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1.0 INTRODUCTION

Handball is a complex nature of sport. It emphasis on running, jumping, sprinting, throwing, hitting, blocking, and pushing, thus, it demands all motor fitness components such as speed, agility, flexibility, strength and explosive power invariably their influence on performance. In addition to technical and tactical skills, it has been shown that high levels of strength, muscle power, and handball throwing velocity are the most important factors that give a clear advantage for successful participation in elite levels of handball leagues (Gorostiaga et.al. 2004). From this, it is believed that to improve their handball performance, elite level players must arrange specific handball conditioning with some additional resistance, as well as sprint and endurance training (Jensen et.al. 1997). The best way to improve sport specific performance in handball training should be a sport specific one. Thus, to develop the performance of team handball players, specific training to be formulated based on the nature of handball. It can be deemed as Handball specific training.

Handball specific training refers to varied forms of training such as resistance, aerobic and plyometric that are most predetermined physical characteristics of performance of team handball players. In implicating the handball specific training, generally used method is progressive in nature either in the individual or consumed. Earlier studies in this area evidenced significantly for progressive in nature, periodized form of high and low intensity and concurrent form on developing the physical fitness components and physiological aspects of players. Those are needed for developing the performance of players. Hence, to investigate the appropriate source in implicating the handball specific training to periodized form or concurrent form, the present study was undertaken the title of the present work is “Effects of different training modalities of
handball specific training on variables of physical, physiological and overall playing ability of team handball players.

1.1 NATURE OF THE GAME

Handball is a sport and is becoming more and more popular in the world. A relatively rapid learning of this game, based on natural human motion, has allowed it to be popularized quickly. The development of the game is also influenced by its attractiveness based in variable action and direct conflict with an opponent. Such conflict calls for a good physical preparation of a player. The competitors playing handball have a neat stature because all the body’s muscles are used in a game. Permanent motion where all the joints of upper and lower limbs work, develops and improves their range of motion. Intense and permanent physical activity generates changes in the central nervous system and in the muscles as well as in organs such as the heart, lungs, liver and kidneys.

Team handball is a complex intermittent sport game, which requires players to have well developed aerobic and anaerobic capacities (Dudley&Djamil, 1995, Fleck et.al. 1992). Several motor abilities such as sprinting, jumping, flexibility, and throwing velocity are considered as important aspects of the game that contribute to the high performance of the team (Fogelholm, 1994, Helgerud et.al. 2001, Houston et.al. 1981). On the other hand, in a modern handball player model, specific anthropometric characteristics play a supportive role in helping athletes perform better under the actual competitive conditions (Muijen et.al. 1991, Ramsay et.al. 1990). More specifically, body height, body mass, palm span and palm length are important in improving athletes’ performance and are considered as basic criterion for athletes’ selection in various playing positions (Muijen et.al. 1991, Torranin et.al. 1979). Wider palm span and longer palm length influence specific motor abilities such as dribble, passing, catching and ball throwing and contribute to maximizing throwing velocity.
In modern sports, international competition has become fierce, involving ever younger ages. The evaluation of young athletes' performance is mainly based on physical fitness and anthropometric parameters, which give a clear picture of the athletes' quality and form the criteria for their promotion to a higher level. Team positions in team handball can be broadly classified as goalkeepers, first line players, and second line players (Jensen et.al. 1997, Loftin et.al. 1996). During the evolution of the game, certain positions have been classified according to the specific individual playing positions (Bosco et.al. 1983, Houston et.al. 1981, Mikkelsen and Olesen, 1976). These positions are: back players, wing players, pivots, centre backs and goalkeepers. Time motion studies have shown that in the course of the game handball players perform different activities depending on their positions (Delamarche et.al. 1987, Mikkelsen and Olesen, 1976). During the game, wings seem to cover the longest total distance and the longest distances while sprinting (Hakkinen and Sinnemaki, 1991, Mikkelsen and Olesen, 1976), while backs seem to execute the largest number of throws (Hickson, 1980).

1.2 FUNDAMENTAL SKILLS IN HANDBALL

It is basic skills necessary for playing the game and all other complex Skills are the product of speed, accuracy, form and adaptability and combination of these basic skills. The mastery of the fundamental skill is very essential in improving the standard of the game. The fundamental skills are catching and passing, dribbling, faking, fainting, shooting, and goalkeeping.

Dribbling

Dribbling skill enhances the possession of the ball on a fast-break with no teammate to pass to and no defender between you and the goal, dribble to continue for a shot on goal. If used three steps in a one-on-one situation to successfully fake a defender, then see an open space to the goal,
one dribble will permit you an additional three steps to continue to the goal for a shot. When unable to pass to a teammate, dribbling will allow you to avoid a 3-second violation resulting in a free-throw for the opponent.

After receiving the ball and before dribbling a player holds the ball with both hands. The ball is being dribbled sideways at hip level. Bouncing on the ground is performed by the combined action of the elbow and wrist joints. The angle of the bounced ball depends on the speed that the player is moving at. The faster the run the more the angle becomes obtuse. If an opponent comes closer, a player must lower his position as well as the dribbling, protecting the ball from being taken by the opponent.

**Passing**

Passing is one of the basic technical elements. A pass must be accurate, fast and tactically useful. A decision to whom a pass should be directed depends on the player’s position in a particular situation. A pass should be directed to that player, whose position may menace the opponent.

If the scoring opportunity is not clear, the rhythm of the attack will continue by passing the ball to a teammate. Consistent, accurate passing ensures the pace and continuity of team plays and keeps pressure on the defense by allowing each attacker the opportunity to be a scoring threat.

**Shooting**

Shots are one of the most important elements of handball. They are vital elements that decide the scores. While shooting the muscles of the lower and upper limbs, pelvic region and trunk are extremely engaged. One can assume that shooting is performed similarly to passing, but with a stronger action of the trunk and upper limbs. The shot power is conditioned by the distance and hand action time on a ball. The greater the distance that the hand on the ball covers in the time unit the stronger the shot will be (a ball reaches a higher velocity) performed. The names of shots have been
derived from the way the players move on the court and the position of his/her body to the ground.

