EFFECTS OF CONTINUOUS AND INTERVAL RUNNING PROGRAMS ON AEROBIC AND ANAEROBIC CAPACITIES OF HIGHSCHOOLBOYS AGED 14-16 YEARS

A Master's Thesis Presented

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Scope and method of study:Effects of eight weeks of continuous and interval running programs on maximum aerobic and anaerobic power were assessed comparatively in 43 Turkish highschoolboys aged 14-16 years. In addition effects of these training methods on percent body fat, lean body weight, resting heart rate and resting blood pressure were also studied. The subjects were categorised into a control (n=15), a continuous running (n=14), and an interval running (n=14) groups. Standardized field tests were used to measure the subjects' aerobic and anaerobic capacities. All measurements were accomplished within one week before and one week after the study. Subjects within the continuous running group ran 4.8km three times a week for eight weeks at 80% of their maximum heart rate (HR max). The interval group ran four sets of 1.2 km (total 4.8 km) at 90% of subjects' HRmax with a work-to-relief ratio of 1:1.A ten-second post-exercise heart rate was used to ascertain the intensity of the exercise programs. The control group had no exercise regimes. Statistical analysis included paired t-Test and Analysis of Variance (ANOVA).
Findings and Conclusions: In general, improvements in aerobic power of 9.92%, 18.13% and 24.12% were found ($P<0.05$) in the control group, continuous running and interval running categories respectively.

Improvements in anaerobic power of 6.78%, 11.16% and 10.55% were found in the control, continuous, and interval running categories respectively. However there was no significant difference among the groups ($P>0.05$).

In contrast to the control group, the exercising groups resting heart rate was reduced ($P<0.05$). It was reduced 13.78% and 11.06% in the continuous and interval running groups, respectively.

In exercising groups percentage of body fat was lowered in contrast to control group. It was reduced 9.67% and 13.13% in continuous and interval running groups, respectively. However, these changes were not found significant ($P>0.05$). Meanwhile, lean body weight of subjects in all categories was slightly increased but this increment was not significant ($P>0.05$).

Also, non-significant decreases in resting systolic and diastolic blood pressures were noted in all subjects at different categories ($P>0.05$) except diastolic blood pressure of subjects in control group.

ADVISER's APPROVAL ____________________

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Konu: DEVAMLI VE INTERVAL KOŞU PROGRAMLARININ 14-16 YAŞ ERKEK LİSE ÖĞRENCİLERİNİN AEROBİK VE ANAEROBİK KAPASİTELERİ ÜZERİNE ETKİLERİ
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Çalışmanın Metodu ve Alanı:8 haftalık devamlı ve interval koşu programlarının 14-16 yaş grubu toplam 43 Türk erkek lise öğrencisinin aerobik ve anaerobik kapasiteleri, üzerindeki etkileri karşılaştırmalı olarak tesbit edildi. Buna ilaveten bu antreman metodlarının öğrencilerin vücut yağ yüzdesi, yağsız vücut ağırlıkları, istirahat kalp atım sayıları ve istirahat kan basınçları üzerindeki etkileri ayrıca araştırıldı. Denekler kontrol grubu (n=15), devamlı koşu grubu (n=14) ve interval koşu grubu (n=14) olarak kategorilere ayrıldı. Deneklerin aerobik ve anaerobik kapasitelirini ölçmek için standardize edilmiş alan testleri uygulandı. Bütün ölçümler antrenman programından bir hafta önce ve bir hafta sonra gerçekleştirildi. Devamlı koşu grubundaki denekler 8 hafta boyunca haftada 3 kez olmak kaydıyla 4.8 km. mesafeyi maksimum kalp atım sayılarının %80 ile koştular. Interval gruptaki denekler ise aynı mesafesi (4.8 km) 1.2 km'lik 4 set şeklinde maksimal kalp atım sayılarının %90'ına eşit bir yüklenme ile koştular. Yüklenme ve dinlenme oranı 1:1 olarak belirlendi. Egzersizin şiddetini tesbit etmek için egzersizin hemen bitiminde alınan 10 saniyelik kalp atım sayısı kullanıldı. Kontrol grubundaki deneklere hiçbir egzersiz rejimi uygulanmadı. İstatistiksel analizler 't-Test ve varyans analizi (ANOVA) sonuçlarına göre yapıldı.
Bulgular ve Sonuçlar: Genel olarak aerobik kapasitede anlamlı artışlar tesbit edildi. ($P<0.05$). Bu artışlar kontrol grubunda %9.92, devamlı koşu grubunda %18.13 ve interval koşu grubunda %24.12 olarak bulundu. Anaerobik kapasitedeki gelişmeler ise kontrol grubunda %6.78, devamlı koşu grubunda %11.16 ve interval koşu grubunda %10.55 olarak bulundu. Buna rağmen gruplar arasında anlamlı bir farklılık bulunmadı ($P>0.05$). Kontrol grubunun aksine egzersiz gruplarının istirahat kalp atım sayıları azaldı. ($P<0.05$). Bu azalma devamlı koşu grubunda %13.78, interval koşu grubunda ise %11.06 olarak gerçekleşti. Egzersiz grubunda vücut yağ yüzdeleri kontrol grubunun aksine azaldı. Bu azalma devamlı koşu grubunda %9.67 interval koşu grubunda ise %13.13 olarak belirlendi. Fakat bu azalmalar istatistiksel açıdan anlamlı bulunmadı ($P>0.05$). Ayrıca bütün gruplardaki deneklerin yağsız vücut ağırlıklarında az oranda bir artış tesbit edildi. Fakat bu artış istatistiksel açıdan anlamlı bulunmadı ($P>0.05$).

Bütün grupların istirahat sistolik ve diastolik kan bısıncı seviyelerinde anlamsız düşüşler kaydedilmesine rağmen ($P>0.05$) sadece kontrol grubu deneklerin diastolik kan basınçlarında çok az bir artış gözlendi.

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

Physical activity is an essential component of the behavioral repertoire of adolescent. Scientific literature is replete with considerable evidence suggesting that the pattern and level of habitual physical activity are of particular relevance to the development of physical performance capacity in children (Andersen, 1980). In recent years, there has been an increasing involvement of young persons in competitive sports requiring endurance training. This has led to an unprecedented interest in the effects of intensive physical training on adolescent (Cunningham, 1984).

Daniels and Oldridge (1971) have suggested that endurance training in children will not increase the dimensional and functional components of maximum aerobic power (VO_2 Max) beyond the increase associated with growth. Others have, however, suggested that vigorous physical training at childhood and adolescence has positive effects not only on the components of maximum aerobic power but also favorably alters body composition, muscular strength and endurance (Becker and Vaccaro, 1983; Clarke, 1979).

Evidence now supports the contention that children can be exercised aerobically for extended periods while exhibiting an efficient oxygen transport system. A number of investigators have reported children performing work safely at heart rates above 200 beats per minute. Maximal oxygen uptake (the single best measure of cardiorespiratory fitness) when corrected for body size differences, has been shown to be equal to, or higher than adults values (Gabbard, 1987).

Research conducted on adults has shown maximal aerobic capacity (VO_2 Max) to be primary determinant for success in distance running. A second factor important in predicting long distance running performance in adults has been found to be running economy (the steady-state oxygen requirement at a given speed). Among athletes with similar VO_2 Max values, running economy accounts for a large and significant amount of variation in running performance. A more economical runners use less oxygen (ml. kg^{-1}. min^{-1}) at a given submaximal workload and thus has the potential for maintaining that speed for a longer period of time than a less economical runner. Improvement in running economy through training has been shown to improve performance Astrand (1952), Daniels and Oldridge (1971), and Daniels et. al., (1978) all noted that running economy improves throughout later childhood and adolescence.

Some findings show that in both young and middle-aged men who habitually exercise aerobically at 65 to 80% of maximal oxygen uptake, the time spent for training was associated with body composition, energy requirements and aerobic capacity (Meredith, et.al., 1987).

Moderate exercise has been shown to favorably affect a variety of parameters associated with cordiovascular health aerobic capacity, body fatness and blood lipids which have been linked with the susceptibility to cardiovasucular disease. Although exercise can beneficially alter each of these variables few studies have systematically attempted to determine which type of exercise optimally affects each of these parameters.

The physical fitness of school-age children has received considerable attention in recent years, due partly to a growing concern that habitual physical activity levels may be declining in the young. Of particular concern are the levels of cardiovascular fitness, due to the postulated relationship between this factor and the risk of contracting coronary heart disease in adulthood (Boreham, 1990).

Aerobic conditioning is an important aspect of many team and individual sporting activities and the measurement of aerobic power is the best indicator of an athlete's aerobic system status (Macnaughton, 1990).

The effects of exercise on aerobic capacity has been widely studied. Various researchers have observed increases in maximal oxygen uptake (VO_2 Max) using interval or continuous training programs (Thomas, 1984; Bhambhani, 1985).

Aerobic capacity refers to the maximum rate at which one's body can use oxygen. It takes two or three minutes of exercise to reach a level of oxygen consumption such that one's body begins to need more oxygen to meet its energy needs. Because of this delay, anaerobic system supplies energy at the beginning of any type of exercise, be it of short duration or an endurance event. Between the third and tenth minute of exercise both the anaerobic and aerobic systems at work. Beyond ten minutes, the aerobic systems supplies energy (Stamford, 1987).

An analysis of the intensity, duration and specific demands of a sport can lead to an understanding of the metabolic pathways that provide energy. In turn, this information can be used to establish appropriate training program (Noble, 1986; Berg et.al., 1989). However, when various combinations of intensity and duration have been compared, several studies indicate that intensity is not a significant determinant of change in maximum oxygen uptake when the total energy expenditure is held constant (Berg et.al., 1989).

Astrand and Rodahl (1987) cite evidence favoring vigorous but submaximal exercise in the development of VO_2 Max. Furthermore, they compared the effectiveness of specific work-rest ratios. One particularly effective combination consisted of 3 minute work intervals alternated with 3 minute recovery period in other words ratio of 1:1.

Some studies showed that anaerobic threshold and aerobic capacity could be changed with endurance training, however, the exact level at which the training should be performed was not clearly defined (Gibbons et.al., 1983).

Generally, the more frequent and longer the training program the greater will be the fitness benefits (Fox et. al., 1988). This is particularly true with respect to endurance training. For example more frequent (2 versus 4 days per week) and longer duration (7 versus 13 weeks) endurance interval training programs have been shown to produce less cardiorespiratory stress during submaximal exercise. It can be recommended that the training frequency for endurance programs should be between 3 and 5 days per week, and for sprint or anaerobic training programs 3 days per week (Fox et.al., 1988).

Perry and others (1988) have shown that interval dance training can be successfully applied to aerobic dance and should be considered a more effective training alternative to the conventional aerobic dance programs that use continuous training.

