Chapter I
INTRODUCTION

“In sports training, nothing happens by accident, rather by Design of the training program”.


Soccer is one of the most widely played sports in the world, and players need technical, tactical and physical skills to succeed. In part, professional soccer is more concerned with selection rather than development. Top soccer players do not necessarily have an extraordinary capacity in any of the areas of physical performance. Soccer training is largely based on the game itself, and a common recruitment pattern from player to coach and manager reinforces this tradition. New developments in understanding adaptive processes to the circulatory system and endurance performance as well as nerve and muscle adaptations to training and performance have given rise to more effective training interventions. Endurance interval training using an intensity at 90–95% of maximal heart rate in Three to Eight minute bouts have proved to be effective in the development of endurance, and for performance improvements in soccer play. Strength training using high loads, few repetitions and maximal mobilisation of force in the concentric mode have proved to be effective in the development of strength and related parameters.

The new developments in physical training have important implications for the success of soccer players. The challenge both for coaches and players is to act upon the new developments and change existing training practice. Individual technique, tactics and physical resources share importance when evaluating performance
differences in soccer. The average importance of each of these first level analytic approaches to differences in performance is close to one-third. Within physical resources, strength and power and their derivatives acceleration, sprinting and jumping share importance with endurance in explaining differences in physical resources within the soccer performance (Hoff & Helgerud, 2004, p.166).

Efforts to improve soccer performance often focus on technique and tactics at the expense of fitness and applied physiology. During a 90-minute game, elite level players run 8–12km at an average intensity close to the lactate threshold (LT). The highest work rate, oxygen uptake (VO$_2$) or heart rate (HR) in dynamic work using large muscle groups, where production and elimination of lactate are balanced, is defined as LT. The high-intensity bouts that are dependent on anaerobic or alactic energy sources are restored using aerobic energy. This makes it necessary for the player to spend a substantial time at intensity lower than LT. In a study of elite junior soccer players, the LT was 82–85% of maximal oxygen uptake (VO$_2$max) and 87–90% of maximal heart rate (HRmax). Another LT protocol derived from fixed blood lactate values (3 or 4 mmol/L) gave corresponding values for elite adult male players. The distance covered during a game is thus related to both the aerobic power of the player and the player’s capacity to sustain a high fractional utilisation of aerobic power (Hoff & Helgerud, 2004, p.166).

Maximum oxygen uptake is most effectively elevated by exercise intensities of 80–100% of VO$_2$max (about 40% of maximal intensity). For a muscle adaptation to occur, an extended period of training appears to be essential, and therefore, the mean intensity should be below 80% of VO$_2$max. This does not imply that high-intensity training does not elevate the number of capillaries and mitochondrial volume in the
muscles engaged in the training, but the duration of this type of training is often too short to obtain optimal adaptations at a local level (Thomas Reilly, 1996, p.54).

VO$_2$max is probably the single most important factor determining success in an aerobic endurance sport. However, within the same person, peak oxygen transport is specific to a given type of activity. Therefore, in order to obtain relevant values, emphasis is placed on testing in sport-specific activities. Intermittent exercise at 90–95% of HR$_\text{max}$ for 3–8 minutes involves a major load on the oxygen transporting organs. When training at this intensity, the improvement in VO$_2$max ranges from 10–30% within an 8 to 10 week training period, with individual variations due to initial level of fitness, duration and frequency of training. When training at low intensity at 60–80% of HR$_\text{max}$, only a 5–10% increase in VO$_2$max has been observed in sedentary study participants. When exercising at intensities higher than eliciting VO$_2$max, the VO$_2$ as well as the cardiac output and stroke volume may even reach lower values than at a slightly lower work rate. There is no evidence to support the assumption that it is important to engage the anaerobic processes to an extreme degree in order to train the aerobic motor power. At these high intensities, blood lactate concentration rises rapidly and exercise tolerance is compromised (Hoff & Helgerud, 2004, p.172).