In team handball, shooting is the final action in an attack – the payoff punch. There are four basic handball shots, the “set shot” is the most natural of all shooting actions and is simply the overhand pass thrown hard. The “jump shot” is the most used shot in handball. Developing the ability to jump and shoot over the defense, as well as jumping inside the goal area, will make you a more effective scoring threat. The “wing shot” is the jump shot performed at a difficult shooting angle. Finally, the “fall shot” is the basic technique of the circle runner. It allows you to receive the ball on the 6-meter line and shoot without using three steps. The player must be able to choose and execute the appropriate shot as the opportunities present themselves. No matter what position they play.

1.3 SPORTS TRAINING

The term ‘Training’ is widely used in sports. Some experts especially belonging to sports medicine understand sports training as basically doing physical exercise. Training aims at improving the fitness of persons. The very purpose of the training program is aid in the development of acceptable levels of health – and health related physical fitness and promote the acquisition of basic movement skills. To achieve these things, training should have some basic principles. Of these the most basic principle of training is overload. Most physiological systems can adapt to functional demands that exceed those encountered in normal daily life. Training often systematically exposes selected physiologic systems to intensities of work or function that exceed those to which the system is already adapted. To avoid excessive overload because physiologic systems cannot adapt to stresses to extreme consistency refers to most physiologic systems require exposure to overloading activities three times a week or more. The required frequency of training however depends on the season, the athlete, activity
and the specific component of fitness. There is no substitute for consistency in a training program. The athlete might participate in endurance training six times a week and resistance training three times a week. Specificity means the effects of training are highly specific to the participation physiologic system overloaded, to the particular muscle groups used, and to the particular muscle fibers performing the work progression is the Successful training programs plan for a steady rate of progression over a long period. The athlete has to improve over several years of participation; the training program must progress so that the appropriate physiologic systems continue to be overloaded. However, too rapid an increase of the training stress may lead to exhaustion and impaired performance. Individuality means factors such as age, sex, maturity, current fitness level, years of training, body size, somato type and psychological characteristics should be considered by the coach in designing each athlete’s training regimen. In large groups in which absolute individualization of training programs may be impractical, the coach should strive for individualization by homogeneously grouping athletes.

1.4 SPORTS-SPECIFIC TRAINING

The Greek physician Galen (AD 129 – 210) is generally accepted to be the originator of sports specific training. Whilst he was chief physician to the Gladiators, Galen devised training drills to replicate movements from the arena, as seen in the 1960 film Spartacus. Galen’s gladiator drills are also referred to as functional training, that is, exercises consisting of movements that are specific to a particular sport. With practice we may get better at performing these exercises but to date there is no conclusive evidence that this makes any difference to your sporting performance or normal everyday function of the muscles specifically targeted.

Sports scientist Michael Yessis states that sports specific training must fulfill one or more of the following criteria:- The exercise must
duplicate the exact movement witnessed in a certain segment of the sports skill. The exercise must involve the same type of muscular contraction as used in the skill execution. The special exercise must have the same range of motion as in the skill action. So perhaps the best sport specific exercise program, by definition, is playing own sport. The focus of training should be on the quality of movement wanted. To do this one need to develop his level of self-awareness and observational skills of himself in action (www.fitness-programs-for-life.com, 2005)

1.4.1 Need of Sports Specific Training

Sports Specific Training can help to improve strength, flexibility and stamina whereby the players can improve his performance in specific sports. For this sports specific training is in need to all about developing physical conditions to improve performance and skills at a particular sport. Also, understanding the needs of the game, training/practicing at the correct pace in order to meet sports requirements. “Sport-specific” is the new marketing buzzword when it comes to strength and conditioning programs for youth. Training that is specific to the demands of a particular sport does have merit at the higher levels, assuming the athlete is developmentally sound. A good athlete is a combination of raw athleticism (big, strong, fast, and adaptable) and sport-specific skill (skill involved with a specific sport like hitting, kicking, or dribbling). When parents and athletes are looking for a coach to help them be better at their sport, they must realize the difference between the two factors involved with being a good athlete. Sport-skill coaches (baseball coaches, basketball coaches) are specialists in developing the specific skill sets needed for that game. Athletic performance coaches or “strength and conditioning” coaches are specialists in making an athlete generally faster, stronger, more mobile, and more reactive. Unless either of these coaches has extensive, qualified experience in developing both factors of athleticism (raw and specific skill), they can’t create a program that optimizes both. One of the well-established laws of
motor learning is that the only way to improve a skill is to practice that skill as accurately as possible (www.EliteFTS.com.). Besides sports specific training improve the neuromuscular adaptations, athleticism and injury prevention and decreased rehabilitation time. To facilitate how a person does deliver oxygen to their working muscles, they need to train, or participate in activities that will build up the energy stores needed for their sport. This is referred to as metabolic training. Metabolic training is generally divided into two types: aerobic and anaerobic.

1.5 HANDBALL SPECIFIC TRAINING

Periodized handball specific training was comprised of resistance training, aerobic training, plyometric training, handball specific drill practice, and playing the game. This training was executed by adapting periodization principles of high intensity with low volume and low intensity with high volume for resistance and aerobic training modules alone. As for plyometric training is concerned, which was treated progressive in nature.

