INFLUENCE OF PLYOMETRIC TRAINING PACKAGES WITH AND WITHOUT RESISTANCE TRAINING ON SELECTED BIO MOTOR PHYSIOLOGICAL VARIABLES AND SKILL PERFORMANCE FACTORS AMONG WOMEN HOCKEY PLAYERS

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This dissertation is her original work and it has not previously formed the basis for the award to any candidate for any degree, diploma, associateship or other similar titles. This dissertation represents, entirely an independent work on the part of the candidate but for the general guidance by me.

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Dedicated

to

my Spouse

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INTRODUCTION

1.1 TRAINING

The term "Training" is widely used in sports. It denotes the process of preparation for some task, extends to a number of days and even months and years. The word "training" is generally understood to be a synonym of doing exercise. In a narrow sense training is physical exercise for the improvement of performance. It involves constructing an exercise programme to develop an athlete for a particular event. Now-a-days it is applied for any organized formation purposefully aimed at the rapid increase in physical, physiological, psychological, mental and technical – motor performance capacity of sports men.

The broader meaning of training refers to the acquisition of knowledge, skills, and competencies as a result of teaching of vocational or practical skills and knowledge that relate to specific useful competencies.

1.2 SPORT TRAINING

Sport training is a systematic process extending over a long period. It aims to prepare a sportsman based on the scientific principles for better performance through physical exercise. The improvement of physical fitness includes improvement of general health and organic functions as well as increasing the strength and stability of the musculo-skeletal system. Sports activities consist of motor movement and action and their success depends largely on how correctly they are performed. Techniques of training and improvement of tactical efficiency play a vital role in the training process.

"Sports training are a pedagogical process of sports perfection in which systematic effect on psycho-physical performance ability and performance readiness aims at leading the sportsman to high and the highest performance. Through active and conscious interaction with the given demands in sports training, the sportsman's personality develops according to the norms and standards of socialist society".

Sport training at present is mostly based upon the competitive motives. Each nation is trying to achieve top level performance in order to win international competitions. Today's records are proved to be lower than the performance of tomorrow. This is because stress has been given on the quality rather than the quantity of training. Hence training in sports has become an important factor for performance and excellence as well. As sports competitions are increasing day by day, the varieties of training also increase from time to time, which enhances the performance.

1.3 TYPES OF TRAINING

Different training methods have been commonly used to improve the physical fitness and its related standards of performance of the players. They include plyometric training, aerobic training, anaerobic training, interval training, fartlek training, altitude training, yogic practices, resistance training, hypoxic training, continuous training, alternate pace training etc.,

1.4 PLYOMETRIC TRAINING

Plyometrics refers to exercises that enable a muscle to reach maximal strength in as short a time as possible. Such exercises usually involve some form of jumping, but other modes of exercise also exist. The elements "ply" and "metric" come from Latin roots for 'increase" and "measure", respectively; the combination thus means "measurable increase". Plyometric exercises utilize the force of gravity (e.g., step off a box) to store energy in the muscles (potential energy). This energy is then utilized immediately in an opposite reaction (e.g., immediately jump up, upon landing), so the natural elastic properties of the muscle will produce kinetic energy. This method of training is based on the belief that pre-stretching a muscle prior to a concentric contraction will result in a more powerful concentric contraction.

Plyometrics refers to bodily movement that involves an eccentric (lengthening) muscle contraction immediately and rapidly followed by a concentric (shortening) contraction. This is often referred to as the stretch-shortening cycle. The phase between these two contractions is referred to as the amortization phase i.e plyometric exercise involves an eccentric contraction, a brief amortization phase which means no change in muscle length and a short concentric contraction delivering maximum force in a short period of time.

Energy stored during the eccentric phase is partially recovered during the concentric phase. In order to best use this stored energy the eccentric phase must be rapidly followed by the concentric action.

Plyometrics (also known as "plyos") is a type of exercise training designed to produce fast, powerful movements, and improve the functions of the nervous system, generally for the purpose of improving performance in sports. In plyometric movements, a muscle is loaded and then contracted in rapid sequence, using the strength, elasticity and innervations of muscle and surrounding tissues to jump higher, run faster, throw farther, or hit harder, depending on the desired training goal. It is used to increase the speed or force of muscular contractions, providing explosiveness for a variety of sport-specific activities. This has been shown across the literature to be beneficial to a variety of athletes ranging from injury prevention, power development and sprint performance amongst others.

The ability to apply force rapidly i.e., speed-strength (reactive force) is the major goal of plyometric training. The speed-strength ability is known as power. Therefore this training should not be considered an end in itself, but as part of an overall program (stretching, running, strength training nutrition, etc). Plyometrics are used to develop speed–strength after an athlete has begun a proper strength and conditioning program ***(Kumar, 2013).***

Rathod, (2011) opines plyometric exercises are typified by hopping, bounding and jumping movements. These exercises demand a high force of contraction in response to a rapid loading of lengthening muscles. For this reason, they should be more accurately called reversible action or rebound exercises. The training effort increases the force production in the muscles, but the movements are performed at faster speed than weight-training exercises. Thus rebound exercises are more specific to the sprinting and jumping movements in games and sports. These exercises should be done in 3-5 sets of 8 repetitions for each leg, with at least one minute rest between sets. The quality and speed of the movement is the priority. This should be done with maximum efforts over 30-60m. Again, at least one minute rest between runs should be allowed so that quality can be maintained. With this kind of training the aim is to develop the maximum speed; endurance should not become a factor.

1.5 TYPES OF PLYOMETRIC TRAINING

Plyometric Training is classified as below:

- ❖ Lower Body Plyometrics
- ❖ Upper Body Plyometrics
- ❖ Trunk Plyometrics

1.5.1 Lower Body Plyometrics

- ❖ These are appropriate for virtually any athlete and any sport.
- ❖ Direction of movement varies by sport, but many sports require athletes to produce maximal vertical or lateral movement in a short amount of time.
- ❖ There are a wide variety of lower body drills with various intensity levels and directional movements. They are:

Jumps in Place:

These drills involve jumping and landing in the same spot. Jumps in place emphasize the vertical component of jumping and are performed repeatedly, without rest between jumps; the time between jumps is the stretch-shortening cycle's amortization phase. Examples of jumps in place include the squat jump and tuck jump.

Standing Jumps:

These emphasize either horizontal or vertical components. Standing jumps are maximal efforts with recovery between repetitions. The vertical jump and jumps over barriers are examples of standing jumps.

Multiple Hops and Jumps:

Multiple hops and jumps involve repeated movement and may be viewed as a combination of jumps in place and standing jumps. An example of a multiple jumps is the zigzag hop.

Bounds:

Bounding drills involve exaggerated movements with greater horizontal speed than other drills. Volume for bounding is typically measured by distance but may be measured by the number of repetitions performed. These drills normally cover distances greater than 98 feet (30m) and may include single and double leg bounds in addition to the alternated-leg bounds.

Box Dills:

These drills increase the intensity of multiple hops and jumps by using a box. The box may be used to jump on or off. The height of the box depends on the size of the athlete, the landing surface and the goals of the program. Box drills may involve one, both or alternating legs.

Depth Jumps:

Depth jumps use gravity and the athlete's weight to increase exercise intensity. The athlete assumes a position on a box, steps off, land and immediately jumps vertically, horizontally or to another box. The height of the box depends on the size of the athletes, the landing surface and the goal of the program. Depth jumps may involve one or both legs.

1.5.2 Upper Body Plyometrics

This is important for playing variety of sports that require explosive upper-body movements. Participating in an upper-body plyometric-training program builds power in the muscles of abdomen, arms, back, chest and shoulders. Drills include medicine ball throws, catches, and several types of push-ups.

1.5.3 Trunk Plyometrics

- Exercises for the trunk may be performed "plyometrically" provided that movement modifications are made.
- Specifically, the exercise movements must be shorter and quicker to allow stimulation and use of the stretch reflex.

1.6 BENEFITS OF PLYOMETRIC TRAINING

Plyometrics develop strength and speed by conditioning the neuromuscular and elastic characteristics of the muscle. The main objective of plyometric training for runners is to produce greater power by training the muscles to contract more quickly and forcefully from an actively pre-stretched position.

The benefits of plyometrics are simple, but elite athletes need more speed, more stamina and more power, be it in running, jumping, throwing, swimming or any another sport-specific movement. It's about the efficient use and manipulation of muscles to produce consistent peak performance, not about building bulkier muscles.

The plyometric exercises further facilitate competitive athletes who want a permanent, physical edge to the next level of competition by adopting their bodies to do what they want them to do. It is sometimes used to build muscles back as part of rehabilitation or physical therapy; plyometrics are still primarily for use by athletes who are in training and are already strong, fit and flexible as it prevents injury. It also helps to be strong and engaged in a strength-building routine.

1.7 RESISTANCE TRAINING

Resistance training is an anaerobic form of exercises. This training program can be used to enhance the ability of the body to perform a very high force and power out puts for a very short period of time to improve the ability of the body by doing repeated bouts of maximal activity.

Tang et al., (2008) defines resistance training is a conditioning that involves the progressive use of a wide range of resistive loads and a variety of training modalities (eg. free weights, weight machines, elastic cords and body weight) designed to enhance fitness and sports performance and it is an anaerobic form of exercises. It enhances the ability of the body to perform at a very high force or power outputs for a very short period of time.

Stone (1990) explains enhancement of the attributes associated with physical performance like endurance, strength, power and speed is possible with appropriate resistance training methods.

According to ***Bloomfield, (1994)*** resistance training is an accepted training method for athletes in a variety of sports to increase muscle strength, muscle hypertrophy, improved body composition and sports performance with the proper exercise prescription and training goals.

Mosby, (2009) opines that resistance training improves muscular strength by gradually increasing the ability to resist force through the use of free weights, machines, or by using the person's own body weight. Strength training sessions are designed to impose increasingly greater resistance, which in turn stimulates development of muscle strength to meet the added demand.

Resistance training can be resulted in hypertrophy of the muscle, partly through an enlargement of muscle fibers. In addition, training with high resistance can change the fiber type distribution in the direction of faster twitch fibers. There is also neuromotor effect of strength training and part of the increase in muscle strength can be attributed to changes in the nervous system **(*Davies, 2006*).**

1.8 TYPES OF RESISTANCE TRAINING

Basically resistance training is classified into three main types, they are:

- Isotonic Resistance Training
- Isometric Resistance Training
- Isokinetic Resistance Training

1.8.1 Isotonic Resistance Training

Isotonic resistance training is the most common form of strength training which uses free weights such as dumbells and barbells. It is said to occur that the weight remains constant throughout the range of movement. These exercises have many physiological and physical benefits, such as increasing bone stress, overall energy and promoting weight loss. Isotonic exercise promotes the development of muscle endurance, muscle tone and muscle strength. These movements have also been shown to improve ligaments and tendon strength, helping to prevent injuries, improve posture and develop joint stability.

1.8.2 Isometric Resistance Training

Isometric resistance training involves muscular actions in which the length of the muscle does not change and there is no visible movement at the joint. They occur against an immovable resistance. It may be completed with sub maximal muscle action. For instance full body exercises that involves sub maximal contractions.

1.8.3 Isokinetic Resistance Training

Isokinetic resistance training is the newest form of resistance training, allows a person to operate at a constant speed against a weight or resistance. This method uses machinery designed to develop strength through a full range of motion. It allows for the duplication of certain sports movements like throwing and kicking ***(www.slideshare.net).***

1.9 BENEFITS OF RESISTANCE TRAINING

The goal of resistance training is to gradually and progressively overload the musculoskeletal system so as to get stronger, strengthen the bones and the muscles. Any fitness programme should include resistance training, along with aerobic exercise and flexibility training in order to strengthen the cardiovascular system, focusing primarily on the large muscle groups of the lower body. This training also offers a way of balancing and developing all the major muscle groups, including those in the chest, arms, back and abdomen. According to medical research, the resistance training strengthens the muscular system, the skeletal system, and improves bone density (decreases the chance of osteoporosis) and increases metabolism.

Resistance training further improves the functional performance of the neuromuscular system, the system of muscles and nerve pathways that directs and controls movement. It produces increased strength, superior movement performance and general fitness, including enhanced function of the respiratory, cardiac and metabolic systems. Other improvements include an increase in muscle mass, strengthening of connective tissue and supportive tissue as well as improvements in posture and physique.

Structuring a resistance training program with Burke Spencer's Fitness Partner encourages the lifetime physical activity in students ages 8+ to improve neural motor skills and strength, to improve bone development by increasing bone density, to improve the strength of bone connective tissue to strengthen the heart muscle and to improve muscle energy capacity. It also helps to maintain good flexibility. The ability of the body to resist the stresses resulting from an injury and can be increased by obtaining a greater amount of strength. Therefore a well -planned resistance training program should be a part of everyone's health, fitness and lifestyle regardless of age, gender or goals.

According to ***Ada (2006)*** the benefits of weight training include greater muscular strength, improved muscle tone and appearance, increased endurance, enhanced bone density, and improved cardiovascular fitness.

1.10 COMBINED RESISTANCE AND PLYOMETRIC TRAINING

The importance of resistance training to sports performance has been supported by many studies which have demonstrated that resistance training in the form of weight training and more recently, combined with plyometric training have enhanced greater competitive performances.

According to ***Hakkinen et al., (1993)*** the strength training in combination with some explosive types of exercises is recommended as a part of overall physical training to maintain the functional capacity of an individual. For explosive muscle performance, the underlying factors are muscle fiber type, muscle hypertrophy and enzymatic and neural adaptations. The power type strength training has greater impact on the leg muscles and joints, as well as to prevent injury risks and its adherence. For being effective in improving the explosive muscle performance, combined training programs should be designed in order to achieve easily, effective concerning the time spent in exercises, low in expenses, and they should give consideration to the exercise history, health status and musculoskeletal symptoms and diseases of the individual.

1.11 THE GAME OF HOCKEY

Hockey is one of the most popular games in the world in general and India in particular. Hockey being most competitive sports, a player who is physically fit not only enjoy more but he is also capable of using all the skills attained and mastered by them throughout, right from the beginning to the end of the game. The twin combination of both skills and physical fitness is indispensable for a player without either of which the player will not be able to achieve much, specifically in order to play any ball game competently.

Star player must have the stamina to run for at least three hours at a stretch, strength to execute the skills like hitting, pushing, scooping more forcibly, speed to run quickly with or without the ball, power to execute any skill with maximum force in minimum possible time as for trying in shooting circle and clearing the ball from dangerous zone, agility to rapidly change body position and direction like in tackling and dodging, balance the ability to maintain body equilibrium during vigorous movement like shooting on wrong foot and a player should have good reaction during stopping, tackling and in goal keeping as well.

1.12 ORIGIN OF HOCKEY

Hockey today is one of the most thrilling spectacular sports in the world, a symbol of raggedness and skill and exciting from start to finish. It is played with a nerve that makes both the players and spectators satisfied. The very essence of the game lies in its obvious aggressiveness which makes it worth watching and playing. However dangerous it seems to be, the individual responsibility and team work that makes it transcend the line of cruelty and it is this quality of the game which leaves the spectators so enraptured.

When History of hockey was first written, there was so existing proof or historical reference to such a primitive form of hockey. In 1992, a sculpture relic was found in Athens, which forged a powerful link in the long chain of evidence that the "Stick and Ball" game with stocks similar to those used in hockey was played nearly thousand year's ago.

This game was called by different words / terms across the world in the passage of time. It was called as "Hurley of Hurling" in ancient Greeks. The Romans called it "Harpastum" derived from Harp ago, the Persians called it "Polo", the Turks called it "Holani", French called as "Shehna", Germany "Kolbe", Dutch "Hetkolven", Iresh "Baire", Shinty", in Scotland, Club Ball, Banchy, Hockey, Howkey, or Horky in many eastern countries of Europe.

1.13 DEVELOPMENT OF HOCKEY

Though there is no definite origin of the game, a beginning has made to the primitive instincts of man hitting an object with something. About 500 years ago the Persians are known to have played from the horse backs a game like Polo. The young ones imitated the game with short sticks and stones or pebbles. A bas relief unearthed (514-449 BC) shows some Athenians at play, two of whom actually engaged in a Hockey bully.

The roots of hockey are buried deep in antiquity. Crude sketches found on the walls of prehistoric caves may lend substantial information on the fanciful notion that the caveman knocked at a stone with a primitive club for his amusement when he was not locked in mortal combat with his deadly enemy, the Iguanodon. Historical records showed that a rudimentary form of game was played in Egypt 400 years ago and in Ethiopia around 1000 B.C. It was the only team game practiced by the Greek in the epoch of Themistocles [525-449]. The ancient Azteus of South America and the Red Indian tribes of North America played a savage stick-and ball-game several centuries before Columbus discovered the New World.

The British pride is that, they originated the game and gave it to the world. In the pre-Christian era, a stick and ball game had been in practice in the British Islands. Later it came to be known in Ireland as Hurley, in Scotland as Shinty and in England and Wales as Bendy, as these games seem to have been played with ball and stick teaming resemblance to the modern one. From England the French People borrowed this game and spread to the whole of the continent. Its popularity in the world can be judged in terms of Federation International De Hockey (F.I.H.), this now comprises of more than 130 National Federations as its member.

1.14 ORIGIN AND DEVELOPMENT OF HOCKEY IN INDIA

Hockey in India became popular with the rule of British. It was when the British army regiments played the game, the Indian regiments in the early years of 15th century picked up the game and followed the tradition of playing the game of hockey, then gradually this adopted by the masses.

Hockey in India rooted its first ever in house hockey club in Calcutta, which was formed in the year 1885 – 86. The credit goes to the people of Calcutta who played a leading role in popularizing the game in India and takes the pride of place. After that the hockey clubs in Bombay and Punjab were started.

The game hockey was mainly played in the northern part of our country like Punjab and Haryana known as "Khido Kunti" by them. When the Britishers introduced modern hockey, in an organized manner the game became very popular and reached the nook and corners of other parts of our country. The standard of the game reached dizzy heights.

1.17 ROLE OF WOMEN IN HOCKEY

The women's game quickly developed in many countries. The International Federation of Women's Hockey Association (IFWHA) was formed in the year 1927. The pioneer members were Australia, Denmark, England, Ireland, Scotland, South Africa, the United States and Wales. After celebrating their respective Golden Jubilees - the FIH in 1974 and the IFWHA in 1980 - the two organisations came together in 1982 to form the FIH.

The growth of the International Hockey Federation from its early beginnings has been most impressive. Denmark joined in 1925, the Dutch men in 1926, Turkey in 1927, and in 1928 - the year of the Amsterdam Olympics - Germany, Poland, Portugal and India joined. India's addition marked the membership of the first non-European country.

By 1964, there were already 50 countries affiliated with the FIH, as well as three Continental Associations - Africa, Pan America and Asia. In 1974, there were 71 members. At present, the International Hockey Federation consists of five Continental Associations with 127 member associations.

The FIH serves as the 'guardian' of the sport. It works in co-operation with both the national and continental organizations to ensure consistency and unity in hockey around the world. The FIH not only regulates the sport, but also responsible for its development and promotion so as to guarantee a secure future for hockey.

1.18 BIO-MOTOR VARIABLES

Movements in sports and games are highly specific as a result of experience and training. Motor abilities are causal to fundamental body movements and specific to sports skills. For successful performance of a skill, components of motor ability contribute independently and interdependently. The role of motor abilities, such as, strength, endurance, speed, flexibility, agility and coordinative abilities are the prerequisites for motor actions in all sports. Their improvement and maintenance is crucial in sports training ***(Matveyev, 1981).***

Motor ability factors are required in all sports in different proportions and should be specific to the game as the skills are different for each sporting activity. If a performer has a large number of these components, he is said to be a natural athlete, that is he, By the time when India represented in the Olympic Games for the first time in Amsterdam in 1928 they overshadowed the pioneers of the game such as England. India emerged as Olympic Hockey champions in their debut in 1928 and maintained their supremacy in the next consecutive five Olympics and stood as number one in the world till 1960. In 1980 Moscow Olympic, India regained the gold. Now hockey is considered as our National game. It occupies an important place in the Indian history.

1.15 HOCKEY AS NATIONAL GAME OF INDIA

Hockey in India has a glorious past. The golden era of Indian hockey was considered from 1928 to 1956. India won six consecutive gold medals in Olympic Games during this period, playing a total of 24 matches by winning all the matches. It scored a massive number of 178 goals and conceded only seven. There were some legendary players in the history of hockey in India. Amongst them are Dhyan Chand, K.D. Singh, Zafer Iqbal, Mohd. Shahid and Dhanraj Pillai etc., Dhyan Chand "Father of Hockey" was the most legendary amongst all and known as the magician of hockey as well as "Hockey Wizard". All these legendary players geared the position of hockey to greater heights. The love and devotion of innumerable players and spectators towards the game brought International recognition and consequently hockey was acclaimed as Indian national game.

1.16 FORMATION OF INDIAN HOCKEY FEDERATION

The Indian hockey federation (I.H.F.) is the central administrative body for the game of hockey in India until Indian Hockey came into existence. The hockey federation was formed in 1925 with Clonel Bruce Turnbull as president and M.S.Ansari as secretary. The federation held its first national championship at Kolkata in 1928, where the united provinces emerged winner and Rajputana as runner-up.

On 28th April 2008, Indian Hockey Federation was dissolved and an ad-hock committee was formed by the IOA (Indian Olympic Association) to supervise the game in India. Aslam Sher Khan was appointed as the president of the ad-hock body, the other members were Zafar Iqbal, Ashok Kumar, Dhanraj Pillay etc. Now Indian Hockey is an approved (by IOA and FIH) governing body for field hockey in India as first president Aslam Sher Khan who was an Olympian.

possesses the foundation from which he can develop excellence in a number of motor activities. It only furnishes the base from which excellence can be achieved by becoming proficient in those skills, which are specific to that particular sport. Some of the components have rather large potential while others have limited potential for development.

Combination of several movements such as speed, strength, balance, coordination, and flexibility contributes to the execution of total movement. A very high score in motor ability test would mean that the person has a high degree of present ability for most of the sports ***(Mathew, 1978).***

1.19 BIO-MOTOR VARIABLES CHOSEN FOR THE STUDY

High level of performance of hockey players may depend upon the physical variables or motor ability. The term physical ability is synonymously used with general motor ability. The components of physical ability are speed, power, agility, endurance, speed endurance, strength, strength endurance, flexibility, co-ordination, explosive power and abdominal strength etc.

Among the various motor abilities the investigator has chosen speed, agility, and cardio respiratory endurance for the present investigation.

1.19.1 Speed

Speed is an important ingredient in many sports. It is the ability to move from one place to another in the shortest possible time. It is primarily innate, yet it can be improved through practicing the technique and movement efficiency.

Optimum speed is based on a repetition which will be depending on the muscle group being used and the specific requirements of the sports or activity, if the movement is speeded up. This will make the exercise shorter and less repetition and likely to produce a more dynamic kind of strength, mainly through adaptation by the nervous system i.e. neurogenic effects. It will be slower movements which will tend to strengthen the muscles more effectively.

Speed appears in different forms in different sports such as reaction ability, reaction time, movement speed, acceleration, to locomotor ability and speed endurance. But the different types of speed abilities are relatively independent of each other ***(Suresh, 2003).***

Importance of Speed for Hockey

Speed is one of the main requisites of motor fitness, which enables a player for higher performance in certain motor tasks. Speed may vary from individual to individual. It is the capacity of an individual to perform successive movements of the same pattern at a faster rate and considered as the most important physical fitness components that is highly essential for many physical activities. It can be improved by practice to the coordinated movements and by learning proper techniques.

Speed is the performance pre-requisite to do motor actions under given conditions (movement task, external factor and individual pre-requisite) in minimum time. It is a determining factor in the explosive sports such a sprints, jumps and most field events. Strength is highly related to speed. Generally the team events win with higher speed and strength, because they are the faster game. Speed is more valuable in team games like hockey, football, basketball and track events.

The performance of any game depends upon physical variables. For any competitive sports activities speed is highly essential to achieve high-level performance. After the introduction of the artificial surfaces namely Astroturf, Poly grass and Super turf, the ball moves faster than other surfaces. Hockey players playing in forward line must have good speed with the ball and without the ball to score more goals and also to fullback to receive the ball from the teammates. Speed is more essential for half line and fullbacks when it arrive they also should run faster to defend their goal being scored by the opponents. Therefore speed is considered as one of the most important physical variables for a hockey player to achieve high level performance.

1.19.2 Agility

Agility plays a vital role in all games and sports, when an athlete participates in games and sports he/she has to bring about a purpose of change in direction and movement of various parts of the body.

The speed and agility cannot be separated from each other. In sports and games speed and agility are very intimately inter-related. Agility is the ability of an individual to co-ordinate his movements and synchronize them according to the requirements of changing condition in fast start and quick change in direction are fundamental to good performance particularly in all team games.

Agility is the ability to change the direction of the body or its parts rapidly. It depends primarily on strength, reaction time, speed of movement and specific muscle co-ordination. People with great agility have said to be less injury prone because of their ability to make quick adjustment in body position and direction of movement. In court and field games fast start and stops and quick change in direction are fundamental to speed performance.

Importance of Agility for Hockey

Agility is another important physical variable. Agility may be explained as the physical ability, which enables an individual to rapidly change body position and direction in a precise manner. **Johnson and Nelson (1974)** say, Agility is defined as "the physical ability which enables an individual to rapidly change body position and direction". Agility plays a significant role in the training of technique and in competition. The aim in training skills is to bring the player closer and closer to the ideal form of the sequence of movement.

Changing position and direction of the body quickly at a higher speed is very much useful in speed games like hockey, basketball, soccer etc., In any physical activity or in a game situation, the controlled ability to step, to start and to change direction rapidly and more quickly, is an essential factor and this quality decides one's performance level and the speed acquiring any skill.

Hockey players must have good agility in the play field with the ball and without the ball. Agility is more important for all the hockey players who are playing different positions like forwards, halfbacks and fullbacks. After removing the obstruction rules in hockey movements with and without the ball become more important for the attacker to control over the ball during the game to beat or to dodge the defender. When the forwards are having the ball, it is very difficult for the defender to tackle because if the defender allows the forward to their right side and tackle the forward turn towards their left side and dodge the defender easily. If the defender allows left side and dodge the defender without any difficulty. Defender also will make a semi circular movement either to the left or the right and can clearly make a pass to the teammate without any difficulty.

1.19.3 Cardio Respiratory Endurance

Endurance or stamina is the terms used to cover cardio respiratory fitness. It is a measure of an efficient heart and lung system and can only be developed by exercise which involves the heart and lung and their capacity to supply oxygen to the working area of the body. Endurance is of two types, muscular endurance and a cardiovascular endurance. Cardiovascular fitness is sometimes called cardio respiratory fitness. This type of high level of fitness is possessed by the participants in long distance race and team games ***(Pickering, 1965).***

Cardio respiratory endurance is also frequently called cardio-vascular endurance, cardiovascular fitness, aerobic capacity and aerobic fitness or is sometimes more broadly termed “endurance” although endurance may also refer to the ability of the muscle to do repeated work without fatigue. It is also one of the five components of physical fitness.

Endurance activities have been found to be high value for maintenance of organic health or increasing general resistance against various disorders.

Importance of Cardio Respiratory Endurance for Hockey

Field hockey is considered to be an endurance event. Various skills in field hockey demands display of specific strength and endurance. A definite degree of strength of arm muscle is required to do the basic skills like hitting, pushing, and scooping. Hockey requires a higher degree of running ability. The extension of the Hockey field is large, so that the players should able to run the whole field without fatigue and compete with their opponents. So, that the quality of muscular endurance and cardio respiratory endurance is highly required for a hockey player ***(Seaton et al., 1983).***

The simplification of the rules not only attracts the players but also the spectators. The game of hockey is played seventy minutes with an interval of ten minutes. Playing in the artificial surface and in other surfaces continuously for seventy minutes is more difficult. The players who have good endurance can only play the game continuously without fatigue, and also can perform better. After the introduction of the artificial surface the players are unable to continue to play better for a longer period because artificial surfaces require highly fit players. The game has become more faster after the change of offside rule and the introduction of the rolling substitution. The player has to run faster and play the game continuously for seventy minutes and it requires more endurance capacity to do better performance. Hence endurance is vital for the hockey players.

1.20 PHYSIOLOGICAL VARIABLES CHOSEN FOR THE STUDY

Physiology is the study of the functions of the physical parts of the living beings. It analyses the performances of living being, like how it feeds, how it moves, how it adopts to the changing circumstances, and how it spawns new generations, how the various parts of the body normally work, and how their activities are regulated, coordinated and integrated for maintaining the well being of the organism as a whole ***(Singh, 2001).***

Training increases muscle size, strength, power and develops endurance for straining work. Physical exercise contributes to improve the posture and appearance through the development of proper muscle tone, greater joint flexibility and good feeling of well – being. It generates pore energy and thus contributes to greater individual's productivity for both physical and mental task. The person who is physically fit has more strength, energy and stamina; an improved sense of well being; better protection from injury and improved cardio respiratory functions ***(William, 1994).***

Among the various Physiological variables the investigator has selected the following variables which are related to the game of hockey.

- ❖ Breath Holding Time
- ❖ Resting Pulse Rate
- ❖ Respiratory Rate

1.20.1 Breath Holding Time

It is the duration of time through which one can hold his/ her breath without inhaling and exhaling after a deep inhalation.

There are two types of breath hold time

1. **Positive Breath Holding Time:** Individual's ability to hold breath after a voluntary forced maximal inhalation.
2. **Negative Breath Holding Time:** Individual's ability to hold breath after a voluntary forced maximal exhalation.

The simplest measure of breath-holding is its duration. It is a voluntary act. Breath-hold duration being prolonged by large lung inflations and hyperoxia and being shortened by the converse maneuvers and by increased metabolic rate.