As it is mentioned earlier the interval training prescription can be modified in terms of intensity and duration of the exercise interval, the length and type of relief interval, the number of work intervals (repetition) and the number of repetition blocks or sets per workout. Adjustment of any or all of these can easily be made to meet the specific requirements for different performances. This offers flexible options for developing the anaerobic and aerobic energy transfer systems. A longer work interval engages the aerobic systems whereas shorter exercise intervals place greater overload on the anaerobic energy systems.

Continuous training involves steady-paced exercise performed at either moderate or high intensity for a sustained duration. By its nature continuous training is submaximum and therefore, can be engaged in for considerable time relative comfort. It is believed that over-distance training produces the largest aerobic adaptations (McArdle et.al., 1981).

The effects of physical training on anaerobic power in children have rarely been reported in the literature. Most previous studies on anaerobic power have been assessing the effectiveness of various strength training on improving vertical jump performance in athletes and non athletes (Blattner, 1979; Brown, 1986). Such methods includes isometric, isotonic, isokinetic and polymetric or depth jumping training. Furthermore a few previous research has investigated the effects of prolonged interval training on anaerobic power in untrained adolescents. Although continuous and interval trainings are some of widely used methods of physical training the relative merits of them in influencing adolescents' aerobic and anaerobic capacities have been controversial.

Research evidence concerning the relative influence of these training methods on children's aerobic and anaerobic capacities is largely inconclusive.

1.1.Statement of the Problem

The purpose of this study was to assess the effectiveness of a program of continuous and interval running on aerobic and anaerobic power in male highschool students aged 14-16 years. It was also purported to determine which of the training program was more effective for physiological changes in the subjects such as resting heart rate, resting blood pressure, percentage of body fat, and lean body weight.

1.2.Null Hypothesis

1.There was no difference between continuous and interval running programs on aerobic power of schoolboys aged 14-16 years.

2.There was no difference between continuous and interval running programs on anaerobic power of schoolboys aged 14-16 years.

3.There was no difference between effects of continuous and interval running programs on resting heart rate, resting blood pressure, percentage of body fat, and lean body weight of the subjects.

1.3.Limitations

1.A total of 45 schoolboys aged 14-16 years who were students at a high school (Merkez İmam Hatip Lisesi) in Ankara were participated in this study.

2.All subjects were chosen among untrained persons who volunteered to participate in this study.

3.Subjects were certified to be physically fit to participate in the running program without medical history of any cardiorespiratory diseases, such as, atheroschlerosis, asthma, emphysema, and hypertension.

1.4.Assumptions

1.Subjects followed all pre and post-test, and training instructions and exerted maximum effort while being tested.

2.All the subjects were untrained.

3.Aerobic and anaerobic capacities, percent body fat, resting heart rate and resting blood pressure were measured correctly.

1.5.Significance of the Study

The objective measurement of maximum aerobic power of children appears to be more difficult than adults, and the accuracy of the measurement of aerobic power of children has been questioned. Considerable studies have reported aerobic power responses in children consequent to physical training. The majority of the cross sectional studies indicate that maximum aerobic power values for physically trained groups are higher than those of untrained groups with the differences being less in younger children but greater in teenage years (Mirwald, 1981).

Anaerobic power can be defined as the maximal ability of the anaerobic systems (ATP-PC+Lactic acid) to produce energy. The ATP-PC system can be measured directly, but it requires invasive techniques (muscle biopsy). Indirectly, this system can be estimated by recording peak power output (kg-meters sec^{-1}) over a short period of time, less than 10 seconds (Noble, 1986).

Intense exercise leading to exhuastion in a few minutes or less is heavily dependent on anaerobic energy release (Jacobs, et.al., 1983; Saltin, 1990). It has been shown that despite a large O_2 uptake the anaerobic energy release exceeds the aerobic when the exercise lasts less than 1 min (Medbo and Tabata, 1989). A large anaerobic capacity is therefore of great importance for success in sports with short bursts of intense exercise. In line with this idea, the sprint-trained subjects, who had competed at a high level in anaerobic types of sports for 5 yr or more, had a 30% larger anaerobic capacity compared with untrained and endurance-trained subjects. Hence, subjects successful in anaerobic types of sports did have a larger anaerobic capacity. This higher anaerobic capacity may be due to training, genetic factors, or a combination of both (Medbo and Burgers, 1990).

Adeniran and Toriola (1988) stated that elevated levels of body fat and blood pressure are major factors involved in the pathogenesis of coronary heart disease. Since regular participation in physical activity could lead to significant changes in body composition and cardio-respiratory system, it is widely conceived that physical training could beneficially reduce the risk of coronary heart disease. Thus, as children participate in physical activity, alterations in their body composition and cardiovascular system should be important features in their growth and development.

Results of studies concerning the relative effects of continuous and interval training programs on aerobic and anaerobic capacity, percent body fat, blood pressure, and resting heart rate in adolescents have rarely been reported in the literature. For this reason, this study has great importance in order to find out the effects of continuous and interval training methods on these physiological characteristics of schoolboys aged 14-16 years.

1.6.Definition of Terms

Aerobic Power: The maximal amount of oxygen that can be consumed per minute during maximal exercise.

Anaerobic Power: The maximal ability of the anaerobic systems (ATP - PC and Lactic Acid) to produce energy.

Adolescence: Transition period between childhood and adult development (Noble, 1986).

Continuous Training: Exercises performed to completion without relief periods.

Interval Training: A system of physical conditioning in which the body is subjected to short but regularly repeated periods of work stress interspersed with adequate periods of relief (Mathews and Fox, 1976).

CHAPTER II

REVIEW OF THE LITERATURE

Aerobic capacity refers to the maximum rate at which one's body can use oxygen. It takes two to three minutes of exercise to reach a level of oxygen consumption such that one's body begins to need more oxygen to meet its energy needs. Because of this delay, the anaerobic system supplies energy at the beginning of any type of exercise, be it of short duration or an endurance event. Between the third and tenth minute of exercise, both the anaerobic and aerobic systems are at work. Beyond ten minutes, the aerobic system supplies the energy (Figure 1) (Stamford and Bryant, 1987).

%Aerobic	0	10	20	30	40	50	60	70	80	90	100
%Anaerobic	100	90	80	70	60	50	40	30	20	10	0
Event (Meters)	100	200	400	800		1.500	3.200		5.000	10.000	42.200
Time (Minutes: seconds)	0:10	0:20	0:45	1:45		3:45	9:00		14:00	29:00	135:00

Figure 1: The approximate percentage of contribution of aerobic and anaerobic energy sources in selected track events. Nonshaded areas represent predominance of one system over the other. The shaded area represents events in which both systems are of nearly equal importance. Adapted from Mathews DK, Fox EL: The Physiological Basis of Physical Education and Athletics. Philadelphia, WB Saunders Co., 1976, p.27.

The changes that occur in maximal oxygen uptake as a result of training should be of considerable interest to the exercise physiologist. It is not surprising to learn that the amount of change to be anticipated depends to a large degree on the extent of fitness prior to the training period. The more sedentary and unconditioned one is, the greater will be increase in VO_2 Max, whereas athletes in training can expect but a modest change (Clarke, 1975).

Physical activity ranging from repeated exercise periods of a few seconds' duration up to hours of continuous activity may involve a major load on the oxygen-transporting organs and thereby induce a training effect, provided the exercise load is sufficiently high. Practical experiences have shown that exercise with large muscle groups for 3 to 5 minutes followed by rest or light physical activity for an equal length of time then a further exercise period, etc., as required by the individuals ambition and the objective of the training, is an effective method of training.

The type of training described for the oxygen-transporting system, with submaximal tempo for periods of 3 to 5 min, may indeed increase the maximal oxygen uptake. When training at 50% of the maximal oxygen uptake, 5 to 10 percent increase in VO_2 Max has been noticed previously in sedentary subject (Astrand, 1987). When training at 70 to 80 percent of maximal oxygen uptake, the improvement is on average 15 percent, however, with large individual variations at least partly due to the initial level of fitness.

Maximal oxygen uptake (VO_2 max l./min) is highest in running and walking uphill, and slightly (6 to 12%) lower in cycling and swimming. The differences may be due to the degree of training, the size of muscle mass involved body position, and conditions for heat exchange (Morehouse et.al., 1976).

Various researchers have observed increases in maximal oxygen uptake (VO_2 Max) using interval or continuous training programs (Thomas, T.R. et.al., 1984).

According to MacArale et.al., (1981) many elite athletes attribute their success to interval training. With the correct spacing of exercise and rest periods, a tremendous amount of work can be accomplished that would not normally be completed in a workout in which the exercise was performed continuously. Repeated exercise bouts (with rest periods or relief intervals) can vary from a few seconds to several minutes or more depending on the desired outcome. The interval training prescription can be modified in terms of intensity and duration of the exercise interval, the length and type of relief interval, the number of work intervals (repetitions) and the number of repetition blocks or sets per workout. This offers flexible options for developing the anaerobic and aerobic energy transfer systems. A longer work interval engages the aerobic systems, whereas shorter exercise intervals place greater overload on the anaerobic energy systems.

Continuous training is popular among joggers and other fitness enthusiast as well as competitive endurance athletes. It is not uncommon for distance runners to run between 100 and 150 miles each week. In one report a man training for the 52,5 mile "Ultramarathon" run twice a day, 20 miles each morning and 13 miles each evening, interpersed with an occasional 30 to 60 mile non stop run at a 7 to 8- minute per mile 800 miles each month and totaled 9.600 miles per year (Mac Ardle et.al., 1981).

The circulatory and metabolic changes achieved from training depend on the type of training (Table 1)

TABLE 1.The relationship between type of training (Aerobic or Anaerobic) and the predicted changes (Noble and Bruce J. 1986)

Predicted training change	Type of training Aerobic	Anaerobic
Rest		
Heart Rate	↓	↓
Stroke Volume	↑	NC
Cardiac Output	NC	NC
Hypertrophy		
Cardiac Muscle	↑	NC
Skeletal Muscle	NC	↑
Submaximal		
Heart Rate	↓	↓
Stroke Volume	↑	NC
Cardiac Output	↑ or NC	NC
VO_2	NC	NC
VE	↓	↓
Blood Flow	↓	NC
HL-a	↓	↓
Maximal		
Heart Rate	↓ or NC	NC
Stroke Volume	↑	NC
Cardiac Output	↑	NC
VO_2	↑	↑ or NC
VE	↑	NC
HL-a	↑	↑

NC, No Change

Noble (1986) stated that aerobic athletes, like cross-country runners and skiers, make changes that reflect the endurance nature of the training and the requirements of the competition. For example, the "Volume stress" of the training increases stroke volume whether it is measured at rest, during submaximal exercise, or during maximal exercise. Thus the heart, which is needed to push large volume of blood and oxygen to the tissues during endurance exercise, is enlarged (hypertrophy of the ventricular cavity) to facilitate this need. Anaerobic sport is a different matter. The task of the sprinter or weight lifter is to make a short-duration explosive effort. In these activities the emphasis is placed on skeletal muscle hypertrophy and training of the nervous system rather than on circulatory and metabolic changes.

