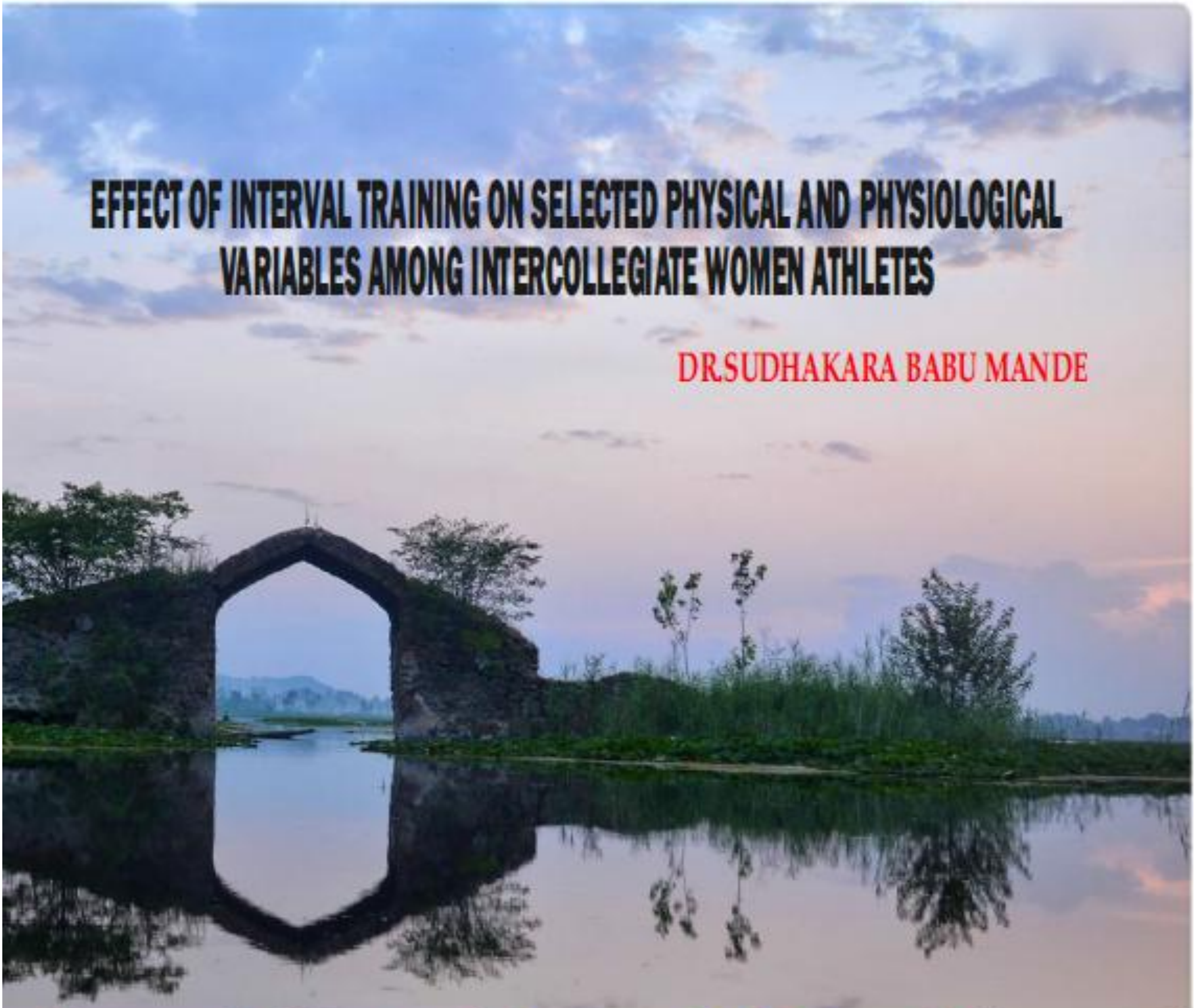
EFFECT OF INTERVAL TRAINING ON SELECTED PHYSICAL AND PHYSIOLOGICAL VARIABLES AMONG INTERCOLLEGIATE WOMEN ATHLETES

DR.SUDHAKARA BABU MANDE



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EFFECT OF INTERVAL TRAINING ON SELECTED PHYSICAL AND PHYSIOLOGICAL VARIABLES AMONG INTERCOLLEGIATE WOMEN ATHLETES

By

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Dedicated to

My Parents, Abraham, Vanakumari.

Wife, Dilleswari.

Daughter, Mythri Sudheepya Paul.

DECLARATION

I hereby declare that the Topic entitled, "**EFFECT OF INTERVAL TRAINING ON SELECTED PHYSICAL AND PHYSIOLOGICAL VARIABLES AMONG INTERCOLLEGIATE WOMEN ATHLETES**" being Published to that it has not previously formed on the basis for the any Topic any other similar title of any wearer Institution.

Place: Kothavalasa

Date: 01-03-2019

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LIST OF ABBREVIATIONS

AK	denylate kinase
ALSPAC	Avon Longitudinal Study of Parents and Children
AN	Anaerobic
ANCOVA	Analysis of Co-variance
ATP	Adenosine triphosphate
BMI	body mass index
Bpm	Beats per minute
CAST2	Children's Activity Scanning Tool2
CG	Control group
CK	creatine kinase
CMJ	counter movement jump
CS	citrate synthase
EG	Experimental group
ES	Effect size
FLAT	The group performing flat surface
GH	growth hormone
HAD	ehydrogenase
HBT	handball training
HIMO	High Mountain
HIS	high-intensity simulation
HIT	high-intensity interval training
HK	hexokinase
Hr	hour
HRR	HR reserve
HRs	Heart Rates
Hz	hertz (Electromagnetic waves)
IA	ntense aerobic
IAAF	nternational Armature Athletic Federation
IAT	Intense Aerobic Training
IFI	intermittent endurance index
IFT	Intermittent Fitness Test

IGF	insulin-like growth factor
IL	interleukin
ISRT	Interval Shuttle Run Test
ITG	interval training group
ITT	individual time trial
IVST	nterventricular septum thickness
Kg	Kilogram
LDH	lactate dehydrogenase
LSPT	Loughborough Soccer Passing Test
LT	lactate threshold
LVEDD	left ventricular end-diastolic
LVESD	left ventricular end-systolic
LVPW	left entricular posterior wall
M	metre
MA	moderate aerobic
MAP	maximal aerobic power
Max	maximum
Min	minute/s
ML	Milliliter/s
MOD	Moderate Intensity
MRS	maximal running speed
MSSR	multiple-stage shuttle run
MVPA	Moderate or Vigorous Physically Activity
Ngxml	nanograms per milliliter of fluid
Nm	Nanometer
OBLA	onset of blood lactate accumulation
PCr	phosphocreatine
PFK	phosphoro fructo knare
PHOS	glycogen phosphorylase
RE	Running Economy
RM	repetition maximum
RPE	rating of perceived exertion
RSA	repeated-sprint ability
RSG	repeated-sprint training group

RSR	Shuttle run
RTT	Runs time trial
Sec	second/s
SEMO	Semi mountanious
SES	socioeconomic status
SLS	Stride Length speed
Tour	Tour de France
TQR	total quality of recovery
TRIMP	training impulse
TT	time trial
TV	Television
UK	United Kingdom
UR	unresisted
USA	United States of America
Vo(2max)	Maximal Oxygen uptake
Vo_2	Oxygen
VO2peak	peak oxygen uptake
VT	ventilatory threshold
Vuelta	Vuelta a España
W(max)	maximal power output maximal
Wk	week
WS	weighted sled
Wv	weighted vest
YY1RT	Yo-Yo Intermittent Recovery Test level

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Chapter-I
INTRODUCTION

The ancient philosopher Aristotle of Greece proclaimed the quality of people, quoted by Bucher as follows: "The body is the temple of the soul and to reach harmony of body, mind and spirit, the body must be physically fit". The efficiency of the human body depends upon many factors. With the enhanced status of sports in society the provision of sports training has become very important although the need for competent training has long been recognized.

Over three thousand years ago, the Greeks saw the need to provide effective and efficient training for the athletes taking part in the Olympics games. But since 1950s many countries have recognized the importance of an effective sports training programme in a wide range of activities not only for the success in major international competitions but also for the development of healthy participants comprehensive sports training programme is the key factors in producing the skillful high performance.

Every human being participates in some kind of sports activity or physical exercise during the course of his life. This exercise may vary for different individuals. It may be walking, jogging, and cycling working in a factory or participation in games and sports. Regular participation in exercise programme markedly influences physical, physiological and mental fitness of an individual.

Life will not be a life without physical activities. Through physical activities alone people were able to survive in earth. The story of evolution throws some light on the nature and type of activities, which are an essential part of modern physical activities which are to be fit for day to day existence and to meet the occasional emergencies that arise. Whatever may the emergency that trust itself on individuals the human beings have to readjust and carry on.

An ideal man should be strong, healthy, broadminded and active. Mujumdar (1950) opines that "Activity is life while stagnation is death".

Proper growth and maintenance of good health occurs due to participation in daily physical activities. It is a biological principle that structure decides function. Man needs vigorous exercises for growth and development. To perform the daily activities in a more efficient manner, the condition of muscles, its strength and endurance are essential. A muscle was must be overloaded in order to be strengthened. (Hooks, 1962)

Physical fitness is a capacity for sustained physical activity. It is to achieve success in every walk of life. The progress of one country depends mainly on the degree of physical fitness of the people. According to Willgoose (1961) "Physical Fitness provides capacity for doing all types of activities". Currently there is wide interest to identify the most effective methods of training for strength and endurance development and this is of special significance for physical education programmes in schools and colleges.

Training is usually defined as a systematic process of repetitive, progressive exercise or work involving the learning process and acclimatization (Gray Kumar, 2002).

Recent evidence shows that the difference between the trained and untrained individuals is that the former is able to increase the cardiac output and transport oxygen to the working muscles at a higher rate than the latter (Clarke and Albert, 1952).

Training is a series of physical activities executed for the purpose of increasing efficiently in running and it should be continued throughout an athlete's lifetime. The specific physical fitness that permits a faster time is acquired most efficiently through scientifically tailored schedule to the length and anticipated speed of the racing distance (Falls, 1968).

Sports training are a specialized process of the physical perfection of the content of which is the planned preparation for top class performance in the event or discipline chosen on the basis of evaluation and training. For improving the standard of play in the field of sports, conditioning exercises play a prominent role. Conditioning is essential for any form of sports or games.

Exercise builds confidence, physical and mental abilities. Cultivates power of will and determination and promotes personal efficiency and a number of positive mental characteristics.

Exercise brings healthful activity to every organ, gland and all of the body; it makes the entire body active and radiantly alive with a feeling, energy and well being that an individual feels very buoyant and alert. Exercise is the best insurance against disease or sickness (Mujumdar, 1950)

1.1 TRAINING

In general usage, the term "training" is used to denote different things. In the broad sense, training today is used to mean any organized instruction whose aim is to increase man's physical psychological, intellectual or mechanical performance rapidly. In the field of sport we speak of training, in the sense of preparing sportsman for the highest levels of performance.

The training is a process of preparing an individual for any event or an activity or job. Training for competitive sports is particularly effective way of developing the personality.

1.2 SPORTS TRAINING

Sports Training is a programme of exercise designed to improve the skills and to increase the energy capacity of an athlete for a particular event, therefore training is essential for the development of physical fitness components (William, J.C.P. and Sperryn, P.N., 1976).

Sports training are the process of sports protection based on scientific and pedagogical principles for higher performance (Hardayal Singh, 1991).

The word training has been a part of human language since ancient times. It denotes the process of preparation for some task. This process invariably extends to a number of days and even months and year. The term "training" is widely used in sports. There is however some disagreements among sports coaches and also sports scientists regarding the exact meaning of the word. Some experts, especially belonging for sports medicine understood sports training as basically doing physical exercise, several terms used in training for example, strength training, interval training, bench step training, technical training and statistical training reflect the line of thinking.

The Basic training procedures will serve better when utilized with modification suited to individuals or a group dealt with. The training programme should look into improving the performance of the athletes and at the same time should prevent injury from taking place (Edward L. Fox, 1984).

Training means a systematic scientific programme of conditioning exercise and physical activities designed to improve the physical fitness and skills of the players or athletics participated. Training means preparing for something for an event or reason of athletic competition, a nursing carrier or operative performance of military combat, much growth and change occur during training.

Training involves periodic assessment of the athlete's status and progress. Training usually varies regular increase in the difficulty of task performance. Training suggests some form of gradual increase in performance output over an extended period of time. Most kind of training needs regular repeated and collective repetition of some of the original movement. Any invariable training implies hard work. Training should result in a level of personal fitness and should be associated with good health. Training is the programme of exercise designed to improve the skills and increase the energy capacities of an athlete for a particular event.

According to Harre (1982), Sports training is a process of athletic improvement, which is conducted on the basis of scientific principles through which systematic development of mental and physical efficiency, capacity and motivation enables athletes to produce outstanding and record breaking athletic performance. Sports training also consists of all those learning influences and processes that are aimed of enhancing sports performance.

According to Hardyal Singh (1991) sports training is pedagogical process, based on scientific principles, aiming at preparing sportsman for higher performances in sports competitions.

The main form of sports training is the application of a physical load through physical exercise.

According to Matveger (1982) sports training is the basic form of an athletes training it is the preparation systematically organized with the help of exercises, which in fact is a pedagogically organized process of controlling an athlete's development.

Martin (1979) said "sports training is a planned and controlled process for achieving a goal, changes in complex sports motor performance, ability to act and behavior are made through measures of content, methods and organization".

The athlete's development in the course of training is brought about by a variety of ways and means. The main form of sports training is the application of a physical load through physical exercise.

There are so many methods of developing the basic performance. Coaches' duty is to select the suitable method of training that would enlighten a smooth way towards better performance. The basic components of physical fitness such as endurance, strength, speed, agility, flexibility can be developed through different training methods.

In the present field of sports the most popular and very much applying method is resistance training. Resistance training is widely used by all expert coaches in training team and athletes.

In the last few years, many strength-training programs are evolved to emphasize strengthening muscle of the core that is muscles of the trunk and pelvis, the core of the body. Core strengthening, especially for players are required for specific sports skills. Thus, particular muscle groups in the core may be more or less important for a given individual. These groups include the abdominal hip muscles, spinal musculature, and trunk muscles.

1.3 INTERVAL TRAINING

In 1956 Olympic games at Melbourne, four athletes created a new Olympic record in 800 M and nine athletes in 1500 M race. This record breaking effort in middle distance and many other events has been the recent trend in Olympics and World championships is the scientific training method which was then and is now being adopted as "interval training" specific to each sport / event.

In interval training the aims of athlete is to run a particular distance, five, ten or 15 times at the same speed and time. The interval in between each run should also be almost the same and the athlete must learn to judge the speed of run.

Interval training develops the ability of the athlete to run at a particular pace. This type of training by adjusting the time, number and distance of the run can be adopted to suit the needs of any middle distance runner. This is flexibility is an advantage of training system.

Interval training is a series of repeated bouts of exercise alternated with period of lighter work or rest (Gray Kumar, 2002).

The rest interval incorporated into the interval training allows initially and then reduces accumulation of fatigue products associated with increased energy utilization and cardiac workload.

The training schedule for one year can be divided into three major components – pre-competition season, competition season and off-season. In off-season and pre-competition seasons the coach should concentrate more on the aerobic endurance and so the repetition of exercise will be more and the time interval will be lesser. In competition season the repetition of exercise will be very less and the interval will be maximum with 90% training intensity. The relief interval training usually is expressed in relation to the work interval. It is a work relief ratio and is expressed at 1:½ , 1:1, 1:2 and 1:3. Thus 1:½ implies that the relief interval is half the time of the work; 1:1 indicates the relief and work intervals are the same and so on (Fox and Mathews, 1974)

1.4 INTENSITY OF TRAINING

Exercise intensity should be checked frequently during and beginning of exercise programme. This requires some practice in taking one's pulse usually in the radial or carotid artery locations, since it is rather difficult to palpate the pulse during exercise. The pulse should be taken for a period of ten seconds immediately after stopping, beginning the count with zero. If the rate is below the prescribed training range, the intensity should be increased and if the rate is above the range, the intensity should be reduced.