1.20.2 Resting Pulse Rate

Resting heart rate is the number of beats felt exactly for one minute. Pulse is rhythmic dilation of an artery, produced by the increased volume of blood pumped into the vessel by the contraction of the heart. The blood rushes through the artery from a heartbeat, it creates a bulge in the artery. The rate at which the artery bulges can be measured by touching it with the fingers or the wrist or neck. Pulse is felt at any area where the artery is lying just beneath the skin and over a firm surface such as bone but most conveniently felt at the radial artery.

The resting heart rate varies gently among different people and for the same person differs under different situations. The lesser heart rate gives good performance for all the sports and games **(Strukie, 1981).**

1.20.3 Respiratory Rate

The respiratory rate is defined as the number of breaths a person takes during a one-minute period of time while at rest.

In general, children have faster respiratory rates than adults, and women breathe more often than men. The normal ranges for different age groups are listed below:

- Newborn : 30 - 60 breaths per minute
- Infant (1 to 12 months) : 30 - 60 breaths per minute
- Toddler (1- 2 years) : 24 - 40 breaths per minute

- Preschooler (3 - 5 years) : 22 - 34 breaths per minute
- School-age child (6 - 12 years) : 18 - 30 breaths per minute
- Adolescent (13 - 17 years) : 12 - 16 breaths per minute
- Adult (Above 17 years) : 12 - 18 breaths per minute

Respiratory rate indicates the lung capacity. The lesser respiratory rate gives good performance for all the games and sports. Regular participation in aerobic activity and other training means reduce the respiratory rate.

1.21 FUNDAMENTAL SKILLS IN HOCKEY AND ITS IMPORTANCE

The skills play a very vital role in the success of modern hockey. The game of hockey is very complicated in terms of skills and team work. In this game, everyone should mastery over fundamental skills. When one has mastered the basic skills of the games, he/she gets a feeling of well being.

Each skill is having its own importance and applied to different situations. A hockey player must be mastery over all the skills to prove his proficiency and ability. High level of performance depends upon proficiency over the fundamental skills. Now a day, matches are won by only those teams who are highly skilled and possessed with greater potential in fitness. The perfection of these skills will have a direct impact on the total performance of the game.

Skill is the combination of brain and body. It is the movement of body, stick and ball carried out by players within the constraints of rules and regulations of the game besides overcoming the problems such as 'controlling the ball', scoring goals in the 5 vs. 4 situation and team defense, i.e. The problem solving has to be done at individual, group and team levels. In addition to the skills on the ball, it is important to develop the movement and positioning of players, which is of paramount importance when defending and providing support on play to the man in possession in attack. The learning and practicing of these skills are of great importance in the development of hockey players as it provides them with a reservoir of knowledge along with technical, tactical and physical abilities to be used to find solution to the problems facing them.

The fast and dynamic game is influenced by many factors i.e., any one situation that is unusual for a situation to be repeated identically; it is impossible to predict that there is only one solution to a problem. Therefore, players are required to use their skills to cope successfully with a wide variety of playing situations (Problems) coincide with the concepts of learning and practicing put forward.

There are number of fundamental skills in the game of hockey. They are as follows:

- Dribbling
- Pushing
- Hitting
- Trapping
- Scooping
- Flicking
- Tackling
- Dodging
- Slap Shot
- Sweep Shot
- Receiving
- Releasing

1.22 SKILL PERFORMANCE FACTORS

Among the fundamental skills, ability to dribble the ball, ability to hit, ability to push, ability to trap the ball and ability to scoop the ball are of primary importance for high level of performance. Hence from the fundamental skills a few selected skills namely Dribbling, Pushing and Hitting were selected for the present investigation.

Importance of Dribbling in Hockey

Dribbling is an art, which will draw the attention of spectators. During the game when the defender is in dangerous zone, completely covered by the opponents, the defenders in position should clear the ball from the dangerous zone by dribbling successfully. Dribbling helps the forwards at the time of scoring, when there is no chance to give pass or to take straight hit into the goal, to control the ball or to make possession of the ball. Therefore, all the players including goalkeeper must be perfect in dribbling. It also helps to proceed forward within time, having full control over the ball and to move according to the aim to be achieved.

According to ***Wein, (1973)*** dribbling is an essential factor in man to man fights in attack and defense in hockey. Effective use of dribbling is actually the fine expression of individuality. The significant of dribbling becomes clear when the attacker beats an opponent and taken a shot at goal. Dribbling can be realized positively and is emphasized in the process of technique training as the strongest weapon in the principles of penetration. It is one of the most important skills in the game of hockey.

- In dribbling one can move the ball from one place to another place.
- Through dribbling one can change movement from the opponents, to give proper pass.
- Possession of the ball can be retained through dribbling.
- Dribbling facilitates one to change direction from one side to other side.
- Dribbling is the only means for a player to move forward or in any direction with the ball.

To go towards the opponent's goal line to achieve the ultimate aim of game, a team has to depend either on dribbling or passing. It helps in having a better approach for a successful dodge and also to control the ball after the completion of a dodge. It develops the ball control and ball sense, which helps a player to execute the skill in a better, way less effort. It helps a team to adopt tactics for slowing down the game and speeding up the game effectively. Dribbling has an immense value to achieve the ultimate aim of the game.

1.22.2 PUSHING

It is accurate way to move the ball speedily over shorter distances. A push is the best pass to use for short distances because it allows for the most control over the ball, thus more accuracy. The stick stays in contact with the ball until it is released for the pass. Moving the ball along the ground using a pushing movement of the stick after the stick has been placed close to the ball. When a push is made, both the ball and the head of the stick are in contact with the ground ***(Wein, 1973)***.

Importance of Pushing in Hockey

In team games the ability of the players to link together and to maintain possession of the ball is largely depend upon effective passing which ultimately leads to a team success. It is the ability of player to play the ball between teammates, either through hit, push, flick, or scoop. The importance of pass is to keep the possession of the ball, and to gain the ground to initiate an effective attack.

For an effective pass, a player must have an idea to use the right stroke at the time to get maximum advantage of the execution. The pass should aim either to eliminate an opponent, to force the opposition's defense to reorganize or to retain possession of the ball.

Pushing is one of the good skills used by many players in hockey. Players use this skill when they want to pass the ball to his own teammates or to score a goal and it is easy for the receiver to collect the ball and to get possession of the ball whenever his teammate uses the push and the ball travels along the ground.

- Push is good for clearance, in dangerous zone.
- For forwards push is beneficial for placements.
- Push is easier to stop than hit.
- It is good for short passing game.
- Push is more accurate than hit.
- Push stroke is more advantage in penalty corner and penalty stroke.
- Push is used for clearance.

1.22.3 HITTING

Hitting is another fundamental skill and the most significantly involved in hockey. It is used for long passes and clearing the ball from the dangerous zone by the defenders and mid-field players. Mostly hitting technique is used to score goal during the penalty corner, to speed up the game, to give cross passes and to give diagonal passes. When the ball crosses the sideline "Hit in" is to be taken. For this the player must be proficient in executing hitting technique. The technique of hitting is very important to take 16 yards free hit, and also to take long corner hit. (Hence every hockey player must be perfect in executing the hitting technique at any time.)

The hit can often be of decisive importance in the outcome of a match. It is one of the most useful technical acquisitions for both defenders and forwards. Its great lies in the endless possibilities for moving the ball quickly to any part of the pitch. The hit is made up of several components and following points are of importance to carry out a hit:

- The position of the player in relation to the ball
- The grip
- The back swing
- The hit itself ***(Horst Wein, 1973)***

According to ***Whitker (1986)*** the hit is to strike the ball hard, accurately and smoothly when the ball is stationary; when the ball and player are moving; when the player has move around the ball to strike it to the right; and when the player has to move around a moving ball to strike it to the right

Importance of Hitting in Hockey

Hitting is the player's most valuable asset. A player can make use of hitting in almost every phase of the game. Hitting is the most valuable weapon in defense and in the preparation and execution of attack. The importance of hitting is to cover maximum distance so that it will reach nearer to the opponent's goals and also helps to score goal.

Sports performances are possible only through sports motor action or movements. The performance of sportsman is significantly affected by the skill with which a sports person executes these actions or movements besides the acquisition of sports technical skills. In all sports one or more skills have to be acquired by doing technical training. In team games, the technical skills serve as basic elements of tactical actions, which are indispensable for good performance in the sports.

1.23 RATIONALE FOR SELECTING THE PROBLEM

Hockey is one of the fastest field sports being played on a 100/60 yards rectangular play field. Now a days the game had a rapid growth and development and switched on to artificial turf surfaces, which requires greater amount of speed, agility, power, endurance, and neuromuscular coordination, besides perfection in techniques or fundamental skills/movements. The highly skilled game largely depends upon physical make up of the body, psychological built up and motor qualities of the player besides the proficiency of skills such as dribbling, hitting, stopping, flicking, scooping, passing and goal shooting.

Hence, the typical field hockey player must be trained for many years to refine technique and to develop the physical fitness factors to reach individual potential level. Though, there are many types of training by which a player can improve the above said qualities, the investigator has selected to assess the effect of plyometric training packages with and without resistance training on selected bio-motor, physiological variables and skill performance factors of women hockey players.

1.24 STATEMENT OF THE PROBLEM

The present study was designed to find out the influence of plyometric training packages with and without resistance training on selected bio-motor, physiological variables and skill performance factors among women hockey players.

1.25 HYPOTHESES

It has been scientifically accepted that any systematic training over a continuous period of time would produce changes in human beings. Based on this concept, the following hypotheses were drawn:

1) There would be significant improvement on selected bio-motor variables due to the influence of plyometric training packages with and without resistance training.

2) There would be significant improvement on selected Physiological variables due to the influence of plyometric training packages with and without resistance training.

3) There would be significant improvement on selected hockey skill performance factors due to the influence plyometric training packages with and without resistance training.

4) There would be significant differences among the experimental groups on the selected bio-motor, physiological variables and hockey skill performance factors of women hockey players.

1.26 DELIMITATIONS

1) Forty five (N = 45) women hockey players who had participated at Intercollegiate hockey tournaments of Periyar University, Salem, Tamil Nadu, India during the year 2012 - 2013 were randomly selected as subjects.

2) The age of the subjects was range from 18 to 21 years.

3) The subjects were divided at random into three groups of fifteen each (n = 15). Group I was given Plyometric training packages with resistance training, Group II subjected to Plyometric training packages without resistance training and Group III acted as control.

4) The duration of the training period was restricted to twelve weeks and the number of sessions per week was confined to three days.

5) The following variables were selected in this study.

I Dependent Variables

a. Bio-motor variables

i. Speed

ii. Agility

iii. Cardio Respiratory Endurance

b. Physiological variables

i. Breath Holding Time

ii. Resting Pulse Rate

iii. Respiratory Rate

c. Skills performance factors

i. Dribbling

ii. Pushing

iii. Hitting

II Independent Variables:

Experimental group – I	:	Plyometric training packages with resistance training
Experimental group – II	:	Plyometric training packages without resistance training
Group-III	:	Control

6) The data were collected prior to and immediately after the training period of twelve weeks.

1.27 LIMITATIONS

The following limitations were considered while organizing the study.

1) The environmental factors such as climatic conditions, atmospheric pressure, temperature and humidity during the training period and collection of data were not taken into consideration.

2) The previous experience of the subjects has been ignored.

3) Psychological factors, food habits, rest period, life style etc., of the subjects could not be controlled.

4) Though the subjects were motivated verbally, no attempt was made to differentiate the motivation levels during the period of training and testing.

5) While training and testing periods, the personal habits and other domestic involvements were not taken into consideration.

1.28 DEFINITION OF OPERATIONAL TERMS

1.28.1 Sport Training

Sport's training is a pedagogical process based on scientific principles aiming at preparing sportsmen for higher performance in sports competitions. ***(Singh, 1991)***

1.28.2 Plyometric Training

Plyometric Training refers to exercises that enable a muscle to reach maximal strength in as short time as possible **(Vern, 1988).**

1.28.3 Resistance Training

A method of improving muscular strength is by gradually increasing the ability to resist force through the use of free weights, machines, or the person's own body weight **(*Mosby, 2009*).**

1.28.4 Motor Fitness

Motor Fitness refers to the ability of an athlete to perform successfully at their sport. **(*Close, 1973*)**

1.28.5 Speed

Speed is the ability to perform rapidly successive movements over a short period of time in a single direction. ***(Singh, 1991)***

1.28.6 Agility

Agility is to perform in a particular activity to change the direction in quick manner ***(Fresh, 1971).***

1.28.7 Cardio Respiratory Endurance

The ability of the heart and lungs to work at optimal efficiency during continuous exercise is called as cardio respiratory endurance ***(Seaton, et al. 1983).***

1.28.8 Breath Holding Time

Breath holding time has been defined as an individual's ability to hold the breath, a voluntary forced maximal inhalation without exhalation during the period of holding the breath ***(Strukie, 1981).***

1.28.9 Resting Pulses Rate

Resting pulse rate is defined as the frequency of heart beats in one minute when a person is in resting condition ***(Johnson, 1982).***

1.28.10 Respiratory Rate

It is the number of breaths taken in a minute or number of inspirations / expirations in a minute ***(Fox and Mathews, 1981).***

1.28.11 Hockey

Hockey is a field game played by both sexes. Each team consists of eleven players who use curved stick to hit the ball along the ground. The object of the game is to send the ball into the opponent's goal, and the team scores greater number of goals wins the game ***(Wein, 1981).***

1.28.12 Dribbling

Dribbling is to proceed further, having full control over the ball in a required speed towards the desired directions preferably towards the opponent's goal ***(Wein, 1973).***

1.28.13 Pushing

"Push" moves the ball along the ground by a pushing movement of the stick after the stick has been placed close to a stationary or rolling ball. When a push is made, both the ball and head of the stick are in contact with the ground ***(Wein, 1973).***

1.28.14 Hitting

Wein (1973) defines hitting is to strike the stationary or the moving ball with the flat side of the stick to a determined destination at a certain speed and also abiding by the rules of the game of hockey. i.e., flat side or face of the stick is only used for playing the ball.

1.29 SIGNIFICANCE OF THE STUDY

The present study would be significant in the following aspects:

1) Plyometric training generally develops explosive power and ultimately, improves the fitness variables. The two different packages of plyometric training used in the present study was a scientifically designed one. Hence it is believed that the players treated with these training modules can be benefited at large with regard to the selected bio-motor ability physiological variables and skill performance factors.

2) One of the objectives of the study is 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.

3) The present study would provide a scientific base and guide lines to the physical educationist, coaches, sports scientist, exercise physiologist and fitness leaders to design the different packages of plyometric training programme using varied modules with a view to develop motor fitness and organic efficiency and performance factors.

4) Findings of this research study would give a basic knowledge to the trainers and fitness experts to envisage and conduct further research in various training methods, intensity and frequency to enhance the performance of hockey players.

5) The result of this study would add to the quantum of knowledge in the areas of training methods, fitness and wellness, exercise physiology and exercise science.

CHAPTER II

REVIEW OF RELATED LITERATURE

CHAPTER – II

REVIEW OF RELATED LITERATURE

The literature related to any problem helps the scholar to discover what is already known, to have a deep insight, clear perspective and better understanding of the chosen problem besides various factors connected with the study. A number of books, journals, and websites were referred. In the following pages, an attempt has been made to present briefly a few of the important researches and studies conducted abroad and in India, as they have significant bearing on the present study.

The review of related literature has been classified under the following headings.

1. Studies on Plyometric Training.
2. Studies on Resistance Training.
3. Studies on Combined Plyometric and Resistance Training.

2.1 STUDIES ON PLYOMETRIC TRAINING.

Miller et al. (2006) determined six weeks of plyometric training on athlete's agility. Subjects were divided into two groups namely plyometric training and control groups. The plyometric training group performed in a six week plyometric training program and the control group did not perform any plyometric training techniques. All the subjects participated in two agility tests: t-test and Illinois Agility Test, and a force plate test for ground reaction times both pre and post testing. Univariate ANCOVAs were conducted to analyze the change scores (post – pre) in the independent variables by group (training or control) with pre scores as covariates. The Univariate ANCOVA revealed a significant group effect $F2, 26 = 25.42$, $p = 0.0000$ for the T-test agility measure. For the Illinois Agility test, a significant group effect $F2, 26 = 27.24$, $p = 0.000$ was also found. The plyometric training group had quicker posttest times compared to the control group for the agility tests. A significant group effect $F2, 26 = 7.81$, $p = 0.002$ was found for the force plate test. The plyometric training group reduced time on the ground on the posttest compared to the control group. The results of this study showed that plyometric training can be an effective training technique to improve an athlete's agility.

Shallaby (2010) identified the effectiveness of plyometric exercises on the special physical abilities and skillful performance of basketball players. A sample of 20 players of 16 years old from El-Shoban El-Muslmeen club in Port Said was acted as subjects. They were divided into two equivalent groups (experimental and control) of 10 players each. The experimental group applied the plyometric exercises and the control group applied the usual program. The program was applied for 12 weeks with 3 training units at 120 minutes for each unit. Through the training unit, the exercises were united between the two groups except for the part of the special physical preparation. The experimental group performed the plyometric exercises while the control group performed the physical exercise. The scientific coefficients were applied to test using a sample outside the study. The scientific coefficients of constancy were between 0.764 and 0.970 and the reliability was between 0.903 and 984. The results pointed to a significant progress in the improvement percentages for the experimental group in all study tests compared to the improvement percentages of the control group, which were respectively: tests of vertical jump at 27.01%, medicine ball push (3 kg) at 20.14%, running 30m × 5n at1.62% and shuttle running at 7.53%, which led to an improvement in the skillful performance (passing at 13.62%, dribbling at 13.46%, under-basket shooting at18.58% and lay-up at 57.97%).

Rajan and Reddy (2012) found out the effect of circuit training for the development of endurance among university hockey male players between the age group of eighteen to twenty one years. The sample for the present study was forty university male hockey players from various colleges of Osmania University in Andhra Pradesh. The experimental group was 20 university male hockey players and control group was 20 university hockey players. The six weeks of training were given to the experimental group which consisted of circuit training on alternate days i.e. three sessions per week and controlled group were given general training. 12 Min run Cooper test were used for pre test and post test for both the experimental and control group to find out the effect of circuit training for the development of endurance. The study showed that due to the circuit training the experimental group has shown vast improvement as compared to the control group in pre test and post test results. It was concluded that the circuit training improved the endurance among university hockey players of Andhra Pradesh.

Buvanendiran and Barathiraj (2013) conducted a study to find out the effect of plyometric training on explosive power of basketball players. For this purpose (N = 30) thirty male basketball players were selected from Mannar district whose age was 18 to 23 years and divided into two groups of fifteen each as experimental group and control group following random procedure. The experimental group underwent Plyometric training over a period of nine weeks whereas control group did not participate in any of the training except their regular activities as per the curriculum. Explosive power was assessed before and after the experimental period for both the groups by using sargeant jump. Independent 't' test was used to analyze the collected data. The results of this study showed that there was a significant improvement on explosive power for plyometric training group compared to control group.

Gnaneshwar and Gopinath (2013) found out the effect of plyometric training, isotonic and combination of isotonic and plyometric training on speed and muscular endurance. For this purpose, forty male students studying Bachelor of Physical Education in the Department of Physical Education and Sports Sciences, Annamalai University, Annamalainagar, Tamil Nadu in the age group of 18 – 23 years were selected as subjects. They were divided into four equal groups consisted of ten subjects, in which group – I underwent plyometric training, group – II underwent isotonic training group, group – III assigned into combined plyometric and isotonic training and group – IV acted as control group. The training period for this study was three days in a week for twelve weeks. Prior to and after the training period the subjects were tested on speed and muscular endurance. The selected criterion variables such as, speed and muscular endurance, were tested by administering, 50 meters dash and sit-ups test. The collected data was analysed by employing analysis of covariance (ANCOVA). Whenever the F ratio was significant, the Scheffe's post hoc test was applied. From the result of the study, it was concluded that all the training groups had improved speed, and muscular endurance.

Kumar (2013) investigated the effect of 6 week plyometric training program on agility of collegiate soccer players. For this purpose 30 soccer players were selected as subjects from C.S.J.M. University, Kanpur. Their age was ranged between 20 to 25 years. The selected subjects were randomly divided into two groups of each consisted of 15 students, namely experimental group 'A' and control group 'B'. Plyometric training for 6 week was assigned to experimental group 'A' and control group 'B' did not undergo any type of experimental training. All the training programmes were scheduled for three days per week for a period of 6 weeks. The agility was measured by administering 't' Test. The data collected from the plyometric training group 'A' and control group 'B' on the criterion measures i.e., agility was statistically analyzed by the application of analysis of covariance (ANCOVA). The mean of pre test for plyometric training group (14.61) and control group (14.73) was recorded. Further the mean of post test for plyometric training group (14.35) and control group (14.99) was also recorded. The result of ANCOVA showed that there was a significant effect of 6 week plyometric training group on agility of collegiate soccer players. In the light of findings it was further concluded that plyometric training improved agility of collegiate soccer players. This meta-analysis extended that the plyometric training improved times in the agility measures because of either better motor recruitment or neural adaptations.

Kumar and Rao (2013) assessed the effect of plyometric exercises for the development of performance ability and speed in long jump. The study consisted of 50 male long jumpers of Osmania University out of which 25 were assigned to experimental group and 25 were in control group. Plyometric exercises such as hopping, bounding, depth jumps, tuck jumps etc were given to experimental group on alternate days i.e. three sessions per week and control group was given the general training for eight weeks. Pre Test and Post Test were conducted by giving the six trials of Long Jump and 30 Meters run to the experimental group and control group. The study revealed that due to the plyometric exercises there was an improvement on experimental group in the performance of ability and speed. The control group showed decreased performance ability and speed due to the general training. It was concluded that explosive power was a combination of speed, muscular endurance and muscular strength, all of which could be developed through plyometric exercises. It was observed that due to plyometric exercises there was a significant improvement in the performance ability and speed among long jumpers.

Singh and Singh (2013) compared the effects of vertical, horizontal and a combination of both vertical and horizontal plyometric exercises (depth jumping) on running speed. A purposively selected sample of 80 male students were randomly assigned into either a control group or groups training the vertical depth jump, horizontal depth jump or a combination of both. The experimental groups trained twice weekly for 10 weeks, performing 6 sets of 10 repetitions per session. Drop height was increased from 20 to 40 cm according to the step method. Running speed was measured by a 45.72 m dash test before and after the 10-week period. Analysis of covariance was applied to compare the scores. A pair-wise comparison was performed using Scheffe's post-hoc test at 0.05 level of confidence. The results showed significant improvements among the three experimental groups as compared to the control group, whereas a comparison between three experimental groups was found to be insignificant. The percentage of performance increased from pre-test to post-test running speed was 2.23%, 2.96% and 3.57% for the groups training vertical, horizontal and both vertical and horizontal depth jumps, respectively. A combination of both vertical and horizontal depth jumping, with a slightly larger emphasis on horizontal plyometric training, could aid sprinters' performance.

Subhabrata Kar (2013) investigated two types of exercise treatment, such as Medicine ball chest throw and Clap pushups introduced to male college students (22-25 yrs. Age gr.) for 4 weeks along with regular physical activities of Bachelor of Physical Education Course. The treatment was given for 4 days per week and 30 min. per day. Before treatment Pre test for arm and shoulder explosive strength was measured for all subjects. According to post test data, the control group showed no improvement on explosive strength performance, extremely significant improvement was shown by experimental group 1 (Treated with Medicine ball chest throw) and also significant improvement was found for experimental group 2 (Treated with Clap pushups).

Vijayalakshmi and Jayapal (2013) found out the effects of plyometric training with yogic practices on selected physical and physiological variables among adolescent boys. To examine 30 adolescent boys were selected from Sri Visweswara Vidyalaya Matric Higher Secondary School, Coimbatore. The age group was range from 13 to 18 years. Subjects were equally divided into two equal group namely experimental group and control group. Plyometric training with yogic practices was given to experimental group. Control group did not participate in any special training programme. The Plyometric training with yogic practices was scheduled for twelve weeks. Prior to and after the training pre–test and post–test was conducted on agility and breath hold time. The data collected from the subjects were statistically analyzed with 't' ratio to find out the significant difference among experimental group and control group. The analysis of the data indicated that plyometric training with yogic practices improved agility and breath holding time.

Amrinder et al. (2014) compared the effects of 4-weeks of plyometric training on two different surfaces, sand and grass on muscle soreness and selected sport-specific performance variables in national level hockey players. Subjects were randomly divided into two groups - grass training group (N = 20) and sand training group (N = 20). After the baseline measurements of strength, endurance, balance, and agility, plyometric training was given for 4-weeks, three sessions per week. Muscle soreness was assessed at the end of each training session on a 7- point likert scale. Post-readings of strength, endurance, balance and agility were taken after the 4-weeks training programme. Data when compared after plyometric training revealed no significant changes between two groups ($p > 0.05$) however, players in the sand group experienced less muscle soreness ($p < 0.05$) than grass group. There was significant improvement ($p < 0.05$) seen in the tested variables in both groups after the training; but no significant interaction was found between the two surfaces after the training. The findings suggested that short-term plyometric training on sand/non-rigid surface induces similar improvements in strength, endurance, balance and agility as on firm surface but induced significantly less muscle soreness.

Asaithambi et al. (2014) found out the effect of different intensities of plyometric exercises on explosive power of collegiate athletes. To achieve these purpose 40 college athletes studying various colleges in Chennai, Tamil Nadu, India were selected as subjects. Their age was ranged from 18 to 25 years. The subjects were divided into two groups of twenty each (n = 20). Group-I underwent Low Intensity Plyometric Training (LIPTG) and Group-II underwent High Intensity Plyometric Training (HIPTG). The duration of the training period was restricted to twelve weeks and the number of sessions per week was confined to three. Explosive Power was selected as criterion variable and it was assessed by vertical jump test. The data collected from the experimental groups were statistically examined using analysis of covariance (ANCOVA). The results indicated that the explosive power showed significant difference between the groups.

Baldon Rde (2014) studied the effects of plyometric training on lower limb kinematics, eccentric hip and knee torques, and functional performance. For this study thirty-six females were divided into two training groups (TG; n = 18) that carried out the plyometric training for 8 weeks, and a control group (CG; n = 18) that carried out no physical training. Twenty-four plyometric training sessions approximately 8 weeks with 3 sessions per week on alternate days were given. Lower limb kinematics (maximum excursion of hip adduction, hip medial rotation, and knee abduction during the single leg squat), eccentric hip (abductor, adductor, medial, and lateral rotator) isokinetic peak torques and knee (flexor and extensor) isokinetic peak torques, and functional performance (triple hop test and the 6-m timed hop test) were selected as variables. After 8 weeks, only the TG significantly reduced the values for the maximum excursion of knee abduction ($P = 0.01$) and hip adduction ($P < 0.001$). Similarly, only the TG significantly increased the eccentric hip abductor ($P < 0.001$) and adductor ($P = 0.01$) torques. Finally, the TG significantly increased the values in the triple hop test ($P < 0.001$) and significantly decreased the values in the 6-m timed hop test ($P < 0.001$) after intervention. It was concluded that Plyometric training altered lower limb kinematics and increased eccentric hip torque and functional performance, suggesting the incorporation of these exercises would save as preventive programs for ACL injuries.

Devaraju (2014) evaluated the effect of plyometric training on explosive strength among Kabaddi players. For this purpose 30 male Kabaddi players from Sivanthi Aditanar College of Physical Education, Tiruchendur, Tamil Nadu were selected at random and their age ranged from 18 to 25 years. Pre test – post test randomized group design was used. The subjects selected were randomly assigned into control and experimental groups of fifteen each and named as Group 'A' and Group 'B'. Group 'A' underwent plyometric training and Group 'B' underwent no training. The data was collected before and after six weeks of training and analyzed by applying analysis of covariance (ANCOVA) to find out the effect of plyometric training programme. The level of significance was set at 0.05. The findings of the study had strongly indicated that plyometric training of six weeks had significant effect on explosive strength of kabaddi players. Hence the hypothesis set that plyometric training programme would have significant effect on explosive strength in light of the same the hypothesis is accepted.

Devaraju (2014) examined the impact of plyometric training on physical fitness variables among ball badminton players. For this study 30 male ball badminton players from Sivanthi Aditanar College of Engineering, Tiruchendur, Tamil Nadu were selected at random and their age ranged from 18 to 25 years. Pre test – post test randomized group design was used. The subjects selected were randomly assigned into control and experimental groups of fifteen each and named as Group 'A' and Group 'B'. Group 'A' underwent plyometric training and Group 'B' did not involve in any training. The data was collected before and after six weeks of training and was analyzed by applying Dependent 't' test in order to find out the impact of plyometric training programme. The level of significance was set at 0.05. The findings of the study had strongly indicated that plyometric training of six weeks had significant impact on selected physical fitness variables i.e., muscular endurance and speed of ball badminton players. Hence the hypothesis set that plyometric training would have significant impact on selected physical fitness variables in light of the same the hypothesis was accepted.

Makaruk et al. (2014) examined the chronic effects of single and repeated jumps training on vertical landing force (VGRF) and jump height in untrained men. The VGRF and jump height were compared after six-week plyometric training programme containing single and repeated jumps, together with two additional parameters: landing time (LT) and range of the knee flexion during landing (KF). Thirty-six untrained physical education students with a plyometric training background were randomly assigned to a single jump group (SJG, $n = 12$), repeated jumps group (RJG, $n = 12$), and control group (CON, $n = 12$). The SJG performed only single jump, the RJG executed repeated (consecutive) jumps, whereas the CON did not perform any exercises at all. A countermovement jump (CMJ), repeated countermovement jumps (RCMJ), and a drop jump (DJ) were tested before and after the training. Only the RJG showed a significantly reduced VGRF ($p < 0.05$) in all tests. Both plyometric groups significantly improved ($p < 0.05$) their jump height in all tests. The LT was significantly greater in the RJG, compared to the SJG, in all tests. The KF was also significantly ($p < 0.05$) greater in the RJG than the SJG for CMJ and RCMJ. The results suggested that repeated jumps were beneficial for simultaneous landing force reduction and jumping performance enhancement.