Age is also a factor, as older individuals seem unable to alter their maximal oxygen uptake appreciably. In fact, a moderately fit person can effect only about 10 to 20 percent increment in VO_2 max even after several months of strenuous training, while a low fit individual may achieve gains of 30 percent or more. Maximal oxygen uptake increases with age during the formative years to maturity and gradually declines during adulthood (Clarke, 1975).

Some seasonal variations can also be observed on VO_2 max of elite runners. Suedenhag and Sjodin (1985) found that the maximal oxygen uptake increased successively during the season and higher during the summer than in winter (74.2 to 77.4 ml. $kg.^{-1}.min^{-1}$). The blood lactate concentration after exhaustion (VO_2 max test) increased significantly from January to May.

Intense exercise of short duration is heavily dependent on energy from anaerobic sources, and subjects successful in anaerobic types of sports may therefore have larger anaerobic capacity and be able to release energy at a higher rate. Performances in these kinds of sports are improved by training, suggesting that the anaerobic capacity is trainable. Medbo and Burgers (1990) found that there was no differences in anaerobic capacity between the untrained and endurance-trained subjects, whereas the sprinters' anaerobic capacity was 30% larger ($P<0.001$). The women's anaerobic capacity was 17% less than the men's ($p=0.03$). Six weeks of training increased the anaerobic capacity by 10%. They concluded that the anaerobic capacity varies significantly between subjects and that it can be improved within 6 weeks. Moreover there was a close relationship between a high anaerobic capacity and a high peak rate of anaerobic energy release.

As a conclusions of a study done by Kasch and his friends (1990), habitual aerobic exercise retarded the usual loss of VO_2 max characterized by aging. Inactivity probably contributed more to VO_2 max loss than did aging in the nonexercising group. The decline of VO_2 max with increasing age was primarily due to a loss of maximal heart rate and Stroke volume in the exercising group.

A moderate-intensity exercise program can reduce high blood pressure, but the specific mechanism for this benefit are not understood. One of these mechanism is weight reduction. Exercise has been demonstrated to decrease blood pressure in association with a decrease in body fat. In fact, one of the criticisms of research demonstrating the blood-pressure-lowering effects of exercise is that the weight loss and decrease in obesity that follow an exercise program confound the issue; it is difficult to determine if the exercise itself lowers blood pressure, or if it is only weight loss facilitated through exercise that is responsible. This problem was first addressed by Hagberg et. al., (1983) who demonstrated that regular aerobic exercise in teenagers lowered blood pressure independent of changes in body weight (Tanji, 1990).

Empirically it has been well known that a fairly long period of training should be necessary to achieve high level performances for young athletes. For example, most of international-caliber speed skaters usually undergo training for at least 10 years. Such extremely long term competitive training may affect not only body composition but also the physical performance capacities such as muscular strength and endurance even in children (Nemoto, 1990).

Erikson (1972) has reported an increase in muscle glycogen, and phosphofructokinase activity in 11-15 year olds following 6-16 weeks of aerobic training. Thus, the improvement in anaerobic capacity contributed to increased anaerobic threshold (AT), eventhough the training program was designed to be aerobic (Haffor, 1990).

The physiological training effects of interval training are well documented (Mac Dougal, 1981). Interval training allows exercise to be performed at a greater intensity for a longer overall time than when work is performed continuously. However, because the intensity and duration of exertion will determine the lactate production and accumulation, it may be of considerable importance when attempting to improve maximum oxygen uptake to train at work loads and durations which optimize oxygen uptake yet minimize lactate accumulation (Olsen, 1988).

Haffor, Harrison and Kirk (1990) have reported that training led to an increase of both anaerobic and aerobic metabolism, at any submaximal work above the anaerobic threshold, for healthy male children aged 11 years. Only a few authors have written about the aerobic-anaerobic transition in children so far. Keul et. al. (1978) only mentioned the value of 190 beats per minute (bpm) as the mean heart rate for the anaerobic threshold of children aged 10-14 years. Simon et.al. (1981) found a heart rate of 186 bpm with 10-13,9 year-old children on the treadmill and a heart rate of 182.8 bpm in young people aged 14-16.7 years (Ilmarinen, 1984).

Maximal oxygen uptake (VO_2 max) is generally considered to be a useful indicator of successful performance in endurance activities when the subjects are heterogenous in terms of VO_2 max. VO_2 max has been reported to have a moderate to poor correlation with triathlon performance. Recently, the anaerobic threshold has been examined as one of several factors other than VO_2 max that may contribute to endurance performance success. Several different investigators have suggested that the anaerobic threshold could be a critical factor in determining the running pace in competitive races. In support of this theory, it was demonstrated that the oxygen uptake measured at the anaerobic threshold was a better predictor of distance running success that either VO_2 max or running economy (Schneider, 1990).

Martin and Kauwel (1990) have studied on continuous assistive-passive exercise (a new exercise modality) and cycle ergometer training in sedentary women. Their results indicated that continuous assistive-passive exercise does not alter sum of seven body girths (ankle, calf, 25% thigh, 50% thigh, umbilicus, below the umbilicus, biceps) or sum of four skinfolds (biceps, triceps, subscapular, and suprailiac) in sedentary postmenapausal women and that two 30 min sessions of cycle training can result in moderate but significant increases in VO_2 max in sedentary postmenapausal women.

In Bandy (a kind of sport) the duration of the competitive match is 90 minutes during which time individual players may skate as much as 20km. The physiological requirements in energy production through aerobic metabolism are therefore expected to be highly demanding. However, considerable demands are also repeatedly placed during the course of the match on anaerobic energy production especially during intensive sprinting conditions of different durations. During the sprints the neuromuscular system has also expectingly a specific and important role (Hakkınen, 1990).

Exercise must be supported by a continuous transformation of substrates in order to produce the ATP molecules essential for muscle contraction. Variations in intensity and duration of exercise must be closely coupled to the events associated with ATP turnover in the skeletal muscle. It is well established that muscle energy production for the purpose of sustaining, the ATP needs range from a high demand for maximal exercise lasting only a short period to a low but continuous demand for prolonged exercise. This has led to the identification of two concepts which characterize the energy production. The maximal rate of exercise per unit of time is thus referred to as the power output while the total amount of exercise performed is defined as the work capacity. Moreover, these concepts have been applied to the three major ATP replenishment systems such that one refers to aerobic power and aerobic capacity (endurance) or anaerobic power and capacity (Serresse, 1989).

Serresse et.al. (1989) have compared the performance of sedentary individuals, physical education students and athletes of various disciplines in 10s and 90s maximal cycle ergometer tests. They have found that mean values of the 10s power and capacity and the 90s capacity tests were significantly higher in Sprinter than in sedentary groups. Sprinters performed significantly better than the marathon runners only in the 10s capacity and power. Body builders and sedentary subjects had similar results in the 90s capacity test. These results indicate that: a)there are differences for the power and capacity measured in predominantly anaerobic tests between athletes from different disciplines and sedentary individuals, and b)gender differences exist for these anaerobic performance indicators, but they appear attenuated in trained subjects.

Steinhaus, et.al. (1990) have evaluated the effects of a four month aerobic conditioning program on heart rate, blood pressure, maximal oxygen consumption (VO_2 max), and physical work capacity of 55-70 year old sedentary individuals. Gains in VO_2 max (ml/kg/min) obtained during a Balke maximal treadmill test in aerobic exercising and control subjects were 27% and 9% respectively. At post testing subjects in both groups demonstrated improved maximal work rate, increased treadmil time, and experienced lower resting and recovery heart rates, lower resting systolic blood pressure, and fewer premature ventricular depolarizations during exercise testing.

Interval training is a special form of repetition running by which individual is able to improve either his oxygen uptake or his oxygen debt tolerence. Classic interval training develops the oxygen uptake system through heart adaptation, which takes place when the individual stops at the end of each run (Johnson, 1982).

Perry et.al., (1986) studied on the effects of 10 weeks of bicycle ergometer training on plasma lipoproteins in fasting venous samples of 6 sedentary male and 6 post menopausal faculty members. They stated that interval aerobic training caused a significant increase in VO_2 max ($P<.05$), and a significant decrement in adiposity. These parameters did not change in the control group. There was a large but non-significant decrease in plasma triglycerides, very low density lipoprotein cholesterol and low density lipoprotein cholesterol in the experimental group as well as a non-significant increase in high density lipoprotein cholesterol in this group.

Michielli et.al.(1981) worked with sedentary faculty members. Three groups of subjects cycled three times per week for 12 weeks at 65%, 75% and 85% of their maximum heart rate. Results showed a significant increase in high density lipoprotein cholesterol and a significant decrease in low density lipoprotein cholesterol. There were no significant changes in the aforementioned lipid parameters in either the 65% training group or the control group. It was concluded that 75% of maximum heart rate was the most desirable training intensity for beneficial changes in the plasma lipid profile to occur.

The typical approach for estimating body composition is based on a model dividing the body into two components, fat and fat-free. The fat free body is further divided into its water, protein, and mineral contents which, collectively, yield a fat-free body density of 1.10 g/cc in adults. Valid application of prediction equations based on this model assumes the group or individual to which it is applied has a similar fat-free body density. As a result of recent investigations, we now know that children have a higher body water content and lower bone mineral than adults, resulting in a lower fat-free body density (Going, 1988).

Elevated levels of body fat and blood pressure are major factors involved in the pathogenesis of coronary heart disease (Shaper et.al.,1985). Since regular participation in physical activity could lead to significant changes in body composition and cardiorespiratory system, it is widely conceived that physical training could beneficially reduce the risk of coronary heart disease. Thus, as children participate in physical activity, alterations in their body composition and cardiovascular system should be important features in their growth and development.

Adeniran et.al. (1988) have studied on the effects of eight weeks of continuous and interval jogging on percent body fat and blood pressure in untrained schoolboys whose mean age was 16 years. They have found that in contrast to the control group the exercise groups had significantly reduced percent body fat ($P<0.05$).

Several lines of research have shown coronary heart disease (CHD) to be a progressive disease with roots in childhood behaviour and life-style patterns known to increase an individual's risk of developing CHD in later life. Coronary heart disease risk factors such as obesity, hypertension, elevated blood lipids, diabetes, and physical inactivity are not uncommon among young children while at this time no longitudinal studies have determined that early childhood control of CHD risk factors will reduce the incidence of heart disease in adult life. However increased physical activity, weight control, and blood chemistry analysis have been suggested as forms of early intervention due to the amount of supporting evidence associated with adults (Gabbard, 1987; Willgoose, 1984; and Dotson, 1988).