For cardiovascular conditioning to take place the intensity should exceed approximately 50 percent at 60 percent of functional capacity (VO_2) and for safety and comfort and may exceed to 75 per cent to 80 per cent. This usually translates to a heart rate training range of 70 per cent to 80 per cent of maximal heart rate.

Maximal heart rate can be estimated to be 220 beats per minute for healthy individuals under age 20. Under age 45 with no coronary risk factors, endurance –

training also tends to show somewhere around 185 to 190 beats per minute. It tends to lower the resting heart rate. In highly trained athletes, it may be as low as or lower than 40 to 45 beats per minute, on the other hand, in healthy but untrained subjects, resting heart rates may be as high as 90 to 100 beats per minute. Thus the trained subject is generally characterized as having a lower resting heart rate and the untrained as a high resting heart rate. The highest attainable heart rate during performance of strenuous work not only depends upon the state of conditioning but also upon age.

For cardiovascular conditioning to take place the intensity should exceed approximately 50 per cent of functional capacity (VO_2) and for safety and comfort not to exceed 75 per cent to percent. This usually translates to a heart rate training range of 70 per cent to 80 per cent of maximal heart rate.

The intensity and length of the work interval should be based upon the primary energy system being used in the activity. Sprinters should have short high intensity intervals whereas marathons may run intervals of 3 miles at race pace or slower. It should be pointed out that the rest interval is really not a time to stop all activity but only a jog or walk period which allows the body to recover somewhat before the next interval begin.

At the age of 20 the maximal heart rate is about 200 which is reduced to approximately 155 at the age of 70. The exact mechanism involved in this age reduced maximal heart rate is not fully understood. It is also pointed out that the type of exercise also definitely influences the increase in heart rate. For example, the greatest acceleration of the heart occurs in exercises of speed such as sprint running where as the smallest increase takes place in exercise of strength such as weight lifting and throwing in exercise that are classified as endurance such as distance running. The heart rate is somewhere between those of speed and strength exercise at the same time, however heart rate recovery take longer following cessation of the endurance exercise.

There are several factors that affect the resulting heart rate besides exercise and training. Although the extent of variation differs with each individual body position has a definite effect upon the heart rate. Generally, the rate is lowest in the recumbent followed by the sitting and standing. It appears that the typical response from the recumbent to the standing position is an increase around 10 to 12 beats per minute. This is done to the influence of the gravity, which lowers the volume of blood returning to the heart. One goes from a reclining position to a sitting or standing position individuals who are physically fit show a similar increase between lying and standing than sedentary individuals.

1.5 INTENSITIES OF TRAINING AND ITS EFFECT

The training effect of exercise depends upon the amount of stress imposed upon the relevant part of the body. There is variation in the resting heart rate response that is used in the exercise gives a better indication of intensity.

Physiological changes ranging from training are generally related to the intensity of the exercise. Intensity is expressed in terms of efforts relative to the subject control capacity. The enhancement of capacity is greater when load of 90% to 100% of the individual capacity are imposed. Maximal loads are potentially injures and painful and re utilized mainly by athletes in their final training for championship performance.

Significant training changes occur at levels of intensity as low as 25% of maximal cardiovascular function of middle aged men improved identically at the intensity of the individuals. Maximum heart rate equal to 70% to 87% of his maximal – oxygen uptake (Anario Anthony, 1972).

1.6 ATHLETES

Athletics is one of the most popular sports around the world. The events are the oldest form of organised sports, and are associated with the simplest physical activities running, throwing a stone, surmounting an obstacle. These activities gradually evolved into sports events such as running, jumping and throwing events.

Athletics is one of the purest of all sports, relying solely on the strength of the human body rather than technological implements to improve performances. Athletics is divided into two main categories; events that take place inside the stadium, and events that take place outside the stadium such as Marathon and road walk (www.athens 2004.com)

Athletics is derived from the Greek word "athlos" meaning contest. Although they were initially associated with all sports, they now specifically refer to track and field events and throws.

Track and Field events he oldest organised sports, have been held for thousands of years. The first organised meets known to history are Olympian Games, which the Greeks initiated in 776 BC. For many years, the Chief Olympian competition was the pentathlon, which comprised discus and javelin throwing foot racing, broad Jumping and wrestling (Geroge T. Bresnaham and W.W. Tottle, 1950). The Romans continued to hold the Olympian contests after they conquered Greece in 146 B.C. in A.D. 394 the Games were abolished by the Roman Emperor, Theodosiusl. For eight centuries thereafter, no organized track and field competitions were held. Revived in England about the middle of the century, track and field gradually became favorite English Sports.

In 1896 the Olympic Games, a modified revival of the Olympian Games were initiated in Athens. The International Armature Athletic Federation (IAAF) is the governing body of rack and field competitions at the international level it establishes rules and approves world record.

Athletics, also known as track and field or track and field athletics, is a collection of sports events that involve running, throwing and jumping. The name is derived from the Greek word 'athlon' meaning 'contest'.

Athletics is an individual sports event of a person in sports field. This sports event varies according to their performance and physical fitness of the body. In the games and sports field, physical fitness components is very essential to achieve the peak performance of an individual. To achieve the goal exactly, the athletes must have dedication of right practices. Hence, physical fitness plays a vital role for each and every synchronized movements of the body.

1.7 PHYSICAL FITNESS

Fitness is a term, which is often used as synonyms to health in a limited manner. Fitness denotes different facts of health. The term fitness is the capacity of the individual to live and function effectively, purposefully, here and now to meet confidently the problems and crises which are among his expectations.

Fitness is a state which characterizes the degree to which a person is able to function. Ability to function depends upon the physical, mental, emotional, social and spiritual components as fitness, all of which are related to each other and are mentally independent. This may be referred to as total fitness (Uppal, 2004).

The physical fitness plays a vital role in the performance. An individual physical fitness and performances depend in the co-ordinative functions of the various factors such as physical, physiological abilities, nutrition, technique, tactics, physique, body size and composition.

Physical fitness is the human body what fine-tuning is to an engine. It enables us to perform up to our potential. Fitness can be described as a condition that helps us for better look, pleasant feel and do our best. More specifically, it is "the ability to perform daily tasks vigorously and alertly, with energy left over for enjoying leisure time activities and meeting emergency demands. It is the ability to endure, to bear up, to withstand stress, to carry on in circumstances where an unfit person could not continue, and is a major basis for good health and well being".

Physical fitness involves the performance of the heart and lungs, and the muscles of the body. And since what we do with our bodies also effects what we can do with our minds, fitness influences to some degree qualities such as mental alertness and emotional stability.

As any one undertakes his fitness programme, it's important to remember that fitness is an individual quality that differs from person to person. It is influenced by age, sex, heredity, personal habits, exercise and eating habits, diet, attitude towards life, anxiety, tension and stress, values of physical fitness, institutional curricular and states policy / legislation. One cannot do anything about the first three factors, however, it is within his power to change and improve the others where needed (Uppal, 2004).

In order to find out the effect of interval training among intercollegiate women athlete's flexibility and muscular endurance were selected for this study as physical fitness variables.

1.8 PHYSIOLOGICAL VARIABLES

For the physiological system of the body to be fit they must function well enough to support the specific activity individual is performing. Moreover different activities make different demands upon the organism with respect to circulatory, respiratory, metabolic and neurological process which are specific to the activity.

The lungs, heart and blood perform a vital function on the body's supply system. They supply to the muscle with necessary fuels, oxygen and carry wastes such as carbon dioxide and lactic acid. Consequently the cardio-respiratory system in the athletes needs to be developed.

The various physiological variables are resting pulse rate, blood pressure, breath holding time, vital capacity, anaerobic power, aerobic power etcetera. The pulse rate and blood pressure are the two variables taken in the side of physiological variables in the study. The pulse rate and blood pressure are the two parameters that belong to the blood circulatory system of the body.

1.8.1 Importance of Physiological Variables

Understanding the importance of physiology in physical education is to study the training effects, to study the ways and means by which the athletes can improve their performance and the principle of training methods. Sports consist of preparation and performance about 99% preparation and 1% performance. They need to make the most, effective use of our preparation time so that our athletes can achieve high level performance. For that the physiological systems should be taken care very much for the adaptation to their particular activities as because function decides structure. The system will change or adapt according to the nature of the activity. Therefore to know this fact among the players is very important for the improvement of performance. Because the level of fitness of physiological system may vary from players to player according to conditional status of the proper functioning of physiological system is needed to achieve in sports.

For the purpose of this study, physiological variables resting pulse rate and vital capacity were selected to find out the effect of interval training on physiological variables among intercollegiate women athletes.

1.9 NEED OF THE STUDY

The training process acts as a means of improvement of sports performance. In order to ensure fast development of sports performance in every individual the physical education teacher, the coaches and the instructors must possess a thorough knowledge of the improvement aspects of sports training. Training demands correct understanding and realization of the sportsman’s strength, capacity and weakness, so planned and formulated that the strong points are further encouraged and developed and his weakness are discriminated and eliminated.

Interval Training improves the functions of the circulatory, the respiratory and the muscle system while practice is largely aimed at improving the control of muscle activity by the nervous system. In this research, the investigator was interested to find out the effect of interval training on selected physical and physiological variables among intercollegiate women athletes.

1.10 OBJECTIVES OF THE STUDY

The study aimed at finding out the physical fitness levels of flexibility and muscular endurance and physiological levels of resting pulse rate and vital capacity of intercollegiate level women athletes.

The study further aimed at formulating suitable interval training for the benefit of women athletes and to find out the effect of the same on selected physical and physiological variables of intercollegiate level women athletes.

1.11 STATEMENT OF THE PROBLEM

The purpose of the study was to find out the **effect of interval training on selected physical and physiological variables among intercollegiate women athletes**.

1.12 HYPOTHESIS

It was hypothesized that:

1. There would be no significant differences due to interval training on physical fitness variables such as flexibility and muscular endurance among intercollegiate women athletes.
2. There would be no significant different due to interval training on physiological variables resting pulse rate and vital capacity among intercollegiate women athletes.

1.13 SIGNIFICANCE OF THE STUDY

The following are the significance of the study.

1. This study may provide suitable interval training programs to help women athletes to improve fitness and thereby the performance in competition.
2. This study will help to find out that interval-training programs are essential to develop athletes' physical fitness levels.
3. The study is significant in suggesting interval training would help in maintaining and improving body weight and shape.
4. This study will provide additional knowledge to the research scholars on interval training and its effect on physical and physiological variables of women athletes.

1.14 LIMITATIONS

This study was limited in the following respects:

1. The study was conducted on intercollegiate level women athletes only.
2. The diet, atmosphere and temperature were not taken into consideration.
3. The performance and skills of the subjects and their background experience in the field of sports and games were not taken into consideration.
4. The psychological and nutritional status of the subjects were not measured in the study, and
5. The subjects were allowed to do their routine work of the college throughout the experiment period.

1.15 DELIMITATIONS

This study was delimited in the following respects:

1. This study was conducted on 40 intercollegiate women athletes from different colleges in Andhra Pradesh.
2. The selected interval training exercises were applied to the subjects in this study.

3. The experiment was conducted for a period of 12 weeks.
4. This study was conducted on the following physical and physiological variables.

Physical Fitness Variables

1. Flexibility
2. Muscular Endurance

Physiological variables

1. Resting Pulse Rate
2. Vital Capacity
3. The age of the subjects ranged from 19 to 24 years.

1.16 DEFINITION OF THE TERMS

The important terms used in this study are defined as follows:

1.16.1 Training

Training has been explained as programme of exercise designed to improve the skills and increase the capacities as resting heart rate.

1.16.2 Interval Training

Fox and Mathews (1974) defined interval training as a system of conditioning or training consisting of a series of repeated bouts of exercise alternated with periods of relief, light or mild exercise usually constitutes the relief period.

1.16.3 Flexibility

Flexibility is defined as the ability of an individual to move the body and its parts through as wide range of motion as possible without undue strain to the articulations and muscles attachments (Hardayal Singh, 1991).

1.16.4 Muscular Endurance

Muscular endurance is the ability of the muscle to continue to perform without fatigue (Fox and Mathews, 1974).

1.16.5 Resting Pulse Rate

Resting pulse rate is defined, as the time from the end of one contraction to the end of the next contraction is a complete heartbeat or pulse or cardiac cycle. The complete cardiac cycle takes less than one second (about 0.08 sec) in a normal adult at rest and it shortened by exercise. The scores of the resting pulse rate is recorded in number of pulse rate per minute.

1.16.6 Vital Capacity

The volume of air that can be moved out of the lungs after maximum inspiration is called vital capacity.

The maximal volume of air that can be forcefully exhaled from the lungs following a maximal expiration.

Chapter-II

REVIEW OF RELATED LITERATURE

A study of relevant literature is essential to get a full picture of what has been done and said with regard to the problem under study. It is an answer to the question why the hypothesis was selected for of the present problem. It is a key to the thinking of the investigator. Collection of relevant literature provides the basic understanding of the problem and the depth. Such a review brings about a deep insight and a clear perspective of the overall field.

David H. Clarke and H. Harrison Clarke (1970) have made it clear that knowledge of the literature of the field will readily reveal problems. The beginner scholar however will not have a broad or a deep understanding of the published research in this field.

To acquire this knowledge is the aim of the graduate programme itself. The following literature collected from various sources will provide the background to the study and guide us to understand the effect of different intensities of interval training on body composition and cardio-respiratory endurance.

The review of literature has been divided into three major sub-sections, namely:

1. Studies on interval training
2. Studies on training on physical fitness
3. Studies on training on physiological variables

2.1 STUDIES ON INTERVAL TRAINING

Wong, P.L. (2010) examined the effect of concurrent muscular strength and high-intensity running interval training on professional soccer players' explosive performances and aerobic endurance. Thirty-nine players participated in the study, where both the experimental group (EG, n = 20) and control group (CG, n = 19) participated in 8 weeks of regular soccer training, with the EG receiving additional muscular strength and high-intensity interval training twice per week throughout. Muscular strength training consisted of 4 sets of 6 RM (repetition maximum) of high-pull, jump squat, bench press, back half squat, and chin-up exercises. The high-intensity interval training consisted of 16 intervals each of 15-second sprints at 120% of individual maximal aerobic speed interspersed with 15 seconds of rest. EG significantly increased ($p <$ or $= 0.05$) 1RM back half squat and bench press but showed no changes in body mass. Within-subject improvement was significantly higher ($p <$ or $= 0.01$) in the EG compared with the CG for vertical jump height, 10-m and 30-m sprint times, distances covered in the Yo-Yo Intermittent Recovery Test and maximal aerobic speed test, and maximal aerobic speed. High-intensity interval running can be concurrently performed with high load muscular strength training to enhance soccer players' explosive performances and aerobic endurance.

Clark, K.P. (2009) determined the longitudinal effects of weighted sled (WS) and weighted vest (WV) sprint training on maximum velocity sprint performance and kinematics. Twenty male collegiate lacrosse players were randomly assigned to a WS group (n = 7) towing 10% body mass, a WV group (n = 6) loaded with 18.5% body mass, or an unresisted (UR) active control group (n = 7). All subjects completed 13 training sessions over 7 weeks. Pre- and post-test measure of sprint time and average velocity across the distance interval of 18.3 to 54.9 m were used to assess sprint performance, whereas high-speed video (300 Hz) and motion-analysis software were used to analyze stride length, stride rate, ground contact time, and flight time. A 3 x 2 repeated measures analysis of variance was performed for each dependent variable and revealed no significant between-group differences for any of the sprint performance or kinematic stride cycle measures. Effect size statistics suggested small improvements in 18.3-m to 54.9-m sprint time and average velocity for the UR group but only trivial improvements for the WS and WV groups. With regard to sprint performance, the results indicate that WS and WV training had no beneficial effect compared with UR training. In fact, for the loads used by WS and

WV in this study, UR training may actually be superior for improving sprint performance in the 18.3-m to 54.9-m interval.