1.6 MODALITIES OF TRAINING

1.6.1 Interval Training

Interval running enables the athlete to improve the workload by interspersing heavy bouts of fast running with recovery periods of slower jogging. The athlete runs hard over any distance up to 1km and then has a period of easy jogging. During the run, lactic acid is produced and a state of oxygen debt is reached. During the interval (recovery), the heart and lungs are still stimulated as they try to pay back the debt by supplying oxygen to help break down the lactates. The stress upon the body causes an adaptation including capillarization, strengthening of the heart muscles, improved oxygen uptake and improved buffers to lactates. All these lead to improved performance, in particular within the cardiovascular system.
1.6.2 Combined Training

It is a highly effective form of physical training that combines both resistance strength training and plyometric explosive power training. The idea is to use the combination of resistance and plyometric exercises to superbly engage the nervous system and activate more fibers. Complex training describes a power-developing workout that combines weights and plyometric exercises. About 10 years ago, these workouts were greeted with great acclaim as research indicated that they could significantly enhance fast twitch muscle fiber power and, therefore, dynamic sports performance. According to Beachle & Earle (1994) complex training is a combination of high intensity resistance training followed by plyometrics. Ebban states that complex training alternates bio mechanically similar high load weight training exercises with plyometric exercises. An example of complex training would include performing a set of squats followed by a set of jump squats. Complex training describes a power-developing workout that combines weights and plyometric exercises. About 10 years ago, these workouts were greeted with great acclaim as research indicated that they could significantly enhance fast twitch muscle fiber power and, therefore, dynamic sports performance.

1.6.3 Combined Aerobic and Resistance Training

Resistance training provides numerous and important health benefits through multiple mechanisms that may reduce the risks for diabetes, heart disease, possibly cancer and disabilities. There is much more extensive and long-standing evidence, however, about the benefits of aerobic training on cardiovascular fitness and disease risk reduction, particularly for reducing the risks of heart disease and for premature death from heart disease. A resistance training protocol for hypertrophy would try to increase protein synthesis and also stress the primarily interested in resistance training. The tricky issue is how to incorporate aerobic training into an overall
programme without undermining strength development or hypertrophy (gaining muscle mass). Docherty and Sporer (2000) have recently attempted in an extensive review article to advance the science by postulating specific physiological mechanisms affected by different training protocols that can predict when there will and will not be interference between aerobic and resistance training. They noted that aerobic training increases maximum oxygen consumption and hence the body's ability to transport and use oxygen is dependent upon both a central component involving adaptations in the cardiopulmonary system and a peripheral component involving adaptations in muscle tissues. Central and peripheral adaptations are, in turn, dependent upon different mechanisms. It does appear that higher the intensity of the stimulus used to increase maximum oxygen consumption (e.g., high intensity interval training), the greater the increase in oxygen consumption. However, the location of the adaptation to aerobic training may shift depending upon the intensity of the stimulus. At lower levels of intensity, it appears that most of the adaptations occur centrally.

With higher intensity training, more adaptations occur peripherally. Docherty and Sporer (2000) noted that research suggests that training between 70% and 80% of VO₂max (70% to 80% of heart rate reserve; about 80% to 85% of maximum heart rate; just slightly below the anaerobic threshold) results in maximal contractile force in the heart and thus maximizes central adaptations important for health benefits. These findings are critical and suggest how concurrent training can be optimized. Aerobic training favourably influences health through central adaptations and there may be no reason to train at levels that will result in more peripheral adaptations. The ability to perform at higher levels does require training at high levels of intensity and specific peripheral adaptations, but such performance levels are not the goal of most people. Aerobic training at very high intensities, through its effects on mechanisms associated with
peripheral adaptations, may be the cause of blunting of strength gains and hypertrophy when aerobic training is done along with resistance training.

Docherty and Sporer (2000) discussed the mechanisms that appear involved in increasing strength and hypertrophy. The basic theory holds that high intensity aerobic training such as interval training affects specific mechanisms in peripheral adaptations such as those involved anaerobic energy system.

1.6.4 Combined Resistance Training with Plyometric Training

According to Hakkinen et al. (1998) the strength training in combination with some explosive types of exercises be recommended as a part of overall physical training to maintain the functional capacity in middle-aged and elderly people. For explosive muscle performance, the underlying factors are muscle fibre type, muscle hypertrophy and enzymatic and neural adaptations. It is also important to investigate the impact of power-type strength training on the low back and leg muscles and joints, as well as the injury risks and adherence, and motivation to training. For being effective in improving the explosive muscle performance, training programs should be designed so as to be motivating, easy to achieve, effective concerning the time spent in exercises, low in expenses, and they should give consideration to the exercise history and present exercise activity, health status and musculoskeletal symptoms and diseases of the individual.

Combining both resistance strength training and plyometric explosive power training is to use the combination of resistance and plyometric exercises to superbly engage the nervous system and activate more fibres (Beachle & Earle (1994). Ebban (2002) states that resistance training followed by plyometric training alternates bio mechanically similar to high load weight training exercises with plyometric exercises. This type of training describes a power-developing workout that combines weights and plyometric exercises. About ten years ago, these workouts were
greeted with great acclaim as research indicated that they could significantly enhance fast twitch muscle fibre power and, therefore, produce dynamic sports performance. The logic behind this pair of exercise is that the resistance work gets the nervous system into full action so that type -II b fibres are available for the explosive exercise; hence a better training benefit of complex training programme can be used in the general, specific and competitive phase of training.

1.7 PERIODIZATION

Periodization is an organized approach to training that involves progressive cycling of various aspects of a training program during a specific period of time. The roots of periodization come from Hans Selye’s model, known as the General Adaptation Syndrome, which has been used by the athletic community since the late 1950s (Fleck, 1999). Selye identified a source of biological stress referred to as eustress, which denotes beneficial muscular strength and growth, and a distress state, which is stress that can lead to tissue damage, disease, and death.