Mallesh and Gandhi (2014) examined the selected physical fitness variables of speed, agility and explosive power, and performance variables of sports competition dribbling, hitting and trapping among the inter university and senior state men hockey players. Sixty hockey players were selected in the ratio of 30 University and 30 State men hockey Players. The thirty subjects of university and senior state men hockey players were equally selected from the Inter University hockey competition and the Senior National Hockey Championship. The selected variables were tested through standardized test of 30mts standing start, 6X10mts shuttle run, standing broad jump, and the performance variables using the standard test of "W" form dribbling, hitting for accuracy and trapping was tested through subjective rating. The collected data were statistically analyzed by using t-test. The significant level was fixed at 0.05. The results of the study proved that there were significant differences in the selected variables between university and senior state men hockey players. Further it was proved that the senior state hockey players were better in all the selected variables in comparison with university men hockey players.

Ramirez-Campillo et al. (2014) examined the effect of a short-term plyometric training program on explosive strength and endurance performance in highly competitive middle- and long-distance runners. Athletes were randomly assigned into a control group (CG, n = 18, 12 men) and an explosive strength training group (TG, n = 18, 10 men). Drop jump (DJ) from 20 (DJ20) and 40 cm (DJ40), countermovement jump with arms (CMJA), 20-m sprint time, and 2.4-km endurance run time test were carried out before and after 6 weeks of explosive strength training. Also, the combined standardized performance (CSP) in the endurance and explosive strength test was analyzed. After intervention, the CG did not show any significant change in performance, whereas the TG showed a significant reduction in 2.4-km endurance run time (-3.9%) and 20-m sprint time (-2.3%) and an increase in CMJA (+8.9%), DJ20 (+12.7%), and DJ40 (16.7%) explosive performance. Strength training group also exhibited a significant increase in CSP, although the CG showed significant reduction. Thus, the result was concluded that properly programmed concurrent explosive strength and endurance training could be advantageous for middle- and long-distance runners in their competitive performance, especially in events characterized by sprinting actions with small time differences at the end of the race.

2.2 STUDIES ON RESISTANCE TRAINING

Felipe et al. (2013) designed to improve explosive and maximal strength would influence rate of force development (RFD). Nine men participated in a 6 weeks knee extensors resistance training program and 9 matched subjects participated as controls. Throughout the training sessions, subjects were instructed to perform isometric knee extension as fast and forcefully as possible, achieving at least 90% maximal voluntary contraction as quickly as possible, hold it for 5 s, and relax. Fifteen seconds separated each repetition (6-10), and 2 min separated each set (3). Pre and post-training measurements were maximal isometric knee extensor (MVC), RFD, and RFD relative to MVC (i.e., $\%MVC \cdot s^{-1}$) in different time-epochs varying from 10 to 250 ms from the contraction onset. The MVC (Nm) increased by 19% (275.8 ± 64.9 vs. 329.8 ± 60.4, $p < 0.001$) after training. In addition, RFD ($Nm \cdot s^{-1}$) increased by 22-28% at time epochs up to 20 ms from the contraction onset (0-10 ms = 1679. 1 ± 597.1 vs. 2159.2 ± 475.2, $p < 0.001$; 0-20 ms = 1958.79 ± 640.3 vs. 2398.4 ± 479.6, $p < 0. 01$), with no changes verified in later time epochs. However, no training effects on RFD were found for the training group when RFD was normalized to MVC. No changes were found in the control group. In conclusion, very early and late RFD responded differently to a short period of resistance training for explosive and maximal strength. The time-specific RFD adaptation highlighted that resistance training programs should be considered as a specific neuromuscular demands of each sport.

Jaipal and Sharma (2013) determined the impact of alternate low and high intensity resistance training on cardiovascular efficiency among adolescents. To achieve this purpose thirty physically active and interested students (N = 30) were selected as subjects and their age ranged between 15 to 18 years. The subjects were categorized into two groups. Group I was subjected to alternate intensity resistance training (AIRT), group II acted as control group (CG). Both the group had fifteen (N = 15) subjects each. The experimental groups underwent their respective experimental treatment for eight weeks, 3 days in a week and single session on every day. Control group was not exposed to any specific training programme besides their curriculum. Cardiovascular efficiency was selected as dependent variable for this study. The collected data was analysed using t-test, to test the significant difference between the mean. The result of the study revealed that alternate low and high intensity resistance training (AIRT) enhanced significant improvement on cardiovascular efficiency (p 0.05) as compared to control group (CG).

Makaruk et al. (2013) examined the effects of resisted and standard sprint training on the kinematics of sprint running acceleration in women. Thirty-six untrained but physically active female college students were randomly assigned to one of three groups: a running resisted training group (RTG, n = 12), a standard training group (STG, n = 12), and a control group (CON, n = 12). All participants in the experimental groups trained three times a week for four weeks, followed by a 1week training break, after which they trained again for four weeks. Pre-training, post-training and detraining (three weeks after completing the training programs) measures of mean running velocity, stride length, stride frequency, knee angle at toe off and foot strike, ground contact time, and flight time were analyzed by a 20 m sprint test. The RTG improved mean running velocity and increased stride length and knee angle at toe off. Simultaneously, the RTG featured decreased stride frequency and increased ground contact time. The STG demonstrated an increase in mean running velocity due to higher stride frequency and a decrease in ground contact time. All of the measured parameters did not significantly decrease after the three-week detraining period. The control group featured no changes. Both resisted and standard sprint training improved speed in sprint-running acceleration in women by improving different sprint kinematic parameters.

Velusamy (2013) found out the effect of varied methods of resistance training on selected physical fitness components of inter collegiate male volleyball players. To achieve these purpose forty five male volleyball players were selected as subjects from affiliated colleges of Bharathiar University, Coimbatore, during the academic year 2012-2013. The subjects were selected on random basis and divided into three equal groups, such as, two experimental groups and one control group. Each group consisted of 15 subjects. Group – I underwent resistance with circuit training (RCT), Group – II administered resistance without circuit training (RWCT) and Group – III acted as control group (CG), did not take part in any specific training. The age of subjects was ranged from18-28 years. Initial reading was taken for both experimental and control groups. Then the experimental groups were treated with resistance cum circuit and resistance without circuit training for six weeks, and the post test was recorded for both experimental and control groups. The collected data were analyzed statistically by using Analysis of Covariance (ANCOVA) to determine the significant difference, if any found among the adjusted post test means on selected dependent variables. In all the cases, 0.05 level of confidence was fixed to test the level of significance. The results of this study showed that experimental groups revealed better performance on selected physical fitness components of inter collegiate male volleyball players.

Hanjabam and Kailashiya (2014) found training related physiological and cardiovascular changes and adaptations in field hockey players. This interventional study was conducted with 30 male field hockey trainees (age: 15.7±1.55 years, range: 13-20 years) underwent training in preparation phase. In addition to the their usual routine of 2 hours per day, 6 times a week of aerobic, anaerobic and skill training session of field hockey; a specialized additional training of 2 hours per day-3 times a week, consisting of sprint, strength - power and agility was incorporated in the schedule. Selected variables measured before and after the 6 week training were compared with paired t test. Upon analysis was found that lean body mass (LBM) of the participants showed significant improvement ($P < 0.05$) after the 6 week training. Significant reduction ($P < 0.05$) was observed in resting heart rate, resting systolic blood pressure, resting diastolic blood pressure, resting double product or rate pressure product. We also found significant changes ($P < 0.05$) in the echocardiographic parameters – increase in left ventricular posterior wall thickness, left ventricular ejection fraction; and decrease in left ventricular end- systolic volume. However when these parameters were expressed relative to LBM, no significant change was seen. Left ventricular end-diastolic diameter and volume, body weight and body mass index too did not change significantly after the training. This 6 week specialized additional training resulted in improvement of body composition and cardiovascular functions of the participants, indicating favorable physiological, morphological and functional adaptations.

Keiner et al. (2014) analyzed the possible correlations between the 1 Repetition Maximum/body mass (SREL) in the front and back squats and COD. The subjects (n = 112) were between 13 and 18 years of age and divided into 2 groups with 4 subgroups (A = under 19 years of age, B = under 17 years of age, and C = under 15 years of age). For approximately 2 years, 1 group (control group [CG]) only participated in routine soccer training, and the other group (strength training group [STG]) participated in an additional strength training program with the routine soccer training. Additionally, the performances in the COD of 34 professional soccer players of the first and second divisions in Germany were measured as a standard of high-level COD. For the analysis of the performance development within a group and pair wise comparisons between 2 groups, an analysis of variance with repeated measures was calculated with the factors group and time. Relationship between the COD and SREL were calculated for the normal distributed data using a plurality of bivariate correlations by Pearson method. The data showed that additional strength training over a period of 2 years significantly affected the performance in the COD. The STG in all subcohorts reached significantly ($p < 0.05$) faster times in the COD than did the CG. The STG amounted up to 5% to nearly 10% better improvements in the 10-m sprint times compared with that of the CG. Furthermore, the data showed significant ($p < 0.05$) moderate to high correlations ($r = -0.388$ to -0.697) between the SREL and COD and long-term strength training improved the performance of the COD. Therefore, long-term resistance training was recommended early as in childhood and adolescent as possible.

Nageswaran (2014) found out the effects of resistance band training on strength, speed and balance among Inter collegiate kabaddi players. Twenty four male inter collegiate kabaddi players studying in Sivanthi Aditanar College of Physical Education, Tiruchendur were randomly selected as subjects. The age of the subjects ranged from 21 to 25 years. The selected subjects were divided into two groups. Group I underwent resistance band training and Group II acted as control. The experimental group was subjected to resistance band training for alternate three days in a week for six weeks. The resistance band training was selected as independent variable and the criterion variables such as strength, speed and balance were selected as dependent variables. Strength was assessed by 1 repetition test, speed was assessed by 50m run and balance was assessed by stork stand test. The experimental design selected for this study was pre and post test randomized design. The data was collected from all the subjects before and after the training period and statistically analyzed by using dependent 't' test and analysis of covariance (ANCOVA). It was found that there was a significant improvement existed due to the administration of resistance band training on strength, speed and balance among inter collegiate kabaddi players when compared to control group.

2.3 STUDIES ON COMBINED PLYOMETRIC AND RESISTANCE TRAINING

Kubo et al. (2007) investigated the effects of plyometric and weight training protocols on the mechanical properties of muscle-tendon complex and muscle activities and performances during jumping. Ten subjects completed 12 weeks (4 days per week (-1)) of a unilateral training program for plantar flexors. They performed plyometric training on one side (PT; hopping and drop jump using 40% of 1RM) and weight training on the other side (WT; 80% of 1RM). Tendon stiffness was measured using ultrasonography during isometric plantar flexion. Three kinds of unilateral jump heights using only ankle joint (squat jump: SJ; countermovement jump: CMJ; drop jump: DJ) on sledge apparatus were measured. During jumping, electromyographic activities were recorded from plantar flexors and tibial anterior muscle. Joint stiffness was calculated as the change in joint torque divided by the change in ankle angle during eccentric phase of DJ. Tendon stiffness increased significantly for WT, but not for PT. Conversely, joint stiffness increased significantly for PT, but not for WT. Whereas PT increased significantly jump heights of SJ, CMJ, and DJ, WT increased SJ only. The relative increases in jump heights were significantly greater for PT than for WT. However, there were no significant differences between PT and WT in the changes in the electromyographic activities of measured muscles during jumping. These results indicated that the jump performance gains after plyometric training were attributed to changes in the mechanical properties of muscle-tendon complex, rather than to the muscle activation strategies.

Ratamess et al. (2007) examined the combined effects of resistance and sprint/plyometric training with or without the meridian elite athletic shoe on muscular performance in women. Fourteen resistance-trained women were randomly assigned into one of 2 training groups: (a) an athletic shoe (N = 6) (AS) group or (b) the meridian elite (N = 8) (MS) group. Training was performed for 10 weeks and consisted of resistance training for 2 days per week and 2 days per week of sprint/plyometric training. Linear periodized resistance training consisted of 5 exercises per workout (4 lower body and 1 upper body) for 3 sets of 3-12 repetition maximum (RM). Sprint/plyometric training consisted of 5-7 exercises per workout (4-5 plyometric exercises, 40-yd and 60-yd sprints) for 3-6 sets with gradually increasing volume (8 weeks) followed by a 2-week taper phase. Assessments for 1RM squat and bench press, vertical jump, broad jump, sprint speed, and body composition were performed before and following the 10-week training period. Significant increases were observed in both AS and MS groups in 1RM squat (12.0 vs. 14.6 kg), bench press (6.8 vs. 7.4 kg), vertical jump height (3.3 vs. 2.3 cm), and broad jump (17.8 vs. 15.2 cm). Similar decreases in peak 20-, 40-, and 60-m sprint times were observed in both groups (20 m: 0.14 vs. 0.11 seconds; 40 m: 0.29 vs. 0.34 seconds; 60 m: 0.45 vs. 0.46 seconds in AS and MS groups, respectively). However, when sprint endurance (the difference between the fastest and slowest sprint trials) was analyzed, there was a significantly greater improvement at 60 m in the MS group. These results indicated that similar improvements were made in peak sprint speed and jumping ability following 10 weeks of training with either shoe. However, high-intensity sprint endurance at 60 m increased to a greater extent during training with the meridian elite athletic shoe.

Adibpour et al. (2012) compared the effect of combined exercises (plyometric and weight training) on vertical jump of female basketball players. Out of 35 basketball players who competed in first division league of Tehran clubs, 16 players (age: 20.38 ± 3.7 yr, weight: 65.5 ± 11.5 kg and height: 174.78 ± 6.23 cm) participated voluntarily in this study. They were randomly assigned into two experimental and control groups. The experimental groups performed plyometric exercises (which consisted of side hop, lay up jump, depth jump) and weight exercises (which included leg press lying, calf raises, leg press standing) 3 days per week for 8 weeks while the control group performed only the vertical jump that was measured with Sargeant Jump test. Both groups took part in the pre and post tests. The accepted level of significance was $p < 0.05$. The results indicated that the significant effect of combined exercises on vertical jump ($p < 0.05$). In addition, the results revealed that the vertical jump of experimental group was significantly greater than control group ($p < 0.05$). Further, the results showed that these exercises could also build up foot muscles and increase explosive feet power. Therefore, the application of combined exercises to jumping sports was suggested.

Sankarmani et al. (2012) compared the effects of weight training with and without plyometrics. 40 intercollegiate athletes were assigned into two training groups namely plyometric cum weight training and weight training. Each group completed a 6 weeks training program. There was more significant improvement in anaerobic power and muscle strength for the athletes trained with plyometric weight training methods than weight training alone. There was significant improvement of vertical jump height, 50 yard dash and 1RM squat performance in plyometrics and weight training group than the weight training group alone. Plyometric with weight training was found to be more effective in improving vertical jump, 50 yard dash and 1 RM squat performance in athletes than the weight training alone.

Bandyopadhyay et al. (2013) found out the effects of plyometric training and resistance training on specific speed of basketball players. For the purpose of the study 60 male basketball players, who had participated in various national/ inter-varsity/ state level tournaments in basketball from West Bengal were selected as subjects. Their age ranged from 18-23 years. Specific speed was selected as a dependent variable and plyometric training and resistance training was considered as independent variables. Pre test-post test randomized group design comprising of two experimental groups (n = 20) namely plyometric training group (PT) and resistance training group (RT) and one active control group (n = 20) were adopted. To test the specific speed of basketball players, 20 meter dash test was used. To compare the effects of plyometric training and resistance training on speed of basketball players, analysis of covariance (ANCOVA) was employed. The level of significance was set at 0.05 level. The result revealed that there was a significant effect on both the plyometric and isolated resistance training programme on specific speed of basketball players.

Christopher et al. (2013) compared the effects of resistance, plyometric, and their combination (complex training) on countermovement vertical jumps (CMVJ) and broad jumps (BDJ). Longitudinal study design with repeated measures was adopted for this study. Thirty four recreationally trained college aged males trained using one of three methods; resistance (RT; n = 13), plyometric (PT; n = 11), or complex (CT; n = 10) training twice weekly for six weeks were assessed pre (W1), mid (W5), and post (W9) training. Measures included: CMVJ height (cm), CMVJ peak ground reaction force (pGRF; N), peak power (Watts), peak power per kilogram (Watts/kg), peak power per kilogram of fat free mass (Watts/kg FFM), BDJ distance (cm), and BDJ peak ground reaction force (pGRF; N). Body mass significantly increased from W1 (83.85 ± 20.54 kg) – W5 (85.26 ± 20.29 kg) for RT and from W1 (81.25 ± 10.43 kg) – W9 (82.49 ± 10.19 kg) for PT. Body fat percentage significantly increased from W5 (18.0 ± 8.0 %) – W9 (20.0 ± 7.0 %) and W1 (18.0 ± 8.0 %) – W9 (20.0 ± 7.0 %) for RT and from W5 (18.0 ± 5.0 %) – W9 (22.0 ± 4.0 %) for PT. Results indicated no statistical differences between groups for any measure at any testing time point. Statistical increases in CMVJ pGRF (PT: W1 (2059.97 ± 314.83 N) – W5 (2145.02 ± 317.00 N); CT: W1 (2255.48 ± 375.79 N) – W5 (2323.19 ± 340.61 N)), CMVJ peak power/kg FFM (PT: W5 (78.32 ± 4.86 Watts/kg FFM) – W9 (82.09 ± 5.59 Watts/kg FFM)), and BDJ distance (PT: W1 (202.0 ± 27.0 cm) – W9 (214.0 ± 19.0cm)) were identified. The significant increase in pGRF and peak power/kg FFM in PT and CT suggested increased force/power production in the muscle mass of their lower limbs. The significant increase in BDJ distance for the PT was likely to have a transfer of training effect.

Haghighi et al. (2013) investigated the effect of plyometric versus resistance training (PT vs. RT) on sprint and skill performance in young soccer players. Thirty elite soccer players participated in this study as subjects and randomly assigned to PT group (n = 10, age: 19.1 ± 1.7 years), RT group (n = 10, age: 18.0 ± 0.81) or control group (n = 10, age: 18.8 ± 1.5 years). The PT group performed 8 weeks lower extremities PT besides the soccer team training. The RT consisted of 2-4 sets of weight training for 4 stations and at an intensity corresponding to 60-90% of 1-RM in each station by 6-12 repetitions besides the soccer team training. The control group performed only the soccer team training during the study. The results showed that the time of sprint running test and dribbling improved after PT and RT ($P < 0.05$). For accuracy of shooting no significant change was observed after 8 weeks PT and RT. In conclusion, although the time of sprint running test and dribbling improved after PT and RT, these training had not shown any effect to improve accuracy of shooting in young soccer players.

Krishnan and Kumar (2013) found out the effect of weight training and plyometric training on strength-endurance and leg strength. For this purpose, thirty normal male students between the age group of 19 – 25 years studying in the faculty of

Agriculture of Annamalai University were selected as subjects. They were divided into three equal groups consisting of ten each, in which group – I underwent weight training, group – II underwent plyometric training and group – III acted as control which did not participate in any specific training. The training period for this study was restricted to three days in a week for twelve weeks. Prior to and after the training period the subjects were tested for strength endurance by conducting sit-ups test and leg strength was assessed by using dynamometer. The statistical toll used for this study was analysis of covariance (ANCOVA). Whenever the 'F' ratio was significant, the Scheffe's test was applied as post-hoc test. It was concluded that after the weight training and plyometric training programme of 12 weeks, strength-endurance and leg strength were improved significantly.

Nelaturi and Kumar (2013) figured out the impact of disconnected and joined weight and plyometric preparing on chosen physical and physiological variables among school men. Physical and physiological variables selected for the study were specific hazardous force, husky perseverance, brawny quality, speed, resting beat rate, breathing holding time and cardiovascular continuance. 80 school men learner were chosen at irregular from in and around the Krishna region of Andhra Pradesh, their age ranged from 18-23 years. They were partitioned into four equivalent bunches of 20 subjects. Group-A experienced weight preparing; Group-B experienced Plyometric preparing and Group-C experienced joined preparing for three days for every week for 12 weeks and Group D went about as a control that did not include any preparing separated from the customary curricular exercises. It was concluded that resting beat rate was essentially enhanced by the weight preparing gathering, plyometric preparing assembly and joined together preparing gathering when contrasted and control group. Resting beat rate was fundamentally enhanced by the consolidated preparing gathering when contrasted and weight preparing assembly and plyometric preparing group. Resting beat rate was essentially enhanced by the weight preparing gathering when contrasted and plyometric preparing group. Breath holding time was fundamentally enhanced by the weight preparing assembly, plyometric preparing assembly and consolidated preparing gathering when contrasted and control group. There was no huge change in breath holding time when analysed between weight preparing gatherings, Plyometric preparing gathering and joined together preparing group. Cardio vascular continuance was fundamentally enhanced by the weight preparing aggregation, Plyometric preparing gathering and consolidated preparing assembly when contrasted and control group. Cardio vascular persistence was essentially enhanced by the joined together preparing gathering when contrasted and weight preparing assembly and plyometric preparing group. There was no noteworthy in cardio-vascular perseverance when looked between weight preparing gathering and plyometric preparing gathering.

Robert and Murugavel (2013) evaluated and compared the effect of plyometric, resistance and sprint training on acceleration speed, flight time and jump height of male basketball players. To achieve this purpose, thirty basketball players were selected from affiliated colleges of Bharathiar University, Coimbatore. The results revealed that the 8 weeks plyometric resistance training, and sprint training programme significantly improved the acceleration speed, flight time and jump height of basketball players. Further plyometric training group performed better jump height and flight time compared with RTG and STG and the sprint training improved the acceleration speed better than RTG and STG after 8 week training programme.

Shafeeq et al. (2013) determined the impact of resistance training, plyometric training and combined resistance and plyometric training on strength and power out puts in young boys. Sixty physically active students, aged between 17-20 years (mean age +/- 1.9 years) participated in the study and they were randomly assigned into four equal groups with fifteen subjects each. Group I was involved with resistance training, group II plyometric training, group III combined resistance and plyometric training and group IV acted as control group. The experimental groups underwent their respective experimental treatment for eight weeks, 3 days a week and one session per day. Control group was not exposed to any specific training apart from their regular activities. Leg strength, elastic strength and explosive power were taken as variables for this investigation. The pre and post tests were conducted one day before and after the experimental treatment. The collected data were treated with Analysis of Covariance and Scheffe's test was applied as a post hoc test to determine which of the paired means differed significantly. The result of the study revealed that all the three trainings such as resistance training, plyometric training and combined resistance and plyometric training produced significant improvement on leg strength, elastic strength and explosive power ($p < 0.05$) as compared to control group.

It was concluded that the combined training protocol produced greater impact than resistance and plyometric training.

Vijayalakshmi and Jayabal (2013) determined the effects of combination of own body resistance exercises and plyometrics with and without yogic practices on selected physical and physiological variables among adolescent boys. Sixty adolescent boys ranging between 13 and 18 years were selected and divided into three equal groups and they were trained for twelve weeks. Prior and after the training pre–test and post–test was conducted on agility, flexibility and resting pulse rate. Statistical analysis was done using ANOVA. The result showed that the experimental groups showed remarkable increases in the agility, flexibility and resting pulse rate than the control group.

Zeareia et al. (2013) compared the effects of plyometric and resistance training on explosive power and speed in young female Taekwondo players. A total of 20 Taekwondo players (Ag = 20.4 ± 1.6 yrs) volunteered to participate in the study. The subjects were randomly assigned into either a plyometric or a resistance training groups. Either group participated in a 6-week training program, three sessions a week. Kolmogorov-Smirnov and t-tests were run to examine the normality of the data and to compare the mean scores of the two groups, respectively ($P < 0.05$). The results showed no significant difference between the effect of plyometric and resistance trainings on explosive power and speed in young female Taekwondo players. Research has shown that neuromuscular coordination, reflective electrical activity, increased muscular contraction speed and using more motor units result from either training method, which might have improved explosive power and speed in Taekwondo players. Still, considering the similar effects of plyometric and resistance trainings, it was recommended that either method could be used consistently applying the principle of training diversity.

Khodajo et al. (2014) investigated the effect of 8 weeks of strength and plyometric training on anaerobic power, explosive power and strength quadriceps femoris muscle in soccer players. 20 male soccer players whose age between 20-30 volunteers participated in the study. They were assigned in strength ($n = 10$) and plyometric ($n = 10$) groups. Both groups performed selected soccer-specified strength and plyometric for 8 weeks. Data was analyzed using paired and independent t-test. The results showed that strength

Quadriceps femoris muscle increased in post-test compared to pre-test in strength training group (p = 0.015) and explosive power was also significantly increased in post-test compared to pre-test in plyometric training group (p = 0.021). Between-groups comparison showed better records in explosive power for plyometric compared with strength training group after eight weeks (p = 0.049). The results showed that both strength and plyometric training improved physical fitness in soccer players. Therefore, it was recommended that both types of training program could be included in increasing the maximum performance of soccer players.

Krishnan and Rajan (2014) investigated the effect of plyometric training, plyometric training parallel with closed kinetic chain resistance training on the development of selected physiological variables. To achieve this purpose, Forty five subjects were selected at random and their ages ranged from 17 to 19 years. The subjects were divided into three equal groups. The study was formulated as a true random group design, the subjects (n = 45) were assigned into three equal groups of fifteen each. The groups were assigned as Plyometric Training (PT), Plyometric Training Parallel with Closed Kinetic Chain Resistance Training (PTPCKCRT) and Control Group (CG) in an equivalent manner. The selected criterion variables; physiological variables were: systolic blood pressure, diastolic blood pressure and resting heart rate. All the subjects were tested prior to and after the experimental programme. Analysis of Covariance (ANCOVA) was applied to analyse the significant differences. The 0.05 level of confidence was fixed as the level of significance. Based on the result of the study it was concluded that, the plyometric training programme parallel with closed kinetic chain resistance training programme produced a significant development on resting heart rate. It was further concluded that the plyometric training programme parallel with closed kinetic chain resistance training programme produced insignificant development on systolic blood pressure, diastolic blood pressure than plyometric training programme.

Nageswaran (2014) found out the impact of plyometric training packages with and without resistance training on leg explosive power of men basketball players. The study was administrated on thirty men(N = 30) basketball players who were selected randomly as subjects studying in various arts colleges affiliated to Bharthidasan University, Tiruchirappalli, Tamil Nadu, India, and classified them into three groups, namely plyometric training with resistance (n = 10) plyometric training without resistance (n = 10) and control group (n = 10). The experimental groups underwent their respective training for 10 weeks. Leg explosive power was selected as dependent variable and assessed by standing broad jump. The collected data was analysed by applying analysis of covariance (ANCOVA). Since three groups were involved, whenever the 'F' ratio was found to be significant for adjusted post means, Scheffe's test was followed as a post hoc test to determine which of the paired means difference was significant. The results of the study suggested that plyometrtic training with resistance training showed significant difference among the experimental groups.

Taheri et al. (2014) investigated the effect of plyometric and resistance training on agility, speed and explosive power in soccer players. 30 male soccer players whose age was between 18-25 voluntarily participated in the study. They were randomly assigned into plyometric (n = 15) and resistance (n = 15) groups. Both groups performed selected soccer-specific plyometric and resistance training for 8 weeks. Data was analyzed using paired t-test, independent t-test, and covariance. The results showed that levels of agility, speed, and explosive power in plyometric training group (p = 0.0001), and agility and explosive power in resistance training group (p = 0.0001) were significantly improved in post-test compared to pre-test. Between-groups comparison showed better records in agility, speed and explosive power for plyometric compared with resistance training group after eight weeks (respectively p = 0.032, p = 0.0001 and p = 0.002). According to the results, it was concluded that both plyometric and resistance training exercises increased agility and explosive power and reduced sprint time in football players. Plyometric exercises also showed more favorable effects on study variables compared with resistance exercises. Therefore, these types of training methods were suggested to soccer players for improving speed and performance skill.

CHAPTER III

METHODOLOGY

CHAPTER – III

METHODOLOGY

This Chapter describes the procedures adopted for selection of subjects, selection of variables, experimental design, selection of test, competency of the tester, instruments reliability, subject's reliability, reliability of data, orientations of the subjects, pilot study, training programme, administration of the test, collection of data and statistical technique adopted were explained in detail.

3.1 SELECTION OF SUBJECTS

The purpose of the study was to find out the influence of plyometric training packages with and without resistance training on selected bio-motor, physiological variables and skill performance factors among women hockey players. To execute this investigation the research scholar employed random sample of forty five women hockey players among the hockey players who had represented from various affiliated colleges of Periyar University inter-collegiate hockey tournament at Salem, Tamil Nadu, India during the year 2012-2013. Their age was range between 18 to 21 years. The selected subjects were assigned into two experimental groups such as plyometric training packages with resistance training (Group I), plyometric training packages without resistance training (Group II) and control group (Group III) of fifteen (n = 15) each. The experimental groups were subjected to their respective training programmes for a period of twelve weeks and three alternate days in a week in addition to their regular academic schedules. However, control group was not exposed to any specific training but they took part in their regular schedule. The subjects were free to with draw their consent in case of feeling any discomfort during the period of their participation but there was no drop out in this study. The age, height and weight of the subjects were ranged from 18 to 21 years, 155 to 162 cm and 48 to 52 kg respectively, and the means were 19.5 years, 158 centimeters and 50 kilograms respectively.

3.2 SELECTION OF VARIABLES

The investigator reviewed all the available scientific literatures pertaining to the problem under study from books, research papers, and websites. The following bio-motor, physiological variables and hockey skill performance factors were selected by considering the feasibility and availability of instruments relevant to the present study.