Research conducted on adults has shown maximal aerobic capacity (VO_2 max) to be the primary determinant for success in distance running. A second factor important in predicting long distance running performance in adults has been found to be running economy (the steady-state oxygen requirement at a given speed). Among athletes with similar VO_2 max values, running economy accounts for a large and significant amount of variation in running performance. A more economical runner uses less oxygen ($ml.kg^{-1}.min^{-1}$) at a given submaximal workload and thus has the potential for maintaining that speed for a longer period of time than a less economical runner. Improvement in running economy through training has been shown to improve performance (Petray, 1985). Astrand and Rodahl (1987) noted that running economy improves throughout later childhood and adolescence.

Few studies have examined the effects of training on running economy in children. No significant changes in running economy were found as a result of the specific training regimen utilized in two short-term studies (Petray, 1985).

Meredith et.al. (1987) have showed that in both young and middle-aged men who habitually exercised aerobically at 65 to 80% maximal oxygen uptake, the time spent training was associated with body fat, energy requirements, and aerobic capacity. The declining physical capacity and increasing body fat often decribed within this age range (22 and 59) are likely due to decreased amount of physical activity, with age being of secondary importance.

Bhambhani and Signh (1985) have studied to examine the effects of three training intensities on the maximum oxygen uptake (VO_2 max) and ventilatory equivalents for oxygen (V_E/VO_2 ratio) and carbon dioxide (V_E/VCO_2 ratio) at submaximal and maximal workloads. It was concluded that continuous and interval training programs were equally effective in improving VO_2 max and submaximal ventilatory efficiency, regardless of initial fitness level, provided the total amount of work completed was equalized. Such training programs, however, were unable to modify the maximal ventilatory efficiency in either fitness category.

Brown et.al. (1972) examined 9 girls 8-13 years of age, before and after 12 weeks of crosscountry running and observed an increase in VO_2 max 26.2%.

Becker and Vaccaro (1983) studied to examine the effects of eight weeks of endurance training on the anaerobic threshold of male children ranging in age from nine to eleven. In addition, the effects of this training program on maximal oxygen uptake, pulmonary ventilation and maximal heart rate were also examined. Following training, the mean anaerobic threshold of the training group increased from 25.95 $ml.kg^{-1}.min^{-1}$ (67% VO_2 max) to 33.23 $ml.kg^{-1}.min^{-1}$ (71% VO_2 max), the mean VO_2 max increased from 39.00 $ml.kg^{-1}.min^{-1}$ to 46.99 $ml.kg^{-1}.min^{-1}$, the mean ventilatory equivalent max ($\dot{V}E$ max) increased from 59.32 L/min to 59.56 L/min and maximum heart rate (HR max) increased from 196.63 to 200.50 beat/min.

Gibbons et.al., (1983) studied on anaerobic threshold (AT) and Aerobic capacity (AC) in females (n=29) during a maximum oxygen consumption test on a motorized treadmill using the modified Balke protocol. They found that aerobic capacity and anaerobic threshold were improved in females by training at 40% above anaerobic threshold, at anaerobic threshold and at 40% below anaerobic threshold. However, the AT groups showed a greater degree of improvement in anaerobic threshold than the other two groups.

Cearly et.al. (1984) found significant improvements in VO_2 max in 14 college females following a 10-week, 3-day per week aerobic dance program. The program consisted of a 10-15minute warm-up followed by 40-45 minutes of continuous dancing and concluded with a 10-minute cool down period.

Perry et.al. (1988) studied comparison of training responses to interval versus continuous aerobic dance by using 66 subjects with mean aged 20 and they showed that interval dance training can also be successfully applied to aerobic dance and should be considered a more effective training alternative to the conventional aerobic dance programs that use continuous training.

Vaccora and Clinton (1981) found a significant improvement in VO_2 max in subject engaging in a 10-week program of aerobic dance. They concluded however that a 10% improvement in VO_2 max was lower than other programs using cycling or jogging to improve cardiovascular endurance.

Eickoff et.al (1983) found that a 10 week aerobic dance program was ineffective in reducing heart rate response to a submaximal workload on the stationary bicycle ergometer.

Cardiovascular improvement generally results in a significant decrease in heart rate response to a submaximal workload (Mathews, 1976).

The intensity and duration of exercise are both recognized as key factors in conditioning. However, when various combinations of intensity and duration have been compared, several studies indicated that intensity was not a significant determinant of change in maximum oxygen uptake (VO_2 max) when the total energy expenditure was held constant (Sharkey, 1970; Pollock and Wilmore, 1984).

The intensity of submaximal exercise has traditionally been expressed relative to VO_2 max. Some researchers observed that endurance time was related to % VO_2 max by a decaying exponential function. This expression of exercise intensity, however, assumes that a given %VO_2 max represents a similar metabolic stress for all individuals (McLellan, 1985).

Costil et.al. (1985) reduced their training volume by 50% and increased the swimming speed. All of the subjects swam personal records in 100 and 200 yard distances although their VO_2 max did not change. Swimming power was assessed out of water on a mechanical devices which allowed movements of the arm and shoulder to mimic those of swimming. Power was inversely related to training distance and peaked when training volume was at its lowest in the training cycle. The results suggest the importance of matching training pace and competitive pace, and suggest that more training is not necessarily better training.

The primary adaptation to aerobic exercise is improved delivery of oxygen to the muscles. This is accomplished because of changes in the blood and heart. Training increases blood volume and raises the level of oxygen-carrying hemoglobin in red blood cells. The heart becomes capable of ejecting greater amounts of blood with each beat or "Stroke". This increase in stroke volume results in fewer heart beats being needed to circulate a given amount of blood.

Highly trained endurance athletes typically have resting heart rates as low as 30 to 40 bets/min. But their maximal heart rate does not change and therefore the increased stroke volume provides more oxygen during exhaustive exercise (Stamford, 1983).

Training also results in several changes that help in the prevention of heart disease, such as reduction of body fat due to the large number of calories burned, lowered blood concentrations of cholesterol and triglycerides, increased levels of high-density lipoprotein cholesterol, and reduction of high blood pressure (Stamford, 1983).

Physically active people possess considerably less total body fat than their inactive contemporaries (Fox, et.al., 1988).

At rest, fat and carbohydrate contribute about equally to the energy supply, as they also do during light or moderate exercise in the fasting individual. As the exercise progresses, fat contributes in an increasing amount to the energy yield. During moderately heavy exercise (in fasting subjects) which may be endured for 4 to 6 hours (including rest pauses) as much as 60 to 70 percent of energy may be derived from fat at the end of the exercise period. In subjects on a normal diet, engaged in exercise of such an intensity that the metabolic processes were essentially aerobic, they found that about 50 to 60 percent of the energy was supplied by fat (Astrand and Rodahl, 1987).

During inactivity or habitual training, the body weight may remain relatively constant although inactivity often produces a gradual weight gain. During intensive training the density of the body increases while the skin-fold thickness decreases. An increased body density, i.e., with a 0.01 unit, indicates a reduction in fat content. This is also supported by the reduced skin-fold thickness observed. At the same time, there is a certain proportional increase in the muscle mass and the blood volume (Astrand and Rodahl, 1987).

To gain perspective regarding the role of exercise in weight control, 55 studies were reviewed in which protocols varying in duration from 6 to 104 weeks were used. The mean loss of fat across these studies was only 1.6%. The implication of this review is that exercise, although effective, cannot be counted on for large weight reductions. Diet is a more effective method for those who need to lose a large amount of fat (Downey, 1971). However, it should be remembered that the 1.6% average reported can be misleading. Experiments that used the right combination of frequency, intensity, and duration were more effective than others (Noble, 1986).

CHAPTER III

METHODS AND PROCEDURE

The purpose of this study was to asses the effectiveness of a program of continuous and interval running on aerobic and anaerobic power in male highschool students aged 14-16 years. It is also purported to determine which of the training program is more effective for physiological changes in the subjects such as, resting heart rate, resting blood pressure, percentage of body fat, and lean body fat.

3.1.Selection of Subjects

A total of 45 untrained healthy boys aged 14-16 years who were students at a highschool (Merkez İmam Hatip Lisesi) in Ankara volunteered to participate in this study.

Subjects were randomly assigned to a control group (n=15), a continuous running group (n=15), and an interval running group (n=15).

However, two boys (one from each running group) did not complete 80% of the running schedules. Consequently, the information obtained from them was excluded from the analysis. Therefore, the data of 43 schoolboys were actually analysed.

3.2.The Collection of Personal Data

The collection of personal information was done by interviewing each subject and recording the information on individual forms shown on Appendix A.

3.3.Test Administration

The running program was carried out on a 400m track. Each running session was conducted between 14:00 p.m. and 16:00 p.m. three times in a week for eight weeks.

During the training period atmospheric temperature was ranged from 0.4°C to 20.2°C and relative humidity was between 35% and 82%.

Each running schedule was preceded by a five minute warm up including calisthenics.

3.3.1.Continuous Training

Subjects in the continuous running group ran 4.8 km at 80% of their maximum heart rate (HR max) which were estimated from 220 minus the subjects' age according to Fox, Bowers and Foss (1988). A running pace of eight minutes per 1.2 km was used to guide the speed of running.

Because of the difficulty in monitoring heart rate while running, a ten second post exercise heart rate was used to cross-check the intensity of exercise for the continuous and interval training groups.

3.3.2. Interval Training

Interval running consisted of jogging for sets of 1.2 km at about 90% of subjects maximum heart rate. Each running interval was interspersed with a relief interval which was equal the time that subject spent to complete 1.2 km with a given maximum heart rate. This was amounted to a work relief ratio of 1:1. In addition, during rest interval subjects' heart rate was measured. According to Fox, Bowers and Foss (1988) for men and women less than 20 years old, both athletic and nonathletic, the heart rate should drop at least to 140 beats per minute between repetitions and to 120 beats per minute between the sets.

During relief interval subjects walked or flexed their arms and legs termed rest-relief.

3.3.3. Measurement of Aerobic Power

The Coopers 12 Minute Run/Walk test was used to measure subjects maximum aerobic power.

The runners started behind a line and upon the signal ran (and walked if necessary) as many laps as possible within 12 minutes. Initially, each runner was assigned a spotter who maintained a count of the number of laps and rans immediately to the spot where the runner was at the instant the whistle or command to stop was given (Tamer, 1989).

The maximal oxygen uptake (VO_2 max) was predicted by the Balkes formula as a result of total distance covered in 12 minutes run/walk test.

VO_2 in ml/kg/min.=33.3 + (x-150) 0.178 ml/kg/min.

x=The distance covered in one minute.

3.3.4.Measurement of Anaerobic Power

The vertical jump or Sargent Jump Test was used to measure subjects' anaerobic power. The differences between a subjects' standing reach and the height to which he can jump and touch was determined. Anaerobic power output for each subject was calculated as follows;

$$P = 4.9\ (W)\ \sqrt{D}$$

P=Anaerobic power expressed in kg-meter/second (kg-m/sec)

W=Body weight

D=Jump reach score

Each student was allowed three trials of maximum vertical jumps and the best of three attempts was regarded as the criterion score.