Greig, M. and Siegler, J.C. (2009) investigated the influence of soccer-specific fatigue on the peak eccentric torque of the knee flexor muscles. DESIGN: Descriptive laboratory study. SETTING: Controlled laboratory environment. PATIENTS OR OTHER PARTICIPANTS: Ten male professional soccer players (age = 24.7 +/- 4.4 years, mass = 77.1 +/- 8.3 kg, Vo(2max) = 63.0 +/- 4.8 mL x kg(-1) x min(-1)). INTERVENTION(S): Participants completed an intermittent treadmill protocol replicating the activity profile of soccer match play, with a passive halftime interval. Before exercise and at 15-minute intervals, each player completed isokinetic dynamometer trials. MAIN OUTCOME MEASURE(S): Peak eccentric knee flexor torque was quantified at isokinetic speeds of 180 degrees x s(-1), 300 degrees x s(-1), and 60 degrees x s(-1), with 5 repetitions at each speed. RESULTS: Peak eccentric knee flexor torque at the end of the game (T(300eccH105) = 127 +/- 25 Nm) and at the end of the passive halftime interval (T(300eccH60) = 133 +/- 32 Nm) was reduced relative to T(300eccH00) (167 +/- 35 Nm, P < .01) and T(300eccH15) (161 +/- 35 Nm, P = .02). CONCLUSIONS: Eccentric hamstrings strength decreased as a function of time and after the halftime interval. This finding indicates a greater risk of injuries at these specific times, especially for explosive movements, in accordance with epidemiologic observations. Incorporating eccentric knee flexor exercises into resistance training sessions that follow soccer-specific conditioning is warranted to try to reduce the incidence or recurrence of hamstring strains.

Buchheit, M. (2009) compared the effect of high-intensity interval training (HIT) versus specific game-based handball training (HBT) on handball performance parameters. Thirty-two highly-trained adolescents (15.5+/-0.9 y) were assigned to either HIT (n=17) or HBT (n=15) groups, that performed either HIT or HBT twice per week for 10 weeks. The HIT consisted of 12-24 x 15 s runs at 95% of the speed reached at the end of the 30-15 Intermittent Fitness Test (V(IFT)) interspersed with 15 s passive recovery, while the HBT consisted of small-sided handball games performed over a similar time period. Before and after training, performance was assessed with a counter movement jump (CMJ), 10 m sprint time (10 m), best (RSAbest) and mean (RSAmean) times on a repeated sprint ability (RSA) test, the V(IFT) and the intermittent endurance index (iEI). After training, RSAbest (-3.5+/-2.7%), RSAmean (-3.9+/-2.2%) and V(IFT) (+6.3+/-5.2%) were improved ($P<0.05$), but there was no difference between groups. In conclusion, both HIT and HBT were found to be effective training modes for adolescent handball players. However, HBT should be considered as the preferred training method due to its higher game-based specificity.

Meckel, Y. (2009) documented that Exercise training efficiency depends on the intensity, volume, duration, and frequency of training, as well as on the athlete's ability to tolerate it. Recent efforts to quantify the effects of aerobic exercise training on hormonal response have suggested that exercise lead to simultaneous changes of antagonistic mediators. The effects of anaerobic exercise on these mediators are not known. Therefore, the aim of the present study was to evaluate the effects of a brief sprint interval session on the balance between anabolic (growth hormone [GH]--> insulin-like growth factor [IGF]-I axis) and catabolic hormones (cortisol), and circulating inflammatory cytokines such as interleukin (IL)-6. Twelve healthy elite junior handball players (17-20 years) participated in the study. Exercise consisted of a 4 x 250-m run on a treadmill, at a constant intensity of 80% of the personal maximal speed. Each run was separated by 3 minutes of rest. Blood samples were collected before, immediately after each 250-m run, and 1 hour after the last run. Exercise led to significant increases in GH (0.3 +/- 0.2 to 5.1 +/- 2.2 ngxml, $p < 0.05$), IGF binding protein (IGFBP)-3 (4191 +/- 2.48 to 4875 +/- 301 ngxml, $p < 0.05$), IL-6 (1.3 +/- 0.2 to 2.1 +/- 0.3 pgxml, $p < 0.002$), testosterone, and testosterone/cortisol ratio, and to a significant decrease in IGFBP-1 levels. Levels of IL-6 remained elevated 1 hour after the end of exercise. Exercise had no significant effects on IGF-I and cortisol levels. Changes in the GH-IGF-I axis and testosterone/cortisol ratio after the brief sprint interval exercise suggested exercise-related anabolic adaptations. The increase in IL-6 may indicate its important role in muscle tissue repair after anaerobic exercise. Changes in the anabolic-catabolic hormonal balance and in inflammatory mediators can be used as an objective tool to gauge the training intensity of different types of anaerobic exercises and training periods.

Esteve-Lanao, J. (2008) determined the effects of a running-specific, periodized strength training program (performed over the specific period [8 weeks] of a 16-week macrocycle) on endurance-trained runners' capacity to maintain stride length during running bouts at competitive speeds. Eighteen well-trained middle-distance runners completed the study (personal bests for 1500 and 5000 m of 3 minutes 57 seconds +/- 12 seconds and 15 minutes 24 seconds +/- 36 seconds). They were randomly assigned to each of the following groups (6 per group): periodized strength group, performing a periodized strength training program over the 8-week specific (intervention) period (2 sessions per week). Non-periodized strength group, performing the same strength training exercises as the periodized group over the specific period but with no week-to-week variations; and a control group, performing no strength training at all during the specific period. The percentage of loss in the stride length (cm)/speed (m.s) (SLS) ratio was measured by comparing the mean SLS during the first and third (last) group of the total repetitions, respectively, included in each of the interval training sessions performed at race speeds during the competition period that followed the specific period. Significant differences ($p < 0.05$) were found in mean percentage of SLS loss between the 3 study groups, with the periodized strength group showing no significant SLS change (0.36 +/- 0.95%) and the 2 other groups showing a moderate or high SLS loss (-1.22 +/- 1.5% and -3.05 +/- 1.2% for the non-periodized strength and control groups, respectively). In conclusion, periodized, running-specific strength training minimizes the loss of stride length that typically occurs in endurance runners during fatiguing running bouts.

Brink, M.S. (2010) investigated the relation between training load, recovery, and monthly field test performance in young elite soccer players to develop training guidelines to enhance performance. In a prospective, non-experimental cohort design, 18 young elite soccer players registered training and match duration for a full competitive season by means of daily training logs. Furthermore, session rating of perceived exertion (RPE) and total quality of recovery (TQR) scores were recorded. Weekly duration (TL(d)), load (duration x session RPE = TL(rpe)), and TQR scores were calculated for 1 and 2 weeks before a monthly sub-maximal interval shuttle run tests to determine interval endurance capacity. Participants spent on average 394.4 +/- 134.9 minutes per week on training and game play with an average session RPE of 14.4 +/- 1.2 (somewhat hard) and TQR of 14.7 +/- 1.3 (good recovery). Random intercept models showed that every extra hour training or game play resulted in enhanced field test performance ($p < 0.05$). Session RPE and TQR scores did not contribute to the prediction of performance. The duration of training and game play in the week before field test performance is most strongly related to interval endurance capacity. Therefore, coaches should focus on training duration to improve interval endurance capacity in elite soccer players. To evaluate the group and individual training response, field tests should be frequently executed and be incorporated in the training program.

Roescher, C.R. (2010) reported that The development of intermittent endurance capacity, its underlying mechanisms and role in reaching professional level in soccer was investigated. The sample included 130 talented youth soccer players aged 14-18, who became professional (n = 53) or non-professional (n = 77) players in adulthood. In total 229 Interval Shuttle Run Test (ISRT) scores were taken over five years. Players who became professionals improved from age 14 to 18 on average from 68 to 109 runs in contrast to players who remained amateurs (from 73 to 93 runs). A longitudinal model was developed using linear mixed model procedures. Intermittent endurance capacity can be predicted adequately with a two-level hierarchical model ($p < 0.05$). Anthropometric characteristics and playing position did not improve model fit ($p > 0.05$). The estimated ISRT score necessary to reach professional level is: ISRT=-375.77-62.89+(51.20+4.20)* age-1.50* age (2)+3.54* hours of soccer training+1.18* additional training hours. In conclusion, intermittent endurance capacity improves with age in talented youth soccer players. From age 15 players who reached the professional level show a faster development than their non-professional counterparts. This development is positively influenced by both soccer specific and additional training Georg Thieme Verlag, K.G. Stuttgart, New York.

Chapman, D.W. (2009) aimed to critically examine the effectiveness of a time-limited and distance-regulated interval training program on subelite field hockey players. Subjects comprised 22 women (26.1 +/- 4.5 years, 62.8 +/- 7.4 kg, 1.7 +/- 0.9 m) and 22 men (22.1 +/- 3.2 years, 74.9 +/- 5.4 kg, 1.8 +/- 0.5 m) field hockey players. Performance tests included a standard 20-m multiple-stage shuttle run (MSSR), a 1000-m repeated-effort (x3) time trial (RTT), and a 100-m repeated-effort (x3) shuttle run (RSR) in an ascending pyramid order. The training program was administered separately to the women and men after a traditional, single-peak, 4-week mesocycle, with the fourth week for recovery. Training consisted of an average total sprint distance of 3,000 m. per session during a 20-week data collection period, with testing administered pre and post. Initial athlete profiling showed a significant ($p < 0.05$) gender difference on all performance tests. The MSSR results were 8.6 +/- 2.5 (range 6.7-10.7) and 12.1 +/- 2.4 (10.2-13.5) women and men, respectively. The RTT and RSR times for women and men were 5:34 +/- 0:30 seconds (4:31-6:21), 5:14 +/- 0:30 seconds (4:27-6:02), 4:12 +/- 0:13 seconds (3:50-4:36), and 4:06 +/- 0:13 seconds (3:47-6:02), respectively. After 20 weeks of training, a small to moderate effect size (ES) was calculated for the women's (n = 12) MSSR (ES = 0.74) and RSR (ES = 0.50) results. A distinct improvement in the MSSR resulted after training for men (n = 16), with a moderate ES (1.34). In contrast, completion times in RSR were marginally reduced, with a small ES (0.49). The findings demonstrate that a 3000-m interval-based conditioning program, when conducted in conjunction with normal-skill game play training, can lead to significant improvements in player conditioning during a competitive season. Future research should employ modified performance tests that more accurately reflect the nature of the game.

Greig, M. and Siegler, J.C. (2009) investigated the influence of soccer-specific fatigue on the peak eccentric torque of the knee flexor muscles. DESIGN: Descriptive laboratory study. SETTING: Controlled laboratory environment. PATIENTS OR OTHER PARTICIPANTS: Ten male professional soccer players (age = 24.7 +/- 4.4

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Impellizzeri, F.M. (2008) examined the effects of aerobic interval training on the decline in short-passing ability caused by a short bout of high-intensity intermittent activities. For this randomized controlled trial, 26 junior soccer players (mean age, 17.8 +/- 0.6 years; mean height, 178 +/- 5 cm; mean body mass, 74.5 +/- 6.9 kg) were recruited. After baseline measurements, subjects were randomly allocated to 1 of 2 groups: the control group (CG) or the aerobic interval training group (ITG). The ITG completed 4 weeks of high-intensity aerobic training, consisting of 4 bouts of running for 4 min. at 90%-95% of maximal heart rate, with 3 min. of active recovery between sets, in addition to normal training. Maximum oxygen uptake, Yo-Yo Intermittent Recovery Test level 1 (YYIRT), and short-passing ability (measured using the Loughborough Soccer Passing Test (LSPT)) were measured before and after a 5 min high-intensity simulation (HIS), reproducing the most intense phase of a match. The ITG (n = 11), but not the CG (n = 10), showed a significant 12% and 4% increase in YYIRT and maximal oxygen consumption after training, respectively, and reduced the worsening in LSPT penalty time after the HIS ($p < 0.05$). The relative exercise intensity during HIS decreased in the ITG only ($p < 0.01$). Our results demonstrated that junior soccer players might benefit from aerobic training to attenuate the decline in short-passing ability caused by a short bout of intermittent activities completed at the same pre-training workload.

Meckel, Y. (2009) documented that Exercise training efficiency depends on the intensity, volume, duration, and frequency of training, as well as on the athlete's ability to tolerate it. Recent efforts to quantify the effects of aerobic exercise training on hormonal response have suggested that exercise lead to simultaneous changes of antagonistic mediators. The effects of anaerobic exercise on these mediators are not known. Therefore, the aim of the present study was to evaluate the effects of a brief sprint interval session on the balance between anabolic (growth hormone [GH]--> insulin-like growth factor [IGF]-I axis) and catabolic hormones (cortisol), and circulating inflammatory cytokines such as interleukin (IL)-6. Twelve healthy elite junior handball players (17-20 years) participated in the study. Exercise consisted of a 4 x 250-m run on a treadmill, at a constant intensity of 80% of the personal maximal speed. Each run was separated by 3 minutes of rest. Blood samples were collected before, immediately after each 250-m run, and 1 hour after the last run. Exercise led to significant increases in GH (0.3 +/- 0.2 to 5.1 +/- 2.2 ngxml, p < 0.05), IGF binding protein (IGFBP)-3 (4191 +/- 2.48 to 4875 +/- 301 ngxml, p < 0.05), IL-6 (1.3 +/- 0.2 to 2.1 +/- 0.3 pgxml, p < 0.002), testosterone, and testosterone/cortisol ratio, and to a significant decrease in IGFBP-1 levels. Levels of IL-6 remained elevated 1 hour after the end of exercise. Exercise had no significant effects on IGF-I and cortisol levels. Changes in the GH-IGF-I axis and testosterone/cortisol ratio after the brief sprint interval exercise suggested exercise-related anabolic adaptations. The increase in IL-6 may indicate its important role in muscle tissue repair after anaerobic exercise. Changes in the anabolic-catabolic hormonal balance and in inflammatory mediators can be used as an objective tool to gauge the training intensity of different types of anaerobic exercises and training periods.

Buchheit, M. (2009) gathered evidence supporting the accuracy of the 30-15 Intermittent Fitness Test (30-15 IFT) for individualizing interval training of young intermittent sport players. In 59 young intermittent sport players (age, 16.2 +/- 2.3 years), we observed the relationships between the maximal running speed (MRS) reached at the end of the 30-15IFT (MRS30-15IFT) and physiological variables elicited by shuttle intermittent runs, including maximal oxygen uptake, explosive power of lower limbs. The ability to repeat intense exercise bouts through cardio respiratory recovery kinetics during exercise. To observe the capacity of the 30-15 IFT to prescribe suitable running intensities for interval training sessions, we compared heart rates (HRs) reached during 3 series of intermittent runs. Where distances were set according to the MRS30-15 IFT and to MRS reached with 2 popular continuous field tests: the University of Montreal track test and the 20-m shuttle run test. The results show that the MRS 30-15 IFT is significantly correlated with all physiological variables elicited by shuttle intermittent runs (P < 0.05). Although mean HR were not different among the 3 series of intermittent runs, HR recorded during the runs based on MRS30-15IFT presented significantly less inter-individual variation than when the continuously determined MRS were used as reference speeds. In conclusion, can say that the 30-15IFT leads to MRS that simultaneously takes into account various physiological qualities elicited when performing shuttle intermittent runs. For scheduling interval training sessions, the MRS30-15IFT appears to be an accurate reference speed for getting players with different physiological profiles to a similar level of cardio-respiratory demand and thus for standardizing training content.