3.2.1 Dependent Variables

The following bio-motor, physiological variables and hockey skill performance factors were selected as dependant variables.

a. Bio-motor Variables

i. Speed

ii. Agility

iii. Cardio Respiratory Endurance

b. Physiological Variables

i. Breath Holding Time

ii. Resting Pulse

iii. Respiratory Rate

c. Hockey skill performance factors

i. Dribbling

ii. Pushing

iii. Hitting

3.2.2 Independent Variables

The following were selected as independent variables.

1. Plyometric training packages with resistance training
2. Plyometric training packages without resistance training
3. Control group

3.3 EXPERIMENTAL DESIGN

The experimental design used in this study was random group design involving forty five subjects who were divided at random into three groups of fifteen each. This study consisted of three independent variables such as plyometric training packages with resistance training, plyometric training packages without resistance training and Control group. All the subjects were tested prior to, and after the training period on bio- motor variables viz., speed, agility, cardio respiratory endurance, physiological variables i.e., breath holding time, resting pulse rate, respiratory rate, and skill performance factors such as dribbling, pushing and hitting among women hockey players.

3.4 SELECTION OF TEST

The present study was undertaken primarily to assess the influence of plyometric training packages with and without resistance training on selected bio-motor variables, physiological variables and skill performance factors among women hockey players. As per the available literatures, the following tests were used to collect relevant data on the selected dependent variables and they were presented in Table - I.

TABLE – I

TESTS SELECTION

S. No.	Criterion Variables	Test Items	Unit of Measurement
1.	Speed	50 Meters Dash	In Seconds
2.	Agility	Illinois Agility test	In Seconds
3.	Cardio Respiratory Endurance	Cooper's 12 Minute Run/Walk Test	In Meters
4.	Breath Holding Time	Stop watch (Manual)	In Seconds
5.	Resting Pulse Rate	Radial Pulse Test	In Numbers
6.	Respiratory Rate	Manual Method	In Numbers
7.	Dribbling	Sodhi *et al.* Hockey Field Test(1995)	Points
8.	Pushing	Sodhi *et al.* Hockey Field Test(1995)	Points
9.	Hitting	Sodhi *et al.* Hockey Field Test(1995)	Points

3.5 COMPETENCY OF THE TESTER

To ensure that the investigator was well versed with the technique of conducting tests, she had a number of practice sessions in the correct testing procedure. All the measurements in this study were taken by the investigator with the assistance of experts in the field of physical education and sport sciences who were also well known about the testing procedure. The tester's reliability was established by test and re-test method.

3.6 INSTRUMENTS RELIABILITY

To conduct the tests on selected criterion variables, instruments such as stop watches, measuring steel tape, cone, plyometric box, medicine ball, hockey sticks and balls available at Sri Sarada College of Physical Education, Salem were used for the study. They were purchased from reliable companies and their calibrations were accepted and found to be accurate enough to serve the purpose of the study.

3.7 SUBJECT RELIABILITY

The intra class correlation value of the below test and retest also indicated subject reliability as the same subjects were used under similar conditions by the same tester.

3.8 RELIABILITY OF DATA

Test and retest method was followed in order to establish the reliability of data by using ten subjects. All the dependant variables selected in the present study were tested twice for the subjects by the same personal under similar conditions. The intra-class co efficient of correlation was used to find out the reliability of the data as suggested by **Johnson and Nelson (1974)** and the results were presented in Table II.

TABLE – II

INTRA CLASS COEFFICIENT OF CORRELATION ON SELECTED DEPENDENT VARIABLE

S. No.	Criterion Variables	'r' value
1.	Speed	0.93*
2.	Agility	0.95*
3.	Cardio Respiratory Endurance	0.94*
4.	Breath Holding Time	0.89*
5.	Resting Pulse Rate	0.96*
6.	Respiratory Rate	0.97*
7.	Dribbling	0.97*
8.	Pushing	0.95*
9.	Hitting	0.97*

Significant at 0.01 level of confidence.

(Table value required for significance at 0.01 level of confidence is 0.77)

Since the obtained 'r' values were much higher than the required value, the data had been accepted as reliable in terms of instruments, tester and the subjects.

3.9 ORIENTATION OF THE SUBJECTS

Prior to the administration of the tests, the subjects were oriented with the purpose of the study and the importance of training programme. Five sessions were spent to familiarize the subjects with the techniques involved in undergoing plyometric training packages with and without resistance training. It helped them to perform the respective training programmes perfectly without any injuries. The subjects of all the groups were sufficiently motivated to perform their assigned tasks during the testing periods.

3.10 PILOT STUDY

A pilot study was conducted to assess the initial capacity of the subjects to fix the training load and also to design the training programme. For that purpose, ten women hockey players who participated at Periyar University Inter – Collegiate hockey tournaments, Salem, Tamil Nadu, India were selected at random and they were given various plyometric training packages with resistance training and plyometric training separately under the watchful eyes of the investigator. Finally, specific plyometric and resistance exercises which were closely related to develop the dependent variables were chosen to design the training programme. The initial load of the subjects was fixed based on the results of the pilot study and the directions given by ***Dan Wathen (1994)***. The training schedule with respective intensities was fixed for plyometric training packages with resistance training and plyometric training without resistance training. While constructing the training programme considering the basic principles of sports training i.e., progression of overload and specificity were followed and the individual differences were also taken into consideration.

3.11 TRAINING PROGRAMME

The training modules for the experimental groups have been designed based on the results of the pilot study conducted by the scholar with the help and guidance of experts in sports training .During the training period the experimental group I underwent plyometric training packages with resistance training and experimental group II was involved with plyometric training without resistance training for three alternate days in a week for twelve weeks under the careful supervision of the investigator .The control group was not given any specific training except routine programme .The duration of the training for the experimental groups in all three days was lasted from 60 to 90 minutes in the evening session between 4 .30 to 6 .00 PM which included warm up and cool down .

All the subjects involved in the study were carefully monitored throughout the training programme to keep them away from injuries. They were questioned about their health status quite often and none of them reported any trauma. However, muscle soreness appeared in the earlier period of the training programme but reduced in due course. The detailed training schedule for each group was given in the form of table III and IV by indicating the intensity, repetitions, set and recovery.

Singh (1991) has recommended that the physical preparation for the training session is achieved through optimum warm up of at least six exercises in a definite manner for the purpose of warming of the physical and physiological systems of the organism. It leads to a) increase in muscle and body temperature, b) raising the functional level of the heart and lungs, c) loosening of muscles, ligaments and joints, d) facilitation of motor co-ordination, e) increase in readiness for training activity. Therefore in the present study the warm up consisted of jogging, stretching and loosening exercises.

3.11.1 ASSESSMENT OF ONE REPETITION (1RM)

After selecting the resistance exercise, 1RM was found for each exercise separately by either increasing or decreasing the weight. 1RM is the maximum amount of weight a subject can successfully lift one time through full range of motion.

TABLE – III

TRAINING SCHEDULE FOR PLYOMETRIC TRAINING PACKAGES WITH RESISTANCE TRAINING

EXPERIMENTAL GROUP - I

Weeks	Plyometric exercises and resistance exercises		Recovery		Intensity for Resistance training
	Repetitions	Set (Nos.)	Repetition	Set	
1-3	4-6	2	90 Sec.	3 Min.	65%
4-6	4-6	2	90 Sec.	3 Min.	70%
7-9	6-8	2	90 Sec.	3 Min.	75%
10-12	6-8	2	90 Sec.	3 Min.	80%

EXERCISE PROGRAMME FOR PLYOMETRIC TRAINING PACKAGES WITH RESISTANCE TRAINING

Days	Plyometric exercises	Resistance exercises
MONDAY	Warming up 1. Vertical jump 2. Medicine ball chest pass 3. Box jump 4. Hop (Single leg)	Warming up 1. Arm curl 2. Triceps extension 3. Bench press Cool down
WEDNESDAY	Warming up 1. Medicine ball over head pass 2. Medicine ball sit up throw 3. Hop (Single leg) 4. Burpee	Warming up 1. Lateral pull down 2. Military press 3. Leg press Cool down
FRIDAY	Warming up 1. Plyometric sit up 2. Front obstacle jump 3. Medicine ball over head throw 4. Burpee	Warming up 1. Squat 2. Leg curl 3. Heel raise Cool down

3.11.2 TRAINING PROGRAMME FOR GROUP I

(Plyometric training packages with Resistance training)

The subjects of Group I were involved with plyometric exercises after sufficient warm up for the first thirty minutes followed by resistance exercise for the remaining thirty minutes in a single session as stated in table III .The intensity for plyometric exercises began with 4 - 6 repetitions of 2 sets, and 1RM of 65% for resistance exercise with the same number of repetitions intervened with prescribed recovery periods. Thereafter the intensity was increased by 5% for every three weeks i.e. 70%, 75%, and 80% respectively at the beginning of fourth, seventh, and tenth weeks. The repetition of exercises has also been increased by considering the physiological adaptations of the body during the first six weeks of training .Thus the progression of load technique was applied to maintain overload principle in the training programme

TABLE – IV

TRAINING SCHEDULE FOR PLYOMETRIC TRAINING PACKAGES WITHOUT RESISTANCE TRAINING EXPERIMENTAL GROUP - II

Weeks	Plyometric exercises		Recovery	
	Repetitions	Set (Nos.)	Repetition	Set
1-3	8-9	3	90 Sec.	3 Min.
4-6	10-11	3	90 Sec.	3 Min.
7-9	12-13	3	90 Sec.	3 Min.
10-12	14-15	3	90 Sec.	3 Min.

EXERCISE PROGRAMME FOR PLYOMETRIC TRAINING PACKAGES

Days	Plyometric exercises
MONDAY	Warming up 1. Vertical jump 2. Medicine ball chest pass 3. Box Jump 4. Hop (Single leg) Cool Down
WEDNESDAY	Warming up 1. Medicine ball over head pass 2. Medicine ball sit up throw 3. Hop (Single leg) 4. Burpee Cool down
FRIDAY	Warming up 1. Plyometric sit up 2. Front obstacle jump 3. Medicine ball over head throw 4. Burpee Cool down

3.11.3 TRAINING PROGRAMME FOR EXPERIMENTAL GROUP II

(Plyometric training without Resistance training)

After adequate warm up, the subjects of Group II were involved in selected plyometric exercises with prescribed repetitions and sets intervened recovery periods as shown in the table IV. The load progression technique was adopted in the training to maintain overload principle.

3.12 CONTROL GROUP

The control group was engaged in practicing the hockey skills in a traditional way without any special coaching or training.

3.13 DESCRIPTION OF PLYOMETRIC EXERCISES

3.13.1 VERTICAL JUMP

Execution:

A vertical jump or vertical leap is the act of raising one's center of gravity higher in the vertical plane solely with the use of one's own muscles; it is a measure of how high an individual or athlete can elevate off the ground (jump) from a standstill.

3.13.2 MEDICINE BALL CHEST PASS

Execution:

- Grab a medicine ball and stand about 3 feet in front of a concrete wall, with feet shoulder width apart.
- Knees should be slightly bent and hold the ball with both hands at chest level.
- Throw the ball at the wall with both hands, as if throwing a chest pass in basketball.
- Straighten your arms forcefully and completely as you throw the ball.
- Catch the ball as it rebounds off the wall, and repeat.

3.13.3 BOX JUMP

Execution

- Stand in front of a secured box or platform.
- Jump onto box and immediately back down to same position and repeat the movement as for as possible (***www.exrx.net).***

3.13.4 MEDICINE BALL OVER HEAD PASS

Execution

- Pair a partner and stand 6-8 feet from your partner.
- Hold the medicine ball above the head and do an overhead pass to your partner.
- While catching the medicine ball, always be prepared with a slight bend in the knees and repeat the procedure.

3.13.5 MEDICINE BALL SIT UP THROW

Preparation:

Sit on floor with knees bent facing partner and holding the medicine ball with both hands. Feet can be secured under weighted or anchored structure.

Execution:

First the subject lies back with ball overhead and taps the ball to floor while sitting up and immediately throws the ball to partner by over head pass and the partner catches the ball slightly above and in front of head and repeat the steps. Continue to volley the ball back and forth by gradually increasing the speed throughout set ***(www.exrx.net)***

3.13.6 HOPS (SINGLE LEG)

Execution:

- Stand on one leg
- Push off with the leg you are standing on and jump forward, landing on the same leg
- Use a forceful swing of the opposite leg to increase the length of the jump but aim primarily for height off each jump

- Land on the ball of the foot
- Keep the foot touch down time to the shortest time possible
- Try to keep the body vertical and straight and perform on both legs
- Jump over 30 to 40 metres distance.
- Allow a full recovery between each set

3.13.7 PLYOMETRIC SIT-UP

Preparation:

Sit on floor facing wall with knees bent, holds the medicine ball with both hands.

Execution:

Hold the ball overhead and tap the ball to floor. Immediately throw the ball to wall from over head. Ball rebounds off from the ball and catches in front of the head. Continue to volley the ball against the wall as possible.

3.13.8 FRONT OBSTACLE JUMP

Preparation:

Stand facing collapsible hurdles or barriers (12" to 36", 30 to 90 cm) set up in a row.

Execution:

Squat down and jump over hurdle with feet together using a double arm swing. Upon landing, immediately jump over next hurdle.

Use both upper and lower body movement's landings closely. Perform two or more jumps in succession ***(www.exrx.net).***

3.13.9 MEDICINE BALL OVER HEAD THROW

Preparation:

Stand facing partner throwing distance apart with one foot forward. First girl raises medicine ball above the head with arms bent. Partner has arm in front ready to receive ball.

Execution:

First the subject throws medicine ball just above partner's head forcefully extending both arms forward. Partner catches ball with both hands, recoils the ball behind head, and immediately throws the ball back to first girl who catches ball and repeats volley and Continue to throw the ball back and forth.

3.13.10 BURPEE

Preparation:

Stand upright with arms to sides.

Execution:

Bend over and squat down. Place hands on floor, slightly wider than shoulder width. While holding upper body in place, kick legs back and body straight, plank position keeping the upper body in place, pull the legs forward under the body returning feet in original position. Rise up to original standing position and intensity can be increased by executing exercise faster ***(www.exrx.net).***

3.14 RESISTANCE EXERCISES

3.14.1 ARM CURL

Preparation:

Hold two dumbbells to sides, palms facing in, arms straight.

Execution:

With elbows two sides, raise one dumbbell and rotate forearm until forearm is vertical and palm faces shoulder. Lower to original position and repeat with opposite arm. Continue to alternate between sides.

3.14.2 TRICEPS EXTENSION

Preparation:

Hold one dumbbell overhead with both hands under inner plate (heart shaped grip).

Execution:

With elbows overhead, lower forearm behind upper arm by flexing elbows. Flex wrists at bottom to avoid hitting dumbbell on back of neck. Raise dumbbell overhead by extending elbows while hyper extending wrists. Return and repeat.

3.14.3 BENCH PRESS

Preparation:

Sit down on bench with dumbbells resting on lower thigh. Kick weights to shoulder and lie back. Position dumbbells to sides of chest with bent arm under each dumbbell.

Execution:

Press dumbbells up with elbows to sides until arms are extended. Lower weight to sides of upper chest until slight stretch is felt in chest or shoulder and repeat the movement .Dumbbells should follow slight arch pattern, above upper arm between elbow and chest at bottom, traveling inward over each shoulder at top. ***(www.exrx.net).***

3.14.4 LAT PULL DOWN

The latissimus dorsi on either side of the middle to upper back is the main target muscle group for this exercise. These muscles are called 'the lats' for short. The "Lat" pull down is an exercise mainly for the back although the shoulders and arms get some workout.

Body Position

- Sit on the seat and adjust the thigh pads so that the quads above the knees sit comfortably under the support. This is to prevent the knees rising up while exerting effort to pull the bar down.
- Grasp the cable bar with a wide overhand grip, knuckles up and sit on the seat with thighs under the support. Alternative grips, narrow and underhand, are possible, but use the wide grip when starting out.

3.14.5 MILITARY PRESS

Preparation:

Grasp barbell from rack or clean barbell from floor with overhand grip, slightly wider than shoulder width and position the bar in front of neck.

Execution:

Press bar upward until arms are extended overhead. Lower to front of neck and repeat.

3.14.6 LEG PRESS

Preparation:

Sit on machine with back on padded support. Place feet on platform and extend hips and knees. Release dock lever and grasp handles to sides.

Execution:

Lower the leg by flexing hips and knees until knees are just short of complete flexion. Return by extending knees and hips and repeat the movement.

3.14.7 SQUAT

Preparation:

From rack with barbell at upper chest height, position bar high on back of shoulders and grasp barbell to sides. Dismount bar from rack and stand with shoulder width stance.

Execution:

Bend knees forward while allowing hips to bend back behind, keeping back straight and knees pointed same direction as feet and descend until thighs are just parallel to floor. Extend knees and hips until legs are straight. Return and repeat.

3.14.8 LEG CURL

Preparation:

Facing bench, stand between bench and lever pads. Lie prone on bench with knees just beyond edge of bench and lower legs under lever pads and grasp handles.

Execution:

Raise lever pad to back of thighs by flexing knees. Lower lever pads until knees are straight and repeat the movement. Keep torso on bench to reduce hyperextension of lower back.

3.14.9 HEEL RAISE

Preparation:

Position toes and balls of feet on calf block with arches and heels extending off. Place hand on support for balance.

Execution:

Raise heels by extending ankles as high as possible. Lower heels by bending ankles until calves are stretched and repeat the movement. Keep knees straight throughout exercise or bend knees slightly only during stretch. Quadriceps serves as synergists muscle if knees are bent slightly during stretch ***(www.exrx.net).***

3.15 ADMINISTRATION OF TESTS

The administration of test of all criterion measures used in this study is briefly detailed below.

3.15.1 BIO-MOTOR VARIABLES

3.15.1.1 SPEED (50 METERS DASH)

Purpose:

To assess Speed

Equipments Used:

Measuring tape, starting clapper and digital stopwatch

Procedure:

The standing start was adopted. The time from the 'clap' to the runner crossing the finish line was taken as the test score. The fractions were rounded off to the next longer one tenth of a second. Two trials were given with sufficient rest in between and better of the two trials was recorded.

Scoring:

Elapsed time was recorded in 1/10 th second.

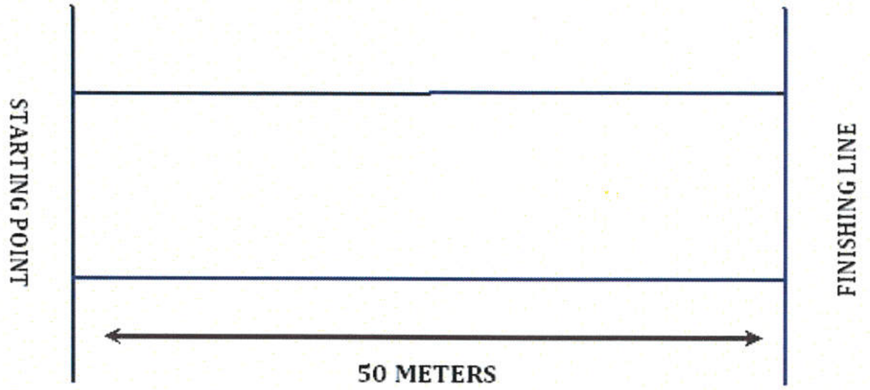

FIGURE : 1

50 METERS DASH

3.15.1.2 AGILITY - ILLINOIS AGILITY TEST (Getchell, 1979)

Purpose:

To test running agility

Equipment required:

Flat non-slip surface, marking cones, stopwatch and measuring tape

Procedure:

The length and width of the course was 10 meters x 5 meters (distance between the start and finish points). Four cones were used to mark the start, finish and the two turning points. Another four cones were placed down the center an equal distance apart. Each cone in the centre was spaced 3.3 meters apart. Subject was asked to lie on her front (head to the start line) and hands by her shoulders. On the command 'Go' the stopwatch was started, at the same time the subject got up as quickly as possible and ran around the course in the direction indicated, without knocking the cones over, to the finish line, at which the timing was stopped.

Scoring:

Timing is recorded in 1/100th of a second.

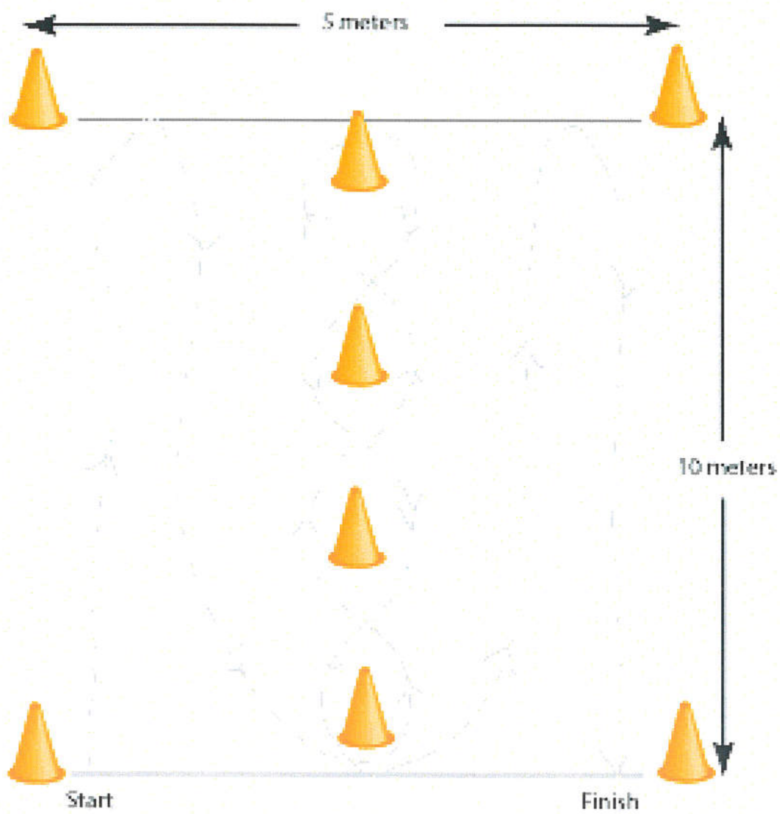

FIGURE : 2

ILLINOIS AGILITY TEST

3.15.1.3 CARDIO RESPIRATORY ENDURANCE

(Cooper's Twelve Minute Run/Walk Test)

Purpose:

To measure cardio respiratory endurance

Equipment:

400 meters track with marking and stopwatch.

Procedure:

The test was administrated on a standard 400 meters track in which the lanes were free of obstacles. The cones were placed at 50 meters interval in the track to measure the distance easily. The subjects were instructed to complete as many laps on the track as possible during the 12 minutes period. On the starting signal the subjects were asked to run interspersed with walking/jogging on the lane. The administrator counted the laps of an individual completed during the 12 minutes test period. While calling out the time lapsed at 3rd, 6th, 9th minutes besides encouraging the subjects verbally. At the end of 12th minute period the administrator gave a whistle to stop and counted the cones to determine the fraction of the last lap completed by each subjects. This distance was added to the distance of number of laps completed, to give the total distance covered during the test.

Scoring:

The distance covered by the subjects for 12 minutes was recorded in meters.

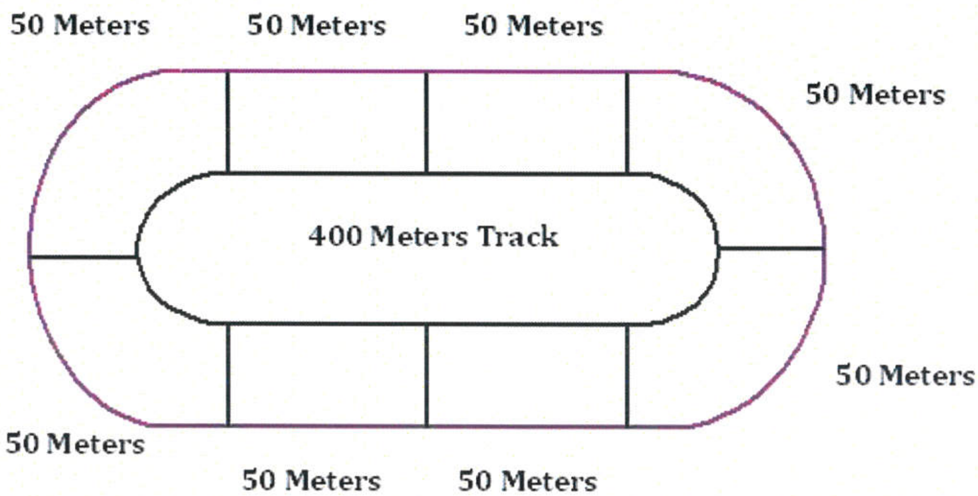

FIGURE : 3

COOPER'S TWELVE MINUTE RUN/WALK TEST

3.15.2 PHYSIOLOGICAL VARIABLES

3.15.2.1 BREATH HOLDING TIME (Manual Method)

Purpose:

To measure the ability of the subject to hold the breathe for longer time

Equipment and materials:

Stop watch with calibration of 1/10th of a second, nose clip, pencil and score sheet.

Procedure:

The test consisted of voluntarily forced inhalation and holding breathe as long as possible without inhaling or exhaling after holding the breath. The subject was asked to sit on the chair with a nose clip clamped over the nostrils and voluntarily forced maximal inhalation through her mouth. The stopwatch was started, once the maximum inhalation was reached by the subject raising the index finger. It was stopped as soon as the subject started to exhale. To prevent exhalation or inhalation through mouth during the recording time the subject was instructed to couple her lips tightly. The investigator carefully monitored on the subject's mouth to avoid exhalation or inhalation through the mouth. Two trials were permitted for each subject and the best time was recorded.

Scoring:

The better of the two breath holding time was recorded in nearest one tenth of a second.

3.15.2.2 RESTING PULSE RATE (Radial Pulse Test)

Purpose:

The purpose of the test was to measure the heart beat per minute.

Equipment used:

Stopwatch with calibration of $1/10^{th}$ of a second was used for the test.

Procedure:

Subject was asked to relax before taking the pulse rate and the pulse rate was recorded in sitting position in the morning. In order to record the pulse rate the finger tips were placed on the radial artery at the thumb side of the wrist about an inch from the base of the thumb. The beat felt at the time was considered as the signal to start counting and the number of pulse were counted for one minute.

Scoring:

The number of pulse beats per minute was recorded.

3.15.2.3 RESPIRATORY RATE (Manual Method)

Objective:

To measure the subject's number of breaths per minute.

Equipment:

Stop watch and Long Bench.

Procedure:

The subject was placed in a comfortable position on the bench. Discomfort could cause the subject to breathe more rapidly. Therefore, the subject's arm was placed in a relaxed position across the abdomen or lower chest, or the hand directly over the subject's upper abdomen. Both the subject's and the researcher's hands rise and fall during the respiratory cycle. This made sure that the count began with a normal respiratory cycle. The complete respiratory cycle consisted of one inspiration and expiration. Once a cycle was observed, start counting the rate of respirations, meanwhile the watch's second hand was also monitored.

Scoring:

Timing of the respirations began with a count of 1. The number of respirations in 30 seconds were counted and then multiplied by 2. Thus the respiratory rate was recorded for one minute.

3.15.3 SKILL PERFORMANCE FACTORS

3.15.3.1 DRIBBLING (SCHMITHALS FRENCH FIELD HOCKEY TEST)

Purpose:

To measure the ability in dribble and control the ball

Equipment:

Hockey sticks and balls, stop watch, hockey field, and score sheet.

Procedure:

The player began the test by standing behind the starting line to her left of the foul line. She was holding a hockey stick and ball on the starting line anywhere to the left of the foul line. She dribbled to the restraining line, keeping the ball to the left of the foul line, sending the ball to the right of the standard while she crossed the left, regained control of the ball, and dribbled it around the second standard going to the right. She then drove the ball back around the starting line and followed it up to hit it again if more distance needed.

Scoring:

Time was taken from "go" signal until the ball crossed the starting line. Six trials were recorded and then averaged for the final score. **(Sodhi et al., 1995)**

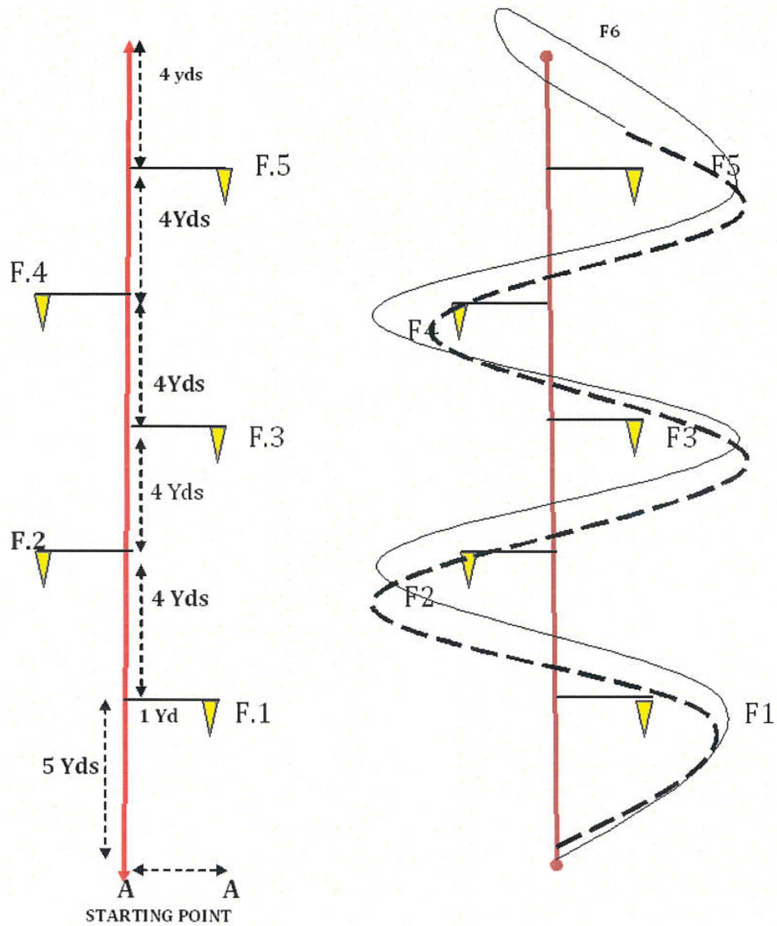

FIGURE : 4

DRIBBLING

3.15.3.2 PUSHING

Purpose:

To measure pushing ability in hockey

Ground markings:

A square of 2 yards was marked on the pitch. Four feet away one-yard long line was marked parallel to line AB. Six balls were placed on this one-yard line. Three scoring gates 2 yards wide were marked 20 yards away from the starting point 'B'. The first gate was made parallel to the line CD, the 3rd gate was drawn parallel to the line AD and the 2nd gate was kept at 45 degree in between the two gates.