3.3.5.Measurement of Percent Body Fat

The Lange Skinfold Caliper was used to measure skinfold tickness at the rightside of the body.

Body density was determined using the formula of Parizkova;

1.131-(0.083xLog of triceps skinfold)

The formula of Parizkova was selected in preference to other similar regression equations (e.g. Wilmore and Behnke, 1969) primarily because of the equation of Parizkova was originally developed for non athletic adolescents (age range, 13-16 years) whose ages were similar to those of the subjects of this study.

The equation of Brozek et.al. which is applicable to adolescents was used to estimate the subjects percentage of body fat;

$(4.570/D_b-4.142) \times 100$, where D_b=Body Density.

Lean body mass was derived succinctly by using the following generalized equation: body weight x (1-%fat/100), according to Carlberg et.al., (1983) and Adeniran and Toriola, (1988).

3.3.6.Measurement of Resting Blood Pressure

Resting blood pressure was measured between 9:00 a.m. and 10:00 a.m. using aneroid sphygmomanometer and stethoscope. The subjects assumed a supine position and were relaxed for at least 10 minutes before blood pressure was taken. While comfortably seated, the cuff was wrapped around the subjects' left arm above the elbow. The artery distal to the cuff was palpated and the cuff was inflated rapidly to a systolic pressure of about 30 mm Hg above the point of disappearance of the pulse. The stethoscope was placed over the occluded brachial artery in the cubital fossa that was the distal to the cuff.

The cuff pressure was released slowly at the rate of 2 to 3 mm Hg per heart beat until the tapping sound of the heart beat was heard. The fifth diastolic phase which indicates the point of disappearance of the Krotkoff sounds was taken as the diastolic pressure. For each subject, two measurements were taken and the average of the two readings was recorded.

3.3.7.Measurement of Resting Heart Rate

Resting heart rate was measured between 9:00 a.m. and 10:000 a.m. using auscultation, which consists of listening to the heart sound with a stethoscope.

The subject assumed a supine position and was relaxed at least 10 minutes before resting heart rate was taken.

3.4.Statistical Analysis of Data

Paired t-Test was used to evaluate pre and post-training results of each group. A probability level of 0,05 or less was taken to indicate significance.

In the statistical analysis, the score obtained by subtracting the post-training data from the pre-training measurements were used as the dependent variables.

Analysis of variance (ANOVA) was computed to test for any significant differences in the all measurements of the groups.

Absolute percent differences were computed as the values (pre-training—post-training/pre-training x 100).

The statistical analysis was carried out using Minitab Package Program.

CHAPTER IV

RESULTS AND DISCUSSION

A total of 45 untrained healthy boys aged 14-16 years who were students at a highschool (Merkez İmam Hatip Lisesi) in Ankara volunteered to participate in this study. Subjects were randomly assigned to a control group (n=15), a continuous running group (n=15), and an interval running group (n=15). However, two subjects (one from each exercising groups) did not complete 80% of the running schedules. Consequently, the information obtained from them was excluded from the analysis. Therefore, the data of 43 schoolboys were actually analysed. All measurements were accomplished within one week before and one week after the study.

The pre-training physical characteristics and physiological measurements of subjects are shown in Table 2

Subjects' pre-training physical measurements such as, height, weight, resting systolic and diastolic blood pressure, resting heart rate, aerobic power, anaerobic power, percent body fat and lean body weight were not significantly different among the groups (P>0.05).

TABLE 2: Subjects' Pretraining Physical Measurements

Variable	Control group (n = 15)	Range	Continuous running group (n = 14)	Range	Interval running group (n = 14)	Range
Age (years)	14.20 ± 0.56	(14-16)	14.35 ± 0.74	(14-16)	14.21 ± 0.42	(14-15)
Height (cm)	156.66 ± 8.73	(141-173)	155.75 ±11.68	(137-175)	159.42 ± 7.37	(148-171)
Weight (kg)	45.63 ±9.62	(32.5-66)	46.71 ±12.29	(30-66)	49.32 ± 7.97	(39-59.5)
Blood Pressure (mmHg)						
Systolic	104.46 ± 7.74	(85-113)	104.14 ±10.12	(90-127)	105.0 ± 9.19	(90-120)
Diastolic	65.73 ± 5.22	(55-70)	67.57 ± 8.83	(50-83)	67.5 ± 7.0	(60-80)
Resting Heart Rate (Beat/min)	80.4 ± 7.45	(72-96)	84.0 ±15.61	(60-108)	83.85 ±13.16	(66-108)
Aerobic Power (ml/kg/min)	39.10 ± 4.42	(31.49-44.27)	42.58 ± 3.54	(36.26-47.33)	37.97 ± 6.81	(26.29-47.45)
Anaerobic Power (kg.m/sec)	59.09 ±14.72	(88.39-37.62)	65.05 ±21.86	(37.24-99.59)	65.11 ±14.03	(44.79-87.82)
Percent Fat (%)	18.17 ± 4.70	(11.31-26.91)	16.44 ± 4.45	(11.31-26.91)	20.40 ± 7.15	(11.31-31.65)
Lean Body Weight (kg)	37.264± 7.681	(26.139-48.533)	38.961±10.161	(31.921-55.096)	39.099± 6.237	(28.505-48.776)

The means, standard deviations and ranges in control group were 14.20 ± 0.56, (14-16) years for age, 156.66 ± 8.73 (141-173) cm for height, 45.63 ± 9.62 (32.5-66) kg for weight, 104.46 ± 7.74 (85-113)mmHg for resting systolic blood pressure, 65.73 ± 5.22 (55-70) mmHg for resting diastolic blood pressure, 80.4 ± 7.45 (72-96) beat/min for resting heart rate, 39.10 ± 4.42 (31.49-44.27) ml/kg/min for aerobic power, 59.09 ± 14.72 (88.39-37.62] kg.m/sec for anaerobic power, 18.17 ± 4.70 (11.31-26.91) % for percent body fat and 37.264 ± 7.681 (26.139-48.533) kg for lean , body weight, respectively.

The means, standard deviations and ranges in continuous running group were 14.35 ± 0.74 (14-16) years for age, 155.75 ± 11.68 (137-175) cm for height, 46.71 ± 12.29 (30-66) kg for weight, 104.14 ± 10.12 (90-127) mmHg for resting systolic blood pressure, 67.57 ± 8.83 (50-83) mmHg for resting diastolic blood pressure, 84.0 ± 15.61 (60-108) beat/min for resting heart rate, 42.58 ± 3.54 (36.26-47.33) ml/kg/min for aerobic power, 65.05 ± 21.86 (37.24-99.59) kg.m/sec for anaerobic power, 16.44 ± 4.45 (11-31-26.91) % for percent body fat, 38.961 ± 10.161 (31.921-55.096) kg for lean body weight, respectively.

Also, the means, standard deviations and ranges in interval running group were 14.21 ±0.42 (14-15) years for age, 159.42 ± 7.37 (148-171) cm for height, 49.32 ± 7.97 (39-59.5) kg for weight, 105.0 ± 9.19 (90-120) mmHg for resting systolic blood pressure, 67.5 ± 7.0 (60-80) mmHg for resting diastolic blood pressure, 83.85 ± 13.16 (66-108) beat/min for resting heart rate, 37.97 ± 6.81 (26.29-47.45) ml/kg/min for aerobic power, 65.11 ± 14.03 (44.79-87.82) kg.m/sec for anaerobic power, 20.40 ± 7.15 (11.31-31.65)% for percent body fat, 39.099 ± 6.237 (28.505-48.776) kg for lean body weight, respectively.

Following eight weeks training period changes in three groups are summarized in Table 3.

TABLE 3: Subjects' Post Training Physical Measurements

Variable	Control group (n = 15)	Range	Continuous running group (n = 14)	Range	Interval running group (n = 14)	Range
Age (years)	14.20 ± 0.56	(14-16)	14.35 ± 0.74	(14-16)	14.21 ± 0.42	(14-15)
Height (cm)	158.3 ± 9.20	(142-175)	156.64 ±11.56	(138-176)	161.03 ± 7.52	(149-173)
Weight (kg)	47.10 ± 9.57	(33-68)	47.84 ±11.83	(32.3-68)	50.21 ± 7.69	(39-63.5)
Blood Pressure (mmHg)						
Systolic	100.0 ±11.64	(80-120)	101.57 ±10.93	(85-125)	98.42 ±11.25	(75-123)
Diastolic	68.73 ± 8.02	(60-90)	66.85 ± 3.91	(60-73)	66.42 ± 6.79	(50-75)
Resting Heart Rate (Beat/min)	83.33 ±12.20	(66-108)	72.42 ± 8.95	(54-90)	74.57 ± 9.02	(54-90)
Aerobic Power (ml/kg/min)	42.98 ± 5.65	(33.00-49.52)	50.30 ± 2.88	(44.52-54.98)	47.13 ± 4.78	(37.54-54.80)
Anaerobic Power (kg.m/sec)	63.10 ±15.83	(42.57-95.83)	72.31 ±22.43	(45.01-110.58)	71.98 ±13.13	(51.05-89.51)
Percent Fat (%)	18.53 ± 5.70	(10.12-28.62)	14.85 ± 4.38	(10.12-23.12)	17.72 ± 7.63	(8.16-30.78)
Lean Body Weight (kg)	38.210± 7.297	(27.226-49.967)	40.874±10.816	(26.712-60.248)	41.159± 6.178	(29.000-49.39)

Summary of pre and post-training changes in continuous and interval running group are shown in Table 4 and in Table 5, respectively.