Pereira, G. (2008) determined a resting interval between counter-movement jumps (i.e., volleyball spikes) that allows the maintenance of maximal jumping performance. Ten male volleyball players (1.85 +/- 0.05 m, 77.2 +/- 10.6 kg, 21.6 +/- 5.3 years) performed 6 experimental jumping sessions. In the first and sixth sessions, maximal counter-movement jump height was measured, followed by sub-maximal counter-movement jumps to the point of volitional fatigue. The number of counter-movement jumps was used as a reference to test the effect of rest period between volleyball spikes. From the second to fifth experimental sessions, 30 maximal volleyball spikes were performed with different resting periods (i.e., 8, 14, 17, and 20 seconds) followed by counter-movement jumps. Between the 15^{th} and 30^{th} spikes, the blood lactate concentration and heart rate were measured. Because the performance on the first and sixth sessions was the same, no training effects were noticed. During the 8-second resting interval set, the lactate concentration increased significantly between the 15^{th} and 30^{th} spikes (i.e., from 3.37 +/- 1.16 mmol to 4.94 +/- 1.49 mmol). The number of counter-movement jumps decreased significantly after spikes compared to those performed without a previous effort (i.e., from 23 +/- 7 jumps to 17 +/- 9 jumps); and these variables were significantly correlated (r = -0.7). On the other hand, the lactate concentration and number of counter-movement jumps were stable across the other resting intervals, without a heart rate steady state. The results indicate that an adequate resting period between spikes allowed participants to achieve a lactate steady state in which the performance was maintained during the exercise. These findings show that resting intervals between

14 and 17 seconds, typical during volleyball matches, are indicated to use in volleyball spike drills due to their capacity to maintain maximal jumping performance.

Ferrari Bravo, D. (2008) compared the effects of high-intensity aerobic interval and repeated-sprint ability (RSA) training on aerobic and anaerobic physiological variables in male football players. Forty-two participants were randomly assigned to either the interval training group (ITG, 4 x 4 min running at 90-95% of HRmax; n = 21) or repeated-sprint training group (RSG, 3 x 6 maximal shuttle sprints of 40 m; n = 21). The following outcomes were measured at baseline and after 7 weeks of training: maximum oxygen uptake, respiratory compensation point, football-specific endurance (Yo-Yo Intermittent Recovery Test, YYIRT), 10-m sprint time, jump height and power, and RSA. Significant group x time interaction was found for YYIRT ($p = 0.003$) with RSG showing greater improvement (from 1917 +/- 439 to 2455 +/- 488 m) than ITG (from 1846 +/- 329 to 2077 +/- 300 m). Similarly, a significant interaction was found in RSA mean time ($p = 0.006$) with only the RSG group showing an improvement after training (from 7.53 +/- 0.21 to 7.37 +/- 0.17 s). No other group x time interactions was found. Significant pre-post changes were found for absolute and relative maximum oxygen uptake and respiratory compensation point ($p < 0.05$). These findings suggest that the RSA training protocol used in this study can be an effective training strategy for inducing aerobic and football-specific training adaptations.

2.2 TRAINING EFFECTS ON PHYSICAL FITNESS

Meyer (2007) recent studies point to the preventive efficacy of low-intensity endurance training in terms of cardiovascular risk factor modification and mortality reduction. In addition, it is frequently recommended as a means of stimulating fat metabolism. It was the intention of this study to clarify if endurance training effectiveness remains unimpaired when exercise intensity is reduced by a certain amount from “moderate” to “low”, but total energy expenditure held constant. For this purpose, 39 healthy untrained subjects (44 +/- 7 yrs, 82 +/- 19 kg; 173 +/- 9 cm) were stratified for endurance capacity and sex and randomly assigned to 3 groups: “moderate intensity” (MOD, n = 13, 5 sessions per week, 30 min each, intensity 90% of the anaerobic threshold [baseline lactate + 1.5 mmol/l]), “low intensity” (LOW, n = 13, 5 sessions per week, intensity 15 bpm below MOD, duration proportionally longer to arrive at the same total energy output as MOD), and control (CO, n = 13, no training). Training was conducted over 12 weeks and each session monitored by means of portable heart rate (HR) recorders. Identical treadmill protocols prior to and after the training program served for exercise prescription and documentation of endurance effects. VO (2max) improved similarly in both training groups (MOD + 1.5 ml x min (-1) x kg (-1); LOW + 1.7 ml x min (-1) x kg (-1); p = 0.97 between groups). Compared with CO (- 1.0 ml x min (-1) x kg (-1)) this effect was significant for LOW ($p < 0.01$) whereas there was only a tendency for MOD ($p = 0.07$). However, objective criteria (HR (max), maximal blood lactate) indicated that a different degree of effort was responsible for this finding. In comparison with CO (mean decrease of 3 bpm), average HR during incremental exercise decreased significantly by 9 bpm (MOD, $p < 0.05$ vs. CO) and 6 bpm (LOW, $p = 0.26$), respectively. However, there was no significant difference between MOD and LOW ($p = 0.60$), but for changes in oxygen uptake at the anaerobic threshold (VO (2AT)), it was observed that MOD was significantly more effective than CO ($p = 0.048$) and LOW ($p = 0.04$). It is concluded that within a middle-aged population of healthy untrained subjects, endurance training effectiveness might be slightly impaired when the training heart rate is chosen 15 bpm lower as compared to moderate intensity, but the total energy output held equal.

Astrand and Radahl (1986) defined lactate systems as anaerobic glycolysis which has essentially the incomplete breakdown of glycogen in the absence of oxygen. It occurred during the period of maximal exercise testing approximately 90 seconds in duration. The results showed that the corresponding increase in muscle activity which caused muscle fatigue due to the accumulation of H^+ one possible explanation for the fatigue was due to the inhibition of phosphoro fructo knare (PFK) which was essential for the production of ATP.

Thorland (1987) reported that young female track runners (N = 31), at least half of whom were between 9 and 12 years of age, the remainder in the average age range of 14+ years, were classified as sprint (<= 400 m) or middle distance runners (up to 3,200 m). They were well-trained and of national junior level. They were tested on a Cybex II dynamometer for peak torque during leg extension, and on a Monarch bicycle ergometer to determine anaerobic power and capacity as revealed by the Wingate Anaerobic Test. Body composition was determined by underwater weighing. Among physical characteristics, there was a relationship to age but not to event classification. Sprinters were no different to distance runners in stature. Fat-free weight was significantly related to performance measures. When other variables were corrected for fat-free weight variance, their associations with performance variables were reduced considerably. In terms of performance, older subjects were stronger at all Cybex II velocities. Event related differences only occurred at higher speeds (240 degrees per second). Among anaerobic power values, only older athletes demonstrated substantially higher levels than the other subjects. There were no significant differences in anaerobic capacity.

Ullrich (1993) found that low intensity exercise without dietary restriction will not result in weight loss or body composition changes in young women. High intensity exercise will result in body composition change.

Green and Dowson (2002) studied the measurement of anaerobic capacity in human body. The study focuses on laboratory measures which attempts to quantity an aerobic capacities. Maximal blood lactate measured was used in both research and athletic settings to decrease anaerobic capacity. Its user was supported by (a) The high correlation observed between maximal blood lactate and short duration exercise performance presumably dependent upon anaerobic capacity, and (b) The higher maximal blood lactate values observed in sprint and power athletes (who would demonstrate higher anaerobic capacities) compared with endurance athletes or untrained people. The later findings may be partially related to the confounding influence of blood volume, which such high variability response to short and long term exercise demands. Maximal blood lactate was known to be influenced by the intensity and duration of the preceding exercise bout. Therefore, it was plausible these factors may also influence the degree for which maximal blood lactate accurately reflects an aerobic capacity.

Williams (2003) conducted a study on children's and adolescents anaerobic performance during cycle ergometry. The anaerobic test friction braked wingate, other tests such as the fork velocity and isokinetic cycle ergometers were becoming more common. There was unequivocal agreement that children's and adolescence anaerobic power scores were lower than those of adults. Qualitative muscular differences were often cited for this disparity rather than difference in the quantity of the muscle, but conclusive research was lacking in this area.

Bacharach and Davillard (2004) examined a study of intermediate and a long-term anaerobic performance of elite Alpine skiers. Many researchers identified that alpine skiers need muscular strength and complex motor skill abilities. After verifying a variety of tests short test of anaerobic capacity came into existence. Seventeen Nationalities ranked male and female Alpine Ski racers from USA were used. The power was measured in them by keeping 30.5 and 90.5 wingate cycle ergometry tests. Through this study they found that capacity of anaerobic power can be altered.

Munakata, H. (2010) designed to clarify the life habits which predispose to development of obesity and can be modified through an appropriate intervention program to combat childhood obesity and its lifestyle-related diseases. A total of 216 school children from Itano Town, a municipality of Tokushima Prefecture, Japan, who are attending the fourth grade (9-10 years) of elementary schools, participated in the study from 2004 to 2007. The study included child's life habits questionnaire, investigating physical activity by recording the daily steps using a pedometer, anthropometric measurements, hematological examination and hemodynamometry in a cross-sectional survey during a two-month period from June to July every year. It concludes that there are considerable gender-related differences for developing obesity and other lifestyle-related diseases; and all intervention strategies against obesity must consider such gender differences. For example, restriction of television watching hours must be intervened for controlling obesity in boys, however for girls, promotion of exercise practice or making more steps per day with adequate sleeping periods should be intervened as the proper approaches for preventing and controlling obesity and other lifestyle-related diseases.

Boddy, L.M. (2010) assessed changes in body mass index (BMI), the prevalence of obesity and changes in aerobic endurance over time in 9-10-year-old schoolchildren. Methods: Participants were recruited by the Sports Linx project from primary schools across Liverpool. Height and weight data were used to calculate BMI. The prevalence of obesity and overweight were estimated using age and sex-specific cut-off points. Performance on the 20-m multi-stage shuttle runs test (20 mMST) was used as a marker of aerobic endurance. Data were available for 13,418 (6,572 boys, 6,846 girls) 9-10-year-old children. Analysis of covariance was completed to assess year-on-year changes in BMI controlling for deprivation (IMD) and 20 mMST performance, and 20 mMST performance controlling for IMD and BMI. Results: No significant changes in BMI from baseline were observed (P > 0.05). Obesity prevalence reduced in girls (2005 = 10.3%, 2008 = 8.52% in 2008). The data for boys showed no reductions in prevalence (2005 = 6.77%, 2008 = 7.87%). The most recent cohort for boys and two most recent cohorts for girls had lower levels of aerobic endurance than baseline (2004-2005) (P </= 0.01). Conclusions: The data suggest a plateau in the yearly increases in BMI in 9-10 year olds independent of deprivation and fitness and a declining prevalence of obesity in girls. Levels of aerobic endurance have declined independent of BMI and deprivation. The current obesity interventions in place appear to be having some impact on BMI, but further investment is urged to promote fitness in children.

Parrish, A.M. (2009) selected Thirteen regional Australian public primary schools participated in the study (2,946 children). The Children's Activity Scanning Tool 2 (CAST2) collected observational playground physical activity data. The research also addressed: length of break, socio-economic status (SES), gender, number of scanning days, and instrument calibration. The proportions of Moderate or Vigorous Physically Activity (MVPA) children at the observed schools ranged from 0.4 to 0.7. The odds ratio of boys being MVPA relative to girls ranged from 0.8581 to 2.137. There were significant differences between the mean proportions of 3 days of activity (range P = .001 to P = .015) and no association between SES school groupings (deviance ratio: 0.48; P = .503). Interrater reliability for instrument calibration using Spearman correlations coefficients ranged from r = .71 to r = .99. There were significant differences between proportions of MVPA children at the 13 schools and between male and female populations. There was no association between playground physical activity and SES. The monitoring period for CAST2 should be at least 3 days. Interrater reliability indicates that correlations between observers were consistently high.

Pirinçci, E. (2010) determined the prevalence of overweight and obesity and related factors in primary school students in Elazig, a city in eastern Turkey. In March-June 2007, a cross-sectional study of children aged 6-11 years old was performed. A total of 1,782 girls and 1,860 boys were observed. Weight and height were measured. Overweight and obesity using age- and sex-specific body mass index (BMI) cut-off points as defined by the International Obesity Taskforce were used. Prevalence of overweight and obesity were 13.2% and 1.6%, respectively. According to gender, the prevalence of obesity in boys was 2.0% and overweight was 13.9%, while in girls, obesity was 1.2% and overweight was 12.5%. It is found that overweight and obesity may be related to factors such as eating while watching television, and eating fast food. It was noted as a health problem that there are overweight students aged between 6 and 11 years attending primary schools in Elazig province.

Riddoch, C.J. (2009) investigated associations between physical activity at age 12 and subsequent adiposity at age 14. Prospective birth cohort study with data collected between 2003 and 2007. Original recruitment in 1991-2 of 14,541 pregnant women living in the former County of Avon (United Kingdom). At age 12, 11,952 children were invited to attend the research clinic. Of these, 7159 attended, and 4150 (1,964 boys, 2,186 girls) provided sufficient data on exposure, outcome, and confounding variables. Fat mass at age 14, measured by dual emission x-ray absorptiometry, associated with physical activity at age 12, measured by accelerometry. Prospective associations of fat mass at age 14 (outcome) with physical activity at age 12 (exposure) were strong for both total activity (accelerometer counts/min) and for daily amount of moderate-vigorous physical activity (min/day). An extra 15 minutes of moderate-vigorous physical activity per day at age 12 was associated with lower fat mass at age 14 in boys (by 11.9% (95% confidence interval 9.5% to 14.3%)) and girls (by 9.8% (6.7% to 12.8%)). The proportion of physical activity due to moderate-vigorous physical activity was between 20% and 30% in boys and girls at the two ages. Higher levels of physical activity, in particular activity of moderate to higher intensities, are prospectively associated with lower levels of fat mass in early adolescence. Interventions to raise levels of physical activity in children are likely to be important in the fight against obesity.

Karacabey, K. (2009) investigated the effect of exercise on leptin, insulin, cortisol and lipid profiles in obese children. A total of 40 obese boys aged 10-12 years with a body mass index (BMI) > or = 30 kg/m(2) were randomly separated into an exercise group (n = 20) that underwent a 12-week aerobic exercise programme and a non-exercise (control) group (n = 20). The BMI, low-density lipoprotein, cortisol, leptin and insulin levels were significantly lower in the exercise group after 12 weeks compared with baseline values, whereas high-density lipoprotein levels were significantly higher. In contrast, in the control group, low-density lipoprotein, cortisol and leptin levels were significantly higher after 12 weeks compared with baseline values while high-density lipoprotein levels were significantly lower. These findings indicate the importance of regular exercise in the regulation of body weight and protection against cardiovascular risk factors in obese children.

Fainardi, V. (2009) investigated the sedentary patterns of school-aged active children admitted to a summer sport school. One hundred-twelve children aged 9-11 years were interviewed through a questionnaire about sedentary behaviors and nutrition habits. Seventy-one per cent of children reported they watch TV seven days a week, girls less than boys (84 +/- 45 minutes vs. 110 +/- 75 minutes) (t = 2.056; p = 0.042). The habit of TV viewing during meals was widespread (38% breakfast, 31% lunch, 62% dinner, 18% every meal). The prevalence of overweight or obesity (58.5%) was significantly higher among boys watching TV at dinner compared to the boys viewing TV only in the afternoon (35%) (chi2 = 4.976; p = 0.026). Fifty-seven per cent of children (65% boys) were accustomed to nibble snacks during TV viewing, and this habit was widespread in overweight or obese boys (chi2 = 4.546; p = 0.033). The dietary patterns of children watching TV include more snack foods and fewer fruits than the dietary patterns of the same children exercising (chi2 = 4.199 p = 0.040). Also in active children the habit to watch television is widespread and, in spite of the tendency to physical activity, 46% of them were overweight or obese; in fact the time spent looking at a TV may be associated to overweight/obesity and this relationship could be explained by the amount of high-density foods consumption during inactivity. Playing video games read a book and listening to music are sedentary lifestyle patterns but these seem not to represent a risk factor for an increased BMI.