Periodization refers to specific methods of manipulating training variables to provide variation in volume and intensity. It permits balanced progression by ensuring the appropriate mix put together in a unified plan. (Bompa, 1998 and Fireman, 1989). Periodized training programs are shown to be more effective in eliciting strength and body mass improvements than non periodized resistance training programmes (Kraemer, et.al, 2002) Periodization is an approach to resistance training programme that includes systematic alternating cycles of weight lifted (intensity) with total repetitions or volume (repetitions x sets) (Fleck, 1999). Through literatures, periodized resistance training module was observed as easily adaptable and proven method to avoid risk factors such as injury, fatigue, soreness and some bone fractures etc. The roots of this exercise programme design date back to the 1950’s and early 1960’s where European coaches, trainers, and
sports scientists were coaching some of the greatest athletes of that period. The coaches and trainers determined that no matter how fit the athletes were, they just couldn’t continue to train harder and harder. So the trainers did something quite revolutionary with their athletes’ training schedules. They methodically had the sportspersons complete resistance training phases that included high-volume, low-intensity resistance workouts, and then alternated these cycles with low-volume, high-intensity training phases. Eventually this scheme of resistance training filtered to the United States in the 1970’s, where it had its rudimentary beginning. Over the last 10 years, different forms of periodization have attained notable popularity in the U.S. (Marx et al, 2001). But the theoretical roots of periodization come from the Canadian scientist, Dr. Hans Selye, who first presented the General Adaptation Syndrome (G.A.S.) theory (Kraemer, 1998). This theory suggests that the body adapts to training in three different phases the alarm stage, resistance stage and “exhaustion” or fatigue stage, caused by training too hard or too long without sufficient recovery. Overtraining is a practical occurrence of what might be occurring in the third phase of the G.A.S. To avoid the exhaustion phase of the G.A.S., there must be some type of orderly change in the stimulus, the Physiology of Periodization. The principle of progressive overload is another physiological concept important to comprehension of the basis of periodization.

Most individuals have approximately 50% of slow-twitch and fast-twitch muscle fiber types, although this varies comparatively between people, and also within a person’s body (McArdle, Katch & Katch, 1996). The physiological and metabolic characteristics of slow-twitch endurance fibers and fast-twitch explosive strength muscle fibers are thoroughly discussed in nearly all the current exercise physiology texts. On the contrary, the physiological explanations why periodization programmes work so effectively are just beginning to be understood by exercise scientists. One accepted explanation is that the systematic training approach
of periodized programmes provides a satisfactory overload to specific muscles fiber types while other fibers are getting necessary recovery (Kraemer, Fleck & Evans, 1996). Thus the recovery is inbuilt in periodization training design. The bottom line is that without proper recovery the body will not achieve all the potential benefits from training. The alternating cycles of high-volume with low-intensity and low-volume with high-intensity provides a satisfactory stimulus/recovery for the different types of muscle fibers, minimizing the possibility of experiencing the exhaustion phase of the G.A.S.

The research has focused primarily on the variation in training volume (total repetitions per workout or total repetitions x mass lifted) and exercise intensity (%1RM). While the underlying mechanisms that explain the differences between periodized and non-periodized programmes remains to be fully investigated and explained (Fleck 1999), the effects on neural adaptations, and the avoidance of overtraining are suggested as possible factors (Fleck 1999, Stone 1999 a & b). Most comparative studies have demonstrated the superiority of periodized over non-periodized in terms of greater changes in strength, body composition, and motor performance (Fleck 1999). These investigations were evaluated based on changes in strength and/or power-related measures. When summarized these studies demonstrate that even over a relatively short period of time (the length of a mesocycle), significantly greater improvements can be realized using systematic variation in training volume and intensity compared to linear using constant sets and reps (i.e.,3 sets of 10 repetitions). In two separate studies, groups using a one-set-to-failure programme were compared to other groups using periodized training principals. Both methods resulted in improvements in strength and power measures over the training period. However, the periodized groups demonstrated significantly greater increases than did subjects in the single set groups (Fleck 1999). An obvious concern in the interpretation of these results is the greater amount
of training volume (reps x sets x total mass lifted) in the periodized programmes, which may account for the differences in performance gains between the groups. However, these findings may furnish evidence for the use of periodized multiple set programmes over single set programmes.

To address the influence of overall training volume, multiple set linear programmes (constant reps and sets) have been compared to periodized programmes (decreased volume-increased intensity with time). In the majority of cases, periodization based programmes still provided significantly greater improvements in performance measures (Fleck 1999, Stone 1999a, Stone 1999b). Therefore, there is evidence to support the idea that appropriate manipulation of volume and intensity over and above just increases in total training volume alone is an important factor in optimizing strength-training effects.

1.7.1 Training Basics in Periodization

Part of a periodized plan is decreasing quality and quantity and goes through a period of active rest resulting in a greater state of readiness to handle a higher training load. Including rest periods in training program is especially beneficial when training with high intensity and / or high volume. Improvements in fitness (as measured by increased strength or endurance) occur during the rest period, not during the training itself. Positive physiological adaptations to training result from correctly timed alternations between stress and regeneration. After a controlled training overload, there is a period when the body adapts to the overload and works to reestablish homeostasis. After it has adapted to the overload, the body is capable of doing more work for an equivalent homeostatic displacement. The basic aim of training, therefore, is to apply a series of stimuli that will displace the homeostasis of the body’s functional systems and provide a stimulus for adaptation and super compensation. If the training stimulus is too small in
either intensity of duration, little or no adaptation will take place. However, if the stress is too severe, the adaptation will be delayed or even prevented.

1.7.2 Periodized Strength Training

The concept of periodized strength training has been utilized by the athletic community at least since the late 1950s. Periodized strength training refers to varying the training program at regular time intervals in an attempt to bring about optimal gains in strength, power, motor performance and/or muscle hypertrophy. A goal of periodized strength training is to optimize training during short (e.g., weeks, months) as well as long periods of time (e.g., years, a life time, or an athletic career). The training variables that can be manipulated in an attempt to optimize the training program include number of sets performed of each exercise, number of repetitions per set, exercises performed, number of exercises performed per training session, rest periods between sets and exercises, resistance used for a set, type of muscle action performed (e.g., eccentric, concentric, isometric), and number of training sessions per day and per week.