TABLE 4: Summary of Pre and Post Training Changes in Continuous Group (n=14)

VARIABLE	PRE-TRAINING	POST-TRAINING	%CHANGE	t RATIO
Age (years)	14.35 ± 0.74	14.35 ± 0.74	0	
Height (cm)	155.75 ±11.68	156.64* ±11.56	+ 0.57	- 6.36
Weight (kg)	46.71 ±12.29	47.84* ±11.83	+ 2.41	- 3.25
Systolic Blood Pressure (mmHg)	104.14 ±10.12	101.57 ±10.93	- 2.46	0.88
Dialostic Blood Pressure (mmHg)	67.57 ± 8.83	66.85 ± 3.91	- 1.06	0.29
Resting Heart Rate (Beat/min)	84.0 ±15.61	72.42* ± 8.95	-13.78	4.07
Aerobic Power (ml/kg/min)	42.58 ± 3.54	50.30* ± 2.88	+18.13	-10.04
Anaerobic Power (kg.m/sec)	65.05 ±21.86	72.31* ±22.43	+11.16	-10.04
Percent Fat (%)	16.44 ± 4.45	14.85 ± 4.38	- 9.67	1.96
Lean Body Weight (kg)	38.961±10.161	40.874*±10.816	+ 4.91	- 4.57

*Significantly different (P<0.05)

Table 5: Summary of Pre and Post Training Changes in Interval Group (n=14)

VARIABLE	PRE-TRAINING	POST-TRAINING	%CHANGE	t RATIO
Age (years)	14.21 ± 0.42	14.21 ± 0.42	0	
Height (cm)	159.42 ± 7.37	161.03* ± 7.52	+ 1	- 4.51
Weight (kg)	49.32 ± 7.97	50.21 ± 7.69	+ 1.8	- 1.65
Systolic Blood Pressure (mmHg)	105.0 ± 9.19	98.42* ±11.25	- 6.26	2.73
Dialostic Blood Pressure (mmHg)	67.5 ± 7.0	66.42 ± 6.79	- 1.6	0.55
Resting Heart Rate (Beat/min)	83.85 ±13.16	74.57* ± 9.02	-11.06	2.90
Aerobic Power (ml/kg/min)	37.97 ± 6.81	47.13* ± 4.78	+24.12	- 7.98
Anaerobic Power (kg.m/sec)	65.11 ±14.03	71.98* ±13.13	+10.55	- 5.98
Percent Fat (%)	20.40 ± 7.15	17.72* ± 7.63	-13.13	6.08
Lean Body Weight (kg)	39.099± 6.237	41.159*± 6.178	+ 5.26	- 3.88

*Significantly different (P<0.05)

As a result of analysis of variance for aerobic power (ml.kg/min) there was a significant difference among groups (P<0.05).

Aerobic capacity in control group was increased from 39.10 ± 4.42 ml/kg/min to 42.98 ± 5.65 ml/kg/min. It was also increased in continuous running group from 42.58 ± 3.54 ml/kg/min to 50.30 ±2.88 and in interval running group from 37.97 ± 6.81 ml/kg/min to 47.13 ± 4.78 ml/kg/min. These increments were 9.92%, 18.13%, and 24.12% in control, continuous running and interval running groups, respectively.

Changes in aerobic capacity are shown in Table 6.

TABLE 6: Pre-test and Post-test Aerobic Capacity Values of Subjects

GROUP	AEROBIC CAPACITY (ml/kg/m) PRE-TRAINING	POST-TRAINING	%CHANGE
CONTROL (n=15)	39.10 ±4.42	42.98 ±5.65	+ 9.92
CONTINUOUS (n=14)	42.58 ±3.54	50.30 ±2.88	+18.13
INTERVAL (n=14)	37.97 ±6.81	47.13 ±4.78	+24.12

In this study, pre-training values of the subjects' maximum aerobic power (VO_2 max) are lower than that predicted by MacDougall et.al., (1983) for a cross-section of 2,683 Canadian schoolchildren aged 7-16 years. According to MacDougall et.al., aerobic power in the Canadian schoolgirls at age 11 was 46 ml/kg/min. Kemper and Verschuur (1981) measured VO_2 max in 375 teenagers in Amsterdam who were 13 and 14 years old. They found a mean VO_2 max value of 51 ml/kg/min in the girls and concluded that the increase in absolute VO_2 max with biologic age (from ages 13 to 14 regardless of sex) was due to the increase in total body mass. In this study significant increase was observed in height for all groups participated

(P<0.05). These increments are shown in Table 7.

TABLE 7: Pre-test and Post-test Height Values of the Subjects

GROUP	Height (cm) PRE-TRAINING	POST-TRAINING	%CHANGE
CONTROL (n=15)	156.66± 8.73	158.3 ± 9.20	1.04
CONTINUOUS (n=14)	155.75±11.68	156.64±11.56	0.57
INTERVAL (n=14)	159.42± 7.37	161.03± 7.52	1.00

In addition, except continuous group, weight of the subjects in control group and interval running group were significantly increased (P<0.05). This shows that total body mass of all subjects participated in this study were slightly increased. These increments are shown in Table 8.

TABLE 8: Pre-test and Post-test Weight Values of the Subjects

GROUP	Weight (kg) PRE-TRAINING	POST-TRAINING	%CHANGE
CONTROL (n=15)	45.63± 9.62	47.10± 9.57	3.22
CONTINUOUS (n=14)	46.71±12.29	47.84±11.83	2.41
INTERVAL (n=14)	49.32± 7.97	50.21± 7.69	1.80

According to Astrand and Rodahl (1987) during the first years in life the child grows rapidly, followed by a somewhat slower rate of growth for about a ten-year period. Then comes a second spurt, the increase in height for girls on the average may be about, 7cm and for the boys 10cm in one year.

According to Clarke (1975) a moderately fit person can effect only about a 10 to 20 percent increment in VO_2 max even after several months of strenuous training, while a low fit individual may achieve gains of 30 percent or more. In this study as a result of eight weeks interval training at 90% maximal heart rate 24.12% increment was observed. This increment was 9.92%, 18.13% in control and continuous running groups, respectively.

Astrand and Rodahl (1987) cited that when training at 50% of the maximal oxygen uptake 5 to 10 percent increase in VO_2 max has been noticed in previously sedentary subjects. When training at 70 to 80 percent of maximal oxygen uptake, the improvement is on average 15 percent, however with large individual variations at least partly due to the initial level of fitness.

McArdle et.al., (1981) stated that a longer work interval engages the aerobic system. In this study work to rest ratio in interval running group was 1:1. Therefore interval running program was found more effective on improving the aerobic power.

Astrand and Rodahl (1987) stated that exercising continuously without any rest periods the subject could tolerate high work rate (350 watts) for only 9 min, at the end of which he was completely exhausted. If, instead, he exercised for 30s, rested for 30s, exercise for 30s, and so on, he could complete the work with moderate exertion. The longer the activity periods, the more exhausting the exercise appeared, even though the rest periods were correspondingly increased. Some of the results of studies showed that with exercise periods of 3 min interrupted by 3-min rest periods, the load on the oxygen-transporting organs was maximal (oxygen uptake, 4.60 liters. min^{-1}, heart rate 188, and the degree of exertion was particularly high (blood lactate 13.2 mM). In this study subjects exercised approximately between 4.5 to 8 min and rested 4,5 to 8 min. For this reason higher maximum oxygen uptake was observed in interval running group.

Adeniran et.al. (1988) studied on Nigerian schoolgirls aged 13 to 17 years. As a result of eight weeks continuous and interval training in general, improvements in aerobic power of 1.6%, 10.2% and 11.5 were found in the control group, continuous running and interval running group, respectively. Post-training value of aerobic power of the male adolescents of this study was higher than the 38.6 to 41.7 ml/kg/min reported for 68 female students aged 13 to 17 years.

Following the eight week cycling program in young children aged 9-11 years which was studied by Becker and Vaccaro (1983) the mean VO_2 max of the training group increased 7.99 ml/kg/min. (20%) from 39.00 ml/kg/min to 46.99 ml/kg/min while that of the reference group increased 4.58 ml/kg/min (10%) from 41.71 ml/kg/min to 44.00 ml/kg/min. The increase in VO_2 max in the present study is similar with this study.

Thomas et.al. (1984) studied effects of different running program (continuous and interval running) on VO_2 max, percent fat and plasma lipids. Analysis of Covariance indicated that only the interval group improved more than the control in VO_2 max. However, presented study indicated that both interval and continuous groups improved in VO_2 max.

It is generally accepted that the performance of an endurance work of high intensity is related to maximum oxygen consumption, which has long been utilized as a measure of cardiorespiratory fitness. The objective measurement of VO_2 max in children appears to be more difficult than in adults, and the accuracy of the measurement of aerobic power in children has been questioned. While some studies have reported significant increases in VO_2 max and maximum work capacity in either boys and girls (Vanfraechem, 1978; Adeniran, 1988; Becker and Vaccaro, 1983), a few other studies have noted no such changes (Kellet, DW et. al., 1978 and Miyamura, M. 1973). the lack of improvement in some studies may be attributed to the athletic involvement of the subjects prior to the training programme or to the maturative age of the children (Adeniran, 1988).

It is clearly noticed that improvements of both aerobic and anaerobic capacities of subjects in control group are higher in comparison with literature. Table 9 shows summary of pre-post training changes in control group.

TABLE 9: Summary of Pre and Post Training Changes in Control Group (n=15)

VARIABLE	PRE-TRAINING	POST-TRAINING	%CHANGE	t RATIO
Age (years)	14.20 ± 0.56	14.20 ± 0.56	0	
Height (cm)	156.66 ± 8.73	158.3* ± 9.20	+ 1.04	- 5.97
Weight (kg)	45.63 ± 9.62	47.10* ± 9.57	+ 3.22	- 5.84
Systolic Blood Pressure (mmHg)	104.46 ± 7.74	100.0 ±11.64	- 4.26	1.34
Dialostic Blood Pressure (mmHg)	65.73 ± 5.22	68.73 ± 8.02	+ 4.56	- 1.55
Resting Heart Rate (Beat/min)	80.4 ± 7.45	83.33 ±12.20	+ 3.64	- 1.19
Aerobic Power (ml/kg/min)	39.10 ± 4.42	42.98* ± 5.65	+ 9.92	- 6.15
Anaerobic Power (kg.m/sec)	59.09 ±14.72	63.10* ±15.83	+ 6.78	- 3.14
Percent Fat (%)	18.17 ± 4.70	18.53 ± 5.70	+ 1.98	- 0.63
Lean Body Weight (kg)	37.264± 7.681	38.210*± 7.297	+ 2.53	- 2.54

*Signifficantly different ($P<0.05$)

First, this may be explained that subjects in control group are not completely inactive. They had physical education and sport class and also after the school they run, walk and play especially football, basketball and volleyball in the gym or in the schools' playground.

Second, since they are in adolescent age in which their physical and physiological developments are very rapid.

According to Bompa (1986) a high aerobic capacity positively transfers to the anaerobic capacity. If an athlete improves his/her aerobic capacity the anaerobic capacity will also improve since he/she will be able to function longer before reaching an O_2 debt, and will recover more quickly after building up an O_2 debt.

Following the eight week training period changes in anaerobic power are summarized in Table 10.

TABLE 10: Pre-test and Post-test Anaerobic Values of Subjects

GROUP	ANAEROBIC CAPACITY (kg.m/sec) PRE-TRAINING	POST-TRAINING	%CHANGE
CONTROL (n=15)	59.09 ±14.72	63.10 ±15.83	+ 6.78
CONTINUOUS (n=14)	65.05 ±21.86	72.31 ±22.43	+11.16
INTERVAL (n=14)	65.11 ±14.03	71.98 ±13.13	+10.55

Anaerobic capacity was increased in control group from 59.09 ± 14.72 kg.m/sec to 63.10 ± 15.83 kg.m/sec (6.78%), in continuous running group from 65.05 ± 21.86 kg.m/sec to 72.31 ± 22.43 kg.m/sec (11.16%), and in interval running group from 65.11 ± 14.03 kg.m/sec to 71.98 ± 13.13 kg.m/sec (10.55%). Although there were significant improvements in anaerobic power within the groups ($P<0.05$), analysis of variance indicated that there were no significant differences among the groups ($P>0.05$). Both continuous running and interval running programs have approximately same effect on improving the anaerobic capacities of schoolboys aged 14-16 years.

