated by this study indicates that pulmonary function is not affected by weight training and that no differences exist between the two weight training protocols. The null hypotheses were retained at the level of 0.05 significance (p < .05). These results may be explained by the fact that adolescent training has a minimal effect on development of pulmonary function. This conclusion is based upon numerous investigations by Berryhill et al. (1968), Brynteson and Sinning (1973), Reuschlein et al. (1968), and Swenson and Zanner (1967). The lack of effectiveness of physical training on pulmonary functions at maturity was noted in these studies.
Ekblom (1969) and Shapiro et al. (1964) have suggested that physical training during growth should have a potentially greater effect on lung capacity. In conclusion, perhaps early weight training would contribute to the development of the chest and trunk, thus increasing pulmonary function beyond the rate of natural growth. However, further study on early training is required in order to validate this theory.
V. Summary, Conclusions, and Recommendations

Summary

The purpose of this study was to determine the effects of an eight-week power weight training program and a conventional weight training program on selected pulmonary function measurements (FVC and FEV₁). A secondary purpose was to compare the effects of a power weight training program to a conventional weight training program, with respect to the development of pulmonary function.

The subjects for the study were 23 male college undergraduates of Oregon State University, ranging in age from 18 to 23 years. At the time of selection, each subject was enrolled in either: 1) a power weight training activity class; 2) a beginning weight training class; or 3) a beginning bowling class. The power weight training group and the control group (from the bowling class) consisted of seven subjects each, and the conventional weight training group consisted of nine subjects.

Prior to the start of the experimental period, the pulmonary function of all subjects were tested. The experimental groups were engaged in intense power weight training and conventional weight training sessions of one hour each, two days per week for a period of eight weeks. The core exer-
cises of the power weight training group were the bench press and the squat, as well as a mini-weight circuit. The conventional weight training group executed the basic low-intensity, high-repetition weight training program in the form of circuit training. Following the training period, a test was administered to determine the effects of the two programs of weight training on pulmonary functions.

The results were analyzed using the paired t-test to determine if there were significant differences between the pre-test and post-test mean scores. Comparisons of the result of the two training programs were made by using a one-way analysis of covariance.

Although there were changes in the values of FVC and FEV$_1$ in each group, they were statistically insignificant ($p < .05$). Also, no significant differences were found between the power weight training group and the conventional weight training group in the selected pulmonary function measurements (FVC and FEV$_1$) ($p < .05$).

**Conclusions**

Based upon the results of the eight-week power weight training and conventional weight training programs, the increase in FVC and FEV$_1$ for the two experimental groups was not significant between the means of the pre-test and post-test values. Therefore, it was concluded that neither power weight training nor conventional weight training had signif-
significant effects on pulmonary functions in this selected sample.

The hypothesis stating that there is no significant difference between the means of FVC and FEV₁ for students in a power weight training program and a conventional weight training program as a result of training was retained (p < .05). Differences between the two training methods were not reflected by differences in FVC or FEV₁ (p < .05).

Recommendations

The following recommendations are made as a result of this investigation:

1. Further research is needed to ascertain the influence of weight training on pulmonary function measurements in developing adolescents. There exists a need to determine if early weight training produces any further increase of pulmonary functions beyond the increase occasioned by growth.

2. Random selection of the population, including unfit individuals, should be included in future studies.

3. Specific research should be directed at determining the effect of circuit weight training on pulmonary functions.

4. A longitudinal study should be conducted to determine the effect of weight training on pulmonary functions.
5. A larger number of subjects should be included in any future study.