The term intensity is frequently used when describing weight-training programs to refer to the weight lifted of repetition maximum weight used to perform a certain number of repetitions (repetition maximum, RM). The highest intensity that can be used is a one repetition maximum weight. A weight allowing the performance of more than one repetition of an exercise is thus a lower training intensity. The term training volume will be used in reference to the total number of repetitions per set, and number of repetitions implies a higher training volume. Unfortunately, despite the virtually limitless combination of these training variables, the majority of studies examining the effectiveness of periodized training have focused on strength/power gains and manipulated only training intensity and training volume.
1.8 RESISTANCE TRAINING

Resistance training is an important tool for achieving a complete healthy life. Resistance training is not just for people who are athletes, want to build or tone muscle, or are using resistance training to achieve a better-looking body. Resistance training does improve the look and tone of the body but it is now known to be more than just a specialized exercise activity. According to the American Sports Medicine Institute (ASMI), resistance training is a "specialized method of conditioning designed to increase muscle strength, muscle endurance, and muscle power". Resistance training can be performed in a variety of ways; with resistance machines, free-weights (dumbbells and barbells), rubber tubing, or your own body weight, as in doing pushups, squats, or abdominal crunches. The goal of resistance training, the ASMI says, is to "gradually and progressively overload the musculoskeletal system so it gets stronger". Regular resistance training will strengthen the bones, building and strengthening the muscles.

Keith Cinea, a certified strength and conditioning specialist and educational program coordinator for the National Strength and Conditioning Association, says that any fitness program should include resistance training, along with aerobic exercise and flexibility training. Aerobic workouts, which strengthen the cardiovascular system, focus primarily on the large muscle groups of the lower body, he says. Strength training offers a way of balancing that out by challenging all the major muscle groups, including those in the chest, arms, back and abdomen.

1.8.1 Adaptations to resistance training

The effects of resistance training on muscular strength, muscular hypertrophy, muscle fiber, muscular power, muscular endurance, heart rate, and body composition are briefly described in the following aspects.
1.8.2 Muscular strength

The increases in muscular strength during the initial periods of a resistance-training programme are not associated with changes in cross-sectional area of the muscle (Sale, 1988). Changes in strength evidenced in the first few weeks of resistance training are more associated with neural adaptations (Moritani & deVries, 1979), which encompass the development of more efficient neural pathways along the route to the muscle. Long-term changes in strength are more likely to be attributable to hypertrophy of the muscle fibers or muscle group (Sale, 1988). The range of increase of strength is quite variable to the individual and may range from 7% to 45% (Kraemer, 1994). It should be noted that strength results appear to be velocity specific. Velocity specificity best characterizes the probability that the greatest increases in strength occur at or near the velocity of the training exercise (Behm & Sale, 1993). Adaptations with resistance training enable greater force generation and include enhanced neural function (e.g., greater recruitment, rate of discharge) (Leong et al, 1999), increased muscle CSA (Alway et al, 1989), changes in muscle architecture, and possibly a role of metabolites for increased strength. The magnitude of strength enhancement is dependent on the muscle actions used, intensity, volume, exercise selection and order, rest periods between sets and frequency.

1.8.3 Muscular hypertrophy

It is well known that resistance training induces muscular hypertrophy (Jackson, et al, 1990). Muscular hypertrophy results from an accumulation of proteins, through either increased rate of synthesis, decreased degradation, or both (Booth and Thomason, 1991). The time course of muscle hypertrophy has been examined during short-term training periods in previously untrained individuals. The nervous system plays a significant role in the strength increases observed in the early stages of
adaptation to training. However, by 6-7 weeks of training, muscle hypertrophy becomes evident, although changes in the quality of proteins, fiber types, and protein synthetic rates take place much earlier. From this point onwards, there appears to be interplay between neural adaptations and hypertrophy in the expression of strength. Less muscle mass is recruited during resistance training with a given intensity once adaptation has taken place. These findings indicate that progressive overloading is necessary for maximal muscle fiber recruitment and consequently muscle fiber hypertrophy.

1.8.4 Muscle fiber

The increase in size of muscle is referred to as hypertrophy which is associated with long-term resistance training. Increases in the cross-sectional area of muscle fibers range from 20% to 45% in most training studies. Muscle fiber hypertrophy has been shown to require more than 16 workouts to produce significant effects. In addition, fast-twitch (glycolytic) muscle fiber has the potential to show greater increases in size as compared to slow-twitch (oxidative) muscle fiber (Hather, Tesch, Buchanan, & Dudley, 1991).

1.8.5 Muscular power

The expression and development of power is an important perspective from sports performance and lifestyle as well. Power is produced when the same amount of work is completed in a shorter period of time, or when a greater amount of work is performed during the same period of time. Neuromuscular contributions to maximal muscle power include maximal rate of force development (RFD) (Adams, 1999), muscular strength at slow and fast contraction velocities, stretch-shortening cycle (SSC) performance and coordination of movement pattern and skill.
Several studies have shown improved power performance following a traditional resistance-training programme. Yet the effectiveness of traditional resistance training methods for developing maximal power has been questioned because this type of training tends to only increase maximal strength at slow movement velocities rather than improving the other components contributing to maximal power production. Thus, alternative resistance training programmes may prove to be more effective. A programme consisting of movements with high power output using relatively light loads has been shown to be more effective for improving vertical jump ability than traditional strength training. It appears that heavy resistance training with slow velocities of movement leads primarily to improvements in maximal strength, whereas power training (utilizing light to moderate loads at high velocities) increases force output at higher velocities and RFD. However, it is important to simultaneously train for strength over time to provide the basis for optimal power development. Heavy resistance training may actually decrease power output unless accompanied by explosive movements. The inherent problem with traditional weight training is that the load is decelerated for a considerable proportion (24-40%) of the concentric movement. This percentage increases to 52% when performing the lift with a lower percentage (81%) of 1 RM lifted or when attempting to move the bar rapidly in an effort to train more specifically near the movement speed of the target activity.