Procedure:

To commence the test, the player standing on AB line pull the ball from the one yard line inside the squares, by extending the stick or taking one step outside and pushed it through gate one. She pushed the next ball through gate 2 and so on performing in the same sequence until she pushed all the 6 balls or till the time of 25 seconds expired.

Scoring:

She scored 2 points if the ball passed through the gate. The maximum score was 12 points ***(Sodhi et al., 1995).***

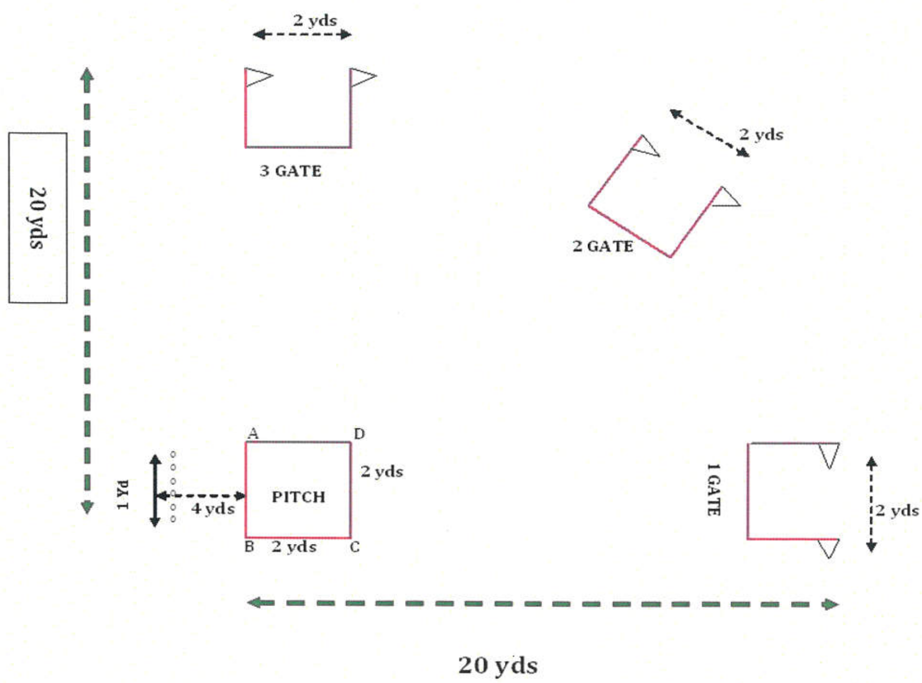

FIGURE : 5

PUSHING

3.15.3.3 HITTING

Purpose:

To assess the hitting ability in hockey

Ground markings:

Six balls were placed in pairs at 45^0, 90^0 and 135^0 on one foot line of a semi circle of five yards radius, whose straight line AB was drawn parallel and opposite to the goal line thirty yards, inside the ground. Two flags were placed on the goal line, one yard inside from each goal post.

Procedure:

The players starting from mid point (C) of semi circle straight line had to take first ball placed at 135 degree and hit the ball while in motion from the semi circle for a goal. She took the next ball from 90-degree line and hit in the same way. The third ball was taken from 45 - degree spot and a similar hit is repeated till all the 6 balls were finally hit while keeping the same sequence within a span of 25 sec.

Scoring:

Two points were awarded if the ball crossed the goal line in between the 2 flags. One point was awarded if the ball passed between the flag and goal post on either side. No point was given if the ball hit the goal post and rebounds off in or outside the ground. One point was given when the ball strike the flag post or after hitting the goal post crossed over the goal line. The maximum marks that a subject could score were 12.

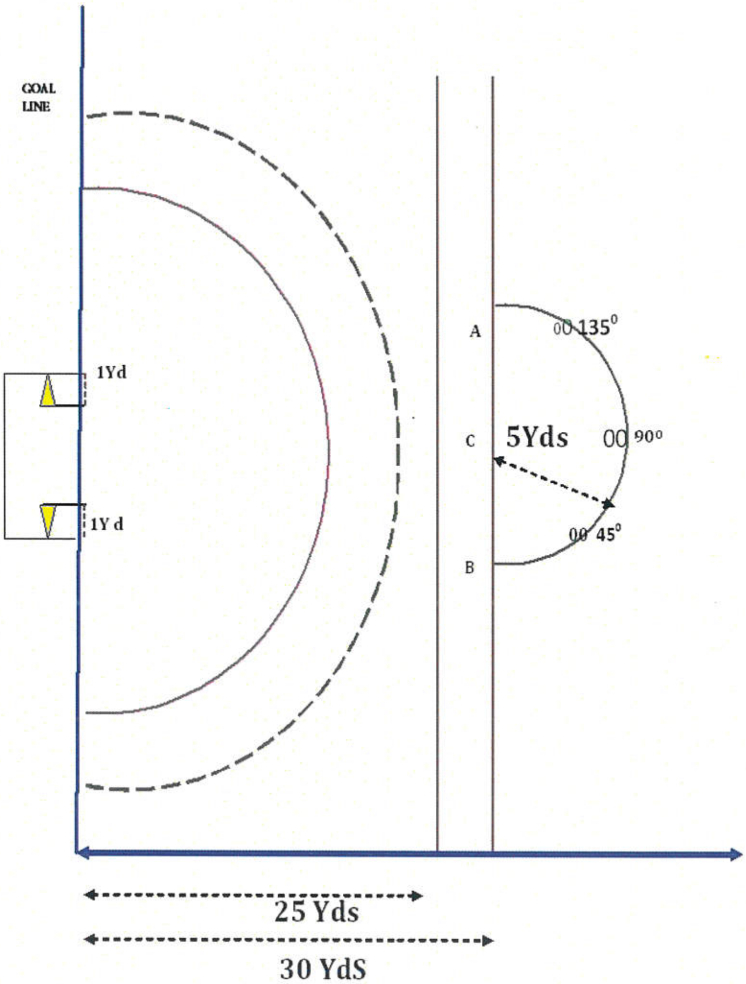

FIGURE : 6

HITTING

3.16 COLLECTION OF THE DATA

The data on speed was assessed by 50 meters dash, agility was assessed by Illinois agility test, cardio respiratory endurance by cooper's 12 minutes run/walk, breath holding time was estimated by the time of holding the breath, resting pulse rate and respiratory rate by manual method, hockey skill performance factors such as dribbling, pushing and hitting was assessed by standard field hockey tests. Pre test data were collected before the training programme and post test data were collected immediately after the training period. In all the cases, the data were collected for two consecutive days.

3.17 STATISTICAL TECHNIQUE

The data collected from all the subjects were statistically examined for significant improvement by dependent 't' test. The subjects selected for this study was assigned into three groups of fifteen each. No attempt was made to equate the groups in any manner. Hence, to make adjustments for difference in the initial means and to test the adjusted post test means for significant differences if any, the analysis of covariance (ANCOVA) was used. Scheffe's test was followed as a post hoc test to determine which of the paired means difference was significant. In all the cases 0.05 level was fixed as the level of significance to test the hypotheses.

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER – IV

RESULTS AND DISCUSSION

The analysis of the data collected with regard to the study has been presented in this chapter. The purpose of the study was to find out the influence of plyometric training packages with and without resistance training on selected bio-motor, physiological variables and skill performance factors among women hockey players. The experimental design used in this study was pre - post test random group design involving forty five women hockey players who had participated at Intercollegiate tournaments of Periyar University representing from the affiliated colleges of Periyar university limits during the academic year 2012-13 were randomly selected as subjects.

The selected subjects were randomly assigned into two experimental groups and a control group of fifteen (n = 15) each. The age of the subjects was range from 18 to 21 years. Experimental group I was subjected to plyometric training packages with resistance training and Experimental group II was involved with plyometric training packages without resistance training for three alternate days in a week for duration of twelve weeks and the third group acted as control group.

The data collected from three groups before and after the experimental period were statistically analyzed to find out the significant improvement by using dependent 't' test. No attempt was made to equate the groups in any manner. Hence, to make adjustments for difference in the initial means and to test the adjusted post test means for significant differences among the groups, the analysis of covariance (ANCOVA) was used. In all cases 0.05 level of confidence was fixed to test the significance.

4.1 TEST OF SIGNIFICANCE

This is the essential part of the thesis in achieving the conclusion by examining the hypothesis. The procedure of testing the hypothesis was either by accepting or rejecting the same in accordance with the results obtained with respect to the level of confidence.

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

4.2 COMPUTATION OF ANALYSIS OF COVARIENCE AND POST HOC TEST

4.2.1 RESULTS ON SPEED

The means and dependent 't' values on speed of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control groups have been analyzed and the results are presented in Table V.

TABLE – V

SUMMARY OF MEAN STANDARD DEVIATION AND DEPENDENT 't' TEST FOR THE PRE, POST AND ADJUSTED POST TESTS ON SPEED OF EXPERIMENTAL AND CONTROL GROUPS

(Score in Seconds)

Test		Plyometric training packages with resistance training (Group-I)	Plyometric training packages without resistance training (Group-II)	Control group
Pre Test	Mean	8.90	8.91	8.85
	SD	0.36	0.34	0.39
Post Test	Mean	8.31	8.39	8.87
	SD	0.34	0.45	0.40
Adjusted Post Test	Mean	8.30	8.36	8.90
't' Test		4.60*	3.61*	0.09

**Significant at .05 level.*

The table value required for 0.05 level of significance with df 14 is 1.761.

Table V shows the pre-test mean values of speed of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control groups are 8.90, 8.91 and 8.85 respectively; the post-test mean values are 8.31, 8.39 and 8.87 respectively; and the adjusted post-test mean values are 8.30, 8.36 and 8.90 respectively. The obtained dependent t- values between the pre and post test means on speed of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control groups are 4.60, 3.61 and 0.09 respectively. The table value required for significant difference with df 14 at 0.05 level is 1.761.

Since the obtained ‘t’ values of plyometric training packages with resistance training (Group-I) and plyometric training packages without resistance training (Group-II) are greater than the table value. This implies that plyometric training packages with resistance training (Group-I) and plyometric training packages without resistance training (Group-II) have significantly improved the performance of speed.

The analysis of covariance on speed of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control groups have been analyzed and presented in Table VI.

TABLE – VI

ANALYSIS OF COVARIANCE ON SPEED BETWEEN EXPERIMENTAL GROUPS

	Source of variance	Sum of square	Df	Mean squares	F-Ratio
Pre Test	Between	0.029	2	0.02	0.11
	Within	5.65	42	0.13	
Post Test	Between	2.71	2	1.35	8.53*
	Within	6.67	42	0.16	
Adjusted Post Test	Between	3.22	2	1.61	37.97*
	Within	1.74	41	0.04	

***Significant at 0.05 level of confidence.**

(The table value required for significance at 0.05 with df 2 and 42 and 2 and 41 are 3.22 and 3.21 respectively)

Table VI shows that the obtained F- value of 0.11 for pre test mean of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control groups on speed is less than the required table value of 3.22 for significance with df 2 and 42 at 0.05 level of confidence.

The obtained F- value of 8.53 for post test mean of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control groups on speed is more than the required table value of 3.22 for significance with df 2 and 42 at 0.05 level of confidence.

The obtained F- value of 37.97 for adjusted post test mean of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control groups on speed is higher than the required table value of 3.21 for significance with df 2 and 41 at 0.05 level of confidence.

The above statistical analysis indicates, there is a significant improvement in speed after the training. Further to determine which of the paired means has significant improvements, Scheffe's post hoc test was applied and the results are presented in Table-VII.

TABLE – VII

SCHEFFE'S TEST FOR THE DIFFERENCES BETWEEN THE ADJUSTED POST-TEST MEANS ON SPEED

(Scores in seconds)

Adjusted post-test means				
Plyometric training packages with resistance training (Group-I)	**Plyometric training packages without resistance training (Group-II)**	**Control group**	**Mean difference**	**Confidence interval**
8.30	8.36		0.06	0.12
8.30		8.90	0.60*	0.12
	8.36	8.90	0.54*	0.12

** Significant at 0.05 level of confidence.*

Table-VII shows the significant differences between the adjusted post-test means of plyometric training packages with resistance training group and control group, plyometric training packages without resistance training group and control group are, .60 and 0.54. As the confidence interval required to be significant at 0.05 is 0.12 and the obtained values are greater than the required value, it is observed that the significant difference is found to be existed. However, there is no significant difference found between the adjusted means of plyometric training packages with resistance training and plyometric training packages without resistance training groups as the difference between the mean value 0.06 is less than the confidence interval of 0.12.

The pre test and post test mean values of plyometric training packages with resistance training, plyometric training packages without resistance training and control groups on speed are graphically represented in figure -1.

The adjusted post test mean values of speed are represented through bar diagram for better understanding of the results of the study in figure -2.

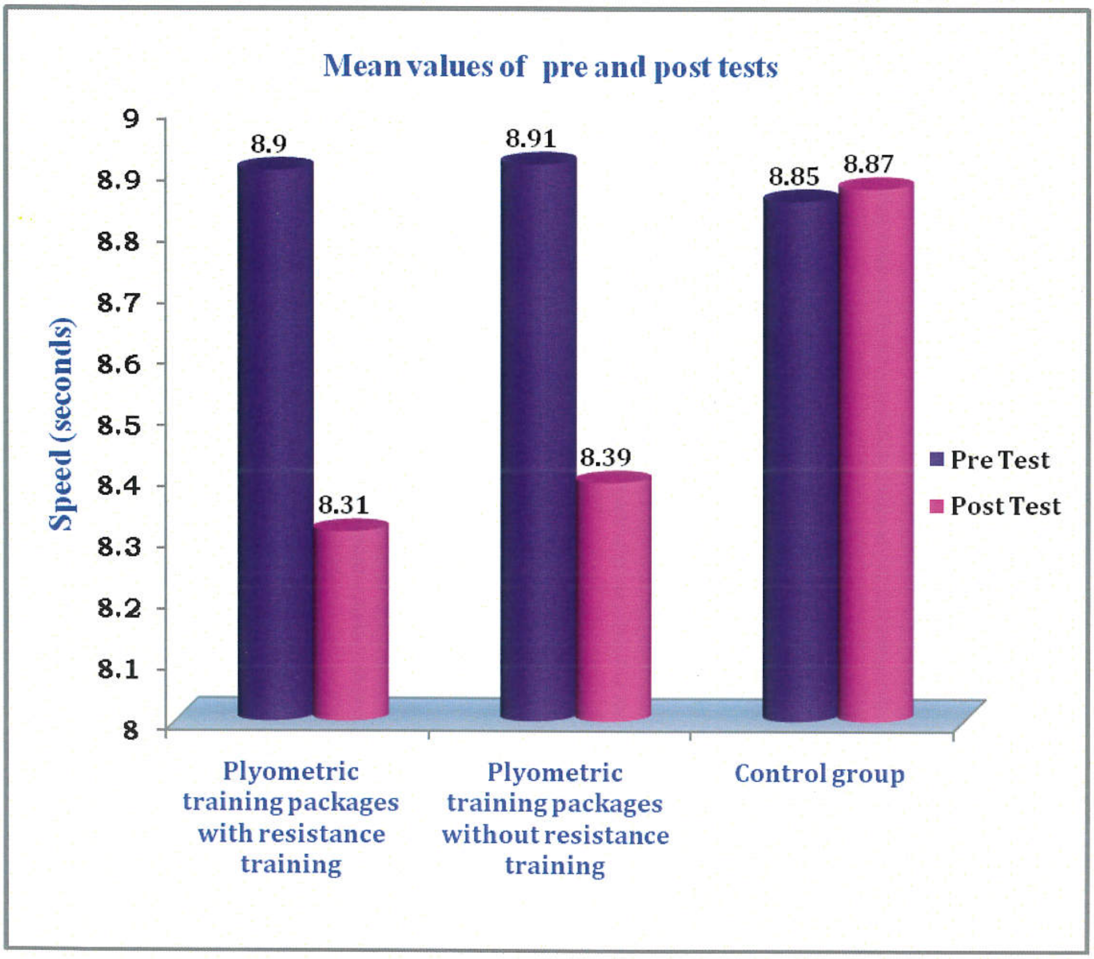

FIGURE: 7

Bar Diagram Showing the Pre and Post Test Mean Values of Plyometric Training Packages with Resistance Training (Group-I), Plyometric Training Packages without Resistance Training (Group-II)) and Control Groups on Speed

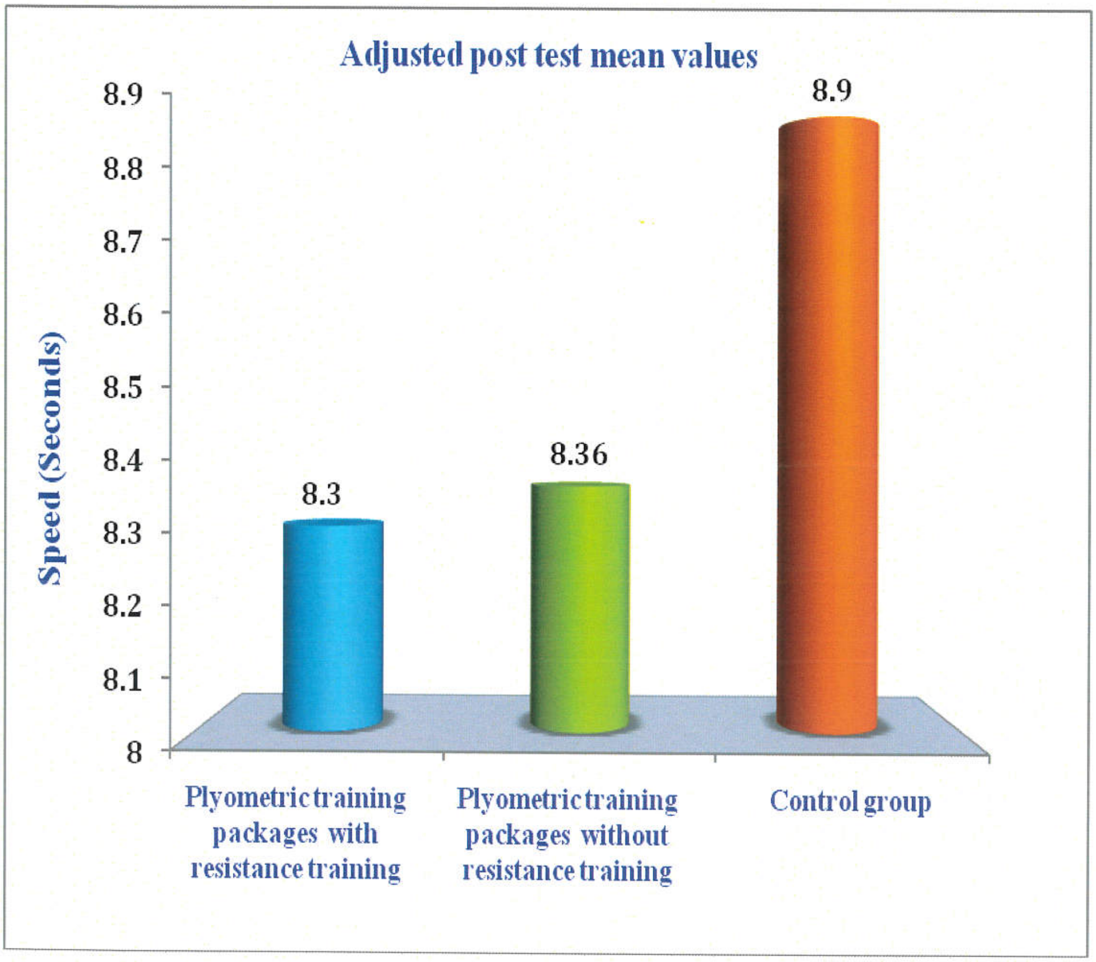

FIGURE: 8

Bar Diagram Showing the Adjusted Post Test Mean Values of Plyometric Training Packages with Resistance Training (Group-I), Plyometric Training Packages without Resistance Training (Group-II) and Control Groups on Speed

4.2.2 DISCUSSIONS ON THE FINDINGS OF SPEED

The post hoc analysis of obtained ordered adjusted means proves that the significant differences are observed between plyometric training packages with resistance training group and control group, plyometric training packages without resistance training group and control group at 0.05 level of confidence. However, there is no significant difference is found between plyometric training packages with resistance training and plyometric training packages without resistance training groups

Further the post hoc analysis reveals, there is significant difference existed among the experimental groups in comparison to the control group. But significant difference is not observed between the training groups. Hence it is concluded that both plyometric training packages with resistance training group and plyometric training packages without resistance training group is equally better in increasing the speed of hockey players.

The findings of the present study are in agreement with the earlier studies of the following researchers:

Devaraju (2014) stated that the plyometric training of six weeks had significant impact on selected physical fitness variables i.e., muscular endurance and speed of ball badminton players.

Gnaneshwar and Gopinath (2013) found that plyometric training, isotonic and combination of isotonic and plyometric training improved the speed and muscular endurance of male students.

Rajesh Kumar & Prabhakar Rao (2013) observed that due to plyometric exercises there was a significant improvement in the performance ability and speed among long jumpers.

Singh and Singh (2013) found combination of both vertical and horizontal depth jumping, with a slightly larger emphasis on horizontal plyometric training, could aid sprinters' performance.

Nageswaran (2014) found that there was a significant improvement existed due to the administration of resistance band training on strength, speed and balance among inter collegiate kabaddi players.

Taheri et al. (2014) proved both plyometric and resistance training exercises increased agility and explosive power and reduced sprint time in football players.

Haghighi et al. (2013) showed that the time of sprint running test and dribbling improved after plyometric training and Resistance training.

4.2.3 RESULTS ON AGILITY

The means and dependent 't' values on agility of plyometric training packages with resistance training (group-I), plyometric training packages without resistance training (group-II) and control groups have been analyzed and the results are presented in Table VIII.

TABLE – VIII

SUMMARY OF MEAN STANDARD DEVIATION AND DEPENDENT 't' TEST FOR THE PRE, POST AND ADJUSTED POST TESTS ON AGILITY OF EXPERIMENTAL AND CONTROL GROUPS

(Score in Seconds)

Test		Plyometric training packages with resistance training (Group-I)	Plyometric training packages without resistance training (Group-II)	Control group
Pre Test	Mean	10.53	10.62	10.51
	SD	0.37	0.29	0.40
Post Test	Mean	9.87	10.13	10.52
	SD	0.42	0.23	0.40
Adjusted Post Test	Mean	9.89	10.08	10.55
't' Test		4.54*	5.17*	0.01

Significant at .05 level.

The table value required for 0.05 level of significance with df 14 is 1.761.

Table VIII shows the pre-test mean values of agility of plyometric training packages with resistance training (group-I), plyometric training packages without resistance training (group-II) and control group are 10.53, 10.62 and 10.51 respectively; the post-test mean values are 9.87,10.13 and 10.52 respectively; and the adjusted post-test mean values are 9.89, 10.08 and 10.55 respectively on agility. The obtained dependent t-values between the pre and post test means on agility of plyometric training packages with resistance training (group-I), plyometric training packages without resistance training (group-II) and control group are 4.54, 5.17 and 0.01 respectively. The table value required for significant difference with df 14 at 0.05 level is 1.761.

Since the obtained 't' values of plyometric training packages with resistance training (group-I) and plyometric training packages without resistance training (group-II) are greater than the table value. This implies that plyometric training packages with resistance training (group-I) and plyometric training packages without resistance training (group-II) have significantly improved the performance of agility.

The analysis of covariance on agility of plyometric training packages with resistance training (group-I), plyometric training packages without resistance training (group-II) and control groups have been analyzed and presented in Table IX

TABLE – IX

ANALYSIS OF COVARIANCE ON AGILITY BETWEEN EXPERIMENTAL GROUPS

Test	Source of variance	Sum of square	Df	Mean squares	F-Ratio
Pre Test	Between	0.10	2	0.05	0.40
	Within	5.42	42	0.13	
Post Test	Between	3.17	2	1.58	12.01*
	Within	5.54	42	0.13	
Adjusted Post Test	Between	3.49	2	1.74	36.58*
	Within	1.95	41	0.05	

Significant at 0.05 level of confidence.

(The table value required for significance at 0.05 with df 2 and 42 and 2 and 41 are 3.22 and 3.21 respectively)

Table IX shows that the obtained F- value of 0.40 for pre test mean of plyometric training packages with resistance training (group-I), plyometric training packages without resistance training (group-II) and control groups on agility is less than the required table value of 3.22 for significance with df 2 and 42 at 0.05 level of confidence.

The obtained F- value of 12.01 for post test mean of plyometric training packages with resistance training (group-I), plyometric training packages without resistance training (group-II) and control group on agility is more than the required table value of 3.22 for significance with df 2 and 42 at 0.05 level of confidence.

The obtained F- value of 36.58 for adjusted post test mean of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control group on agility is higher than the required table value of 3.21 for significance with df 2 and 41 at 0.05 level of confidence.

The above statistical analysis indicates, there is a significant improvement in agility after the training. Further to determine which of the paired means has significant improvements, Scheffe's post hoc test was applied and the results are presented in Table-X.

TABLE – X

SCHEFFE'S TEST FOR THE DIFFERENCES BETWEEN THE ADJUSTED POST-TEST MEANS ON AGILITY

(Score in Seconds)

Adjusted post-test means				
Plyometric training packages with resistance training (Group-I)	**Plyometric training packages without resistance training (Group-II)**	**Control group**	**Mean difference**	**Confidence interval**
9.89	10.08		0.19*	0.12
9.89		10.55	0.66*	0.12
	10.08	10.55	0.47*	0.12

** Significant at 0.05 level of confidence.*

Table X shows the significant differences between the adjusted post-test means of plyometric training packages with resistance training group and plyometric training packages without resistance training group, plyometric training packages with resistance training group and control group, plyometric training packages without resistance training group and control group are 0.19, 0.66 and 0.47. As the confidence interval required to be significant at 0.05 is 0.12 and the obtained values are greater than the required value, it is observed that the significant difference is found to be existed.

The pre test and post test mean values of plyometric training packages with resistance training, plyometric training packages without resistance training and control groups on agility are graphically represented in figure -3.

The adjusted post test mean values of agility are represented through bar diagram for better understanding of the results of the study in figure -4.