Castro-Piñero, J. (2009) studied the influence of body weight on the muscular strength level across age groups was also examined. Explosive strength was assessed by the throw ball test (upper body), standing broad jump, and vertical jump tests (lower body). Upper-body muscular endurance was assessed by push-ups, bent arm hang, and pull-ups tests, and abdominal muscular endurance was assessed by sit ups, curl ups in 30 seconds, and curl ups tests. Body mass index (BMI) was calculated. Participants were categorized according to the BMI international cut-ofF-values as underweight, normal weight, overweight, and obese. Boys had significantly better scores than girls in all the studied tests, except in the 3 upper-body muscular endurance tests in the 6- to 7-year-old group and in the push ups test in the 8- to 9-year-old group. Underweight and normal weight individuals showed similar strength levels. Both underweight and normal weight children and adolescents had significantly higher performance than their overweight and obese counterparts in the lower-body explosive strength tests and in the push-ups test in boys and bent arm hang test in both boys and girls. In conclusion, percentile values of 9 muscular strength tests are provided. Percentile values are of interest to identify the target population for primary prevention and to estimate the proportion of adolescents with high or low muscular strength levels. The overweight and obese groups had worse scores than their underweight and normal weight counterparts, whereas the underweight group had a similar performance to the normal weight group.

2.3 STUDIES ON EFFECT OF TRAINING ON PHYSIOLOGICAL VARIABLES

Impellizzeri (2002) this study was designed to quantify and describe the intensity profile of cross-country mountain-biking races using heart rate (HR) recorded during competitions. Nine mountain bikers participated in four cross-country circuit races of international and national levels. Each cyclist was tested before the competitions to determine lactate threshold (LT), the onset of blood lactate accumulation (OBLA4), and the relationship between percentage of maximum HR and percentage of VO(2max). To control for inter-subject variability, only the five off-road cyclists who completed all four competitions were included in the statistical analysis. The four races' mean absolute and relative time expressed in percentage of race duration (147 +/- 15 min) spent in the Easy(Zone) (HR below LT) were 27 +/- 16 min and 18 +/- 10%, in the Moderate(Zone) (HR between LT and OBLA4) were 75 +/- 19 min and 51 +/- 9%, and in the Hard(Zone) (HR above OBLA4) were 44 +/- 21 min and 31 +/- 16%. The average HR was 171 +/- 6 beats x min(-1), corresponding to 90 +/- 3% of maximum (84 +/- 3% of VO(2max). This study shows that cross-country events are conducted at very high intensity, especially at the start of the race. Coaches must take into account the distribution of the effort and the high exercise intensity characteristic of mountain-biking cross-country events when prescribing specific training programs.

Padilla (2001) evaluate exercise intensity and load during mass-start stages in professional road cycling, using competition heart rate (HR) recordings. Seventeen world-class cyclists performed an incremental laboratory test during which maximal power output (Wmax), maximal HR (HRmax), onset of blood lactate accumulation (OBLA), lactate threshold (LT), and a HR-power output relationship were assessed. An OBLAZONE (HROBLA +/- 3 beats. min-1) and an LTZONE (HRLT +/- 3 beats.min-1) were described. HR was monitored during 125 flat (< 13 km uphill, < 800-m altitude change; FLAT), 99 semi-mountainous (13-35 km uphill, 800- to 2000-m altitude change; SEMO), and 86 high-mountain (> 35 km uphill, > 2000-m altitude change; HIMO) stages. Each cyclist's competition power output was estimated from competition HR and individual HR-power output relationships. Competition training impulse (TRIMP) values and time spent at "easy," "moderate," and "hard" zones were estimated from HR and race duration. Average %HRmax were 61 +/- 5%, 58 +/- 6%, and 51 +/- 7% in HIMO, SEMO, and FLAT stages, respectively, and estimated average power outputs were 246 +/- 44, 234 +/- 43, and 192 +/- 45 W. Competition HR values relative to HROBLA and HRLT were, respectively, 69 +/- 6, 79 +/- 9% in HIMO; 65 +/- 7, 74 +/- 11% in SEMO; and 57 +/- 8, 65 +/- 10% in FLAT stages. The amount of TRIMP in HIMO, SEMO, and FLAT stages were, respectively, 215 +/- 38, 172 +/- 31, and 156 +/- 31. Percentage time spent in the "moderate" and "hard" zones was highest in HIMO (22 +/- 14, 5 +/- 6%) followed by SEMO (15 +/- 13, 5 +/- 5%) and FLAT (9 +/- 7, 2 +/- 2%) stages. %HRmax, time distribution around HROBLA and HRLT, TRIMP, and load zones reflected the physiological demands of different mass-start cycling stage categories. The knowledge of these demands could be useful for planning pre-competition training strategies.

Padilla (2008) examined the exercise intensity and load of the mountain passes of the major 3-week races according to their difficulty (length and slope) and position within the stage, using competition heart rate (HR). Sixteen world-class cyclists performed a laboratory test to assess maximal power output (W (max)), maximal HR (HR(max)), HR reserve (HRR), onset of blood lactate accumulation (OBLA), lactate threshold (LT) and a HR-power output relationship. HR was monitored during 68 OFF, 172 FIRST, and 134 SECOND category passes. Passes were also classified as BEGINNING, MIDDLE or END if they were placed in the first, second or final thirds of a stage, respectively. The training impulse (TRIMP) was calculated from HR and climb duration. %HRR was significantly higher in OFF and FIRST (77 +/- 7% in both), than SECOND (74 +/- 7%). Competition HR relative to HR(OBLA)R and HR(LT)R were higher in OFF (86 +/- 8, 98 +/- 11%) and FIRST (87 +/- 7, 100 +/- 11%) than SECOND (83 +/- 9, 95 +/- 13%). %HRR was lower in OFF situated in BEGINNING (66 +/- 1%) than in MIDDLE (82 +/- 5%) and END (77 +/- 7%); in FIRST situated in BEGINNING (74 +/- 9%) than in MIDDLE (79 +/- 5%); and in SECOND situated in BEGINNING (69 +/- 9%) compared to END (75 +/- 8%). The amount of TRIMP in OFF, FIRST and SECOND were 115 +/- 30, 72 +/- 29 and 41 +/- 19 ($P < 0.05$). In conclusion, the present study showed that mountain passes are highly demanding and that their intensity is related not only to the difficulty of the ascents but also to the position within the stage. The knowledge of these demands could be useful for planning pre-competition training strategies.

Fernández-García (2000) made a study to quantify the intensity of competition during two professional bicycle stage races: the Tour de France (Tour) and Vuelta a España (Vuelta). The HR responses of 18 world class cyclists were recorded during the races and compared with HR ranges that corresponded to four intensities of exercise that were measured in the laboratory with an incremental test to exhaustion 2 wk before each race. The four intensities were: Anaerobic (AN) over the individual anaerobic threshold, which was over 90% of VO2max; intense aerobic (IA), which was between 70 and 90% of VO2max; moderate aerobic (MA), which was between 50% and 70% of VO2max; and recovery (RE), which was < 50% of VO2max. The stages were divided in individual time trial (ITT), flat, or mountain. The mean HR of the Vuelta and Tour were, respectively, 133.8 +/- 17.9 and 134 +/- 18.6 beats x min(-1). The mean total time of each stage was 269.6 +/- 122 and 259.4 +/- 119.9 min. The mean stage time over IAT was 17.5 +/- 15.7 and 24.7 +/- 26 min; the IA time was 75.2 +/- 47.6 and 79.6 +/- 48.3 min; the MA was 97.2 +/- 57.4 and 89.5 +/- 54.9 min. Finally the RE time was 79.6 +/- 60.5 and 65.4 +/- 69.7 min. The percentage of participation related to total time of the race was, respectively, in the

Vuelta and the Tour, 12.99 and 16.8% in AN exercise intensity, 29.5 and 29.2% in IA, 32.4 and 31.9% in MA, and 25.1 and 25.2% in RE. There are no differences in AN time among flat, mountain, and ITT stages in each race, except for the mountain stages in the Tour. Cycling is a high intensity sport because approximately 93 min in flat and 123 min in mountain stages were above 70% of VO2max. In addition, the time spent at IAT was roughly 20 min regardless of stage type, suggesting that the anaerobic capacity limits performance.

Smith (2003) compare the effects of two high-intensity, treadmill interval-training programs on 3000-m and 5000-m running performance. Maximal oxygen uptake (.VO(2max)), the running speed associated with .VO(2max) (v.VO(2max)), the time for which v.VO(2max) can be maintained (T(max)), running economy (RE), ventilatory threshold (VT) and 3000-m and 5000-m running times were determined in 27 well-trained runners. Subjects were then randomly assigned to three groups; (1) 60% T(max), (2) 70% T(max) and (3) control. Subjects in the control group continued their normal training and subjects in the two T(max) groups undertook a 4-week treadmill interval-training program with the intensity set at v.VO(2max) and the interval duration at the assigned T(max). These subjects completed two interval-training sessions per week (60% T(max)=six intervals/session, 70% T(max) group=five intervals/session). Subjects were re-tested on all parameters at the completion of the training program. There was a significant improvement between pre- and post-training values in 3000-m time trial (TT) performance in the 60% T(max) group compared to the 70% T(max) and control groups [mean (SE); 60% T(max)=17.6 (3.5) s, 70% T(max) =6.3 (4.2) s, control=0.5 (7.7) s]. There was no significant effect of the training program on 5000-m TT performance [60% T(max)=25.8 (13.8) s, 70% T(max)=3.7 (11.6) s, control=9.9 (13.1) s]. Although there were no significant improvements in .VO(2max), v.VO(2max) and RE between groups, changes in .VO(2max) and RE were significantly correlated with the improvement in the 3000-m TT. Furthermore, VT and T(max) were significantly higher in the 60% T(max) group post- compared to pre-training. In conclusion, 3000-m running performance can be significantly improved in a group of well-trained runners, using a 4-week treadmill interval training program at v.VO(2max) with interval duration of 60% T(max).

Denadai (2006) the objective of this study was to analyze the effect of two different high-intensity interval training (HIT) programs on selected aerobic physiological indices and 1,500 and 5,000 m running performance in well-trained runners. The following tests were completed (n=17): (i) incremental treadmill test to determine maximal oxygen uptake (VO2 max), running velocity associated with VO2 max (vVO2 max), and the velocity corresponding to 3.5 mmol/L of blood lactate concentration (vOBLA); (ii) sub-maximal constant-intensity test to determine running economy (RE); and (iii) 1500 and 5000 m time trials on a 400 m track. Runners were then randomized into 95% vVO2 max or 100% vVO2 max groups, and undertook a 4 week training program consisting of 2 HIT sessions (performed at 95% or 100% vVO2 max, respectively) and 4 sub-maximal run sessions per week. Runners were retested on all parameters at the completion of the training program. The VO2 max values were not different after training for both groups. There was a significant increase in post-training vVO2 max, RE, and 1,500 m running performance in the 100% vVO2 max group. The vOBLA and 5,000m running performance were significantly higher after the training period for both groups. It concludes that vOBLA and 5,000 m running performance can be significantly improved in well-trained runners using a 4 week training program consisting of 2 HIT sessions (performed at 95% or 100% vVO2 max) and 4 sub-maximal run sessions per week. However, the improvement in vVO2 max, RE, and 1500 m running performance seems to be dependent on the HIT program at 100% vVO2 max.

Laursen and Jenkins (2002) while the physiological adaptations that occur following endurance training in previously sedentary and recreationally active individuals are relatively well understood, the adaptations to training in already highly trained endurance athletes remain unclear. While significant improvements in endurance performance and corresponding physiological markers are evident following sub-maximal endurance training in sedentary and recreationally active groups. An additional increase in sub-maximal training (i.e. volume) in highly trained individuals does not appear to further enhance either endurance performance or associated physiological variables [e.g. peak oxygen uptake (VO2peak), oxidative enzyme activity]. It seems that, for athletes who are already trained, improvements in endurance performance can be achieved only through high-intensity interval training (HIT). The limited research which has examined changes in muscle enzyme activity in highly trained athletes, following HIT, has revealed no change in oxidative or glycolytic enzyme activity, despite significant improvements in endurance performance ($p < 0.05$). Instead, an increase in skeletal muscle buffering capacity may be one mechanism responsible for an improvement in endurance performance. Changes in plasma volume, stroke volume, as well as muscle cation pumps, myoglobin, capillary density and fibre type characteristics have yet to be investigated in response to HIT with the highly trained athlete. Information relating to HIT programme optimisation in endurance athletes is also very sparse. Preliminary work using the velocity at which VO2max is achieved (V(max)) as the interval intensity, and fractions (50% to 75%) of the time to exhaustion at V(max) (T(max)) as the interval duration has been successful in eliciting improvements in performance in long-distance runners. However, V(max) and T(max) have not been used with cyclists. Instead, HIT programme optimisation research in cyclists has revealed that repeated supra-maximal sprinting may be equally effective as more traditional HIT programs for eliciting improvements in endurance performance. Further examination of the biochemical and physiological adaptations which accompany different HIT programs, as well as investigation into the optimal HIT programme for eliciting performance enhancements in highly trained athletes is required.

Astrand and Radahl (1986) defined lactate systems as anaerobic glycolysis which has essentially the incomplete breakdown of glycogen in the absence of oxygen. It occurred during the period of maximal exercise testing approximately 90 seconds in duration. The results showed that the corresponding increase in muscle activity which caused muscle fatigue due to the accumulation of H^+ one possible explanation for the fatigue was due to the inhibition of phosphoro fructo knare (PFK) which was essential for the production of ATP.

Green and Dowson (2002) studied the measurement of anaerobic capacity in human body. The study focuses on laboratory measures which attempts to quantity an aerobic capacities. Maximal blood lactate measured was used in both research and athletic settings to decrease anaerobic capacity. Its user was supported by: (a) The high correlation observed between maximal blood lactate and short duration exercise performance presumably dependent upon anaerobic capacity, and (b) The higher maximal blood lactate values observed in sprint and power athletes (who would demonstrate higher anaerobic capacities) compared with endurance athletes or untrained people. The later findings may be partially related to the confounding influence of blood volume which such high variability response to short and long term exercise demands. Maximal blood lactate was known to be influenced by the intensity and duration of the preceding exercise bout. Therefore, it was plausible these factors may also influence the degree for which maximal blood lactate accurately reflects an aerobic capacity.

Karacabey K. (2009) investigated the effect of exercise on leptin, insulin, cortisol and lipid profiles in obese children. A total of 40 obese boys aged 10-12 years with a body mass index (BMI) > or = 30 kg/m(2) were randomly separated into an exercise group (n = 20) that underwent a 12-week aerobic exercise programme and a non-exercise (control) group (n = 20). The BMI, low-density lipoprotein, cortisol, leptin and insulin levels were significantly lower in the exercise group after 12 weeks compared with baseline values, whereas high-density lipoprotein levels were significantly higher. In contrast, in the control group, low-density lipoprotein, cortisol and leptin levels were significantly higher after 12 weeks compared with baseline values while high-density lipoprotein levels were significantly lower. These findings indicate the importance of regular exercise in the regulation of body weight and protection against cardiovascular risk factors in obese children.