The energy for rapid development of muscle force is provided through anaerobic pathways. Activities such as jumping, striking the ball or sprinting short distances are largely anaerobic. On average, an outfield player must undertake a high-intensity effort every 30 s and an all-out sprint every 90 s, and there is a change in the level of activity once every 4–5 s. Whilst anaerobic activities occur less frequently than do bouts of aerobic exercise at lower intensity, they often contribute to the
winning or losing of a game. Their superior speed over short distances was found to distinguish professional soccer players from other game players’ more than aerobic measures. It is essential therefore that, anaerobic energy systems are trained in conjunction with aerobic mechanisms. The aims of anaerobic training can be expressed as: a) to improve the rate of force development and the peak force achieved during brief, fast movements; b) to improve speed over short distances; c) to enhance the provision of anaerobic energy so that an all-out sprint can be sustained for longer without training; d) to improve the capability of performing repeated sprints by enabling the player to recover quickly from strenuous efforts. These aims refer to power and acceleration, speed and speed endurance (production and repetition) respectively. These components of physical conditioning for soccer must be complemented by other attributes that form unique requirements of the game. These include agility, reactions, timing of movements and implementation of games skills accurately and often at speed. There is a wealth of practices for training these characteristics, adapted from training theory rather than based on experimental evidence (Thomas Reilly, 2007, pp.83-84).

In the aerobic context of a soccer match, the most interesting events during a match are represented by high-intensity work, such as sprints, tackles and shots. A sprint bout occurs every 90 seconds, lasting 2–4 seconds. Sprinting constitutes 1–11% of the total match distance, corresponding to 0.5–3.0% of effective play time. Defining sprints as lasting a minimum of 2 seconds, the number of sprints per player per game was found to be 6–12 for a good junior team. A professional soccer player performs about 50 turns sustaining forceful contractions to maintain balance and control of the ball against defensive pressure during a game. A variety of training methods are used in an effort to increase strength and power, mostly in sports
demanding acceleration and explosive force development such as sprinting and jumping. Strength is defined as the integrated result of several force-producing muscles performing maximally, either isometrically or dynamically during a single voluntary effort of a defined task. Typically, maximal strength is defined in terms of 1RM in a standardised movement, for example the squat exercise. Power is a product of force and the inverse of time, i.e. the ability to produce as much force as possible in the shortest possible time (Hoff & Helgerud, 2004, p.172).

Improved oxygen uptake improves soccer performance as regards distance covered, involvements with the ball, and number of sprints. Large improvements in oxygen uptake have been shown using interval running. A similar physiological load arising from interval running could be obtained using the soccer ball in training. Performing high intensity 4 min intervals dribbling a soccer ball around a specially designed track together with regular soccer training is effective for improving the VO₂max of soccer players, with no negative interference effects on strength, jumping ability, and sprinting performance (McMillan, Helgerud, Macdonald & Hoff, 2005, pp.273-277).

Strength and power share importance with endurance in soccer play. Maximal strength is one basic quality that influences power performance. An increase in maximal strength is usually connected with an improvement in relative strength and, therefore, with improvement of power abilities. A significant relationship has been observed between 1RM and acceleration and movement velocity. This maximal strength/power performance relationship is supported by jump test results as well as in 30m sprint results. By increasing the available force of muscular contraction in appropriate muscles or muscle groups, acceleration and speed in skills critical to
soccer such as turning, sprinting and changing pace may improve (Hoff & Helgerud, 2004, p.175).

Training for muscle strength entails use of the overload principle and progressive resistance exercise offers a means by which the training stimulus can be upgraded on a regular basis. The intensity can be regulated by use of the RM principle, which can be determined from a single maximum effort (1-RM) or a number of repeated efforts (e.g. 10-RM). The training programme may be designed on the basis of the number of repetitions of each specific exercise, the number of sets of these repetitions and the rest periods in between. The intensity of the exercise or the level of force demanded by the active muscle determines the type and number of motor units that are recruited. Therefore strenuous efforts for brief repetitions (e.g. 6 – 6-RM) represent a good means of activating the majority of the muscle fibres. When all of the motor units are recruited, the muscle can exert its greatest possible force. Training for power must exploit the force–velocity characteristic of muscle.