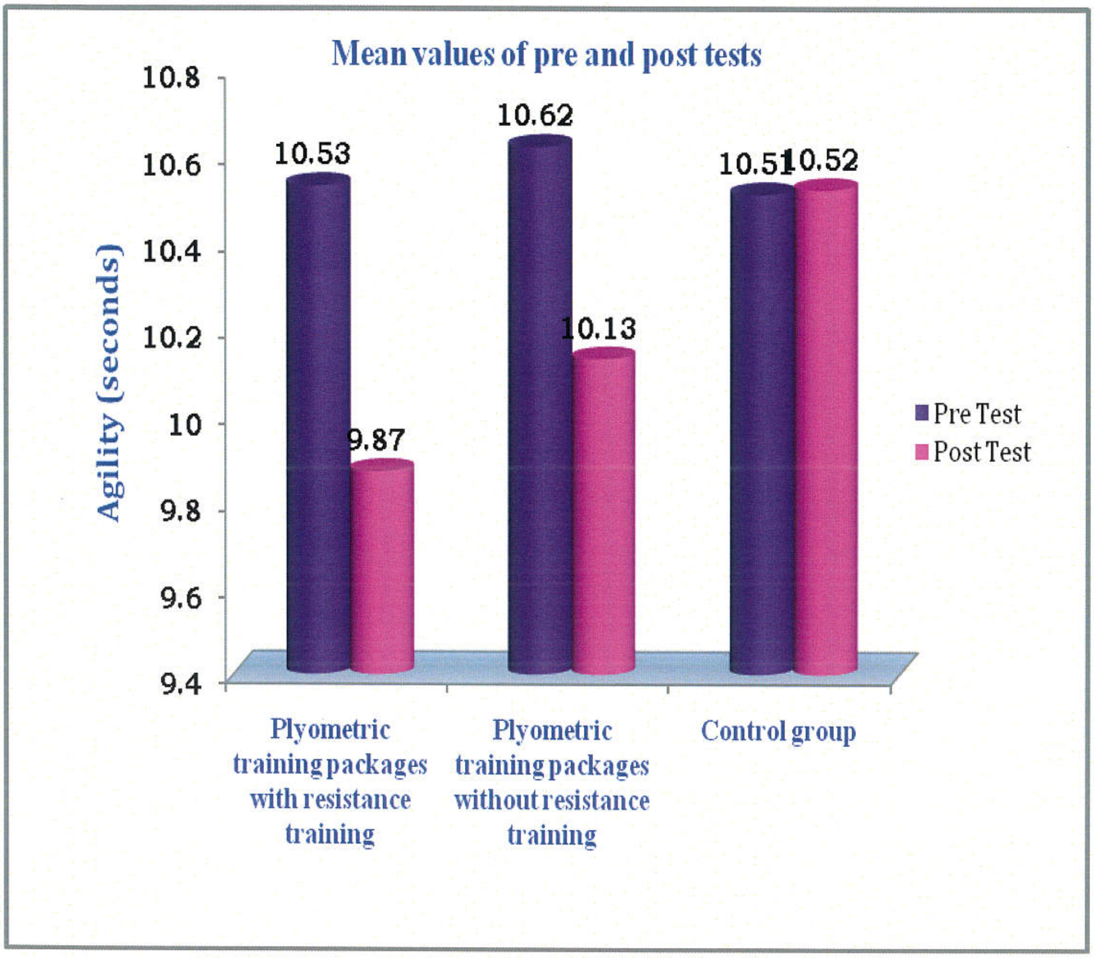

FIGURE: 9

Bar Diagram Showing the Pre and Post Test Mean Values of Plyometric Training Packages with Resistance Training (Group-I), Plyometric Training Packages without Resistance Training (Group-II) and Control Groups on Agility

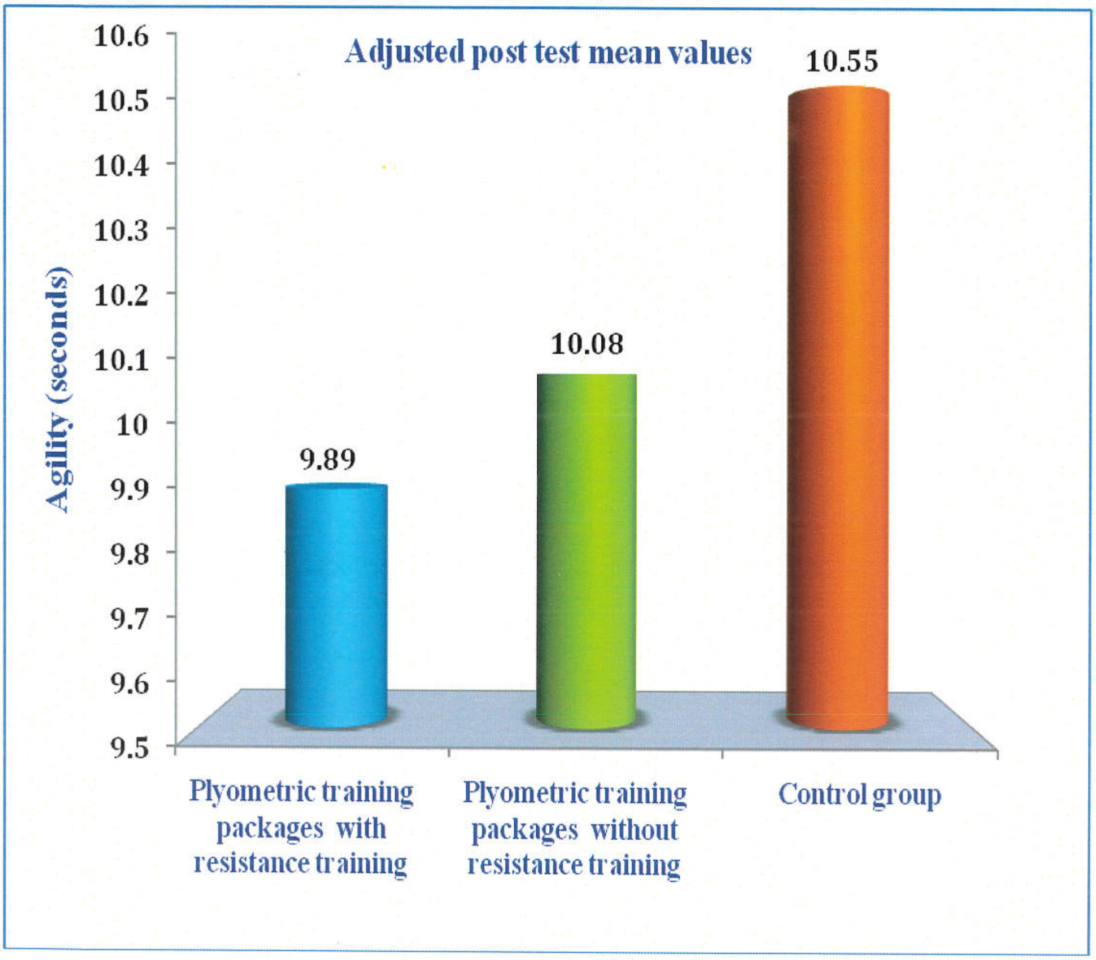

FIGURE: 10

Bar Diagram Showing the Adjusted Post Test Mean Values of Plyometric Training Packages with Resistance Training (Group-I), Plyometric Training Packages without Resistance Training (Group-II) and Control Groups on Agility

4.2.4 DISCUSSIONS ON THE FINDINGS OF AGILITY

The post hoc analysis of obtained ordered adjusted means proves that the significant differences are observed between plyometric training packages with resistance training group and plyometric training packages without resistance training group, plyometric training packages with resistance training group and control group, plyometric training packages without resistance training group and control group at 0.05 level of confidence .

The results of the study show that plyometric training packages with resistance training significantly differed on agility when compared to plyometric training packages without resistance training and control group. Plyometric training packages without resistance training group also significantly differed on agility when compared to plyometric training packages with resistance training and control groups. Hence it is concluded from the results, that both plyometric training packages with resistance training and plyometric training packages without resistance training are better method to improve the agility of hockey players. Among the training, plyometric training packages with resistance training is found to be much better than plyometric training packages without resistance training in improving the performance of agility of hockey players.

The findings of the present study are in agreement with the earlier studies of the following researchers:

Raj kumar (2013) showed that there was a significant effect of 6 week plyometric training group on agility of collegiate soccer players.

Taheri et al. (2014) proved both plyometric and resistance training exercises increased agility and explosive power and reduced sprint time in football players.

Vijayalakshmi and Jayabal (2013) reported that plyometric training with yogic practices improved agility and breath holding time.

Miller et al. (2006) showed that plyometric training can be an effective training technique to improve an athlete's agility.

4.2.5 RESULTS ON CARDIO RESPIRATORY ENDURANCE

The means and dependent 't' values on cardio respiratory endurance of plyometric training packages with resistance training (group-I), plyometric training packages without resistance training (group-II) and control groups have been analyzed and the results are presented in Table XI.

TABLE – XI

SUMMARY OF MEAN STANDARD DEVIATION AND DEPENDENT 't' TEST FOR THE PRE, POST AND ADJUSTED POST TESTS ON CARDIO RESPIRATORY ENDURANCE OF EXPERIMENTAL AND CONTROL GROUPS

(Score in Meters)

Test		Plyometric training packages with resistance training (Group-I)	Plyometric training packages without resistance training (Group-II)	Control group
Pre Test	Mean	1481.33	1468.00	1468.67
	SD	101.34	118.33	102.74
Post Test	Mean	1635.33	1857.33	1475.33
	SD	134.85	123.03	105.89
Adjusted Post Test	Mean	1627.46	1591.57	1478.97
't' Test		3.54*	2.71*	0.18

Significant at .05 level.

The table value required for 0.05 level of significance with df 14 is 1.761.

Table XII shows the pre-test mean values of cardio respiratory endurance plyometric training packages with resistance training (group-I), plyometric training packages without resistance training (group-II) and control group are 1481.33, 1468.00 and 1468.67 respectively; the post-test means values are 1635.33,1857.33 and 1475.33 respectively; and the adjusted post-test mean values are 1627.46, 1591.57 and 1478.97

respectively on cardio respiratory endurance. The obtained dependent t- values between the pre and post test means on cardio respiratory endurance of plyometric training packages with resistance training (group-I), plyometric training packages without resistance training (group-II) and control group are 3.54, 2.17 and 0.18 respectively. The table value required for significant difference with df 14 at 0.05 level is 1.761.

Since the obtained 't' values of plyometric training packages with resistance training (group-I) and plyometric training packages without resistance training (group-II) are greater than the table value. This implies that plyometric training packages with resistance training (group-I) and plyometric training packages without resistance training (group-II) have significantly improved the performance of cardio respiratory endurance.

The analysis of covariance on cardio respiratory endurance of plyometric training packages with resistance training (group-I), plyometric training packages without resistance training (group-II) and control groups have been analyzed and presented in Table XII

TABLE – XII

ANALYSIS OF COVARIANCE ON CARDIO RESPIRATORY ENDURANCE BETWEEN EXPERIMENTAL GROUPS

Test	Source of variance	Sum of square	Df	Mean squares	F-Ratio
Pre Test	Between	1693.33	2	846.67	0.07
	Within	487586.67	42	11609.21	
Post Test	Between	202240.00	2	101120.00	6.81*
	Within	623440.00	42	14843.81	
Adjusted Post Test	Between	179820.47	2	89910.23	16.69*
	Within	2.49	41	5388.13	

Significant at 0.05 level of confidence.

(The table value required for significance at 0.05 with df 2 and 42 and 2 and 41 are 3.22 and 3.21 respectively)

Table XII shows that the obtained F- value of 0.07 for pre test mean of plyometric training packages with resistance training (group-I), plyometric training packages without resistance training (group-II) and control groups on cardio respiratory endurance is less than the required table value of 3.22 for significance with df 2 and 42 at 0.05 level of confidence.

The obtained F- value of 6.81 for post test means of plyometric training packages with resistance training (group-I), plyometric training packages without resistance training (group-II) and control groups on cardio respiratory endurance is more than the required table value of 3.22 for significance with df 2 and 42 at 0.05 level of confidence.

The obtained F- value of 16.69 for adjusted post test means of plyometric training packages with resistance training (group-I), plyometric training packages without resistance training (group-II) and control groups on cardio respiratory endurance is higher than the required table value of 3.21 for significance with df 2 and 41 at 0.05 level of confidence.

The above statistical analysis indicates, there is a significant improvement in cardio respiratory endurance after the training. Further to determine which of the paired means has significant improvements, Scheffe's post hoc test was applied and the results are presented in Table-XIII.

TABLE - XIII

SCHEFFE'S TEST FOR THE DIFFERENCES BETWEEN THE ADJUSTED POST-TEST MEANS ON CARDIO RESPIRATORY ENDURANCE

(Score in Meters)

Adjusted post-test means				
Plyometric training packages with resistance training (Group-I)	**Plyometric training packages without resistance training (Group-II)**	**Control group**	**Mean difference**	**Confidence interval**
1627.46	1591.57		35.89	43.32
1627.46		1478.97	148.49*	43.32
	1591.57	1478.97	112.60*	43.32

** Significant at 0.05 level of confidence.*

Table X shows the significant differences between the adjusted post-test means of plyometric training packages with resistance training group and control group, plyometric training packages without resistance training group and control group are 148.49 and 112.60. As the confidence interval required to be significant at 0.05 is 43.32 and the obtained values are greater than the required value, it is observed that the significant difference is found to be existed. However, there is no significant difference found between the adjusted means of plyometric training packages with resistance training and plyometric training packages without resistance training groups as the difference between the mean value 35.89 is less than the confidence interval of 43.32.

The pre test and post test mean values of plyometric training packages with resistance training, plyometric training packages without resistance training and control groups on cardio respiratory endurance are graphically represented in figure -5.

The adjusted post test mean values of cardio respiratory endurance are represented through bar diagram for better understanding of the results of the study in figure -6.

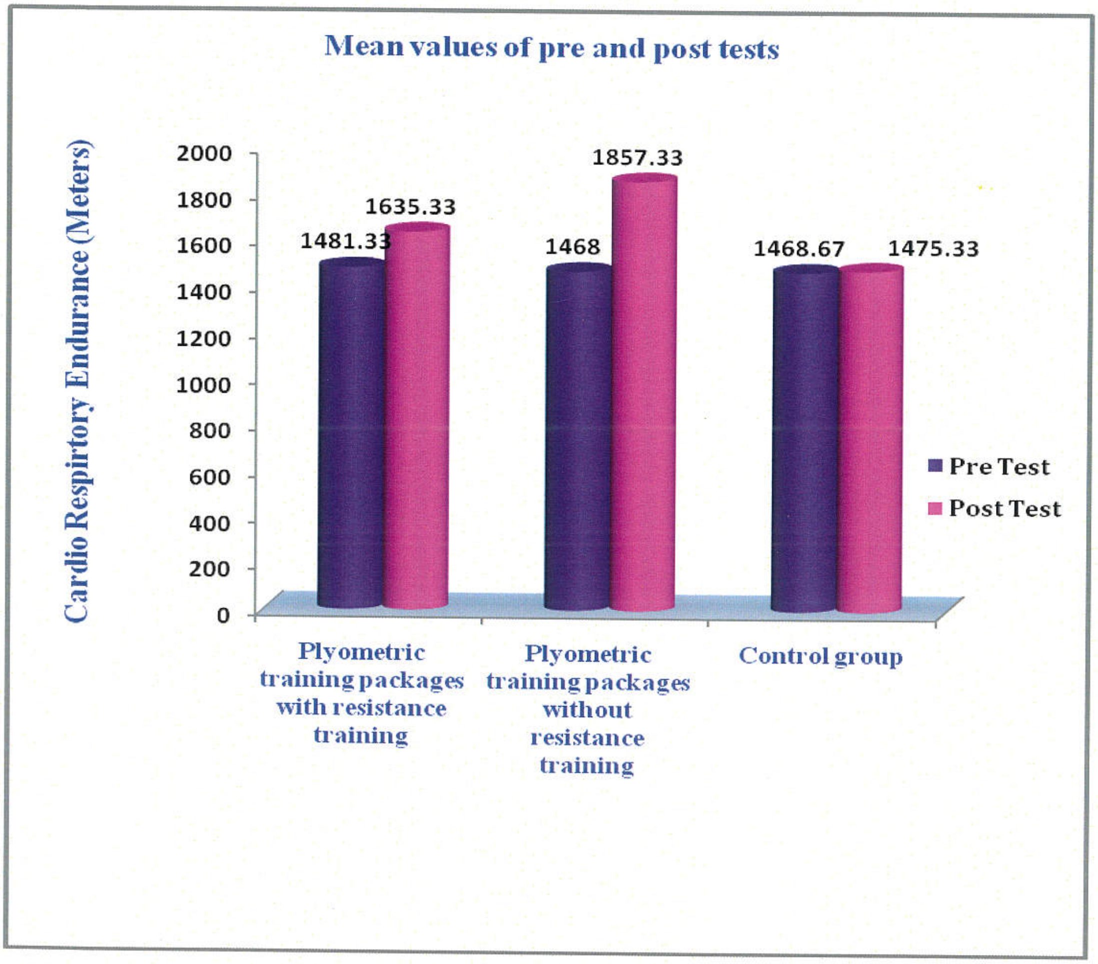

FIGURE: 11

Bar Diagram Showing the Pre and Post Test Mean Values of Plyometric Training Packages with Resistance Training (Group-I), Plyometric Training Packages without Resistance Training (Group-II) and Control Groups on Cardio Respiratory Endurance

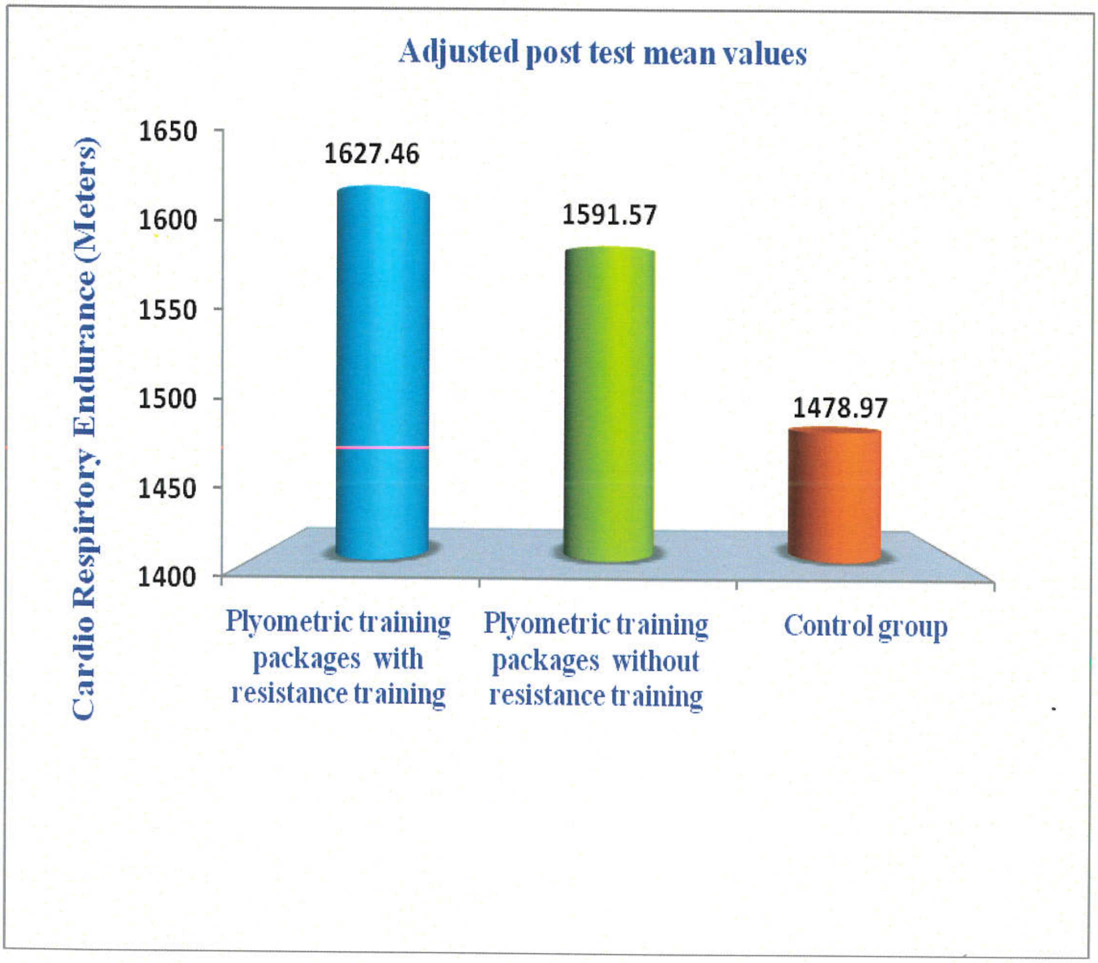

FIGURE: 12

Bar Diagram Showing the Adjusted Post Test Mean Values of Plyometric Training Packages with Resistance Training (Group-I), Plyometric Training Packages without Resistance Training (Group-II) and Control Groups on Cardio Respiratory Endurance

4.2.6 DISCUSSIONS ON THE FINDINGS OF CARDIO RESPIRATORY ENDURANCE:

The post hoc analysis of obtained ordered adjusted means proves that the significant differences are observed between plyometric training packages with resistance training group and control group, plyometric training packages without resistance training group and control group at 0.05 level of confidence. However, there is no significant difference is found between plyometric training packages with resistance training and plyometric training packages without resistance training groups.

Further the post hoc analysis reveals, there is significant difference existed among the experimental groups in comparison to the control group. But significant difference is not observed between the training groups. Hence it is concluded that both plyometric training packages with resistance training group and plyometric training packages without resistance training group is equally better in increasing the cardio respiratory endurance of hockey players.

The findings of the present study are in agreement with the earlier studies of the following researchers:

Jaipal and Sharma (2013) revealed that alternate low and high intensity resistance training (AIRT) enhanced significant improvement on cardiovascular efficiency.

Lakshmikrishnan and Sivakumar (2013) found after the weight training and plyometric training programme of 12 weeks, strength-endurance and leg strength.

Amrinder et al. (2014) suggested that short-term plyometric training on sand/non-rigid surface induces similar improvements in strength, endurance, balance and agility as on firm surface but induced significantly less muscle soreness.

Rajan and Reddy (2012) reported that Circuit training improve the endurance among University Hockey players of Andhra Pradesh.

4.2.7 RESULTS ON BREATH HOLDING TIME

The means and dependent ‘t’ values on breath holding time of plyometric training packages with resistance training (group-I), plyometric training packages without resistance training (group-II) and control groups have been analyzed and the results are presented in Table XIV

TABLE – XIV

SUMMARY OF MEAN STANDARD DEVIATION AND DEPENDENT 't' TEST FOR THE PRE, POST AND ADJUSTED POST TESTS ON BREATH HOLDING TIME OF EXPERIMENTAL AND CONTROL GROUPS

(Score in Seconds)

Test		Plyometric training packages with resistance training (Group-I)	Plyometric training packages without resistance training (Group-II)	Control group
Pre Test	Mean	29.40	29.47	30.07
	SD	2.64	2.62	2.58
Post Test	Mean	33.60	31.73	29.67
	SD	2.35	2.74	2.44
Adjusted Post Test	Mean	33.82	31.90	29.28
't' Test		4.60*	2.32*	0.44

Significant at .05 level.

The table value required for 0.05 level of significance with df 14 is 1.761.

Table XIV shows the pre-test mean values of breath holding time of plyometric training packages with resistance training (group-I), plyometric training packages without resistance training (group-II) and control groups are 29.40, 29.47 and 30.07 respectively; the post-test means values are 33.60, 31.73 and 29.67 respectively; and the adjusted post-test mean values are 33.82, 31.90 and 29.28 respectively. The obtained dependent t- values between the pre and post test means on breath holding time of plyometric training packages with resistance training (group-I), plyometric training packages without resistance training (group-II) and control group are 4.60, 2.32 and 0.44 respectively. The table value required for significant difference with df 14 at 0.05 level is 1.761.

TABLE – XV

ANALYSIS OF COVARIANCE ON BREATH HOLDING TIME BETWEEN EXPERIMENTAL GROUPS

Test	Source of variance	Sum of square	Df	Mean squares	F-Ratio
Pre Test	Between	4.04	2	2.02	0.30
	Within	286.27	42	6.82	
Post Test	Between	116.13	2	58.07	9.17*
	Within	265.87	42	6.33	
Adjusted Post Test	Between	153.86	2	76.93	110.16*
	Within	28.63	41	0.70	

**** Significant at 0.05 level of confidence.***

(The table value required for significance at 0.05 with df 2 and 42 and 2 and 41 are 3.22 and 3.21 respectively)

Table XV shows that the obtained F- value of 0.30 for pre test mean of plyometric training packages with resistance training (group-I), plyometric training packages without resistance training (group-II) and Control group on breath holding time is less than the required table value of 3.22 for significance with df 2 and 42 at 0.05 level of confidence.

The obtained F- value of 9.17 for post test mean of plyometric training packages with resistance training (group-I), plyometric training packages without resistance training (group-II) and control group on breath holding time is more than the required table value of 3.22 for significance with df 2 and 42 at 0.05 level of confidence.

The obtained F- value of 110.16 for adjusted post test mean of plyometric training packages with resistance training (group-I), plyometric training packages without resistance training (group-II) and control group on breath holding time is higher than the required table value of 3.21 for significance with df 2 and 41 at 0.05 level of confidence.

The above statistical analysis indicates that there is a significant improvement in breath holding time after the training. Further to determine which of the paired means has significant improvements, Scheffe's post hoc test was applied and the results are presented in Table-XVI.

TABLE – XVI

SCHEFFE'S TEST FOR THE DIFFERENCES BETWEEN THE ADJUSTED POST-TEST MEANS ON BREATH HOLDING TIME

(Score in Seconds)

Adjusted post-test means				
Plyometric training packages with resistance training (Group-I)	**Plyometric training packages without resistance training (Group-II)**	**Control group**	**Mean difference**	**Confidence interval**
33.82	31.90		1.92*	0.49
33.82		29.28	4.54*	0.49
	31.90	29.28	2.62*	0.49

Significant at 0.05 level of confidence.

Table X shows the significant differences between the adjusted post-test means of plyometric training packages with resistance training group and plyometric training packages without resistance training group, plyometric training packages with resistance training group and control group, plyometric training packages without resistance training group and control group are 1.92, 4.54 and 2.62. As the confidence interval required to be significant at 0.05 is 0.49 and the obtained values are greater than the required value, it is observed that the significant difference is found to be existed.

The pre test and post test mean values of plyometric training packages with resistance training, plyometric training packages without resistance training and control groups on breath holding time are graphically represented in figure -7.

The adjusted post test mean values of breath holding time are represented through bar diagram for better understanding of the results of the study in figure -8.

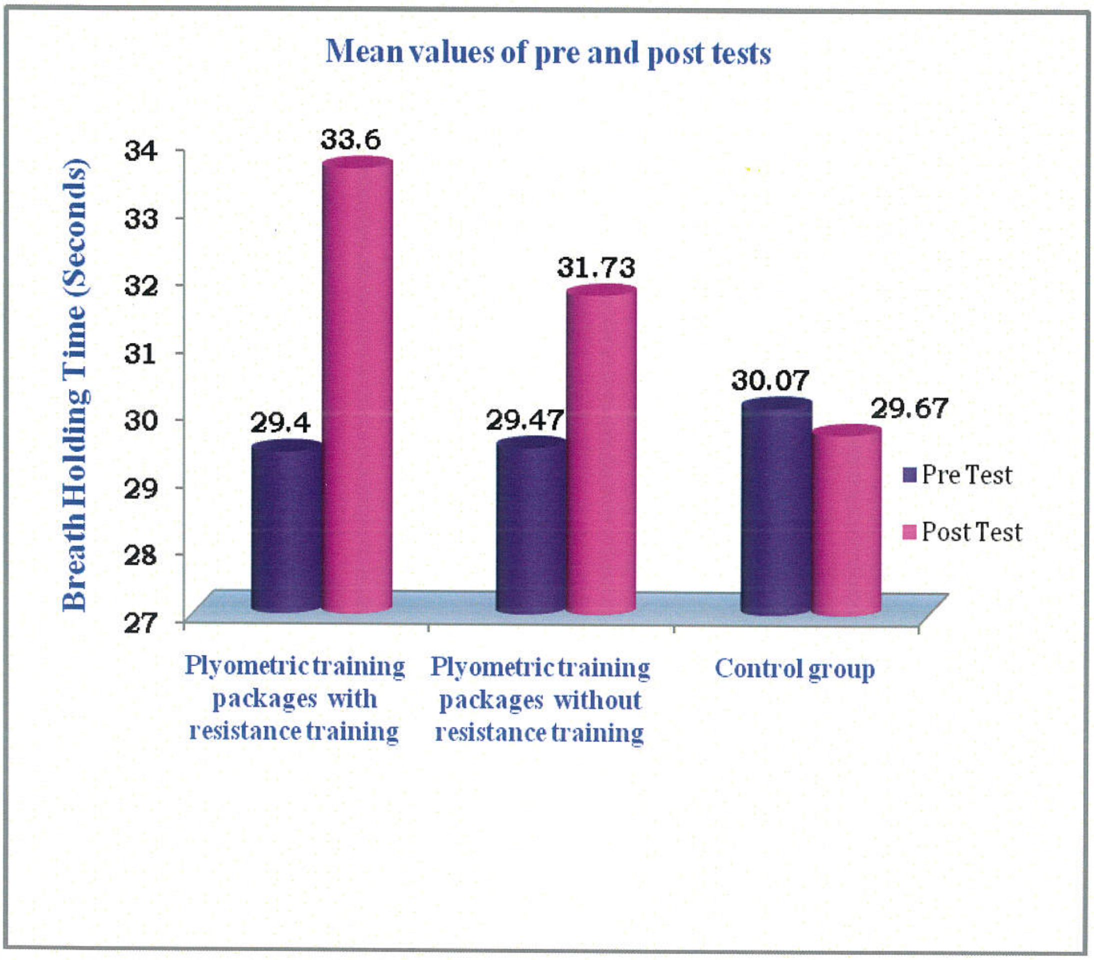

FIGURE: 13

Bar Diagram Showing the Pre and Post Test Mean Values of Plyometric Training Packages with Resistance Training (Group-I), Plyometric Training Packages without Resistance Training (Group-II) and Control Groups on Breath Holding Time

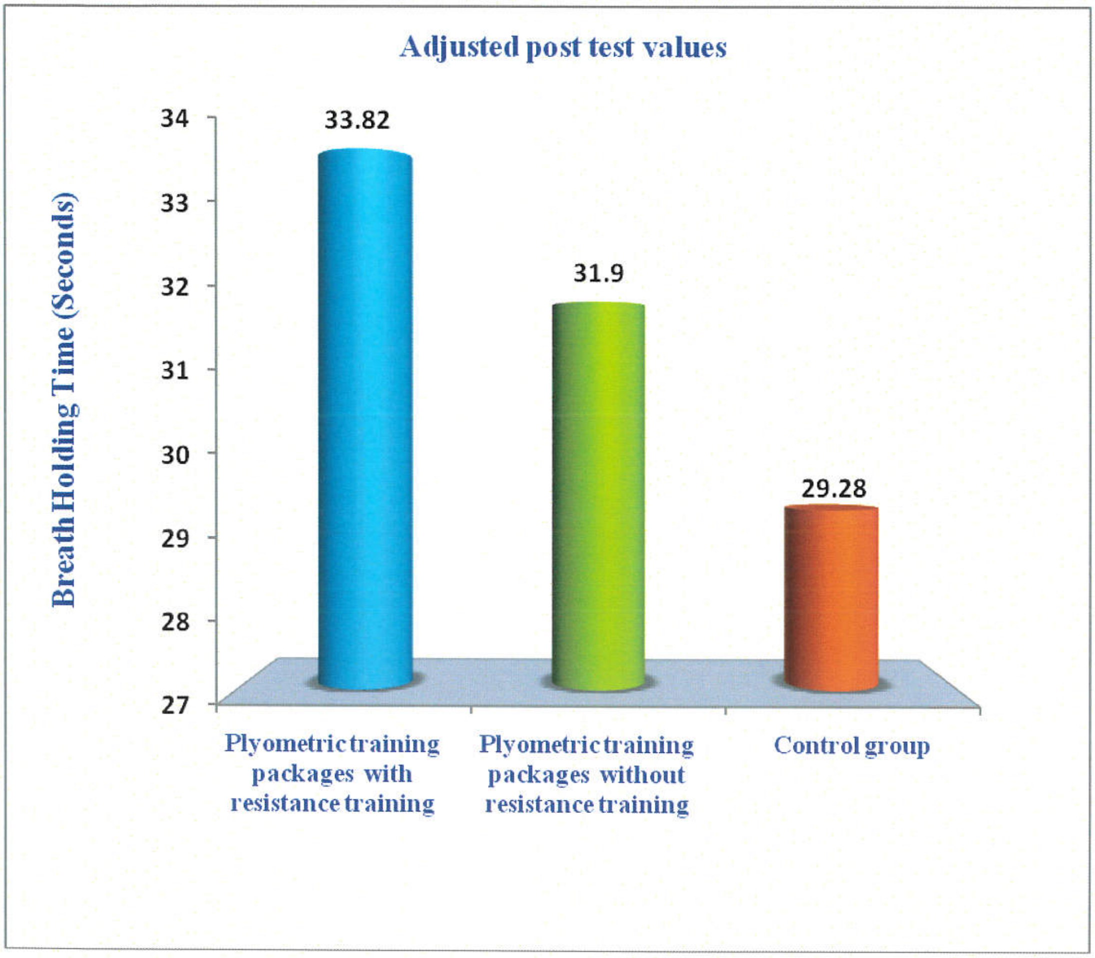

FIGURE: 14

Bar Diagram Showing the Adjusted Post Test Mean Values of Plyometric Training Packages with Resistance Training (Group-I), Plyometric Training Packages without Resistance Training (Group-II) and Control Groups on Breath Holding Time

4.2.8 DISCUSSIONS ON THE FINDINGS OF BREATH HOLDING TIME

The post hoc analysis of obtained ordered adjusted means proves that the significant differences are observed between plyometric training packages with resistance training group and plyometric training packages without resistance training group, plyometric training packages with resistance training group and control group, plyometric training packages without resistance training group and control group at 0.05 level of confidence.