Ross, A, and Leveritt, M. (2001) reported that the adaptations of muscle to sprint training can be separated into metabolic and morphological changes. Enzyme adaptations represent a major metabolic adaptation to sprint training, with the enzymes of all three energy systems showing signs of adaptation to training and some evidence of a return to baseline levels with detraining. Myokinase and creatine phosphokinase have shown small increases as a result of short-sprint training in some studies and elite sprinters appear better able to rapidly breakdown phosphocreatine (PCr) than the sub-elite. No changes in these enzyme levels have been reported as a result of detraining. Similarly, glycolytic enzyme activity (notably lactate dehydrogenase, phosphofructokinase and glycogen phosphorylase) has been shown to increase after training consisting of either long (>10-second) or short (<10-second) sprints. Evidence suggests that these enzymes return to pre-training levels after somewhere between 7 weeks and 6 months of detraining. Mitochondrial enzyme activity also increases after sprint training, particularly when long sprints or short recovery between short sprints are used as the training stimulus. Morphological adaptations to sprint training include changes in muscle fibre type, sarcoplasmic reticulum, and fibre cross-sectional area. An appropriate sprint training programme could be expected to induce a shift toward type IIa muscle, increase muscle cross-sectional area and increase the sarcoplasmic reticulum volume to aid release of Ca(2+). Training volume and/or frequency of sprint training in excess of what is optimal for an individual, however, will induce a shift toward slower muscle contractile characteristics. In contrast, detraining appears to shift the contractile characteristics towards type IIb, although muscle atrophy is also likely to occur. Muscle conduction velocity appears to be a potential non-invasive method of monitoring contractile changes in response to sprint training and detraining. In summary, adaptation to sprint training is clearly dependent on the duration of sprinting, recovery between repetitions, total volume and frequency of training bouts. These variables have profound effects on the metabolic, structural and performance adaptations from a sprint-training programme and these changes take a considerable period of time to return to baseline after a period of detraining. However, the complexity of the interaction between the aforementioned variables and training adaptation combined with individual differences is clearly disruptive to the transfer of knowledge and advice from laboratory to coach to athlete.

Linossier, M.T. (1987) studied the effect of sprint training and detraining on supramaximal performances was studied in relation to muscle enzyme adaptations in eight students trained four times a week for 9 weeks on a cycle ergometer. The subjects were tested for peak oxygen uptake (VO2peak), maximal aerobic power (MAP) and maximal short-term power output (Wmax) before and after training and after 7 weeks of detraining. During these periods, biopsies were taken from vastus lateralis muscle for the determination of creatine kinase (CK), adenylate kinase (AK), glycogen phosphorylase (PHOS), hexokinase (HK), phosphofructokinase (PFK), lactate dehydrogenase (LDH) and its isozymes, 3-hydroxy-acyl-CoA dehydrogenase (HAD) and citrate synthase (CS) activities. Training induced large improvements in Wmax (28%) with slight increases (3%) in VO2peak ($P < 0.10$). This was associated with a greater glycolytic potential as shown by higher activities for PHOS (9%), PFK (17%) and LDH (31%) after training, without changes in CK and oxidative markers (CS and HAD). Detraining induced significant decreases in VO2peak (4%), MAP (5%) and oxidative markers (10-16%), while Wmax and the anaerobic potential were maintained at a high level. This suggests a high level in supramaximal power output as a result of a muscle glycogenolytic and glycolytic adaptation. A long interruption in training has negligible effects on short-sprint ability and muscle anaerobic potential. On the other hand, a persistent training stimulus is required to maintain high aerobic capacity and muscle oxidative potential. This may contribute to a rapid return to competitive fitness for sprinters and power athletes.

Delise, P. (2011) analysed 87 asymptomatic healthy athletes with frequent VPB (>100/24 h). Of these, 44 (group D) underwent at least 3 months' detraining, whereas 43 (group C) continued sporting activity. Athletes underwent 24-h Holter monitoring at the baseline after 5.2 ± 4 (group D) and 7.2 ± 5 (group C) months. Basal characteristics were similar in both groups. Comparison of the basal and follow-up Holter results revealed no significant difference in the mean number of VPB/24 h in either group. In group-D, the number of VPB/24 h declined from 8126 ± 8129 to

7998 ± 10 976 (P = 0.48), whereas in group-C it rose from 6027 ± 6374 to 6600 ± 8590 (P = 0.51). VPB either disappeared or were markedly reduced (<100 VPB/24 h) in 2/44 (4.5%) group-D and 4/43 (9%) group-C athletes. In neither group did the number of couplets or non-sustained ventricular tachycardia change significantly. In healthy athletes, frequent VPBs discovered by chance during pre-participation screening may not be a manifestation of 'athlete's heart', but may depend on other causes; in the latter case screening may simply reveal a pre-existing asymptomatic phenomenon; the usefulness of detraining in ascertaining eligibility for sport should be further investigated.

Mujika, I. (2010) documented that the training load is markedly reduced during the taper so that athletes recover from intense training and feel energized before major events. Load reduction can be achieved by reducing the intensity, volume and/or frequency of training, but with reduced training load there may be a risk of detraining. Training at high intensities before the taper plays a key role in inducing maximal physiological and performance adaptations in both moderately trained subjects and highly trained athletes. High-intensity training can also maintain or further enhance training-induced adaptations while athletes reduce their training before a major competition. On the other hand, training volume can be markedly reduced without a negative impact on athletes' performance. Therefore, the training load should not be reduced at the expense of intensity during the taper. Intense exercise is often a performance-determining factor during match play in team sports, and high-intensity training can also elicit major fitness gains in team sport athletes. A tapering and peaking program before the start of a league format championship or a major tournament should be characterized by high-intensity activities.

Liu, T.C. (2008) reported that Athletes frequently adjust their training volume in line with their athletic competition schedule, onset of sport injury, and retirement. Whether maintenance of partial training activity during the detraining period can preserve optimal body composition and insulin sensitivity is currently unknown. Sixteen elite kayak athletes (mean VO2max: 58.5 ml.kg (-1).min(-1), s = 1.77) were randomly assigned to a totally detrained group (age: 20.8 years, s = 0.7; body mass index: 23.74, s = 0.54) or partially detrained group (age: 21.8 years, s = 0.7; body mass index: 23.20, s = 1.02), whereby totally detrained participants terminated their training routine completely and the partially detrained participants preserved approximately 50% of their previous training duration with equivalent intensity for one month. Body mass, waist circumference, oral glucose tolerance test, insulin, leptin, cortisol, and testosterone were measured during the trained state and after detraining. Waist circumferences for both the partially detrained and totally detrained groups were significantly elevated after detraining, with no group difference. However, body mass was reduced in both groups. Significant elevations in the area under the curve for insulin and fasted leptin with detraining were observed. These changes were greater in the totally detrained participants. In conclusion, the present results show that maintaining partial training activity cannot prevent an increase in waist circumference. During the detraining period, the magnitude of increase in plasma insulin and leptin concentrations was regulated in an activity-dependent manner.

Calderón Montero, F.J. (2007) identified 200 potentially relevant studies from 1966 to June 2006 and eliminated 187 studies that did not fulfil the objectives of the study. It identified 13 studies with echocardiographic assessment of heart adaptation following variation in training loads in elite or sub-elite endurance-trained athletes. It performed a meta-analysis by studying the changes in the left ventricular end-diastolic (LVEDD), left ventricular end-systolic (LVESD), left ventricular posterior wall (LVPW) and interventricular septum thickness (IVST) dimensions induced by training. A significant positive overall effect size on echocardiographic outcomes was found following training, using the fixed effect model on LVPW, LVEDD, LVESD and IVST. LVPW and LVEDD were significantly higher following training. Studies reported an increase in LVEDD and LVPW, following endurance training. However, the heterogeneity of the studies and the sensitivity of echocardiography technique can be two reasons, for which the results do not allow to state unequivocally that the adaptation to endurance training of highly trained hearts stems from increments of diastolic diameter of the left ventricle and lateral wall of the left ventricle (LVPW).

2.4 SUMMARY OF RELATED LITERATURE

In this chapter, the investigator reviewed related studies on the effects of interval training, effect of training on physical fitness variables, effect of training on physiological variables. The reviews proved that there was scope for further research in finding out the effect of interval training on physical fitness variables and physiological variables among intercollegiate women athletes.

Based on the experience the investigator gained through review of related literature, the investigator formed suitable methodology to be adopted in this study, which is presented in Chapter-III.

Chapter-III
METHODOLOGY

This chapter describes the methodology and procedure adopted. This includes the selection of subjects, selection of variables, research design, procedure for administering the test items, selection of test items, collection of data and statistical technique employed for analyzing the data.

The purpose of the study was to find out the effect of interval training interval training on selected physical and physiological variables among inter collegiate women athletes.

3.1 SELECTION OF SUBJECTS

The subjects taken for the present study were 40 inter collegiate level women athletes from different colleges in Andhra Pradesh, who represented their colleges in intercollegiate level athletic meets. The subjects were selected on a random basis and were allotted to two groups (control and experimental groups) by random assignment. The age of the subjects ranged from 19 to 24 years with mean age of 20.5 years.

3.2 SELECTION OF VARIABLES

The investigator reviewed books, journals, and research articles on effect of interval training on selected physical and physiological variables and selected the following variables for the purpose of this research.

3.2.1 Dependent Variables

Physical Fitness Variables

1. Flexibility
2. Muscular Endurance

Physiological Variables

3. Resting Pulse Rate
4. Vital Capacity

3.2.2 Independent Variable

1. 12 weeks interval training

3.3 EXPERIMENTAL DESIGN

The primary responsibility of the investigator is to adopt the appropriate experimental methodology before proceeding with data collection (David H. Clarke and H. Harrison Clarke, 1984).

A pre-test-post-test randomized group design was used for this study. The randomly selected 40 Inter collegiate women athletes were divided into two groups randomly consisting of twenty women athletes in each group. Before the training pre-test was taken for all the groups on selected physical and physiological variables. The control group did not undergo any type of training. Experimental group was provided with interval training for 12 weeks. At the end of twelve weeks interval, training post-test was conducted on selected variables. The differences between the initial and final scores were considered as the effect of interval training among women athletes. To statistical significant, the obtained data were subjected to statistical treatment using ANCOVA. In all cases 0.05 was fixed to test the hypothesis of this study.

3.4 PILOT STUDY

A pilot study was conducted to assess the initial capacity of the subjects in order to fix the exercise load. For this purpose, ten women athletes, who were not the subjects for this, were selected and the proposed intensities of interval training were given to them.

Based on the response of the subjects in the pilot study and during the training, the training schedule for experimental group was constructed. However the individual differences were not considered. This enabled the investigator to adopt suitable training schedule for this study.

3.5 CRITERION MEASURES

By glancing the literature, and in consultation with professional experts, the following variables were selected as the criterion measures in this study.

1. Flexibility was measured through sit and reach test and scores recorded in nearest centimeters.
2. Muscular endurance was measured through bend knee sit-ups test and the scores recorded in counts per minute.
3. Resting Pulse Rate was determined through the radial artery beats and the scores recorded in number of beats per minute.
4. Vital capacity was measured using Spiromter and the scores recorded in milliliters.

3.6 RELIABILITY OF DATA

Establishing the instrument reliability, tester's competency and subject reliability ensured the reliability of data

3.6.1 Instrument Reliability

Swiss made stop watches calibrated to one tenth of a second were used in this study for recording the timings and this stop watch times were compared with other watches in different situations and they were considered reliable. A standard measuring steel tape, spirometer and other equipment were used for this study. All the instruments used were standard and therefore their calibrations were accepted accurate enough for the purpose of the study.

3.6.2 Tester's Competency

The test-retest processes established reliability. Nine students from all the three groups were tested on selected variables. The repeated measurement of individuals on the same test is done to determine reliability. It is a univariate not a bivariate situation; it makes sense then to use a univariate statistics like the interclass correlation coefficient (Ted Allen Baumgartner and Jackson, 1975).

The intraclass correlation coefficient obtained for test-retest data are presented in Table-I.

Table I
Intra Class Correlation Coefficient of Test – Retest Scores

S.No.	Variables	Coefficient of Correlation
1	Flexibility	0.93*
2	Muscular Endurance	0.88*
3	Resting Pulse Rate	0.87*
4	Vital Capacity	0.95*

* Significant at 0.05 level

3.6.3 Subjects Reliability

The intraclass correlation value of the above test and retest also indicated subject reliability as the same subjects were used under similar conditions by the same tester. The co-efficient of reliability were significant at 0.05 level, for the above test under investigation.

3.7 TEST ADMINISTRATION AND COLLECTION OF DATA

The investigator explained the objectives of the test to the subject before the test.

3.7.1 Flexibility (Sit and Reach)

Purpose

To estimate the trunk flexibility

Equipment

Yardstick and measuring steel tape

Procedure

Place the yardstick on the floor and put an 18 inch piece of tape across the 15 inch mark on the yard stick. The tape should secure the yardstick to the floor. The subject sits with the O end of the yardstick between the legs. The subject heel should almost touch the tape at the 15 inch mark and be about 12 inch apart with the legs held straight. The subject bends forward slowly and reaches with parallel hand as far as possible and touches the yardstick. The subject should hold this reach long enough for the distance to be recorded.

Scoring

The best score recorded out of the three trials was the score in flexibility.

3.7.2 Muscular Endurance (Sit-Ups)

Purpose

To estimate the muscular endurance

Equipment

Gymnastic Mats

Procedure

The subject being tested took supine lying position with bent knees, feet flat about 18 inches from the buttocks, and the hands touching the side of the head. A partner holds the subject feet as the exercises performed. The subject touched the elbow to the alternate knee with each sit-up. The subject performs as many sit-ups in one minute as possible.

Scoring

The number of correct repetitions was recorded as the score.

3.7.3 Resting Pulse Rate

Objective

The purpose of this test was to record the number of heart beat per minute.

Equipment

A stop watch (1/100 of a second) and a chair.

Procedure and Scoring

The resting heart rate of all the subjects was recorded in sitting position in the morning session. Before taking the resting heart rate, the subjects were asked to sit in a chair inside a room and relax for 20 minutes. To record the heart rate, finger-tips were placed on the radial artery at the subjects wrist in such a manner that palpation was clear and the number of palpation was counted for one minute.

3.7.4 Vital Capacity

Purpose

The purpose of this test was to find out the maximum quantity of air that can be expired after a full inspiration.

Equipment

Spirometer, mouthpieces and nose clips.

Procedure

Vital capacity was measured by Spirometer in liters. The Spirometer was equipped with a good length of rubber hose. The Spirometer placed at a height where by all the subject can stand erect at the beginning of the test. The mouthpiece was disinfected by an antiseptic solution after use by each subject.

The subjects were asked to take a deep breath for test: There after the fullest possible inhalation, the subject exhaled slowly and steadily bending forward over the hose till the air within his control was expelled.

Care was taken to prevent air from escaping either through nose or around the edges of mouthpiece and was also ensured that the subject during the test did not take a second breath. In case of doubt, the test was repeated. Care was taken to lower the drum without spilling the water, each time after use.

Scoring

The score was taken from the dial of the Spirometer which was recorded in $1/100^{th}$ of a liter.

3.8 TRAINING SCHEDULE OF INTERVAL TRAINING

Warming Up Segment

The subjects prior to the training sessions performed a ten minutes warming up session consisting of 200 meters jogging balanced combination of static stretches as smoothly controlled rhythmic calisthenics and limbering exercises.

After the warm up, interval training were given for 20 minutes. The following exercises was designed to be executed as interval training Interval training group. It was based on progressive loading. The subject was asked to ran;

1. 60 meters within 8 sec. for 10 repetitions and with 10 sec. recovery for each repetition.
2. 100 meters within 14 sec. for 8 repetitions and with 8 sec recovery.
3. 140 meters within 20 sec. for 6 repetitions and with 6 sec recovery.
4. 180 meters within 30 sec. for 4 repetitions with 4 sec. recovery.

Both the training sessions took approximately 30 minutes each.

Cool Down Segment

The interval training sessions concluded with continued light aerobic activities such as walking, standing leg kicks and static stretches to prevent pooling of blood in the lower extremities immediately after the endurance phase, and lower the heart rate gradually towards normal to promote faster removal of metabolic waste products from the muscles. Caution was taken to avoid bent-over stretches for long periods to avoid dizziness

Training Schedule for Interval Training

The researcher experimented with the interval training to experimental group and Table II shows the schedule of training.