1.8.6 Muscular endurance

Muscular endurance has been shown to improve during resistance training (Marx et al, 2001). Traditional resistance training has been shown to increase absolute muscular endurance (the maximal number of repetitions performed with a specific pre-training load) (Kraemer, 1997), but limited effects are observed in relative local muscular endurance (endurance assessed at a specific relative intensity, or percentage of 1 RM) (Mazzetti et al, 2000). Moderate- to low-resistance training with high
repetitions has been shown to be most effective for improving absolute and relative local muscular endurance. A relationship exists between the increase in strength and local muscle endurance such that strength training alone may improve local muscular endurance to a certain extent. However specificity of training produces the greatest improvements. Training to increase local muscular endurance implies the individual to 1) performs high repetitions (long-duration sets) and/or 2) minimize recovery between sets.

1.9 PLYOMETRICS

Plyometrics is one of the power training. It involves powerful muscular contractions in response to a rapid stretching of the involved musculature. These powerful contractions are not a pure muscular event. In fact they primarily involve and augment the nervous system. It is the combination of involuntary reflex (Myotatic “stretch-reflex”) which is then followed by a fast muscular contraction. Plyometric training is now a common element of elite sports training programmers, and is increasingly used by other athletes and their coaches. Plyometric exercises are based on the understanding that a concentric (shortening) muscular contraction is much stronger and it immediately follows an eccentric (lengthening) contraction of the same muscle. It is a bit like stretching out a coiled spring to its fullest extent and then letting it go: immense levels of energy are released in a split second as the spring recoils. Plyometric exercises develop this recoil or, more technically, the stretch/reflex capacity in a muscle. With regular exposure to this training stimulus, muscle fiber should be able to store more elastic energy and transfer more quickly and powerfully from the eccentric to the concentric phase. However, to get the best out of plyometrics one needs adequate preconditioning and that is where weight training can play a crucial role. Moreover, when it comes to selecting the right plyometric moves, the coach or athlete needs to consider the specifics of their sport, the athlete's maturity, his level of pre-conditioning and his
ability to pick up what can be a complex skill. It is logical for athletes to seek to increase the rate of force development, because most sporting movements involve fast movements, for which forces must be generated quickly (Chu, 1996).

1.9.1 Importance of Plyometric training

The importance of plyometrics revolves around the basic concept that a pre-stretched muscle is capable of generating more force. The muscle must be stretched before the concentric movement, and it must occur immediately before the concentric movement. Simply jumping up in the air fulfills these requirements. However, plyometrics can be performed with upper body routines as well; it is not only for lower body things to improve leg speed which will improve running and jumping. One can also perform exercises such as clap push-ups or medicine ball throws off a wall or either straight up in the air. Medicine balls are a great aid to have in order to improve upper body plyometric abilities. It is also proven that plyometric training mixed with strength training can result in greater gains in both departments. However, it is recommended not to perform each on the same day to also avoid over-training and getting the most energy out of each workout. Plyometric training will bridge the gap between strength and speed. It will benefit athletes of all ages if done correctly (Chu, 1996).

1.10 AEROBIC TRAINING

Aerobic exercise is any activity that can be practiced continuously over a longer period. It is a type of exercise that works the body at the lower end of the target heart rate zone, causing the heart and lungs to adapt by becoming stronger. The step test is a sub maximal test for estimating aerobic fitness. It is commonly used in studies involving large numbers of people, like the cardiac fitness. When the body is challenged with a bout of physical exertion, like stepping up and down, the heart rate increases to deliver oxygen to the working muscles. The efficiency with which the
muscles perform the challenge is reflected in the increase in heart rate. The body adapts to regular physical activity by becoming more efficient. A lower heart rate at the end of the 3-minute step test indicates greater aerobic fitness (i.e., more fit). Higher fitness levels are indicative of an active lifestyle, which is what the strive for.

1.11 PHYSICAL VARIABLES

1.11.1 Speed

Speed is the ability to move the body or a part of the body as rapidly as possible from one point to another. It is the rate of movement, or the amount of time it takes for a body or object to travel between two points. Speed is obviously extremely important in all forms of racing, but also in team and goal related sports when someone has the chance to 'runaway' from the opposition. One of the major requirements in many sports is speed. In sports such as sprinting, soccer, cycling, hockey, fencing, games and many other team sports, speed is a major factor determining the overall outcome. In fact, all skill-related components contribute to speed. Speed requires the expenditure of a large amount of energy in a short period. It is an important factor in almost all court and field games. It can make the difference in whether a performer is able to gain an advantage over his opponent. In games like basketball, football, hockey, and team hand ball both acceleration speed and running speed are basic to success (Jensen and Fisher, 1979).

Performing sports skills economically with ease, correct positioning of body levers and good neuro-muscular coordination will result in efficient use of energy and a higher speed of the movement. In addition to relaxation ability, joint flexibility is an important ingredient for performing movements with high amplitude (e.g. long stride in running) which in many sports is essential to execute optimum range of movement for maximum speed. Speed is determined not only by mobility and well synchronized
neuromuscular response but also by the frequency of the precise nervous impulses and strong concentration. This is because quick, explosive movements depend on a high level of power. Willpower and strong concentration are very important factors in achieving high speed. Exercises of will must be included in the training process to achieve a high level of speed.

Fast movements are performed by recruiting the fast twitch fibres, and because of their function and metabolic qualities these fibers constitute the most favorable preconditions for speed performances; for instance, successful sprinters have more than 60 percent fast twitch fibers, as a result of their genetic aptitude. Whereas has stated that speed is the result of both positive and negative forces. Muscular contractions are positive forces, while air or water resistance, gravity, friction, and inertia are some examples of negative forces. Increases in speed can result from decreasing the influence of the negative forces, or both. This illustrates the importance of individualizing training on the basis of the sport or event (deVries (1974).

1.11.2 Agility

Agility is important in all activities that require quick changes in positions of the body and its parts. In basketball, fast starts and stops and quick changes in direction are fundamental for good performance. Agility enables an individual to rapidly and precisely alter the position and direction of the body and is an important ingredient for successful participation in wide variety of sports. An agile person can quickly and efficiently mobilize the large muscle groups of the body in order to make rapid changes in direction of movement. Agility involves coordinating quickly and accurately the big muscles of the body in a particular activity. One’s level of agility is probably a result of both innate capacity and training and experience. It is revealed to a great extent in sports involving
efficient footwork and quick changes in body position force. 
(Barrow and McGee, 1979).