The results of the study show that plyometric training packages with resistance training significantly differed on breath holding time when compared to plyometric training packages without resistance training and control group. Plyometric training packages without resistance training group also significantly differed on breath holding time when compared to plyometric training packages with resistance training and control groups. Hence it is concluded from the results, that both plyometric training packages with resistance training and plyometric training packages without resistance training are better method to improve the breath holding time of hockey players. Among the training, plyometric training packages with resistance training is found to be much better than plyometric training packages without resistance training in improving the performance of breath holding time of hockey players.

The findings of the present study are in agreement with the earlier studies of the following researchers:

Vijayalakshmi and Jayabal (2013) indicated that plyometric training with yogic practices improved agility and breath holding time.

Nelaturi and Kumar (2013) showed Breath holding time was fundamentally enhanced by the weight preparing assembly, plyometric preparing assembly and consolidated preparing gathering when contrasted and control group.

4.2.9 RESULTS ON RESTING PULSE RATE

The means and dependent 't' values on resting pulse rate of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control groups have been analyzed and the results are presented in Table XVII.

TABLE – XVII

SUMMARY OF MEAN STANDARD DEVIATION AND DEPENDENT 't' TEST FOR THE PRE, POST AND ADJUSTED POST TESTS ON RESTING PULSE RATE OF EXPERIMENTAL AND CONTROL GROUPS

(Score in Seconds)

Test		Plyometric training packages with resistance training (Group-I)	Plyometric training packages without resistance training (Group-II)	Control group
Pre Test	Mean	79.20	79.33	79.00
	SD	4.02	4.00	3.18
Post Test	Mean	72.87	76.80	79.33
	SD	2.00	3.32	3.48
Adjusted Post Test	Mean	72.85	76.70	79.45
't' Test		5.46*	1.97*	0.27

Significant at .05 level.

The table value required for 0.05 level of significance with df 14 is 1.761.

Table XVII shows the pre-test mean values of resting pulse rate of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control groups are 79.20, 79.33 and 79.00 respectively; the post-test mean values are 72.87, 76.80 and 79.33 respectively; and the adjusted post-test mean values are 72.85, 76.70 and 79.45 respectively. The obtained dependent t- values between the pre and post test means on resting pulse rate of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control groups are 5.46, 1.97 and 0.27 respectively. The table value required for significant difference with df 14 at 0.05 level is 1.761.

Since the obtained 't' values of plyometric training packages with resistance training (Group-I) and plyometric training packages without resistance training (Group-II) are greater than the table value. This implies that plyometric training packages with resistance training (Group-I) and plyometric training packages without resistance training (Group-II) have significantly improved the performance of resting pulse rate.

The analysis of covariance on resting pulse rate of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control groups have been analyzed and presented in Table XVIII.

TABLE – XVIII

ANALYSIS OF COVARIANCE ON RESTING PULSE RATE BETWEEN EXPERIMENTAL GROUPS

Test	Source of variance	Sum of square	Df	Mean squares	F-Ratio
Pre Test	Between	0.84	2	0.42	0.03
	Within	559.73	42	13.33	
Post Test	Between	318.53	2	159.27	17.63*
	Within	379.47	42	9.03	
Adjusted Post Test	Between	329.60	2	164.80	52.91*
	Within	127.70	41	3.11	

**** Significant at 0.05 level of confidence.***

(The table value required for significance at 0.05 with df 2 and 42 and 2 and 41 are 3.22 and 3.21 respectively)

Table XVIII shows that the obtained F- value of 0.03 for pre test mean of plyometric training packages with resistance training (group-I), plyometric training packages without resistance training (group-II) and control group on resting pulse rate is less than the required table value of 3.22 for significance with df 2 and 42 at 0.05 level of confidence.

The obtained F-value of 17.63 for post test mean of plyometric training packages with resistance training (group-I), plyometric training packages without resistance training (group-II) and control group on resting pulse rate is more than the required table value of 3.22 for significance with df 2 and 42 at 0.05 level of confidence.

The obtained F- value of 52.91 for adjusted post test mean of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control group on resting pulse rate is higher than the required table value of 3.21 for significance with df 2 and 41 at 0.05 level of confidence.

The above statistical analysis indicates, there is a significant improvement in resting pulse rate after the training. Further to determine which of the paired means has significant improvements, Scheffe's post hoc test was applied and the results are presented in Table-XIX.

TABLE – XIX

SCHEFFE'S TEST FOR THE DIFFERENCES BETWEEN THE ADJUSTED POST-TEST MEANS ON RESTING PULSE RATE

(Score in Seconds)

Adjusted post-test means				
Plyometric training packages with resistance training (Group-I)	**Plyometric training packages without resistance training (Group-II)**	**Control group**	**Mean difference**	**Confidence interval**
72.85	76.70		3.85*	1.04
72.85		79.45	6.60*	1.04
	76.70	79.45	2.75*	1.04

** Significant at 0.05 level of confidence.*

Table XIX shows the significant differences between the adjusted post-test means of plyometric training packages with resistance training group and plyometric training packages without resistance training group, plyometric training packages with resistance training group and control group, plyometric training packages without resistance training group and control group are 3.85, 6.60 and 2.75. As the confidence interval required to be significant at 0.05 is 1.04 and the obtained values are greater than the required value, it is observed that the significant difference is found to be existed.

The pre test and post test mean values of plyometric training packages with resistance training, plyometric training packages without resistance training and control groups on resting pulse rate are graphically represented in figure -9.

The adjusted post test mean values of resting pulse rate are represented through bar diagram for better understanding of the results of the study in figure -10.

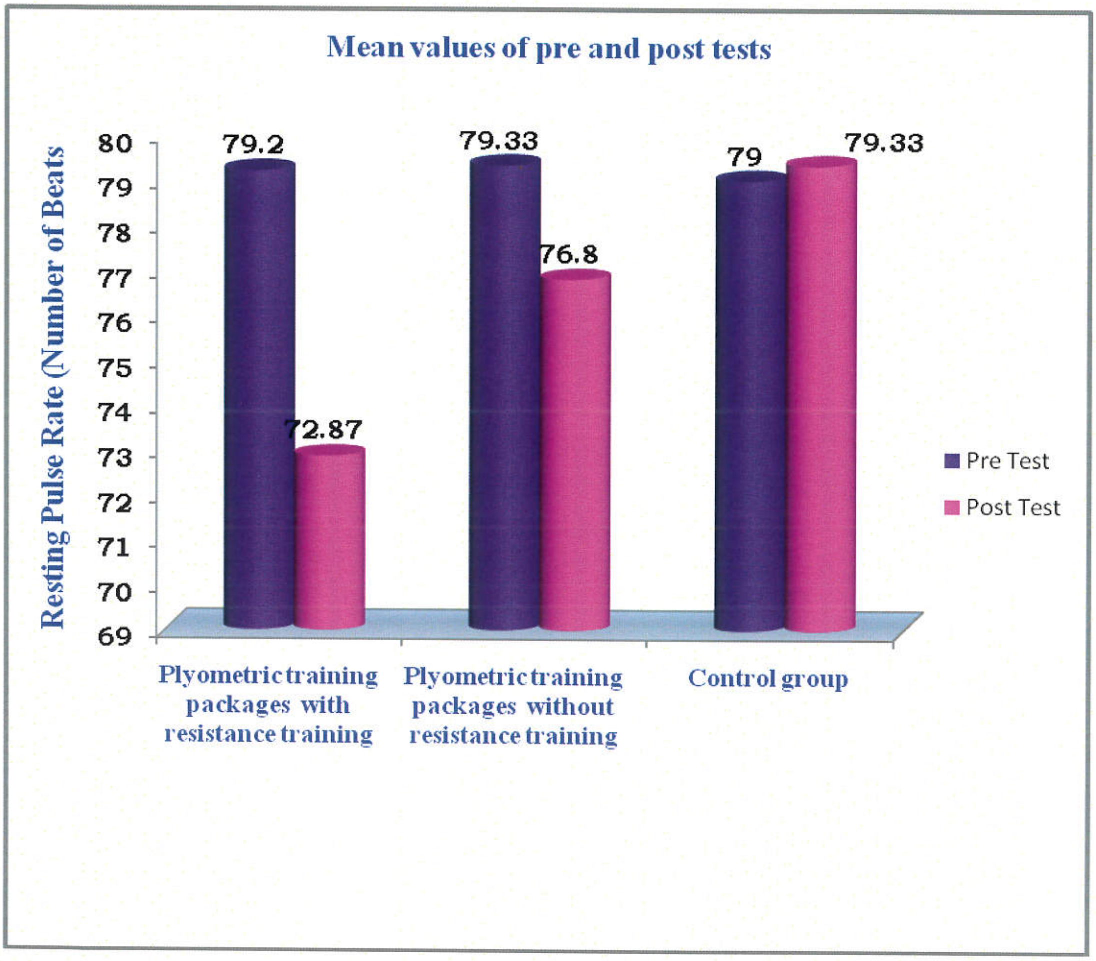

FIGURE: 15

Bar Diagram Showing the Pre and Post Test Mean Values of Plyometric Training Packages with Resistance Training (Group-I), Plyometric Training Packages without Resistance Training (Group-II) and Control Groups on Resting Pulse Rate

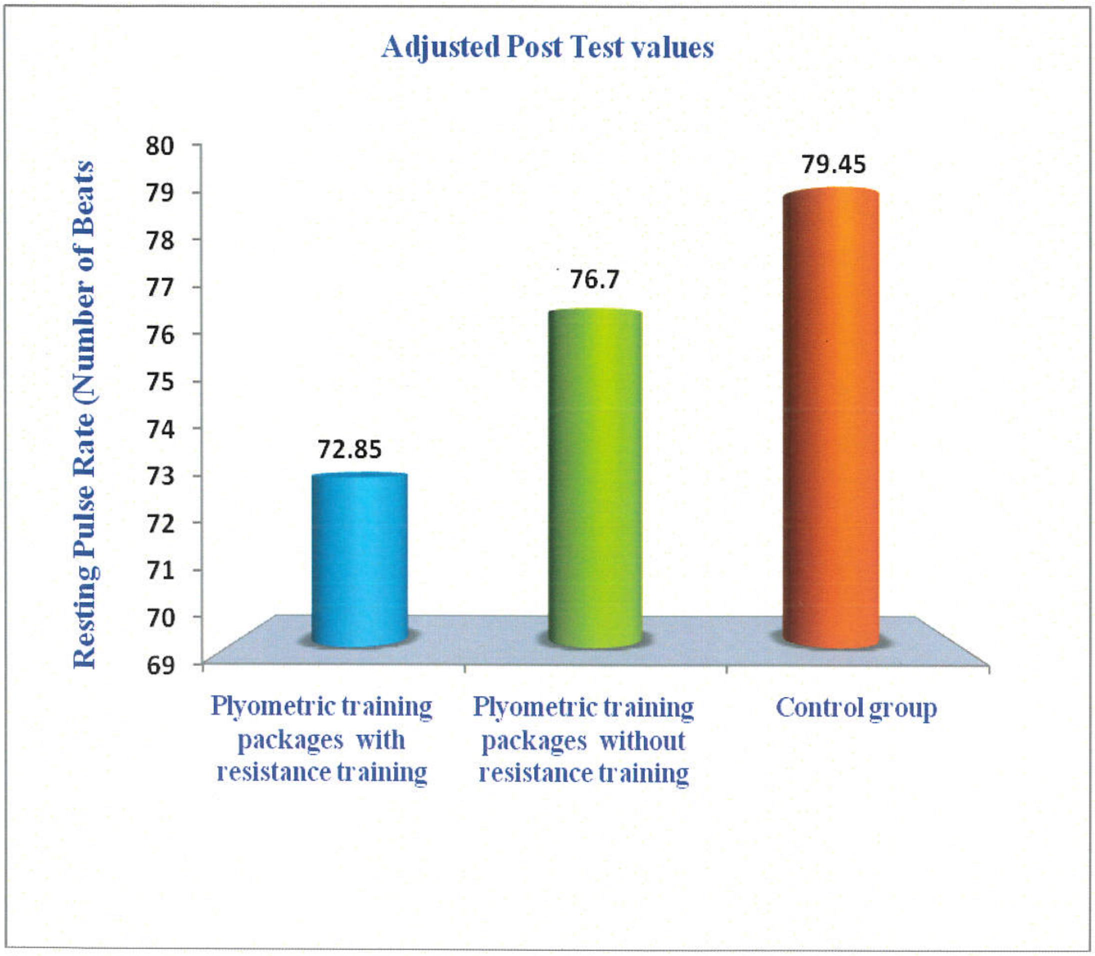

FIGURE: 16

Bar Diagram Showing the Adjusted Post Test Mean Values of Plyometric Training Packages with Resistance Training (Group-I), Plyometric Training Packages without Resistance Training (Group-II) and Control Groups on Resting Pulse Rate

4.2.10 DISCUSSIONS ON THE FINDINGS OF RESTING PULSE RATE

The post hoc analysis of obtained ordered adjusted means proves that the significant differences are observed between plyometric training packages with resistance training group and plyometric training packages without resistance training group, plyometric training packages with resistance training group and control group, plyometric training packages without resistance training group and control group at 0.05 level of confidence .

The results of the study show that plyometric training packages with resistance training significantly differed on resting pulse rate when compared to plyometric training packages without resistance training and control groups. Plyometric training packages without resistance training group also significantly differed on resting pulse rate when compared to plyometric training packages with resistance training and control groups. Hence it is concluded from the results, that both plyometric training packages with resistance training and plyometric training packages without resistance training are better method to improve the resting pulse rate of hockey players. Among the training, plyometric training packages with resistance training is found to be much better than plyometric training packages without resistance training in decreasing the resting pulse rate of hockey players.

The findings of the present study are in agreement with the earlier studies of the following researcher:

Gokulakrishnan and Pushparajan (2014) proved that, the plyometric training programme parallel with closed kinetic chain resistance training programme produced a significant development on resting heart rate.

Vijayalakshmi and Jayabal (2013) proved that the combination of own body resistance exercises and plyometrics with and without yogic practices showed remarkable increases in the agility, flexibility and resting pulse rate.

4.2.11 RESULTS ON RESPIRATORY RATE

The means and dependent 't' values on respiratory rate of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control groups have been analyzed and the results are presented in Table XX.

TABLE – XX

SUMMARY OF MEAN STANDARD DEVIATION AND DEPENDENT 't' TEST FOR THE PRE, POST AND ADJUSTED POST TESTS ON RESPIRATORY RATE OF EXPERIMENTAL AND CONTROL GROUPS

(Score in Seconds)

Test		Plyometric training packages with resistance training (Group-I)	Plyometric training packages without resistance training (Group-II)	Control group
Pre Test	Mean	18.80	18.93	19.00
	SD	2.01	1.75	1.85
Post Test	Mean	15.80	17.73	18.93
	SD	0.68	1.62	1.49
Adjusted Post Test	Mean	15.86	17.72	18.88
't' Test		5.49*	1.95*	0.11

Significant at .05 level.

The table value required for 0.05 level of significance with df 14 is 1.761.

Table XX shows the pre-test mean values of respiratory rate of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control groups are 18.80, 18.93 and 19.00 respectively; the post-test mean values are 15.80, 17.73 and 18.93 respectively; and the adjusted post-test mean values are 15.86, 17.72 and 18.88 respectively. The obtained dependent t- values between the pre and post test means on respiratory rate of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training

(Group-II) and control groups are 5.49, 1.95 and 0.11 respectively. The table value required for significant difference with df 14 at 0.05 level is 1.761.

Since the obtained 't' values of plyometric training packages with resistance training (Group-I) and plyometric training packages without resistance training (Group-II) are greater than the table value. This implies that plyometric training packages with resistance training (Group-I) and plyometric training packages without resistance training (Group-II) have significantly improved the performance of respiratory rate.

The analysis of covariance on respiratory rate of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control groups have been analyzed and presented in Table XXI.

TABLE – XXI

ANALYSIS OF COVARIANCE ON RESPIRATORY RATE BETWEEN EXPERIMENTAL GROUPS

Test	Source of variance	Sum of square	Df	Mean squares	F-Ratio
Pre Test	Between	0.31	2	0.16	0.04
	Within	147.33	42	3.51	
Post Test	Between	74.98	2	37.49	21.20*
	Within	74.27	42	1.77	
Adjusted Post Test	Between	69.62	2	34.81	48.23*
	Within	29.59	41	0.72	

***** *Significant at 0.05 level of confidence.***

(The table value required for significance at 0.05 with df 2 and 42 and 2 and 41 are 3.22 and 3.21 respectively)

Table XXI shows that the obtained F- value of 0.04 for pre test mean of plyometric training packages with resistance training (group-I), plyometric training packages without resistance training (group-II) and control group on respiratory rate is less than the required table value of 3.22 for significance with df 2 and 42 at 0.05 level of confidence.

The obtained F- value of 21.20 for post test mean of plyometric training packages with resistance training (group-I), plyometric training packages without resistance training (group-II) and control group on respiratory rate is more than the required table value of 3.22 for significance with df 2 and 42 at 0.05 level of confidence.

The obtained F- value of 48.23 for adjusted post test mean of plyometric training package with resistance training (Group-I), plyometric packages without resistance training (Group-II) and control group on respiratory rate is higher than the required table value of 3.21 for significance with df 2 and 41 at 0.05 level of confidence.

The above statistical analysis indicates, there is a significant improvement in respiratory rate after the training. Further to determine which of the paired means has significant improvements, Scheffe's post hoc test was applied and the results are presented in Table-XXII.

TABLE – XXII

SCHEFFE'S TEST FOR THE DIFFERENCES BETWEEN THE ADJUSTED POST-TEST MEANS ON RESPIRATORY RATE

(Score in Seconds)

Adjusted post-test means				
Plyometric training packages with resistance training (Group-I)	**Plyometric training packages without resistance training (Group-II)**	**Control group**	**Mean difference**	**Confidence interval**
15.86	17.72		1.86*	0.50
15.86		18.88	3.02*	0.50
	17.72	18.88	1.16*	0.50

**** Significant at 0.05 level of confidence.***

Table XXII shows the significant differences between the adjusted post-test means of plyometric training packages with resistance training group and plyometric training packages without resistance training group, plyometric training packages with resistance training group and control group, plyometric training packages without resistance training group and control group are 1.86, 3.02 and 1.16. As the confidence interval required to be significant at 0.05 is 0.50 and the obtained values are greater than the required value, it is observed that the significant difference is found to be existed.

The pre test and post test mean values of plyometric training packages with resistance training, plyometric training packages without resistance training and control groups on respiratory rate are graphically represented in figure -11.

The adjusted post test mean values of respiratory rate are represented through bar diagram for better understanding of the results of the study in figure - 12.

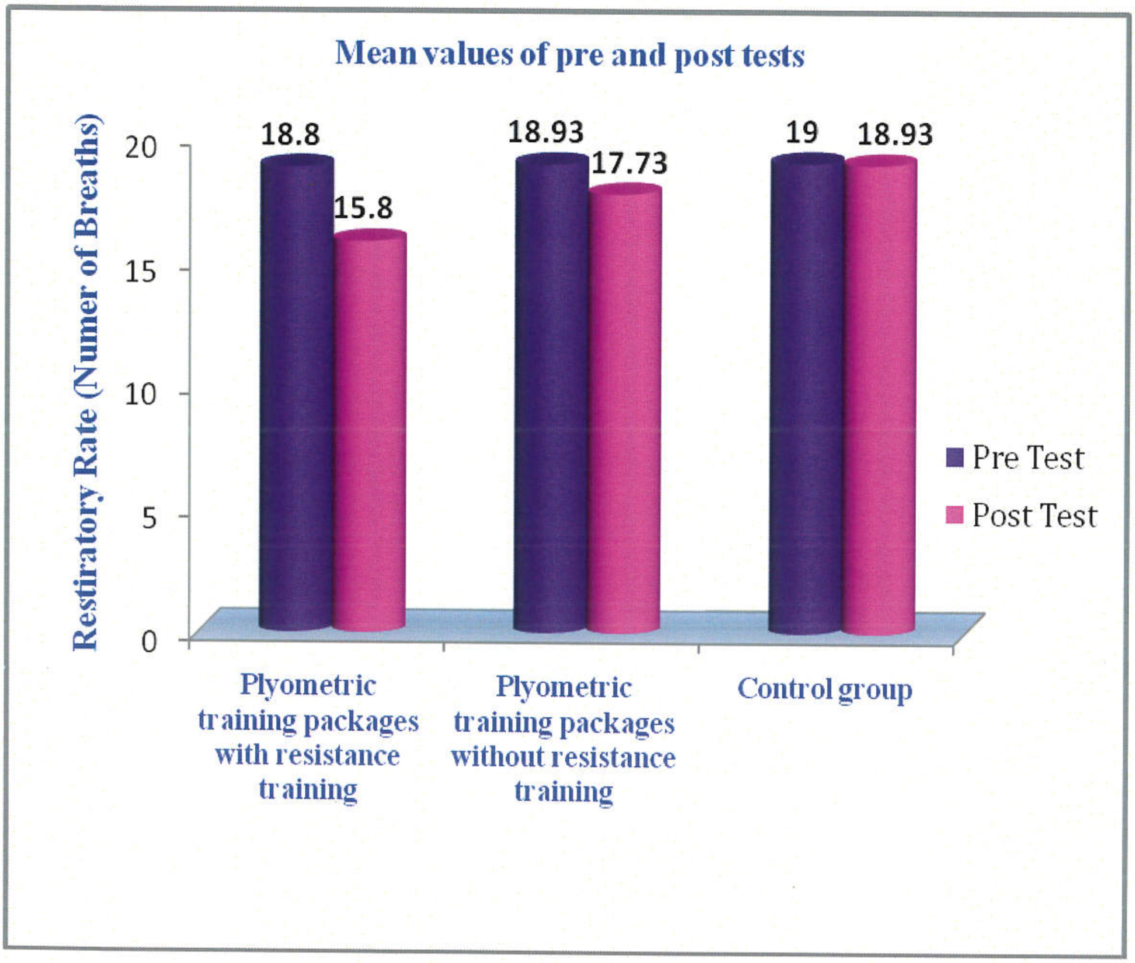

FIGURE: 17

Bar Diagram Showing the Pre and Post Test Mean Values of Plyometric Training Packages with Resistance Training (Group-I), Plyometric Training Packages without Resistance Training (Group-II) and Control Groups on Respiratory Rate

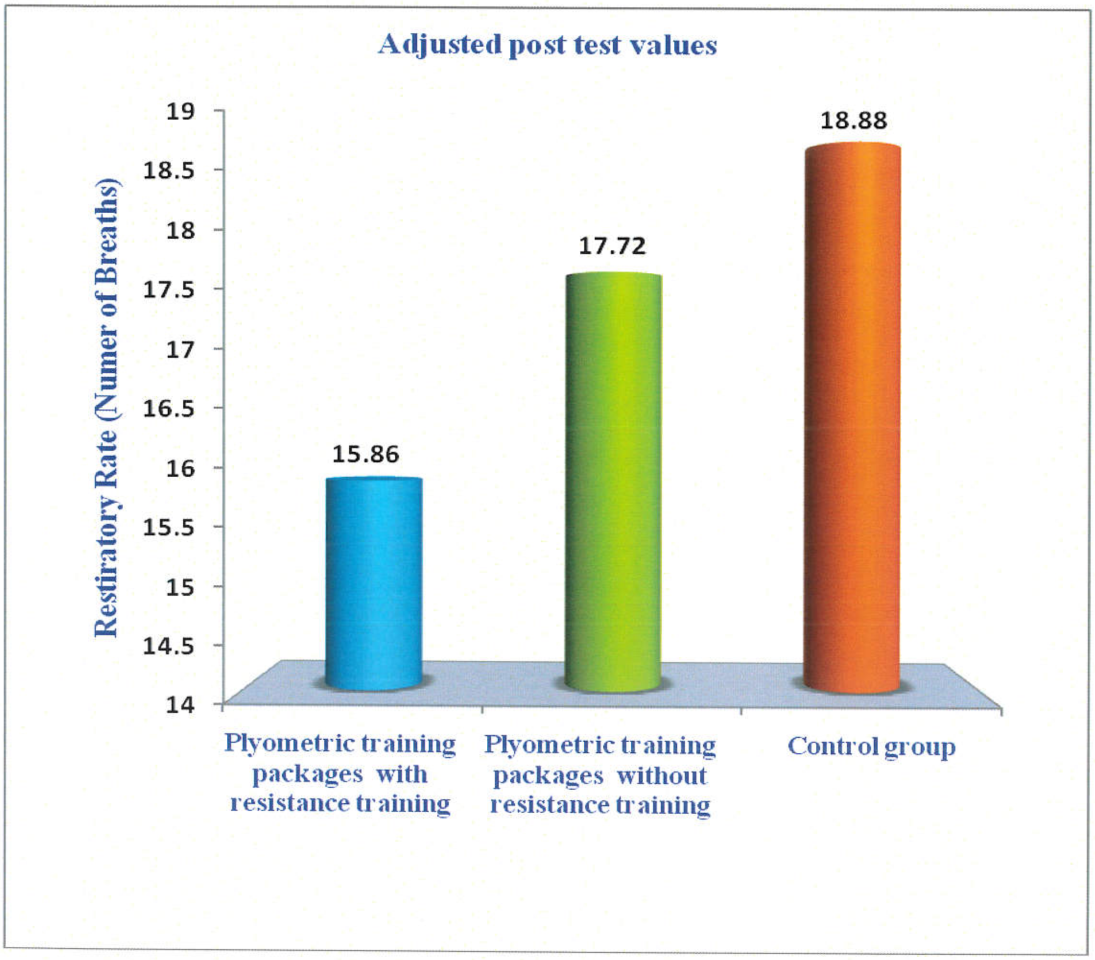

FIGURE: 18

Bar Diagram Showing the Adjusted Post Test Mean Values of Plyometric Training Packages with Resistance Training (Group-I), Plyometric Training Packages without Resistance Training (Group-II) and Control Groups on Respiratory Rate

4.2.12 DISCUSSIONS ON THE FINDINGS OF RESPIRATORY RATE :

The post hoc analysis of obtained ordered adjusted means proves that the significant differences are observed between plyometric training packages with resistance training group and plyometric training packages without resistance training group, plyometric training packages with resistance training group and control group, plyometric training packages without resistance training group and control group at 0.05 level of confidence.

The results of the study show that plyometric training packages with resistance training significantly differed on respiratory rate when compared to plyometric training packages without resistance training and control group. Plyometric training packages without resistance training group also significantly differed on respiratory rate when compared to plyometric training packages with resistance training and control groups. Hence it is concluded from the results, that both plyometric training packages with resistance training and plyometric training packages without resistance training are better method to improve the respiratory rate of hockey players. Among the training, plyometric training packages with resistance training is found to be much better than plyometric training packages without resistance training in improving the respiratory rate of hockey players.

The finding of the present study is in agreement with the earlier studies of the following researchers:

Hanjabam and Kailashiya (2014) found related physiological and cardiovascular changes and adaptation in field hockey players. Results revealed significant reduction ($P < 0.05$) was observed in resting pulse rate, resting systolic blood pressure, resting diastolic blood pressure, resting double product or rate pressure product.

4.2.13 RESULTS ON DRIBBLING

The means and dependent 't' values on dribbling of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control groups have been analyzed and the results are presented in Table XXIII.

TABLE – XXIII

SUMMARY OF MEAN STANDARD DEVIATION AND DEPENDENT 't' TEST FOR THE PRE, POST AND ADJUSTED POST TESTS ON DRIBBLING OF EXPERIMENTAL AND CONTROL GROUPS

(Scores in Seconds)

Test		Plyometric training packages with resistance training (Group-I)	Plyometric training packages without resistance training (Group-II)	Control group
Pre Test	Mean	6.50	6.37	6.47
	SD	0.85	0.79	0.61
Post Test	Mean	10.10	7.63	6.57
	SD	0.85	1.01	0.65
Adjusted Post Test	Mean	10.06	7.69	6.55
't' Test		11.64*	3.83*	0.43

Significant at .05 level.