The Soccer player requires both great force production for muscle development and fast actions for game-related movements. Muscle strength can be increased by a more effective recruitment of muscle fibres contributing to the generation of force and a reduction of neural inhibitory influences. After about 8 weeks longer-term effects are generally associated with increases in cross-sectional area of the muscle. Muscle strength is improved by working against resistance. Suitable exercises can be divided according to the amount of skeletal muscle engaged. Exercises involving the arm and the shoulder joint may be described as light muscle group work whereas large muscle group work employs the muscles of the thigh and those of the trunk. Training these muscle groups in particular is relevant to soccer.
Many soccer clubs have strength training facilities on their premises. The squat thrust is one of the most favoured exercises for games players. It does seem to be relevant to soccer. Wisløff et al. (2004) showed that maximal squat strength was correlated with sprint performance and vertical jumping in elite Norwegian players. More weight can be lowered than lifted, as the muscles work eccentrically when lowering a load compared to contracting concentrically when lifting it. Therefore, a useful modification of the half-squat is to overload the individual beyond maximal lifting capacity and to allow him/her to lower the weight slowly under eccentric muscular control. A weight about 120% of lifting capacity can easily be handled for six repetitions. If the stretching force is 130 to 140% of one concentric repetition maximum (1RM), it is not possible to slow the lowering sufficiently in a free movement resisting gravity to permit the involved muscles to develop maximal tension. Bench press exercise is very popular with all athletes that use weight-training programmes. Bench pressing is ubiquitous in the weight-training programmes of athletes. It has been widely accepted by runners, jumpers and games players. It would seem appropriate for soccer players attempting to improve upper-body strength, making it more difficult for opponents to master them in physical challenges. The main muscles involved are the protractors of the shoulder girdle, the abductors of the scapula and the elbow extensors (Thomas Reilly, 2007, pp.46-52).

Strength and endurance training regimes represent and induce distinctly different adaptive responses when performed individually. Typically, strength-training programs involve large muscle group activation of high-resistance low-repetition exercises to increase the force output ability of skeletal muscle. In contrast, endurance-training programs utilize low-resistance, high-repetition exercises such as running or cycling to increase maximum O₂ uptake (VO₂max). Accordingly, the
adaptive responses in skeletal muscle to strength and endurance training are different and sometimes opposite. Strength training has been reported to cause muscle fiber hypertrophy, associated with an increase in contractile protein, which contributes to an increase in maximal contractile force. Strength training also reduces mitochondrial density and suppresses oxidative enzymes activity which can cause impede endurance capacity, but has minimal impact on capillary density or in the conversion of muscle fiber types from fast twitch (type II fibers) to slow twitch (type I fibers). In contrast, endurance training usually causes little or no muscle fiber hypertrophy, but it does induce increases in mitochondria content, citric acid enzymes, oxidative capacity and the possibility of muscle fiber conversion from fast twitch to slow twitch (Hawley J. A., 2006, pp.355-361).

Concurrent strength and endurance training is undertaken by numerous athletes in various sports in an effort to achieve adaptations specific to both forms of training. Training for both strength and endurance at the same time results in less adaptation compared with training for either one alone: this has been described as the concurrent training effect. Generally, resistance exercise results in an increase in muscle mass, and endurance exercise results in an increase in muscle capillary density, mitochondrial protein, fatty acid-oxidation enzymes, and more metabolically efficient forms of contractile and regulatory proteins. Literature findings to date, investigating the neuromuscular adaptations and performance improvements associated with concurrent strength and endurance training (referred to as concurrent training) have produced inconsistent results. Serious fitness and performance participants routinely battle with the need for concurrent training models which include both anaerobic and aerobic components. Due to the demands of the activity it is valuable to identify the magnitude and intensity of each type of training to optimize
the desired performance characteristics without the adverse effects of overtraining. Although the literature has made it obvious that everyone, regardless of age and gender, needs to perform routine aerobic and anaerobic exercise to maintain healthy function and prevent the onset of disease, performance enhancement at the higher levels requires a finer, more specific balance to elicit desired outcomes (Baar K., 2006, pp.1939-1944).