1.11.3 Strength

Strength is the ability of the individual to exert force against an object. It is the ability to overcome resistance or to act against resistance. Muscle strength is what happens when the nervous system communicates a message to the muscle fibers to contract so as to produce force. Often the force produced by a muscle contraction is against resistance. Strength should not be considered as a product of only muscular contractions. It is in fact a product of voluntary muscular contractions caused by the neuromuscular system. The abdominal strength is very much useful in the field of sports and games. When an individual possess a high degree of abdominal strength, he will be able to perform any type of activity such as running, jumping and throwing. The abdominal strength helps to maintain the body postures, thereby involving in many activities in the field of sports and games. Lifting a load or moving an inanimate or animate object essentially depends on the abdominal muscular strength.

Strength is the most important element in motor performance. Strength is a consistent differentiator of ability to make and to achieve success in sports. Young athletes develop strength through natural, unbroken movements such as jumps, throws and other body weight exercises. Proper strength training serves not only to improve overall performance, but also to secure the body and help the athlete avoid injury.

1.11.4 Lower Extremity Strength

The legs are the primary source of power in many sports. In the great majority of situations they function as part of a closed kinetic chain which means that one leg is always in contact with the ground. Without functional leg strength the athlete can not have speed, strength, power, or suppleness
to perform. We must think of the legs as a functional unit of the whole kinetic chain. "Function is a miraculous and complex combination of systems that are linked and react with each other. In order to understand function as a whole, the parts and components of function must be appreciated." (Gary Gray, 2001) The leg muscles work together to reduce and produce force in the most effective manner for the required activity.

1.11.5 Explosive Power

Successful sporting performance at elite levels of competition often depends heavily on the explosive leg power of the athletes involved. Many team sports also require high levels of explosive power, such as Basketball, Volleyball, Netball and the Rugby and Football codes for success at elite levels of competition. Explosive power comes from the development of speed strength and pure strength. Power represents the amount of work a muscle or muscle group can produce per unit of time. Until recent years power as it relates to sports performance has been the subject of limited research, but in the last decade or so researchers has realized the importance of training for power in a wide variety of sporting activities (Clutch et al, 1983).

Vertical and horizontal jumping, in its many different forms, requires high levels of explosive muscular power. Note power as the equivalent of explosive strength. Power is the equivalent of explosive strength. The term "speed-strength" synonymous with power. Paavolaienen et al (1999) suggested that muscle power is the ability of neuromuscular system to produce power during maximal exercise when glycolytic and oxidative energy production is high and muscle contractility may be limited.
1.11.6 Leg Explosive Power

The strength of the muscles in the limbs is moving and supporting the weight of the body repeatedly over a given period of time in terms as dynamics strength, sometimes, it has been called velocity or speed. The important aspect of this factor is the requirement that the muscular force must be repeated as many times as possible. Explosive strength and dynamic strength involve movement of the body or of its limbs.

1.12 PHYSIOLOGICAL VARIABLES

1.12.1 Maximum Oxygen Consumption (VO₂ max)

Maximum oxygen uptake (VO₂ max) refers to the highest rate at which oxygen can be taken up and consumed by the body during intense exercises. Traditionally, the magnitude of an individual’s VO₂ max has been viewed as one of the most important predictors of endurance. The ability of the cardio respiratory system to transport oxygen to the exercising muscles refers to the central component of VO₂ max. The role of the central component is for oxygen to be transported from the atmosphere and delivered to the muscles where it is utilized during mitochondrial respiration to produce ATP. The major limitations in oxygen delivery are pulmonary diffusion, cardiac output, blood volume and flow. In aerobic work, oxygen is obtained from the air and is transferred from the lungs to the blood and then to the muscles via the circulatory system. Maximal oxygen uptake or maximal aerobic power (VO₂ max) is the indicator of aerobic fitness. As VO₂ max increases, the level of aerobic fitness also increases which refers to individual aerobic capacity. An individual who is fit will have a cardio-respiratory system that is capable of meeting the demands of the tissues under conditions of intense exercise.
1.12.2 Heart Rate

A proportionate reduction in heart rate during sub-maximal exercise accompanies the large stroke volume of elite endurance athletes and stroke volume increase of sedentary subjects. The larger stroke volumes account for the lower exercise heart rates. The heart pumps a large quantity of blood with each beat and adequate blood (oxygen) delivery to the active muscles requires only a small heart rate increase and vice versa for a heart with a relatively small stroke volume.

1.13 SKILL PERFORMANCE VARIABLE

1.13.1 Overall Playing Ability

One of the greatest pleasures in the sports is exposure to performance at its highest level. There is something almost artistic about an athletic that is well beyond the normal and demonstrates exceptional grace speed, and control while performing a skill. Getting to the highest level requires skill attainment, mental toughness, years of purposeful practice and dedication.

Successful skill performance at the highest levels of competition often depends heavily on ability to use high levels of strength as quickly and as explosively.

Many team sports also require high levels of explosive power, such as Basketball, Volleyball, Netball and the Rugby and handball. Until recent years, powers as it relates to sports performances has been the subject of limited research, but in the last decade or so researchers have realized the importance of training for power in a wide variety of sporting activities.

To compete at one's very best in handball; one needs to build the appropriate catching and passing, piston movement, sidestepping, dribbling, shooting, individual defensive skills, individual tactics, offensive combination and defensive combination.
However, it is often assumed that those blessed are born with a higher percentage of fast-twitch muscle fibers, great speed or strength, and having trained and mastered in skills.