6. Comparative studies on pulmonary functions and VO_{2 max} should be conducted.
Bibliography


Appendix
Appendix A

Sample Program for Power Weight Training--Squat and Bench Press

Phase 1:

<table>
<thead>
<tr>
<th>Week</th>
<th>Workout poundage</th>
<th>Repetitions</th>
<th>Sets</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>70% of 1-RM</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>6</td>
<td>3</td>
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</table>

Phase 2:

<table>
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<th>Workout poundage</th>
<th>Repetitions</th>
<th>Sets</th>
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<tr>
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<td></td>
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Phase 3: Split program

Tuesday

<table>
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<th>Week</th>
<th>Workout poundage</th>
<th>Repetitions</th>
<th>Sets</th>
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<td>5</td>
<td>70% of 1-RM</td>
<td>5</td>
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<td>6</td>
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Thursday

<table>
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<th>Week</th>
<th>Workout poundage</th>
<th>Repetitions</th>
<th>Sets</th>
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<td>5</td>
<td>90% of 1-RM</td>
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<td>3</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
<td>3</td>
<td></td>
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<tr>
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<td>6</td>
<td>3</td>
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Sample Workout

<table>
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Appendix B

Sample Workout for Conventional Weight Training

**Phase 1**

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Sets</th>
<th>Repetitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Military Press</td>
<td>3</td>
<td>15-20</td>
</tr>
<tr>
<td>2. Bench Press</td>
<td>3</td>
<td>15-20</td>
</tr>
<tr>
<td>3. Standing Barbell Curl</td>
<td>3</td>
<td>15-20</td>
</tr>
<tr>
<td>4. Sit-Ups</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td>5. Pull-Ups</td>
<td>3</td>
<td>15-20</td>
</tr>
<tr>
<td>6. Bench Step</td>
<td>3</td>
<td>15-20</td>
</tr>
<tr>
<td>7. Leg Curl</td>
<td>3</td>
<td>15-20</td>
</tr>
<tr>
<td>8. Leg Raise</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td>9. Calf Raise</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td>10. One Arm Row</td>
<td>3</td>
<td>15-20</td>
</tr>
</tbody>
</table>
Appendix C

Sample Workout for Conventional Weight Training

**Phase 2**

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Sets</th>
<th>Repetitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Seated Dumbbell Military Press</td>
<td>3</td>
<td>10-15</td>
</tr>
<tr>
<td>2. Pull-Ups</td>
<td>3</td>
<td>Maximum</td>
</tr>
<tr>
<td>3. Dumbbell Bench Press</td>
<td>3</td>
<td>10-15</td>
</tr>
<tr>
<td>4. Three-Way Deltoid Raises</td>
<td>3</td>
<td>10-15</td>
</tr>
<tr>
<td>5. Lungs</td>
<td>3</td>
<td>10-15</td>
</tr>
<tr>
<td>6. Abdominal Crunch</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>7. Round Back Deadlift</td>
<td>3</td>
<td>10-15</td>
</tr>
<tr>
<td>8. Calf Raises</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>9. Bar Dips</td>
<td>3</td>
<td>Maximum</td>
</tr>
<tr>
<td>10. Preacher Curls</td>
<td>3</td>
<td>10-15</td>
</tr>
</tbody>
</table>
## Appendix D

Sample Workout for Conventional Weight Training

### Phase 3

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Sets</th>
<th>Repetitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Bench Press</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>2. Squat</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>3. Military Press</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>4. Leg Curls</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>5. Pull-Ups</td>
<td>3</td>
<td>Maximum</td>
</tr>
<tr>
<td>6. Good Mornings</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>7. Inclined Sit-Ups</td>
<td>3</td>
<td>25</td>
</tr>
<tr>
<td>8. Arm Curls</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>9. Tricep Extension</td>
<td>3</td>
<td>8</td>
</tr>
</tbody>
</table>
Appendix E

Informed Consent Release

In consideration of the benefits to be derived and the data to be generated, the undersigned, a student of Oregon State University, agrees to participate in the research project, "The Effects of Power Weight Training and Conventional Weight Training on Pulmonary Function," under the direction of J. P. O'Shea, Professor of Physical Education, Oregon State University.

The undersigned states that he has read an outline of the proposed study, including the possible risks and benefits, and is participating voluntarily and consents to following the testing and training program outlined. The undersigned also agrees to the use of the data generated as the above agencies may desire.

At any time during the study, if circumstances should arise and the undersigned cannot complete the study, he is free to discontinue.

Oregon State University, as an agency of the State of Oregon, is covered by the State Liability Fund. If any injuries are suffered as a result of the research project, compensation would be available only if it is established that the injury occurred through a fault of the University, its officers or its employees.

__________________________
Participant

__________________________
Date