The subjects' vertical jumping performances may have been positively influenced by their relatively longer limbs and lower post-training body weight in addition to the effects of running.

The post-training values of anaerobic power (measured by the vertical jump test) of the male adolescents of this study is similar to 67.8-69.6 kg.min/sec which was reported by Adeniran (1988) for 68 female students aged 13-17 years and also is higher than the 49.4 to 60.4 kg.m/sec which was reporter by Brown et.al., (1986) for 26 male students who were aged 15 years.

In a study where these variables were taken into account young male power athletes who were 19 to 20 years old performed significantly better than the present subjects in the vertical jump test (Beckenholdt, 1983). This is not surprising since the athletes have had several years of experience in competitive sports training and might have developed the jumping skills needed for optimum sports performance.

Intense exercise leading to exhaustion in a few minutes or less is heavily dependent on energy release. It has been shown that despite a large O_2 uptake the anaerobic energy release exceeds the aerobic when the exercise lasts less than 1 min (Medbo and Burgers, 1990).

A large anaerobic capacity is therefore of great importance for success in sports with short bursts of intense exercise. In line with this idea, the sprint-trained subjects, who had competed at a high level in anaerobic types of sports for 5 year or more, had a 30% larger anaerobic capacity compared with untrained and endurance-trained subjects. Hence, subjects successful in anaerobic types of sports did have larger anaerobic capacity. This higher anaerobic capacity may be due to training, genetic factors or a combination of both. It is a common experience that training first results in a fast improvement (training over a few days to a few months), which is called a short-term effect, followed by a slower, continued improvement over months and years, which is called a long-term effect (Astrand and Rodahl, 1987).

Medbo and Burgers (1990) found that the anaerobic capacity for the sprinters, who had done anaerobic types of training regularly for several years, was larger than for the untrained subjects, while regular endurance training did not seem to influence the anaerobic capacity. Present study indicated that eight weeks continuous and interval running slightly improved the anaerobic capacity. However, this increase found non-significant among the groups ($P>0.05$). To apply sprint type of exercise, genetic factors and the effect of long-term training seem to be even more important.

Changes in percent body fat for all groups were summarized in Table 11.

TABLE 11: Pre-test and Post-test Percent Body Fat Values of Subjects

GROUP	PERCENT FAT (%) PRE-TRAINING	POST-TRAINING	%CHANGE
CONTROL (n=15)	18.17 ±4.70	18.53 ±5.70	+ 1.98
CONTINUOUS (n=14)	16.44 ±4.45	14.85 ±4.38	- 9.67
INTERVAL (n=14)	20.40 ±7.15	17.72 ±7.63	-13.13

In contrast to control group (it was increased from 18.17 ± 4.70% to 18.53 ±, +1.98%) percent body fat was decreased by 9.67% (from 16.44 ± 4.45% to 14.85 ± 4.38%) and 13.13% (from 20.40 ± 7.15% to 17.72 ± 7.63%) in continuous and interval running groups, respectively.

However, there were no significant differences among the groups (P>0.05).

Regular participation in physical activity plays an important role in the regulation of body composition.

Adeniran et.al. (1988) as a result of eight weeks continuous and interval running programs found that in contrast to the control subjects, the runners (aged 13-17 years) had significantly reduced percent body fat. Relative body fat decreased by 1.5%, 8.1%, and 7.2% in the control, continuous and interval running groups, respectively.

Although the results of studies on exercise-related body composition changes at adolescence are confounded by maturational changes, there appears to be a general agreement that youngsters who regularly engaged in physical training are generally leaner, have more lean body weight and have less percent fat than those who are not physical active (Adeniran et.al., 1988). Other significant factors in body composition research are energy expenditure and dietary habit. In this study, subjects' diet was not controlled but they were instructed not to alter their feeding habits throughout the duration of the training programme.

Thomas et.al. (1984) cited that percent body fat decreased in all exercising groups at the end of the continuous and interval training was performed three times per week for 12 weeks. However, no program was superior.

In the present study lean body weights of subjects were increased in all groups ($P<0.05$). However these increments were not found significant among the groups ($P>0.05$).

Changes in lean body weight are summarized in Table 12.

TABLE 12: Pre-test and Post-test Lean Body Weight Values of the Subjects

GROUP	LEAN BODY WEIGHT (kg) PRE-TRAINING	POST-TRAINING	%CHANGE
CONTROL (n=15)	37.264 ± 7.681	38.210 ± 7.297	+ 2.53
CONTINUOUS (n=14)	38.961 ±10.161	40.874 ±10.816	+ 4.91
INTERVAL (n=14)	39.099 ± 6.237	41.159 ± 6.178	+ 5.26

Lean body weights of subjects were increased by 2.53% (from 37.264 ± 7.681 kg to 38.210 ∓ 7.297 kg), 4.91% (from 38.961 ± 10.161 kg to 40.874 ± 10.816 kg), 5.26% (from 39.099 ± 6.237 kg to 41.159 ±6.178 kg) in control, continuous and interval running groups, respectively.

In general, athletes specializing in strength and power tend to have a high lean body weight, while extreme aerobic type athletes tend to have a low lean body weight. Moreover, with respect to relative body fat, athletes involved in sports where body weight is supported in some manner tend to have higher percent body fat values than athletes involved in extreme aerobic type sports (Fleck, 1983 and Wilmore, 1983).

Olsen et.al. (1988) applied two intense (92%-100%) interval training on 12 healthy males who were previously active runners. They found that the body weight of both groups remained nearly constant although the percentage of body fat decreased from 14 to 12.8% in the 100% group ($P<0.05$). The intense nature of the training was thus sufficient to reduce body fat and increase lean body weight. The lean body weight increase was similar in the groups (2,7% in the 100% group, $P<0.05$ and 2.0% in the 92% group $P>0.05$).

At the end of the eight weeks different running programs, changes in resting heart rate of subjects were found significant ($P<0.05$). These changes are summarized in Table 13.

TABLE 13: Pre-test and Post-test Resting Heart Rate Values of the Subjects

GROUP	RESTING HEART RATE (beat/min) PRE-TRAINING	POST-TRAINING	%CHANGE
CONTROL (n=15)	80.4 ± 7.45	83.33 ±12.20	+ 3.64
CONTINUOUS (n=14)	84.0 ± 15.61	72.42 ± 8.95	-13.78
INTERVAL (n=14)	83.85± 13.16	74.57 ± 9.02	-11.06

In contrast to control group resting heart rates of subjects participated in this study were decreased by 13.78% (from 84 ± 15.61 beat/min to 72.42 ± 8.95 beat/min), 11.06% (from 83.85 ± 13.16 beat/min to 74.57 ±9.02 beat/min) in continuous and interval running groups, respectively. This may be explained by an increase in stroke volume as a result of participating in exercises.

The reduction in resting heart rate following the aerobic exercise program is consistent with reports from other studies of aerobic exercise (White et.al., 1984; Steinhaus et.al., 1990; Clarke, 1974; Astrand and Rodahl, 1987; Haffor et.al., 1990).

Continuous exercise may be closer to achieving an optimum for heart development because it allows longer work sessions (Berg and Kris et.al., 1989).

Steinhaus et.al., (1990) studied the effects of four month aerobic conditioning program on heart rate and blood pressure. As a result of their study, although not statistically significant subjects in the aerobic group demonstrated an average four beat per minute reduction in resting heart rate, lowering of systolic and diastolic blood pressure by two and one mmHg, respectively, at rest, and a four beats per minute reduction in recovery heart rate following four months of aerobic exercise.

In the present study results in resting heart rate were found higher in comparison to study done by Steinhaus. However it may be noticed that subjects in the present study were younger and the training time was longer. Also in the Becker and Vaccaros' study (1983) the mean maximal heart rate of the experimental subjects increased 3.87 beats per minute from 196.63 to 200.50. However, these results were not significant at the 0.05 confidence level.

In addition, there were trends toward decreasing of blood pressure in both continuous running and interval running group. But these results were not statistically significant (P>0.05). Changes in resting systolic and diastolic blood pressure (mmHg) are summarized in Table 14.

TABLE 14: Pre-test and Post-test Resting Blood Pressure Values of the Subjects

GROUPS		BLOOD PRESSURE (mmHg) PRE-TRAINING	POST-TRAINING	%CHANGE
CONTROL (n=15)	Systolic	104.46± 7.74	100 ±11.64	- 4.26
	Diastolic	65.73± 5.22	68.73 ± 8.02	+ 4.56
CONTINUOUS (n=14)	Systolic	104.14±10.12	101.57 ±10.93	- 2.46
	Diastolic	67.57± 8.83	66.85 ± 3.91	- 1.06
INTERVAL (n=14)	Systolic	105.0 ± 9.19	98.42 ±11.25	- 6.26
	Diastolic	67.5 ± 7.0	66.42 ± 6.79	- 1.6

In control group while resting diastolic blood pressure was increased from 65.73 ± 5.22 to 68.73 ± 8.02 mmHg (4.56%), systolic blood pressure decreased from 104.46 ± 7.74 mmHg to 100 ± 11.64 mmHg (4.26%).

In continuous running group both systolic (from 104.14 ± 10.12 mmHg to 101.57 ± 10.93 mmHg, 2.46%) and diastolic (from 67.57 ± 8.83 mmHg to 66.85 ± 3.91 mmHg 1.06%) blood pressures were slightly decreased.

In interval running group as in continuous running both systolic (from 105.0 ± 9.19 mmHg to 98.42 ± 11.25 mmH, 6.26%) and diastolic blood pressures (from 67.5 ± 7.0 mmHg to 66.42 ± 6.79 mmHg, 1.6%) were decreased non-significantly (P>0.05).

The pre-training values of the subjects' resting blood pressure indicated that they were normotensive.

A few previous research have assessed the influence of prolonged physical training on blood pressure in children.

Fagard (1985), in a comprehensive review involving adults, concluded that in most studies, resting blood pressure was not significantly influenced by physical training. In addition Adeniran et.al., (1988) studied effects of continuous and interval running on resting blood pressures of schoolboys whose mean age was 16 years. They found non-significant decreases in systolic and diastolic blood pressure levels in all the different categories of subjects.

The results of the present study do not support the hypothesis that continuous and interval training programmes could significantly affect blood pressure in schoolboys. Since the subjects of this study were normotensive, the possible effects of physical training on their blood pressure levels could be more difficult to accomplish.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

As a result of this study significant increases in aerobic power were noted in all the different categories of subjects at $P<0.05$. Thus interval running program was found more effective in improving the aerobic power of schoolboys aged 14-16 years. Therefore null hypothesis was rejected.