Table-II
Showing Training Schedule for Interval Training

Workouts	Monday		Wednesday		Friday	
	Repeti-tion	**Rest**	**Repeti-tion**	**Rest**	**Repeti-tion**	**Rest**
60 M run within 12 sec	8	15 sec	8	15 sec	8	15 sec
100 M run within 20 Sec.	6	25 sec	6	25 sec	6	25 sec
140 M run within 30 sec	4	45 sec	4	45 sec	4	45 sec
180 M run within 40 sec	3	60 sec	3	60 sec	3	60 sec

3.9 STATISTICAL PROCEDURE

These test data must be analysed in ways appropriate to the research design (David H. Clarke and H. Harrison Clarke, 1970).

The following statistical tool, that is, Analysis of Covariance (ANCOVA) was followed to estimate the effect of interval training on selected physical and physiological variables among inter-collegiate women athletes using the formula as suggested by Thomas and Nelson (1990).

Since only two groups were involved in this study, namely, experimental group and control group, the mean comparisons were made through the adjusted means and post hoc analysis was not made (David H. Clarke and H. Harrison Clarke, 1972).

Chapter-IV

RESULTS AND DISCUSSIONS

4.1 OVERVIEW

This chapter deals with the analysis of data collected from the samples under study. The purpose of the study was to find out the effect of interval training interval training on selected physical and physiological variables among intercollegiate women athletes. The subjects taken for the present study were 40 intercollegiate level women athletes from different colleges in Andhra Pradesh, who represented their colleges in intercollegiate level athletic meets. The subjects were selected on a random basis and were allotted to two groups (control and experimental groups) by random assignment. The age of the subjects ranged from 19 to 24 years with mean age of 20.5 years. The investigator reviewed books, journals, and research articles on effect of interval training on physical and physiological variables and selected the flexibility and muscular endurance as physical fitness variables and resting pulse rate and vital capacity as physiological variables. A pilot study was conducted to assess the initial capacity of the subjects in order to fix the exercise load. For these purpose ten women athletes, who were not the subjects for this, were selected and the proposed intensities of interval training were given to them. A pre-test-post-test randomized group design was used for this study. The randomly selected 40 Inter-collegiate women athletes were divided into two groups randomly consisting of twenty women athletes in each group. Before the training pre-test was taken for all the groups on selected physical and physiological variables. The control group did not undergo any type of training. Experimental group was provided with interval training for 12 weeks. At the end of twelve weeks interval training post-test was conducted on selected variables. The differences between the initial and final scores were considered as the effect of interval training among women athletes.

4.2 TEST OF SIGNIFICANCE

As David H. Clarke and H. Harrison Clarke (1984) says, "these data must be analyzed in ways appropriate to the research design. Such analysis can only be appropriate to the research design and be accomplished through the application of pertinent statistics".

This is the vital portion of thesis achieving the conclusion by examining the hypotheses. The procedure of testing the hypotheses was either by accepting the hypotheses or rejecting the same in accordance with the results obtained in relation to the level of confidence.

The test was usually called the test of significance since test whether the differences between four groups or within many groups' scores were significant or not. In this study, if they obtained F-value were greater than the table value, the null hypotheses were rejected to the effect that there existed significant difference among the means of the groups compared and if they obtained values were lesser than the required values, then the null hypotheses were accepted to the effect that there existed no significant differences among the means of the groups under study.

4.2.1 Level of Significance

The subjects were compared on the effect of interval training on selected physical and physiological variables among intercollegiate level women athletes. The selected criterion variables were flexibility, muscular endurance, resting pulse rate and vital capacity. The analysis of covariance (ANCOVA) was used to find out the significant difference if any, between the groups on selected criterion variables separately. In all the cases, 0.05 level of confidence was fixed to test the significance, which was considered as appropriate.

4.3 COMPUTATION OF ANALYSIS OF COVARIANCE

4.3.1 Results on Flexibility

The initial and final means on interval training group and control group on Flexibility through Analysis of Covariance (ANCOVA) is presented in Table-III.

Table-III
ANCOVA RESULTS ON PHYSICAL FITNESS VARIABLE FLEXIBILITY DUE TO INTERVAL TRAINING

	Experimental Group	Control	Source of Variance	Sum of Squares	Df	Mean Squares	Obtained F
Pre-test Mean	14.30	15.10	Between	6.40	1	6.40	1.93
			Within	126.00	38	3.32	
Post-Test Mean	18.45	16.10	Between	55.23	1	55.23	14.30*
			Within	146.75	38	3.86	
Adjusted Post-Test Mean	18.62	15.93	Between	69.37	1	69.37	20.93*
			Within	122.65	37	3.31	
Mean Diff.	4.15	1.00					

Table F-ratio at 0.05 level of confidence for 1 and 38 (df) =4.10, 1 and 37(df) =4.11.
* Significant at 0.05 level

The pre-test mean on experimental group was 14.30, and control group was 15.10 and the obtained F-value was 1.93, which was less than the required F-value of 4.10 to be significant. Hence, it was not significant and the groups were equal at initial stage.

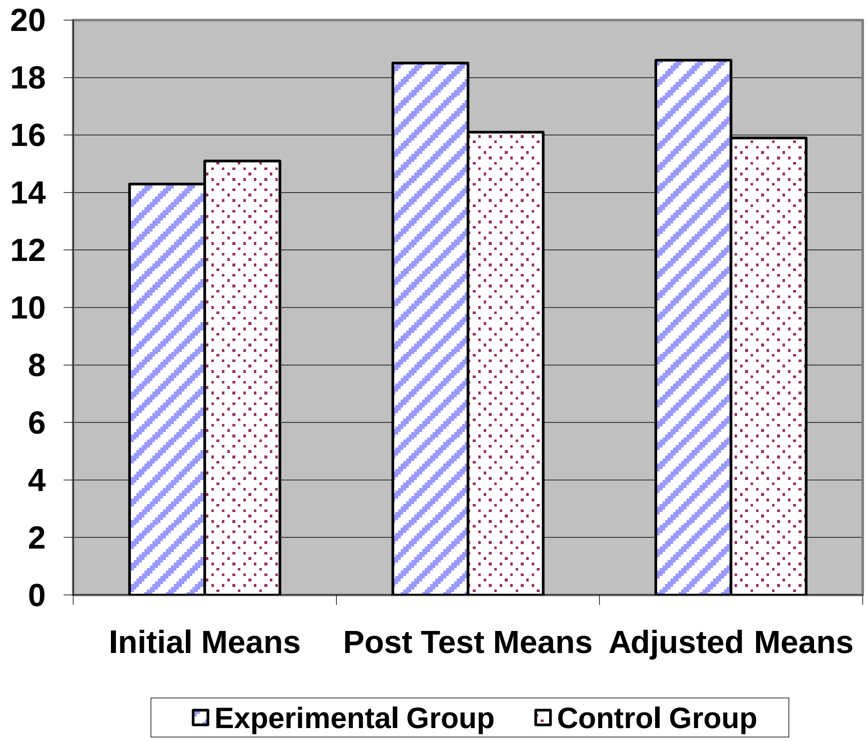
The comparison of post-test mean, experimental group 18.45 and control group 16.10 proved to be significant at 0.05 level as the obtained F-value 14.30 was greater than the required table F-value of 4.10 to be significant at 0.05 level.

Taking into consideration the initial and final mean values adjusted post-test means were calculated and the obtained F-value of 20.93 was greater than the required F-value to be significant 4.11 and hence, there was significant difference.

Thus, it was proved that interval training group gained mean difference of 4.15 which was due to interval training given to intercollegiate women athletes, and the difference was found to be significant at 0.05 level.

The initial, post and adjusted means values of experimental and control group on flexibility is presented in Figure 1 for better understanding of the results of this study.

Figure-1
Bar Diagram Showing Initial, Final and Adjusted Means on Flexibility of Experimental and Control Groups



4.3.1.2 Discussions on Flexibility

The results presented in Table-III proved that the Flexibility has not been significantly improved among control group, as they did not undergo interval training experimental treatment. However, the 12 weeks interval training given to the experimental group significantly improved variable Flexibility among intercollegiate women athletes. The statistical mean difference between initial test and final test of experimental group stood at 18.62 and control group stood at 15.93. And the differences were found to be significant at 0.05 level as the obtained F-value of 20.93 was greater than the required table F-value of 4.11 to be significant at 0.05 level.

Thus, it was proved that interval training was significantly better than control group in improving Flexibility of the intercollegiate women athletes.

4.3.2 Results on Muscular Strength

The initial and final means on interval training group and control group on Muscular Strength through Analysis of Covariance (ANCOVA) is presented in Table IV.

Table-IV
ANCOVA RESULTS ON PHYSICAL FITNESS VARIABLE MUSCULAR STRENGTH TO INTERVAL TRAINING

	Experimental Group	Control	Source of Variance	Sum of Squares	Df	Mean Squares	Obtained F
Pre-test Mean	29.80	30.70	Between	8.10	1	8.10	0.44
			Within	697.40	38	18.35	
Post-test Mean	33.80	29.90	Between	152.10	1	152.10	8.22*
			Within	703.00	38	18.50	
Adjusted Post-test Mean	34.16	29.54	Between	211.19	1	211.19	30.77*
			Within	253.97	37	6.86	
Mean Diff.	4.00	-0.80					

Table F-ratio at 0.05 level of confidence for 1 and 38 (df) =4.10, 1 and 37(df) =4.11.
* Significant at 0.05 level

The pre-test mean on experimental group was 29.80, and control group was 30.70 and the obtained F-value was 0.44, which was less than the required F-value of 4.10 to be significant. Hence, it was not significant and the groups were equal at initial stage.

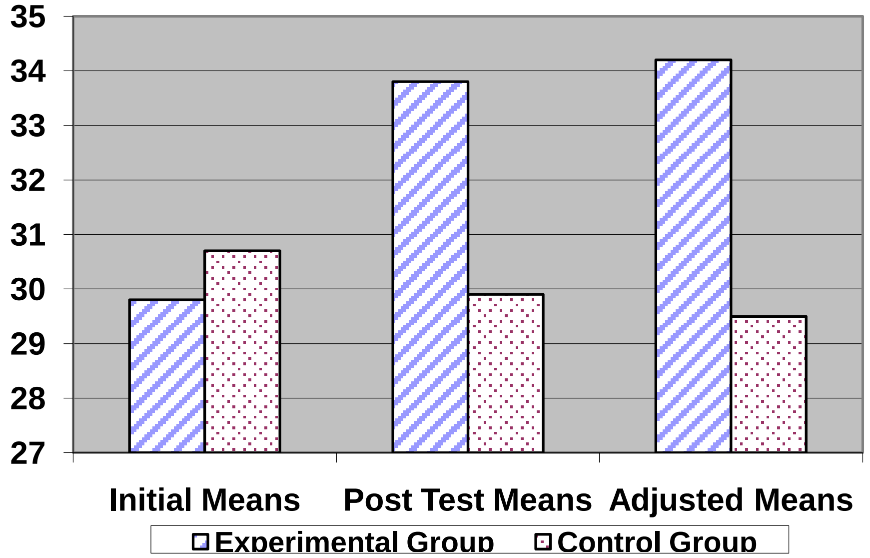
The comparison of post-test mean, experimental group 33.80 and control group 29.90 proved to be significant at 0.05 level as the obtained F-value 8.22 was greater than the required table F-value of 4.10 to be significant at 0.05 level.

Taking into consideration the initial and final mean values adjusted post-test means were calculated and the obtained F-value of 30.77 was greater than the required F-value to be significant 4.11 and hence, there was significant difference.

Thus, it was proved that interval training group gained mean difference of 4.00 which was due to interval training given to intercollegiate women athletes, and the difference was found to be significant at 0.05 level.

The initial, post and adjusted means values of experimental and control group on Muscular Strength is presented in Figure 2 for better understanding of the results of his study.

Figure-2
Bar Diagram Showing Initial, Final and Adjusted Means on Muscular Strength of Experimental and Control Groups



4.3.2.2 Discussions on Muscular Strength

The results presented in Table-IV proved that the Muscular Strength has not been significantly improved among control group as they did not undergo interval training experimental treatment. However, the 12 weeks interval training given to the experimental group significantly improved variable Muscular Strength among intercollegiate women athletes. The statistical mean difference between initial test and final test of experimental group stood at 34.16 and control group stood at 29.54. And the differences were found to be significant at 0.05 level as the obtained F-value of 30.77 was greater than the required table F-value of 4.11 to be significant at 0.05 level.

Thus, it was proved that interval training was significantly better than control group in improving Muscular Strength of the intercollegiate women athletes.

4.3.3 Results on Resting Pulse Rate

The initial and final means on interval training group and control group on Resting Pulse Rate through Analysis of Covariance (ANCOVA) is presented in Table-V.

Table-V
ANCOVA RESULTS ON PHYSIOLOGICAL VARIABLE RESTING PULSE RATE TO INTERVAL TRAINING

	Experimental Group	Control	Source of Variance	Sum of Squares	Df	Mean Squares	Obtained F
Pre-test Mean	66.55	64.00	Between	65.02	1	65.02	2.51
			Within	984.95	38	25.92	
Post-test Mean	62.90	64.25	Between	18.23	1	18.23	0.68
			Within	1011.55	38	26.62	
Adjusted Post-test Mean	61.83	65.32	Between	114.51	1	114.51	13.44*
			Within	315.32	37	8.52	
Mean Diff.	-3.65	0.25					

Table F-ratio at 0.05 level of confidence for 1 and 38 (df) =4.10, 1 and 37(df) =4.11.
* Significant at 0.05 level.

The pre-test mean on experimental group was 66.55, and control group was 64.00 and the obtained F-value was 2.51, which was less than the required F-value of 4.10 to be significant. Hence, it was not significant and the groups were equal at initial stage.

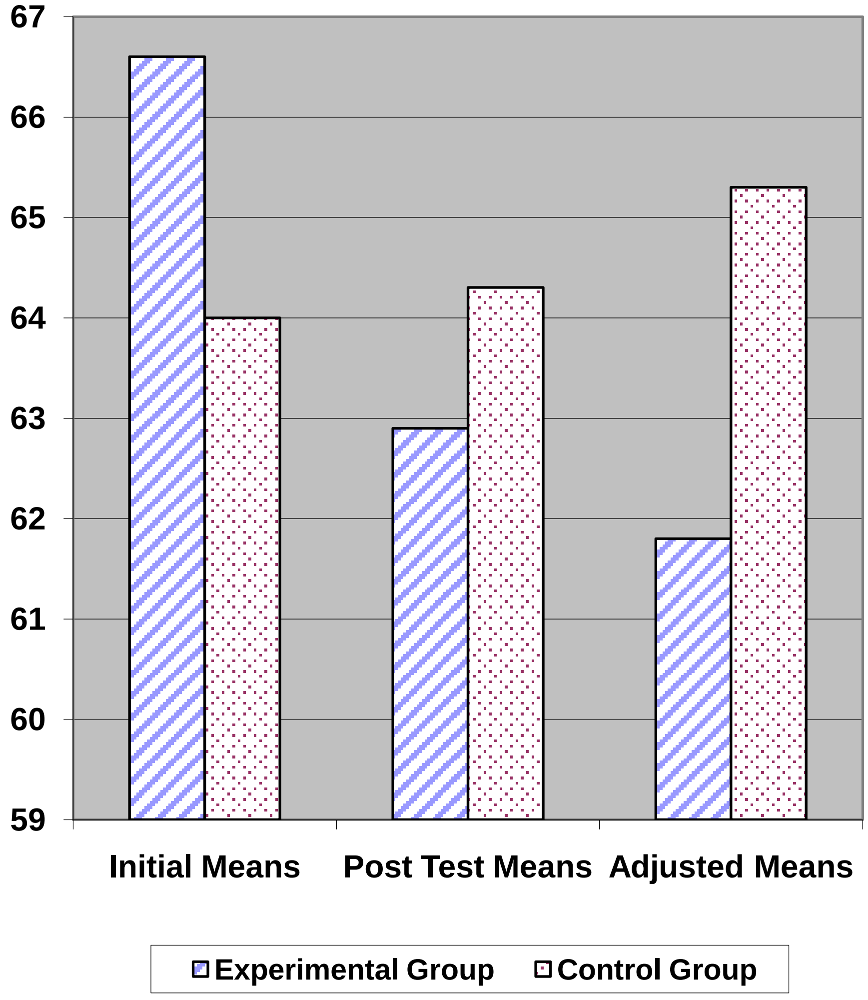
The comparison of post-test means, experimental groups 62.90 and control group 64.25 proved to be significant at 0.05 level as the obtained F-value 0.68 was lesser than the required table F-value of 4.10 to be significant at 0.05 level.