Concurrent strength and endurance training appears to inhibit strength development when compared with strength training alone. Our understanding of the nature of this inhibition and the mechanisms responsible for it is limited at present. This is due to the difficulties associated with comparing results of studies which differ markedly in a number of design factors, including the mode, frequency, duration and intensity of training, training history of participants, scheduling of training sessions and dependent variable selection. Despite these difficulties, both chronic and acute hypotheses have been proposed to explain the phenomenon of strength inhibition during concurrent training. The chronic hypothesis contends that skeletal muscle cannot adapt metabolically or morphologically to both strength and endurance training simultaneously. This is because many adaptations at the muscle level observed in response to strength training are different from those observed after endurance training. The observation that changes in muscle fiber type and size after concurrent training are different from those observed after strength training provide some support for the chronic hypothesis. The acute hypothesis contends that residual fatigue from the endurance component of concurrent training compromises the ability to develop tension during the strength element of concurrent training. It is proposed that repeated acute reductions in the quality of strength training sessions then lead to a reduction in strength development over time. Peripheral fatigue factors such as muscle
damage and glycogen depletion have been implicated as possible fatigue mechanisms associated with the acute hypothesis. Further systematic research is necessary to quantify the inhibitory effects of concurrent training on strength development and to identify different training approaches that may overcome any negative effects of concurrent training (Leveritt M, 1999, pp. 413-427).

Motor unit recruitment can also be influenced by concurrent versus strength or endurance training. Endurance training of moderate intensity tends to recruit slow twitch muscle fibres. These fibres, as described above are more fatigue resistant, supply more oxygen to the muscle cells and are therefore more suited to endurance activities.

Resistance training on the other hand is aimed at maximal force production and recruits all types of muscle fibres in an effort to generate the most force possible. Concurrent training may interfere with maximal recruitment during strength training and thus result in less force production (Shannon Clark, 2005).

Simultaneously training for both strength and endurance results in a compromised adaptation, compared with training for either exercise mode alone. This has been variously described as the concurrent training effect or the interference effect (Hawley J.A., 2009, p.357).

NEED OF THE STUDY

The adaptations seen with endurance training include an increase in each of the following: mitochondrial and capillary density, enzymes of the tricarboxylic acid cycle and electron transport chain, myoglobin, and VO_{2max}. Endurance training has been associated with a decrease in muscle fiber size. Due to the fact that force production is highly correlated with cross sectional area of a muscle, this decrease in
muscle fiber size would likely result in a decrease in strength. Since it is known that the adaptations to training are very specific to the type of training, and that endurance and resistance training clearly cause different adaptations, it seems reasonable that some attenuation of the adaptations caused by one or both of these types of training might occur when they are conducted simultaneously. The literature on strength and endurance training programs suggests that the nature of the adaptive responses to training is specific to the training stimulus. Strength and endurance programs may be antagonistic when combined together (concurrent training) due to these opposing adaptations acquired from each mode in isolation.

It is, therefore, crucial to appropriately select the means of training to meet the need of the sports. This includes selecting in relation to the dominant composition of needs, which can be trained more effectively by Concurrent training, i.e., combining strength training and endurance training?, and which can be best trained in isolated conditions? Thus, makes the investigator to study with isolated and concurrent training on strength, speed, endurance, and power parameters.

Concurrent training is the new area of research in sports training methods. The controversy over the results of the concurrent strength and endurance training, and the lack of sufficient researches concerning the effects on 1RM bench press, 1RM squat, speed, explosive power and VO$_2$max was the key objective to undergo this study. Strength, speed, explosive power and VO$_2$max are important components in almost all sports and games. Thus the investigator got motivated to conduct concurrent strength and endurance training on 1RM bench press, 1RM squat, speed, explosive power and VO$_2$max among soccer players.
STATEMENT OF THE PROBLEM

The purpose of this study was to examine the influence of isolated and concurrent training on performance variables such as 1RM bench press, 1RM squat, speed, explosive power and VO\textsubscript{2}max of soccer players.

RESEARCH QUESTIONS

1. Would the isolated strength training, isolated endurance training and concurrent strength and endurance training programmes influence the selected dependent variables while in the presence of covariate (control)?

2. Would the isolated strength training, isolated endurance training and concurrent strength and endurance training programmes differ each other and also with control group while improving the selected dependent variables?

ASSUMPTIONS

Validity of this study relies on the following assumptions:

1. It was assumed that the participants performed the strength training, endurance training and concurrent strength and endurance training protocol correctly.

2. It was assumed that the participants performed the strength training and endurance training sessions separately, for three alternative days per week.