1.14 OBJECTIVES OF THE PRESENT STUDY

The objectives of the present study were:

1. To study the individualized training effect of periodized handball specific training, combined handball specific training and traditional method of training on physical, physiological and overall playing ability of handball players, and

2. To compare the effects of three modalities of training namely periodized handball specific training combined handball specific training and traditional method of training on physical, physiological and overall playing ability of handball players.

1.15 STATEMENT OF THE PROBLEM

The main purpose of the study was to find out the effects of three different training modalities of handball specific training on physical, physiological and overall playing ability of male collegiate team handball players.
1.16 HYPOTHESES

The hypotheses formulated in the present study were as follows.

1. In studying the individualized effect, it was hypothesized that periodized handball specific training, combined handball specific training and traditional method of training would significantly develop the physical, physiological and overall playing ability of handball players.

2. It was hypothesized that there may be significant difference among the three modalities of training namely periodized handball specific training, combined handball specific training and traditional method of training on physical, physiological and overall playing ability of handball players.

3. It was further hypothesized that periodized handball specific training and combined handball specific training may have significant improvements in developing the physical, physiological and overall playing ability of collegiate handball players than the traditional method of training.

4. It was hypothesized that periodized handball specific training may have significant improvements in developing the physical, physiological and overall playing ability than the combined handball specific training.

1.17 SIGNIFICANCE OF THE STUDY

The present study is significant in the following aspects.

1. The salient feature of the applications of periodized and combined handball specific training used in the present study towards the development of physical, physiological and overall playing ability underlie with specific need and nature of the game of handball.
2. The interventions such as periodized handball specific training and combined handball specific training used in the present study were scientifically structured ones. Hence it was believed that players treated with these training modules can be benefited in time with regard to the development of overall playing ability, physical and physiological variables of handball players.

3. The present study would provide a scientific base and guidance to the physical educationists, coaches, sports scientists, exercise physiologists and fitness leaders to design a combined training programme using the training modules in the present study with the view to develop the variables related to physical, physiological and overall playing ability of handball players.

4. One of the basic objectives of the present study was to extract the full potentials from the players with the feasible means and methods. Having the usage of full potentials, low achievers can be easily made as high achievers. It helps them play matches that are apart competition successfully.

5. Finding of this research study would give a basic knowledge to the trainers and fitness leaders to envisage and conduct further research in various training methods, training programmes, training intensity and training load to enhance the performance of Handball players.

6. Physical educationist and sports scientists have been constantly examining sports performance in relation to the individual skill and fitness standards. Since this study is also in the line of the same, the findings of such type of studies could be utilized in the practical aspects of coaching and training.
7. The findings of the study would provide guidance to physical education teachers and coaches to prepare training schedules for specific games on the basis of the physical and physiological capacity of the players.

8. The findings of this study would add to the quantum of knowledge in the area of training methods.

1.18 DELIMITATIONS

The study was delimited in the following aspects:

1. Subjects of the present study were delimited to 60 Sivagangai district Intercollegiate Handball players who were the participants of district level inter-collegiate tournament.

2. As far as physical fitness components were concerned it was delimited to speed, agility, upper extremity strength, lower extremity strength, leg explosive power and arm explosive power.

3. As far as physiological variables were concerned it was delimited to maximum oxygen consumption and resting heart rate.

4. As far as performance variables were concerned it was delimited to only over all playing ability.

5. In measuring the overall playing ability of handball players ten point scale expert rating method was used.

6. The player’s age ranged from 18 to 25 years.

7. The period of training programme was delimited to 12 weeks.
1.19 LIMITATIONS

The limitations of the present study were as follows:

1. The influence of certain factors like life style, daily routine work, diet and other factors on the results of the study were not taken in to consideration

2. No attempt was made to control the factors like air resistance, intensity of light atmosphere and temperature during training and testing period.

3. The difference in socio economic status and educational back ground of the Handball players were not taken into consideration

4. The basic of knowledge of the subjects in exercise science and their previous experience of physical activities were not taken into consideration

5. Since the subjects were motivated verbally during testing and training periods no attempt was made to differentiate their level of motivation

6. The heredity factors of the subjects and their influence on the selected variables were not taken into consideration
1.20 OPERATIONAL DEFINITION OF TERMS

Handball

Handball refers to team handball. Team handball is a game concomitant in nature. It is played by two teams with seven players each, among them one is goal keeper and other six players are court players. The purpose of the game is to score into the opponent goal post and to prevent the opponent to do so, and try to control the ball in their possession.

Training

Training is programme of exercise designed to improve the skills and increase the energy capacities of an athlete for a particular event.

Sports Specific training

The Greek physician Galen (AD 129 – 210) is generally accepted to be the originator of sports specific training. Galen’s gladiator drills are also referred to as functional training, that is, exercises consisting of movements that are specific to a particular sport.

Handball specific training

Handball specific training is a designed program with the principles of scientific training and knowledge of sports sciences and sports training methods. In this the Resistance training, plyometric training, aerobic training and handball specific drill practices were included.

Different training modalities

Training is preparing the athlete for particular sports by scientifically,
**Resistance Training**

Resistance training is a “specialized method of conditioning, designed to increase muscle strength, muscle endurance and muscle power”.

**Plyometric Training**

“Plyometric training refers to exercise that enables a muscle to reach maximal strength as short as possible”.

**Speed**

Speed is the ability to move the entire body rapidly from one place to another.

**Agility**

Agility is the ability to change direction quickly and effectively while moving as rarely as possible at full speed.

**Strength**

Strength is the ability of an individual to exert maximum force.

**Power**

Power is the product of force (or torque) and velocity, i.e., rate of doing work.

**Maximum Oxygen Consumption (V\textsubscript{O\textsubscript{2} max})**

Maximum oxygen consumption is the highest rate of oxygen consumption attainable during maximal or exhaustive exercise.
Heart Rate

The number of heartbeats per unit of time usually expressed as beats per minute.

Overall Playing Ability

The ability of the player to execute various techniques and tactics of handball skills, like passing, dribbling, shooting, and blocking efficiently and accurately, during the game situation.