Taking into consideration the initial and final mean values adjusted post-test means were calculated and the obtained F-value of 13.44 was greater than the required F-value to be significant 4.11 and hence, there was significant difference.

Thus, it was proved that interval training group gained mean difference of -3.65 which was due to interval training given to intercollegiate women athletes, and the difference was found to be significant at 0.05 level.

The initial, post and adjusted means values of experimental and control group on Resting Pulse Rate is presented in Figure-3 for better understanding of the results of this study.

Figure-3
Bar Diagram Showing Initial, Final and Adjusted Means on Resting Pulse Rate of Experimental and Control Groups



4.3.3.2 Discussions on Resting Pulse Rate

The results presented in Table-V proved that the Resting Pulse Rate has not been significantly improved among control group as they did not undergo interval training experimental treatment. However, the 12 weeks interval training given to the experimental group significantly improved variable Resting Pulse Rate among intercollegiate women athletes. The statistical mean difference between initial test and final test of experimental group stood at 61.83 and control group stood at 65.32. And the differences were found to be significant at 0.05 level as the obtained F-value of 13.44 was greater than the required table F-value of 4.11 to be significant at 0.05 level.

Thus, it was proved that interval training was significantly better than control group in reducing Resting Pulse Rate of the intercollegiate women athletes.

4.3.4 Results on Vital Capacity

The initial and final means on interval training group and control group on Vital Capacity through Analysis of Covariance (ANCOVA) is presented in Table-VI.

Table-VI
ANCOVA RESULTS ON PHYSIOLOGICAL VARIABLE VITAL CAPACITY TO INTERVAL TRAINING

	Experimental Group	Control	Source of Variance	Sum of Squares	Df	Mean Squares	Obtained F
Pre-test Mean	3192.50	3330.00	Between	189062.50	1	189062.50	2.60
			Within	2768375.00	38	72851.97	
Post-test Mean	3412.50	3307.50	Between	110250.00	1	110250.00	1.27
			Within	3300750.00	38	86861.84	
Adjusted Post-test Mean	3471.88	3248.12	Between	468688.96	1	468688.96	14.04*
			Within	1235466.66	37	33390.99	
Mean Diff.	220.00	-22.50					

Table F-ratio at 0.05 level of confidence for 1 and 38 (df) =4.10, 1 and 37(df) =4.11.
* Significant at 0.05 level.

The pre-test mean on experimental group was 3192.50, and control group was 3330.00 and the obtained F-value was 2.60, which was less than the required F-value of 4.10 to be significant. Hence, it was not significant and the groups were equal at initial stage.

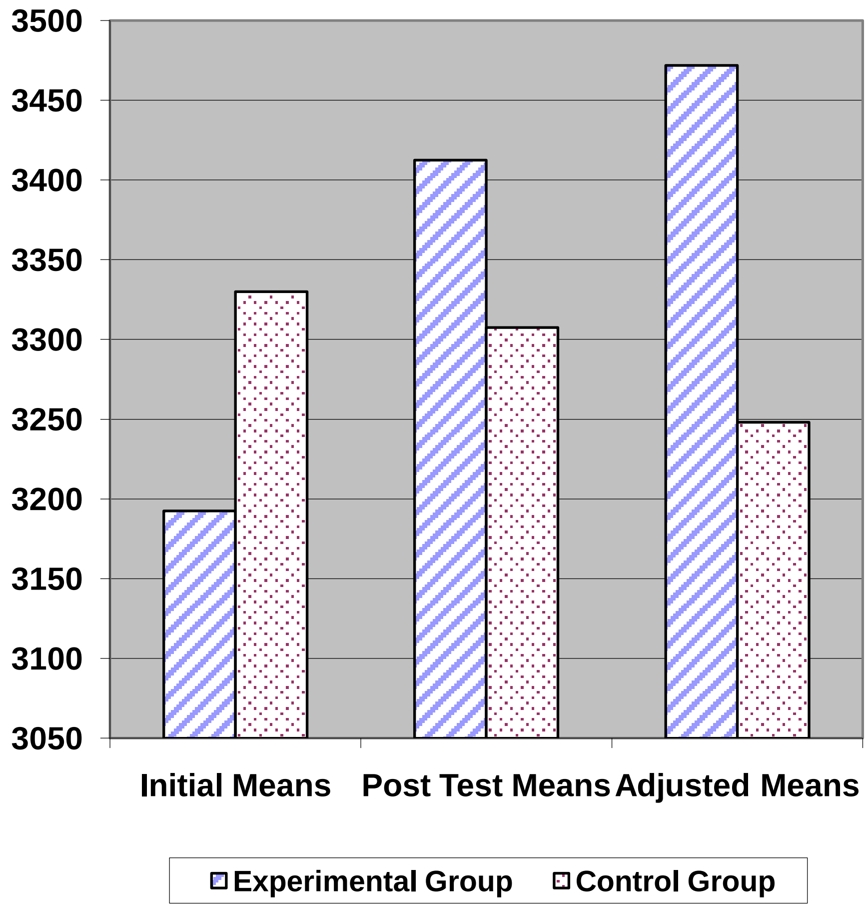
The comparison of post-test means experimental groups 3412.50 and control group 3307.50 proved to be significant at 0.05 level as the obtained F-value 1.27 was lesser than the required table F-value of 4.10 to be significant at 0.05 level.

Taking into consideration, the initial and final mean values adjusted post-test means were calculated and the obtained F-value of 14.04 was greater than the required F-value to be significant 4.11 and hence, there was significant difference.

Thus, it was proved that interval training group gained mean difference of 220.00 which was due to interval training given to intercollegiate women athletes, and the difference was found to be significant at 0.05 level.

The initial, post and adjusted means values of experimental and control group on Vital Capacity is presented in Figure-4 for better understanding of the results of this study.

Figure-4
Bar Diagram Showing Initial, Final and Adjusted Means on Vital Capacity of Experimental and Control Groups



4.3.4.2 Discussions on Vital Capacity

The results presented in Table-VI proved that the Vital Capacity has not been significantly improved among control groups as they did not undergo interval training experimental treatment. However, the 12 weeks interval training given to the experimental group significantly improved variable Vital Capacity among intercollegiate women athletes. The statistical mean difference between initial test and final test of experimental group stood at 3,471.88 and control group stood at 3,248.12. And the differences were found to be significant at 0.05 level as the obtained F-value of 14.04 was greater than the required table F-value of 4.11 to be significant at 0.05 level.

Thus, it was proved that interval training was significantly better than control group in improving Vital Capacity of the intercollegiate women athletes.

4.4 DISCUSSIONS ON HYPOTHESIS

For the purpose of the study, it was hypothesized that:

1. There would be significant differences due to interval training on physical fitness variables such as flexibility and muscular endurance among intercollegiate women athletes.
2. There would be significant different due to interval training on physiological variables resting pulse rate and vital capacity among intercollegiate women athletes.

The results presented in Table-III and Table-IV on effects of interval training on physical fitness variables, flexibility and muscular endurance proved that the obtained F-values 20.93 and 30.77 were greater than the required F-value of 4.11 to be significant at 0.05 level. This proved those selected physical fitness variables, flexibility and muscular endurance were significantly improved due to interval training among intercollegiate women athletes. The formulated hypothesis No. 1 that there would be significant differences due to interval training on physical fitness variables such as flexibility and muscular endurance among intercollegiate women athletes was accepted at 0.05 level.

The results presented in Table-V and Table-VI on effects of interval training on physiological variables, resting pulse rate and vital capacity proved that the obtained F-values 13.44 and 14.04 were greater than the required F-value of 4.11 to be significant at 0.05 level. This proved that selected physiological variables, resting pulse rate and vital capacity were significantly improved due to interval training among intercollegiate women athletes. The formulated hypothesis No. 2 that there would be significant differences due to interval training on physiological variables such as resting pulse rate and vital capacity among intercollegiate women athletes was accepted at 0.05 level.

Chapter-V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 SUMMARY

The purpose of the study was to find out the effect of interval training interval training on selected physical and physiological variables among inter collegiate women athletes. The subjects taken for the present study were 40 inter collegiate level women athletes from different colleges in Andhra Pradesh, who represented their colleges in intercollegiate level athletic meets. The subjects were selected on a random basis and were allotted to two groups (control and experimental groups) by random assignment. The age of the subjects ranged from 19 to 24 years with mean age of 20.5 years. The investigator reviewed books, journals, and research articles on effect of interval training on physical and physiological variables and selected the flexibility and muscular endurance as physical fitness variables and resting pulse rate and vital capacity as physiological variables. A pilot study was conducted to assess the initial capacity of the subjects in order to fix the exercise load. For these purpose ten women athletes, who were not the subjects for these were selected and the proposed intensities of interval training were given to them. A pre-test-post-test randomized group design was used for this study. The randomly selected 40 Inter-collegiate women athletes were divided into two groups randomly consisting of twenty women athletes in each group. Before the training pre-test was taken for all the groups on selected physical and physiological variables. The control group did not undergo any type of training. Experimental group was provided with interval training for 12 weeks. At the end of twelve weeks interval training post-test was conducted on selected variables. The differences between the initial and final scores were considered as the effect of interval training among women athletes.

5.1.1 Level of Significance

The subjects were compared on the effect of interval training on selected physical and physiological variables among intercollegiate level women athletes. The selected criterion variables were flexibility, muscular endurance, resting pulse rate and vital capacity. The analysis of covariance (ANCOVA) was used to find out the significant difference if any, between the groups on selected criterion variables separately. In all the cases, 0.05 level of confidence was fixed to test the significance, which was considered as appropriate.

5.1.2 FINDINGS

The results proved that selected physical and physiological variables, flexibility, muscular endurance, resting pulse rate and vital capacity were significantly beneficially altered due to 12 weeks interval training among intercollegiate women athletes.

5.2 CONCLUSIONS

Within the limitations and delimitations of the study, the following conclusions were drawn:

1. It was concluded that the 12 weeks interval training significantly improved physical fitness variable, flexibility among intercollegiate women athletes.
2. It was concluded that the 12 weeks interval training significantly improved physical fitness variable, muscular endurance among intercollegiate women athletes.
3. It was concluded that the 12 weeks interval training significantly reduced physiological variable, resting pulse rate among intercollegiate women athletes.
4. It was concluded that the 12 weeks interval training significantly improved physiological variable, resting pulse rate among intercollegiate women athletes.

5.3 RECOMMENDATIONS

The findings of the study proved that interval training significantly improved physical fitness variables, flexibility, muscular endurance and vital capacity and beneficially altered resting pulse rate. Hence, it was suggested that interval training might be included in the training schedule for women athletes.

Efforts may be taken to popularize the benefits of interval training for improved performance among athletes.

5.4 SUGGESTIONS FOR FURTHER RESEARCH

Based on the experience gained through this study, the following recommendations were made.

1. Similar study may be conducted to test if longer periods of training would be more effective in improving selected physical and physiological variables among intercollegiate women athletes.
2. Research may also be conducted on the district, state or national level women athletes.
3. Similar studies may be conducted on different age groups in both men and women.
4. Selecting more variables not included in this study with additional performance variables may carry out similar studies.
5. A similar study may be carried out with larger samples and may be compared with the results of the present study.

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APPENDIX-A

RAW SCORES ON FLEXIBILITY

S.No.	Control Group		Interval Training Group	
	Initial	Final	Initial	Final
1	15.0	15.0	15.0	18.0
2	15.0	13.0	15.0	16.0
3	15.0	12.0	11.0	21.0
4	11.0	14.0	15.0	18.0
5	16.0	17.0	15.0	18.0
6	15.0	18.0	15.0	19.0
7	14.0	18.0	11.0	17.0
8	18.0	19.0	16.0	22.0
9	16.0	15.0	15.0	18.0
10	15.0	15.0	16.0	18.0
11	16.0	18.0	16.0	19.0
12	18.0	17.0	16.0	18.0
13	15.0	13.0	12.0	16.0
14	13.0	14.0	15.0	19.0
15	14.0	18.0	11.0	17.0
16	16.0	17.0	15.0	18.0
17	15.0	18.0	15.0	19.0
18	14.0	18.0	11.0	17.0
19	18.0	19.0	16.0	22.0
20	13.0	14.0	15.0	19.0

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APPENDIX-B

RAW SCORES ON MUSCULAR ENDURANCE

S.No.	Control Group		Interval Training Group	
	Initial	Final	Initial	Final
1	25.0	26.0	25.0	32.0
2	30.0	30.0	32.0	33.0
3	35.0	34.0	35.0	38.0
4	27.0	27.0	27.0	31.0
5	28.0	29.0	28.0	33.0
6	28.0	28.0	28.0	32.0
7	35.0	24.0	25.0	28.0
8	32.0	32.0	32.0	35.0
9	35.0	35.0	35.0	41.0
10	27.0	30.0	27.0	31.0
11	40.0	40.0	40.0	43.0
12	28.0	30.0	28.0	32.0
13	24.0	24.0	24.0	28.0
14	28.0	29.0	28.0	32.0
15	34.0	33.0	34.0	39.0
16	28.0	28.0	28.0	32.0
17	35.0	24.0	25.0	28.0
18	32.0	32.0	32.0	35.0
19	35.0	35.0	35.0	41.0
20	28.0	28.0	28.0	32.0

APPENDIX-C

RAW SCORES ON RESTING PULSE RATE

S.No.	Control Group		Interval Training Group	
	Initial	Final	Initial	Final
1	62.0	59.0	65.0	60.0
2	58.0	61.0	64.0	62.0
3	69.0	68.0	63.0	57.0
4	66.0	64.0	65.0	62.0
5	76.0	77.0	62.0	55.0
6	61.0	66.0	68.0	66.0
7	58.0	56.0	68.0	62.0
8	56.0	61.0	60.0	58.0
9	61.0	66.0	68.0	66.0
10	68.0	66.0	73.0	70.0
11	61.0	56.0	65.0	61.0
12	65.0	71.0	69.0	67.0
13	71.0	68.0	69.0	64.0
14	76.0	71.0	65.0	62.0
15	68.0	70.0	73.0	69.0
16	58.0	56.0	68.0	62.0
17	56.0	61.0	60.0	58.0
18	61.0	66.0	68.0	66.0
19	68.0	66.0	73.0	70.0
20	61.0	56.0	65.0	61.0

APPENDIX-D

RAW SCORES ON VITAL CAPACITY

S.No.	Control Group		Interval Training Group	
	Initial	Final	Initial	Final
1	3350.0	3400.0	3150.0	3350.0
2	3450.0	3350.0	3900.0	4075.0
3	3850.0	3800.0	3450.0	3650.0
4	2850.0	3050.0	2950.0	3250.0
5	3350.0	3400.0	3150.0	3350.0
6	3450.0	3400.0	3250.0	3425.0
7	3450.0	3550.0	2850.0	3125.0
8	3850.0	3950.0	3450.0	3650.0
9	2850.0	2800.0	2950.0	3200.0
10	3350.0	3300.0	3150.0	3350.0
11	3350.0	3400.0	3450.0	3650.0
12	3450.0	3550.0	2950.0	3250.0
13	3450.0	3400.0	3150.0	3350.0
14	2850.0	3050.0	3250.0	3425.0
15	3450.0	2400.0	3150.0	3350.0
16	2850.0	2800.0	2950.0	3200.0
17	3250.0	3300.0	3150.0	3350.0
18	3350.0	3400.0	3450.0	3650.0
19	3450.0	3550.0	2950.0	3250.0
20	3350.0	3300.0	3150.0	3350.0

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