3. It was assumed that the participants performed concurrent strength and endurance training, for five days a week two/three alternative days on strength and two/three alternative days on endurance.

4. It was assumed that the participants did not perform any vigorous exercises otherwise mentioned during the course of study.
5. It was assumed that the participants were tested accurately by standardized test items.

6. It was assumed that the participants complied with the best of their ability to the training and testing directions.

**HYPOTHESES**

It has been scientifically accepted that any systematic training over a continuous period of time would lead to improvement in performance. Based on this concept and research questions the following research hypotheses were formulated and it was tested at 0.05 level of confidence.

1. There would be significant improvement on selected performance variables due to the effect of isolated strength training.

2. There would be significant improvement on selected performance variables due to the effect of isolated endurance training.

3. There would be significant improvement on selected performance variables due to the effect of concurrent strength and endurance training.

4. There would be significant differences among the experimental and control groups regarding the magnitude of improvement in the selected performance variables.

**DELIMITATIONS**

The investigation was delimited to the following;

1. To achieve the purpose, sixty men soccer players were selected from Nazareth Margoschis College, Nazareth and JACSI College of Engineering, Nazareth as subjects at random.
2. Subjects between 18 and 25 years of age.

3. Subjects who were not undergone any form of resistance or endurance training at least three months prior to the start of the study were selected.

4. Subjects were randomly placed in one of the four groups, three experimental groups and a control group of 15 each.

5. The following three independent variables were selected for this study;
   a) Isolated Strength Training (ST) (three/two days per week up to 10 weeks)
   b) Isolated Endurance Training (ET) (three/two days per week up to 10 weeks)
   c) Concurrent Training (CT) (5 days/week alternating strength and endurance training sessions up to 10 weeks)
   d) Group IV acted as control (CL).

6. 1RM bench press, 1RM squat, Speed, Explosive power and VO\textsubscript{2}max were selected as dependent variables for this study.

7. The selected variables were tested by using standardized test items.

8. All the subjects were tested on selected criterion variables prior to and immediately after the training period.

**LIMITATIONS**

The following were the limitations of this study.

1. Psychological factors, food habits and daily schedules could not be controlled.

2. No special motivation was given to the subjects during testing and training.
3. Participation in regular team practice and other physical activities by the subjects could not be controlled.

4. Changes in climatic conditions during the training period could not be controlled.

5. The previous experience of the subjects in the field of sports, which might have influenced the training and data collection, was not considered.

6. Self-reported abstinence of any type of exercise-training not prescribed as part of group dependent training.

SIGNIFICANCE OF THE STUDY

1. The result of the study may be useful to the professional colleagues of physical education and sports in strengthening their knowledge about the concurrent strength and endurance training and its effect.

2. This study would help to do more researches in this area.

3. The information gained from this study would allow researchers, trainers, physical education professionals, strength and conditioning coaches, and personal trainers to better prescribe exercise to their players, athletes and clients.

4. The findings of the study would add to the quantum of knowledge in sports training.

5. A unique aspect of this work is that it includes recommendations for the practical use of research findings.

6. The study would help the trainers and coaches to construct their training schedule to improve strength and endurance simultaneously.
OPERATIONAL DEFINITIONS

TRAINING

Training is defined as ‘the process of improving physical fitness by exercise and diet’ (Heather Bateman, 2006, p.211).

SPORTS TRAINING

Sports training is a pedagogical process, based on scientific principles, aiming at preparing sportsmen for higher performances in sports competition (Singh, 1995, p.15).

CONCURRENT TRAINING

Concurrent training by definition means training to achieve multiple training goals at the same time (Mladen Jovanović, 2008).

1RM

1RM is defined as ‘the maximum weight that a person can lift for a single repetition of any given exercise’ (Heather Bateman, 2006, p.150).

SPEED

The capacity of moving a limb or part of the body’s lever system or the whole body with the greatest possible velocity is called speed (Singh, 1991).

EXPLOSIVE POWER

It is defined as the ability to expend energy in one explosive act or in a series of strong sudden movements as in jumping or projecting some object, as far as possible (Kent, 1994).
VO$_2$MAX

VO$_2$max is defined as the highest rate of oxygen consumption attainable during maximal or exhaustive exercise (Wilmore & Costill, 2005).