Although there were significant increases in anaerobic power within the groups, these increments were not significant among the groups at $P>0.05$. Hence, it is concluded that continuous and interval running programs were not superior to each other in effecting the anaerobic power of schoolboys aged 14-16 years. Therefore null hypothesis was accepted.

In exercising groups percentage of body fat lowered in contrast to control group. However these changes were not found significant at $P>0.05$ among the groups. Meanwhile, lean body weight of subjects in all categories slightly increased. But this increment was not significant at $P>0.05$ among the groups. Therefore, null hypothesis was accepted.

In contrast to the control group continuous and interval running group had significantly reduced resting heart rate at $P<0.05$. Therefore, null hypothesis was rejected.

Conversely, non-significant decreases in resting systolic and diastolic blood pressure levels were noted in all the different categories of subjects except diastolic blood pressure of subjects in control group (it was slightly increased) for this reason, null hypothesis was accepted ($P>0.05$).

In addition height of the subjects participated in this study for all categories within the groups were increased significantly at $P<0.05$. However there was no significant changes among the groups ($P>0.05$).

In contrast to interval running group weight of the subjects in control and continuous running group were increased significantly ($P<0.05$). But there was no significant differences among the groups ($P>0.05$).

RECOMMENDATIONS

There is no doubt that more studies are needed to assess the effectiveness of continuous and interval running programs on aerobic and anaerobic capacities, percent body fat, resting heart rate, blood pressure and lean body weight of schoolboys aged 14-16 years.

It is recommended that more subjects should be participated in the study, so the problems of variability associated with a small group may be reduced.

It is also recommended that some measurements such as aerobic capacity, anaerobic capacity should be taken directly in order to increase the accuracy and validity of the measurements.

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APPENDICES

APPENDIX A

PERSONAL DATA FORM

GROUP:

NUMBER:

NAME AND SURNAME:

AGE:

HEIGHT (cm):

WEIGHT (kg):

SKINFOLD OF TRICEPS (mm):

LEAN WEIGHT:

PERCENT BODY FAT:

BLOOD PRESSURE (mmHg):

SYSTOLIC:

DIASTOLIC:

RESTING HEART RATE:

AEROBIC POWER (ml/kg/min):

ANAEROBIC POWER (kg.m/sec):

MAXIMAL HEART RATE: (Beat/min)

TARGET HEART RATE: (Beat/min)

.../.../...

APPENDIX B

DAILY TRAINING RECORD SHEET OF CONTINUOUS RUNNING GROUP

Date :
Temperature :
Relative Humidity :
Total Distance : 4800 m
Each Lap : 400 m

No.	L	A	P	S									Heart Rate	THR
	1	2	3	4	5	6	7	8	9	10	11	12		
1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
13														
14														
15														

APPENDIX C

DAILY TRAINING RECORD SHEET OF INTERVAL RUNNING GROUP

Date :
Temperature :
Relative Humidity :
Total Distance : 4800 m
Each Lap : 400 m

	I. REP.				II. REP.				III. REP.				IV. REP.				
No.	1	2	3	HR	1	2	3	HR	1	2	3	HR	1	2	3	HR	THR
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	
11																	
12																	
13																	
14																	
15																	

APPENDIX D

RAW DATA OF SUBJECTS PARTICIPATED IN PRE-TEST

SUBJECT NO	GROUP	AGE	HEIGHT	WEIGHT	SBP*	DBP**	RHR	AEROBIC P.	ANAEROBIC P	%FAT	LBW
1	K*	16	173	56,5	113	60	72	43,78	88,39	14,10	48,533
2	K	14	156	43,5	100	64	78	39,08	54,00	18,15	35,604
3	K	14	157	66	105	60	84	31,40	81,20	25,64	49,077
4	K	14	151	42,5	110	70	72	36,38	59,44	21,86	33,209
5	K	14	141	32,5	105	70	84	38,49	43,94	16,52	27,131
6	K	14	165	52	110	70	84	44,11	60,87	14,10	44,668
7	K	14	154,5	49	98	70	72	31,81	54,21	26,91	35,814
8	K	14	155	39	96	65	72	42,95	46,69	16,52	32,557
9	K	14	158	41	105	65	72	40,77	54,71	20,21	32,713
10	K	15	163	58	110	70	84	44,27	78,03	18,15	47,473
11	K	14	167	46,5	105	65	90	33,74	59,99	18,15	38,060
12	K	14	145,5	34	115	74	78	35,52	37,62	23,12	26,139
13	K	14	147	36	85	55	96	43,46	47,08	11,31	31,928
14	K	14	152,5	38	100	68	84	39,97	48,60	16,52	31,722
15	K	14	164,5	50	110	60	84	40,71	71,70	11,31	44,345
16	C	16	168	56	113	68	72	44,42	76,95	16,52	46,748
17	C	14	156	47,5	105	70	108	38,89	65,17	14,10	40,802
18	C	14	168	56	118	70	90	36,26	79,31	18,15	45,836
19	C	15	159	50	100	70	72	47,31	75,35	11,31	44,300
20	C	14	162	63,5	127	83	60	42,22	98,86	23,12	48,818
21	C	14	175	66	100	60	66	45,04	99,59	16,52	55,096
22	C	14	144	36,5	100	65	90	40,34	46,36	26,91	26,677
23	C	14	151,5	39	90	60	84	41,01	47,46	14,10	33,501
24	C	16	167	62	105	75	102	47,33	91,92	14,10	53,258
25	C	14	149	39,5	100	75	78	38,34	50,78	18,15	32,330
26	C	14	140	30	100	55	90	43,26	37,24	11,31	26,580
27	C	14	145	39	110	70	108	45,10	54,20	18,15	31,921
28	C	14	137	30	100	75	90	46,66	38,97	16,52	25,044
29	C	14	159	39	90	50	66	39,97	48,59	11,31	34,554
30	I	15	171	56	90	60	68	42,39	80,67	12,90	48,776
31	I	14	148	39	110	65	72	41,26	49,97	18,15	31,921
32	I	15	163	48,5	115	80	108	45,52	70,08	16,52	40,487
33	I	14	168	46	95	60	84	29,14	62,70	14,10	39,514
34	I	14	165	58,5	110	65	78	37,75	77,67	18,15	47,882
35	I	14	162	46	100	60	66	46,56	59,75	16,52	38,400
36	I	14	158	42,5	110	70	102	47,45	50,60	14,10	36,507
37	I	15	154	41,5	100	70	72	40,04	57,30	11,31	36,769
38	I	14	171	59,5	110	80	84	40,79	87,82	21,86	46,493
39	I	14	155	59	110	65	78	30,09	74,55	31,65	40,326
40	I	14	150	39	100	65	102	26,29	44,79	26,91	28,505
41	I	14	155	57	110	70	90	30,12	69,37	33,83	37,716
42	I	14	157	56	120	75	90	36,86	79,80	21,86	43,758
43	I	14	155	42	90	60	80	37,37	46,47	27,77	30,336

SBP:Systolic blood pressure (mmHg)
DBP:Diastolic blood pressure (mmHg)
RHR:Resting heart rate (beat/min)
LBW:Lean body weight (kg)

*K:Control group
C:Continuous running group
I:Interval running group

APPENDIX E

RAW DATA OF SUBJECTS PARTICIPATED IN POST-TEST

SUBJECT NO	GROUP	AGE	HEIGHT	WEIGHT	SBP	DBP	RHR	AEROBIC P.	ANAEROBIC P	%FAT	LBW
1	K	16	175	57	110	60	78	48.28	90.06	18.15	46.654
2	K	14	156	44,5	105	62	78	44.27	56.52	18.15	36.423
3	K	14	158	68	110	70	86	34.93	82.31	28.62	48.538
4	K	14	151	44	90	64	84	43.95	59.20	23.12	33.827
5	K	14	142	33	120	90	66	44.27	42.57	14.10	28.347
6	K	14	168	55	95	70	78	47.65	65.48	15.31	46.579
7	K	14	155	49,5	115	80	78	33.00	59.92	28.62	35.333
8	K	14	157	41	80	60	66	49.52	52.89	14.30	35.137
9	K	14	161	44,5	95	70	78	46.94	64.50	18.15	36.423
10	K	15	165	59	110	70	90	48.40	95.83	15.31	49.967
11	K	14	168,5	48	95	70	90	35.82	63.20	21.86	37.507
12	K	14	147,5	36	85	65	78	36.41	43.57	24.37	27.226
13	K	14	149	38	90	60	108	47.09	50.03	11.13	33.702
14	K	14	153,5	39	95	70	108	38.34	51.00	16.52	32.557
15	K	14	168	50	105	70	84	45.92	69.48	10.12	44.940
16	C	16	169	57	104	60	66	51.10	85.55	14.10	48.963
17	C	14	156	46	100	70	78	47.68	69.04	11.31	40.797
18	C	14	169	56	93	65	78	51.47	86.74	12.90	48.776
19	C	15	160	51	105	65	72	54.98	83.70	14.10	43.809
20	C	14	163,5	63	120	70	54	48.14	102.45	20.21	50.274
21	C	14	176	68	95	65	66	54.73	110.58	11.31	60.248
22	C	14	145	37,5	85	60	66	44.52	51.15	21.86	29.302
23	C	14	152	41,5	100	70	78	49.76	58.08	12.90	36.146
24	C	16	167,5	63,5	110	73	78	51.10	101.82	10.12	57.086
25	C	14	150	42,5	95	70	78	47.39	60.95	23.12	32.674
26	C	14	142	33	100	70	66	50.31	45.01	11.31	29.238
27	C	14	146	39	125	65	90	52.99	57.89	17.33	32,253
28	C	14	138	32,3	90	65	78	51.29	46.32	17.33	26.712
29	C	14	159	40	100	68	66	48.84	53.11	10.12	35.960
30	I	15	173	55	75	50	66	46.05	81.64	10.12	49.390
31	I	14	149	40	100	70	54	48.65	55.98	16.52	33.392
32	I	15	165	51	100	75	84	47.21	82.16	15.31	43.191
33	I	14	168,5	47	93	60	72	47.58	64.95	11.31	41.642
34	I	14	166	56	123	70	90	48.28	78.37	18.15	45.836
35	I	14	166	49,5	105	63	72	53.16	70.14	10.12	44.490
36	I	14	162	44	102	70	72	54.80	61.58	10.12	39.547
37	I	15	157,5	45	90	60	66	49.61	64.53	8.16	41.328
38	I	14	171,5	59	90	65	72	51.32	89.51	18.15	48.291
39	I	14	155	63,5	100	65	78	37.54	88.87	30.78	43.954
40	I	14	150,5	39	90	65	78	41.54	51.05	25.64	29.000
41	I	14	156	57,5	105	75	84	40.79	77.40	29.92	40.296
42	I	14	158,5	55	110	70	78	44.42	86.08	18.15	45.017
43	I	14	156	41,5	95	72	78	48.87	55.48	25.64	30.859