The table value required for 0.05 level of significance with df 14 is 1.761.

Table XXIII shows the pre-test mean values of dribbling of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control groups are 6.50, 6.37 and 6.47 respectively; the post-test mean values are 10.10, 7.63 and 6.57 respectively; and the adjusted post-test mean values are 10.06, 7.69 and 6.55 respectively. The obtained dependent t- values between the pre and post test means on dribbling of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control groups are 11.64, 3.83 and 0.43 respectively. The table value required for significant difference with df 14 at 0.05 level is 1.761.

Since the obtained 't' values of plyometric training packages with resistance training (Group-I) and plyometric training packages without resistance training (Group-II) are greater than the table value. This implies that plyometric training packages with resistance training (Group-I) and plyometric training packages without resistance training (Group-II) have significantly improved the performance of dribbling.

The analysis of covariance on dribbling of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control groups have been analyzed and presented in Table XXIV.

TABLE – XXIV

ANALYSIS OF COVARIANCE ON DRIBBLING BETWEEN EXPERIMENTAL GROUPS

Test	Source of variance	Sum of square	Df	Mean squares	F-Ratio
Pre Test	Between	0.14	2	0.07	0.13
	Within	23.97	42	0.57	
Post Test	Between	98.53	2	49.27	68.37*
	Within	30.27	42	0.72	
Adjusted Post Test	Between	96.15	2	48.07	104.63*
	Within	18.84	41	0.46	

**** Significant at 0.05 level of confidence.***

(The table value required for significance at 0.05 with df 2 and 42 and 2 and 41 are 3.22 and 3.21 respectively)

Table XXIV shows that the obtained F- value of 0.13 for pre test mean of plyometric training packages with resistance training (group-I), plyometric training packages without resistance training (group-II) and control group on dribbling is less than the required table value of 3.22 for significance with df 2 and 42 at 0.05 level of confidence.

The obtained F- value of 68.37 for post test mean of plyometric training packages with resistance training (group-I), plyometric training packages without resistance training (group-II) and control group on dribbling is more than the required table value of 3.22 for significance with df 2 and 42 at 0.05 level of confidence.

The obtained F- value of 104.63 for adjusted post test mean of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control group on dribbling is higher than the required table value of 3.21 for significance with df 2 and 41 at 0.05 level of confidence.

The above statistical analysis indicates, there is a significant improvement in dribbling after the training. Further to determine which of the paired means has significant improvements, Scheffe's post hoc test was applied and the results are presented in Table-XXV.

TABLE – XXV

SCHEFFE'S TEST FOR THE DIFFERENCES BETWEEN THE ADJUSTED POST-TEST MEANS ON DRIBBLING

(Scores in Seconds)

Adjusted post-test means				
Plyometric training packages with resistance training (Group-I)	**Plyometric training packages without resistance training (Group-II)**	**Control group**	**Mean difference**	**Confidence interval**
10.06	7.69		2.37*	0.42
10.06		6.55	3.51*	0.42
	7.69	6.55	1.14*	0.42

** Significant at 0.05 level of confidence.*

Table XXV shows the significant differences between the adjusted post-test means of plyometric training packages with resistance training group and plyometric training packages without resistance training group, plyometric training packages with resistance training group and control group, plyometric training packages without resistance training group and control group are 2.37, 3.51 and 1.14. As the confidence interval required to be significant at 0.05 is 0.42 and the obtained values are greater than the required value, it is observed that the significant difference is found to be existed.

The pre test and post test mean values of plyometric training packages with resistance training, plyometric training packages without resistance training and control groups on dribbling are graphically represented in figure -13.

The adjusted post test mean values of dribbling are represented through bar diagram for better understanding of the results of the study in figure -14.

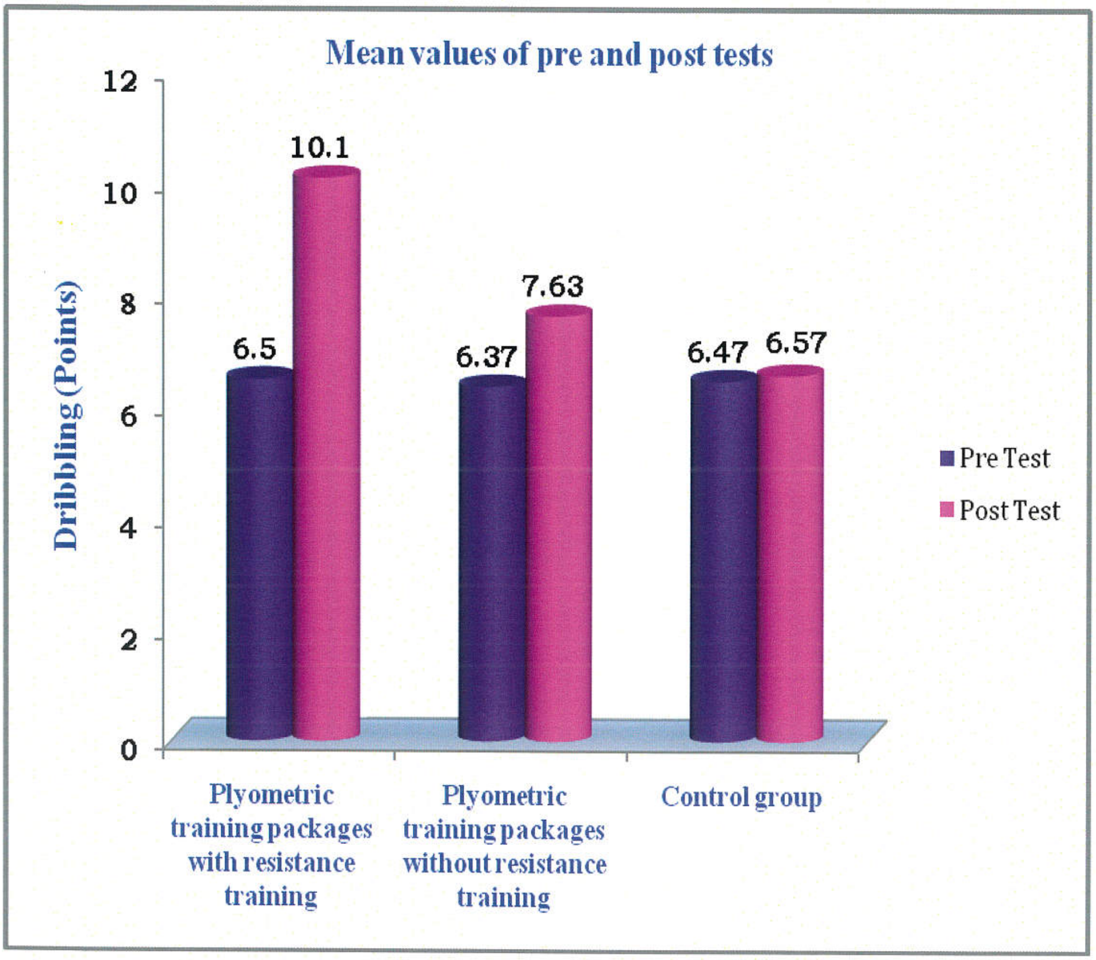

FIGURE: 19

Bar Diagram Showing the Pre and Post Test Mean Values of Plyometric Training Packages with Resistance Training (Group-I), Plyometric Training Packages without Resistance Training (Group-II) and Control Groups on Dribbling

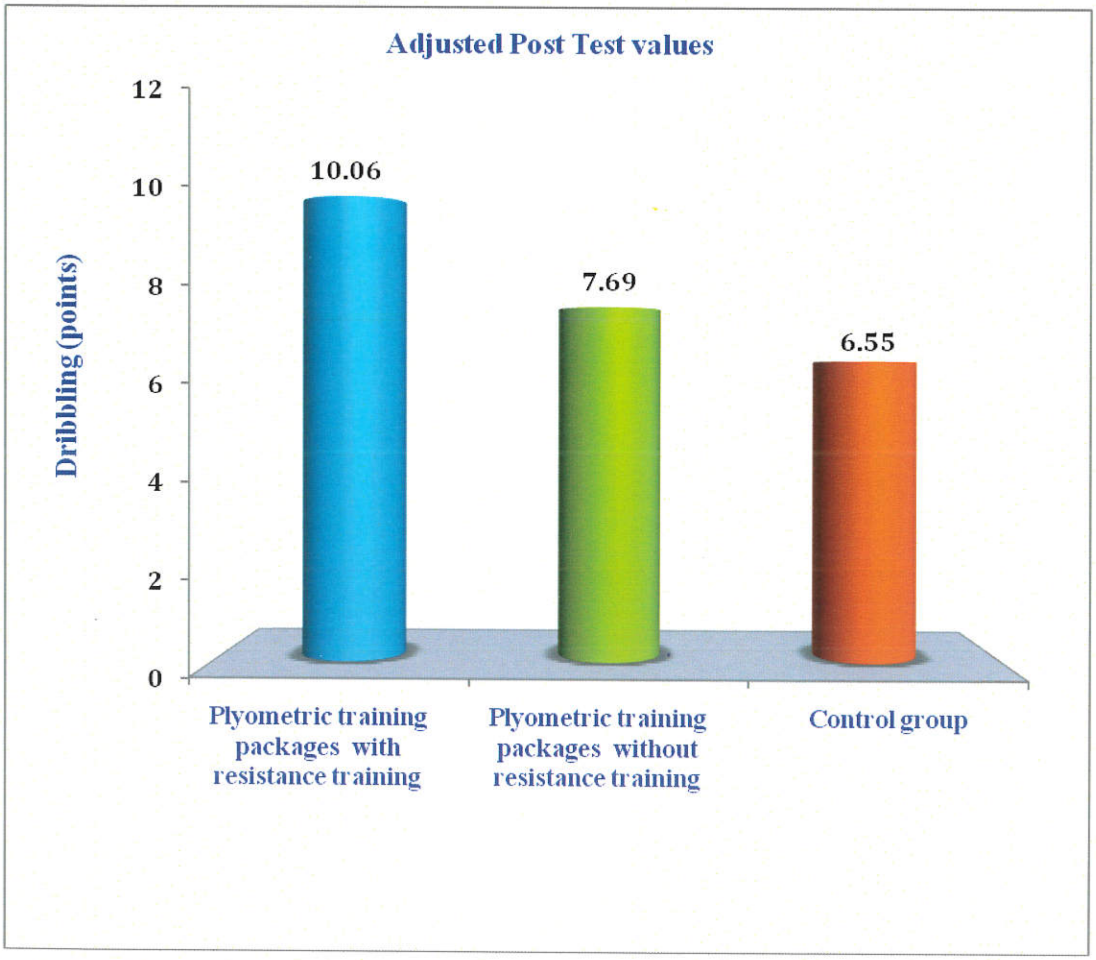

FIGURE: 20

Bar Diagram Showing the Adjusted Post Test Mean Values of Plyometric Training Packages with Resistance Training (Group-I), Plyometric Training Packages without Resistance Training (Group-II) and Control Groups on Dribbling

4.2.14 DISCUSSIONS ON THE FINDINGS OF DRIBBLING

The post hoc analysis of obtained ordered adjusted means proves that the significant differences are observed between plyometric training packages with resistance training group and plyometric training packages without resistance training group, plyometric training packages with resistance training group and control group, plyometric training packages without resistance training group and control group at 0.05 level of confidence.

The results of the study show that plyometric training packages with resistance training significantly differed on dribbling when compared to plyometric training packages without resistance training and control group. Plyometric training packages without resistance training group also significantly differed on dribbling when compared to plyometric training packages with resistance training and control groups. Hence it is concluded from the results, that both plyometric training packages with resistance training and plyometric training packages without resistance training are better method to improve the dribbling of hockey players. Among the training, plyometric training packages with resistance training is found to be much better than plyometric training packages without resistance training in enhancing the performance of dribbling of hockey players.

The findings of the present study are in agreement with the earlier studies of the following researchers

Mallesh and Gandhi (2014) examined that there were significant differences in physical fitness variables of speed, agility and explosive power, and performance variables of sports competition dribbling, hitting and trapping between university and senior state men hockey players.

Taheri et al. (2014) stated that plyometric exercises showed more favorable effects on improving speed and performance skill and suggested to include plyometric training and resistance training for soccer players.

Haghighi et al. (2013) concluded from the results the time of sprint running test and dribbling improved after and PT and RT in young soccer players.

4.2.15 RESULTS ON PUSHING

The means and dependent 't' values on pushing of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control groups have been analyzed and the results are presented in Table XXVI.

TABLE – XXVI

SUMMARY OF MEAN STANDARD DEVIATION AND DEPENDENT 't' TEST FOR THE PRE, POST AND ADJUSTED POST TESTS ON PUSHING OF EXPERIMENTAL AND CONTROL GROUPS

(Scores in Points)

Test		Plyometric training packages with resistance training (Group-I)	Plyometric training packages without resistance training (Group-II)	Control group
Pre Test	Mean	7.60	7.67	7.80
	SD	1.06	1.11	1.01
Post Test	Mean	10.87	9.33	7.87
	SD	0.64	1.05	1.06
Adjusted Post Test	Mean	10.92	9.35	7.80
't' Test		10.25*	4.23*	0.18

****Significant at .05 level.***

The table value required for 0.05 level of significance with df 14 is 1.761.

Table XXVI shows the pre-test mean values of pushing of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control groups are 7.60, 7.67 and 7.80 respectively; the post-test mean values are 10.87, 9.33 and 7.87 respectively; and the adjusted post-test mean values are 10.92, 9.35 and 7.80 respectively. The obtained dependent t- values between the pre and post test means on pushing of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control groups are 10.25, 4.23 and 0.18 respectively. The table value required for significant difference with df 14 at 0.05 level is 1.761.

Since the obtained 't' values of plyometric training packages with resistance training (Group-I) and plyometric training packages without resistance training (Group-II) are greater than the table value. This implies that plyometric training packages with resistance training (Group-I) and plyometric training packages without resistance training (Group-II) have significantly improved the performance of pushing.

The analysis of covariance on pushing of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control groups have been analyzed and presented in Table XXVII.

TABLE – XXVII

ANALYSIS OF COVARIANCE ON PUSHING BETWEEN EXPERIMENTAL GROUPS

Test	Source of variance	Sum of square	Df	Mean squares	F-Ratio
Pre Test	Between	0.31	2	0.16	0.14
	Within	47.33	42	1.13	
Post Test	Between	67.51	2	33.76	38.53*
	Within	36.80	42	0.88	
Adjusted Post Test	Between	72.17	2	36.09	67.24*
	Within	22.00	41	0.54	

Significant at 0.05 level of confidence.

(The table value required for significance at 0.05 with df 2 and 42 and 2 and 41 are 3.22 and 3.21 respectively)

Table XXVII shows that the obtained F- value of 0.14 for pre test mean of plyometric training packages with resistance training (group-I), plyometric training packages without resistance training (group-II) and control group on pushing is less than the required table value of 3.22 for significance with df 2 and 42 at 0.05 level of confidence.

The obtained F- value of 38.53 for post test mean of plyometric training packages with resistance training (group-I), plyometric training packages without resistance training (group-II) and control group on pushing is more than the required table value of 3.22 for significance with df 2 and 42 at 0.05 level of confidence.

The obtained F- value of 67.24 for adjusted post test mean of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control group on pushing is higher than the required table value of 3.21 for significance with df 2 and 41 at 0.05 level of confidence.

The above statistical analysis indicates, there is a significant improvement in pushing after the training. Further to determine which of the paired means has significant improvements, Scheffe's post hoc test was applied and the results are presented in Table-XXVIII.

TABLE – XXVIII

SCHEFFE'S TEST FOR THE DIFFERENCES BETWEEN THE ADJUSTED POST-TEST MEANS ON PUSHING

(Scores in Points)

Adjusted post-test means				
Plyometric training packages with resistance training (Group-I)	**Plyometric training packages without resistance training (Group-II)**	**Control group**	**Mean difference**	**Confidence interval**
10.92	9.35		1.57*	0.43
10.92		7.80	3.12*	0.43
	9.35	7.80	1.55*	0.43

** Significant at 0.05 level of confidence.*

Table XXVIII shows the significant differences between the adjusted post-test means of plyometric training packages with resistance training group and plyometric training packages without resistance training group, plyometric training packages with resistance training group and control group, plyometric training packages without resistance training group and control group are 1.57, 3.12 and 1.55. As the confidence interval required to be significant at 0.05 is 0.43 and the obtained values are greater than the required value, it is observed that the significant difference is found to be existed.

The pre test and post test mean values of plyometric training packages with resistance training, plyometric training packages without resistance training and control groups on pushing are graphically represented in figure -15.

The adjusted post test mean values of pushing are represented through bar diagram for better understanding of the results of the study in figure -16.

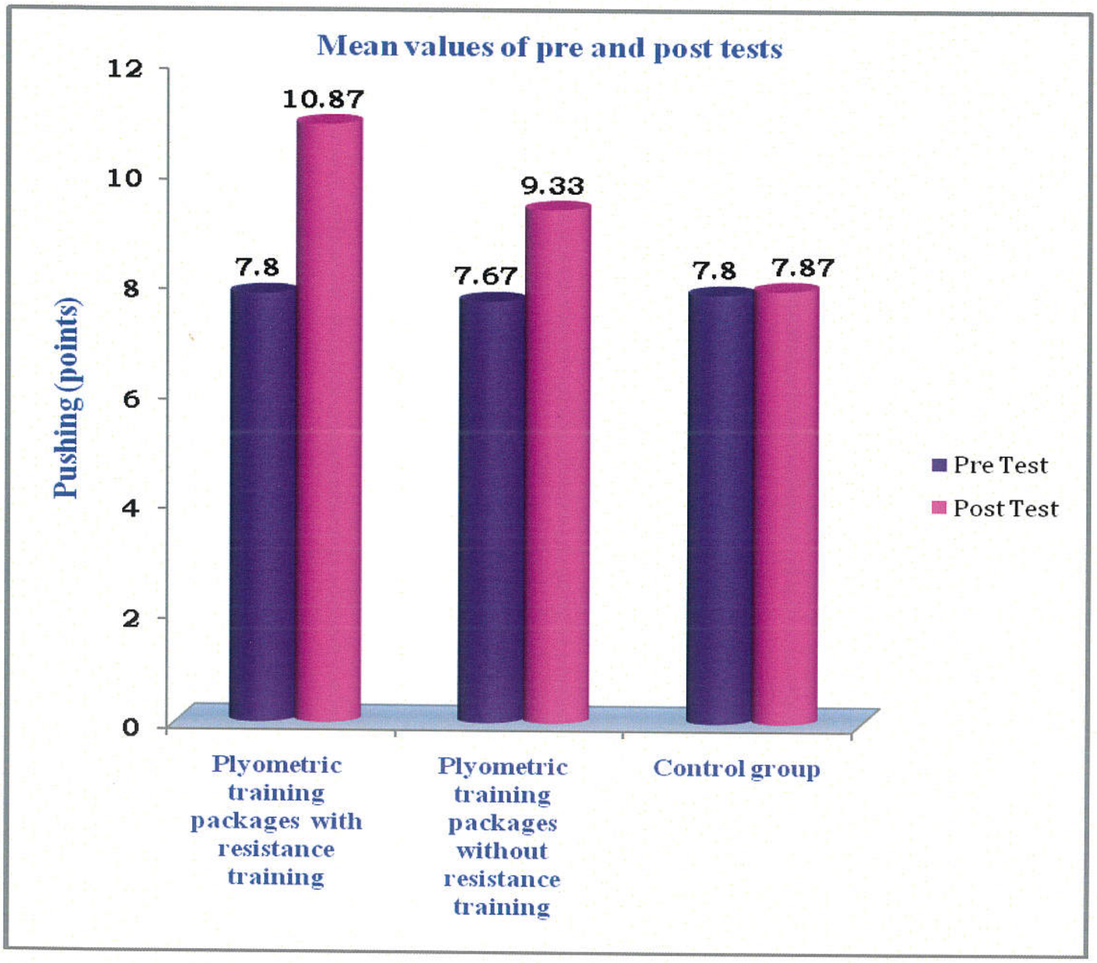

FIGURE: 21

Bar Diagram Showing the Pre and Post Test Mean Values of Plyometric Training Packages with Resistance Training (Group-I), Plyometric Training Packages without Resistance Training (Group-II) and Control Groups on Pushing

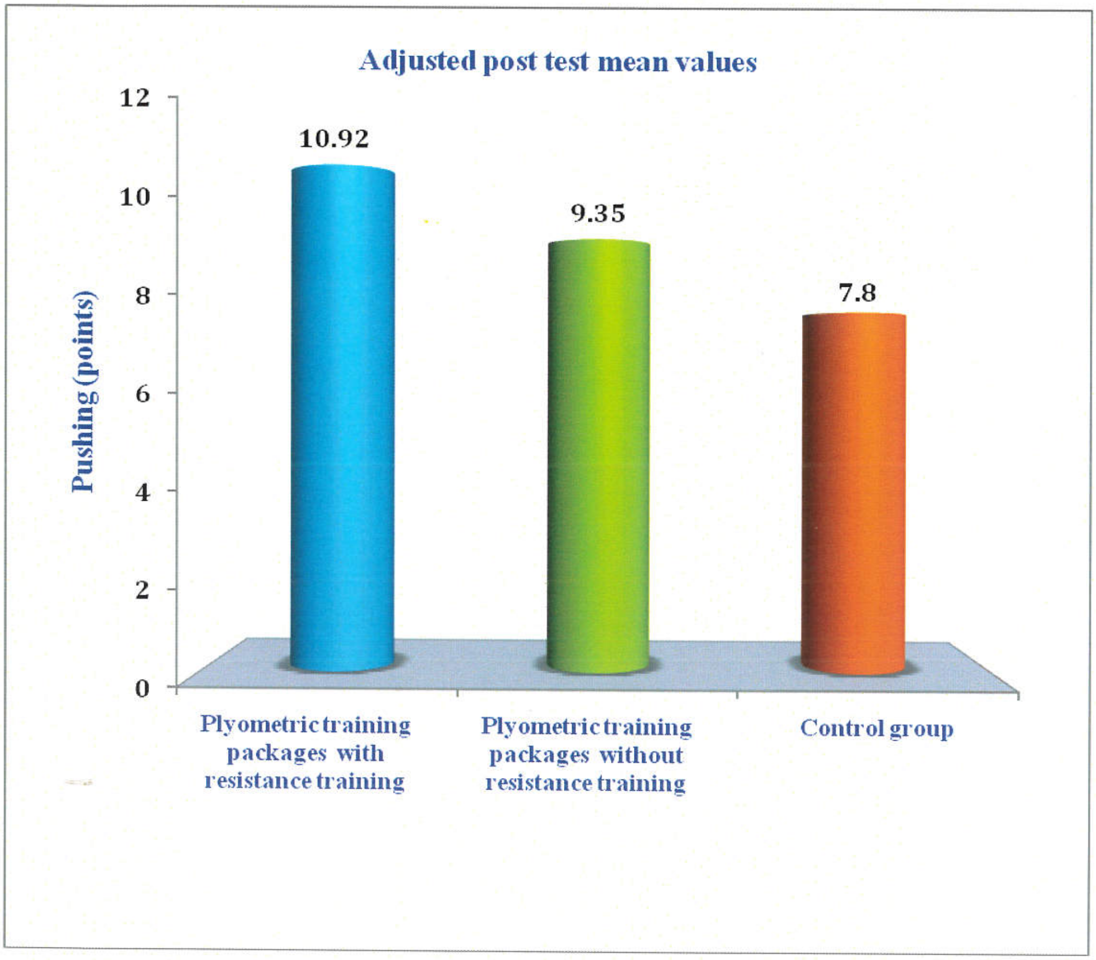

FIGURE: 22

Bar Diagram Showing the Adjusted Post Test Mean Values of Plyometric Training Packages with Resistance Training (Group-I), Plyometric Training Packages without Resistance Training (Group-II) and Control Groups on Pushing

4.2.16 DISCUSSIONS ON THE FINDINGS OF PUSHING

The post hoc analysis of obtained ordered adjusted means proves that the significant differences are observed between plyometric training packages with resistance training group and plyometric training packages without resistance training group, plyometric training packages with resistance training group and control group, plyometric training packages without resistance training group and control group at 0.05 level of confidence .

The results of the study show that plyometric training packages with resistance training significantly differed on pushing when compared to plyometric training packages without resistance training and control group. plyometric training packages without resistance training group also significantly differed on pushing when compared to plyometric training packages with resistance training and control groups. Hence it is concluded from the results, that both plyometric training packages with resistance training and plyometric training packages without resistance training are better method to improve the pushing of hockey players. Among the training, plyometric training packages with resistance training is found to be much better than plyometric training packages without resistance training in enhancing the performance of pushing of hockey players.

The findings of the present study are in agreement with the earlier studies of the following researchers:

Mallesh and Gandhi (2014) examined that there were significant differences in physical fitness variables of speed, agility and explosive power, and performance variables of sports competition dribbling, hitting and pushing between university and senior state men hockey players.

Taheri et al. (2014) stated that plyometric exercises showed more favorable effects on improving speed and performance skill and suggested to include plyometric training and resistance training for soccer players.

4.2.17. RESULTS ON HITTING

The means and dependent 't' values on hitting of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control groups have been analyzed and the results are presented in Table XXIX.

TABLE – XXIX

SUMMARY OF MEAN STANDARD DEVIATION AND DEPENDENT 't' TEST FOR THE PRE, POST AND ADJUSTED POST TESTS ON HITTING OF EXPERIMENTAL AND CONTROL GROUPS

(Scores in Points)

Test		Plyometric training packages with resistance training (Group-I)	Plyometric training packages without resistance training (Group-II)	Control group
Pre Test	Mean	8.00	8.07	8.87
	SD	0.76	0.70	1.19
Post Test	Mean	11.20	10.40	8.73
	SD	0.86	0.74	1.28
Adjusted Post Test	Mean	11.43	10.58	8.32
't' Test		10.81*	8.87*	0.30

Significant at .05 level.

The table value required for 0.05 level of significance with df 14 is 1.761.

Table XXIX shows the pre-test mean values of hitting of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control groups are 8.00, 8.07 and 8.87 respectively; the post-test mean values are 11.20, 10.40 and 8.73 respectively; and the adjusted post-test mean values are 11.43, 10.58 and 8.32 respectively. The obtained dependent t- values between the pre and post test means on hitting of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control groups are 10.81, 8.87 and 0.30 respectively. The table value required for significant difference with df 14 at 0.05 level is 1.761.

Since the obtained ‘t’ values of plyometric training packages with resistance training (Group-I) and plyometric training packages without resistance training (Group-II) are greater than the table value. This implies that plyometric training packages with resistance training (Group-I) and plyometric training packages without resistance training (Group-II) have significantly improved the performance of hitting.

The analysis of covariance on hitting of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control groups have been analyzed and presented in Table XXX.

TABLE – XXX

ANALYSIS OF COVARIANCE ON HITTING BETWEEN EXPERIMENTAL GROUPS

Test	Source of variance	Sum of square	Df	Mean squares	F-Ratio
Pre Test	Between	6.98	2	3.49	4.23*
	Within	34.67	42	0.83	
Post Test	Between	47.51	2	23.76	24.37*
	Within	40.93	42	0.97	
Adjusted Post Test	Between	65.40	2	32.70	62.84*
	Within	21.33	41	0.52	

Significant at 0.05 level of confidence.

(The table value required for significance at 0.05 with df 2 and 42 and 2 and 41 are 3.22 and 3.21 respectively)

Table XXX shows that the obtained F- value of 4.23 for pre test mean of plyometric training packages with resistance training (group-I), plyometric training packages without resistance training (group-II) and control group on hitting is less than the required table value of 3.22 for significance with df 2 and 42 at 0.05 level of confidence.

The obtained F- value of 24.37 for post test mean of plyometric training packages with resistance training (group-I), plyometric training packages without resistance training (group-II) and control group on hitting is more than the required table value of 3.22 for significance with df 2 and 42 at 0.05 level of confidence.

The obtained F- value of 62.84 for adjusted post test mean of plyometric training packages with resistance training (Group-I), plyometric training packages without resistance training (Group-II) and control group on hitting is higher than the required table value of 3.21 for significance with df 2 and 41 at 0.05 level of confidence.

The above statistical analysis indicates, there is a significant improvement in hitting after the training. Further to determine which of the paired means has significant improvements, Scheffe's post hoc test was applied and the results are presented in Table-XXXI.

TABLE – XXXI

SCHEFFE'S TEST FOR THE DIFFERENCES BETWEEN THE ADJUSTED POST-TEST MEANS ON HITTING

(Scores in Points)

Adjusted post-test means				
Plyometric training packages with resistance training (Group-I)	**Plyometric training packages without resistance training (Group-II)**	**Control group**	**Mean difference**	**Confidence interval**
11.43	10.58		0.85*	0.43
11.43		8.32	3.11*	0.43
	10.58	8.32	2.26*	0.43

** Significant at 0.05 level of confidence.*

Table XXXI shows the significant differences between the adjusted post-test means of plyometric training packages with resistance training group and plyometric training packages without resistance training group, plyometric training packages with resistance training group and control group, plyometric training packages without resistance training group and control group are 0.85, 3.11 and 2.26. As the confidence interval required to be significant at 0.05 is 0.43 and the obtained values are greater than the required value, it is observed that the significant difference is found to be existed.

The pre test and post test mean values of plyometric training packages with resistance training, plyometric training packages without resistance training and control groups on hitting are graphically represented in figure -17.

The adjusted post test mean values of hitting are represented through bar diagram for better understanding of the results of the study in figure -18.

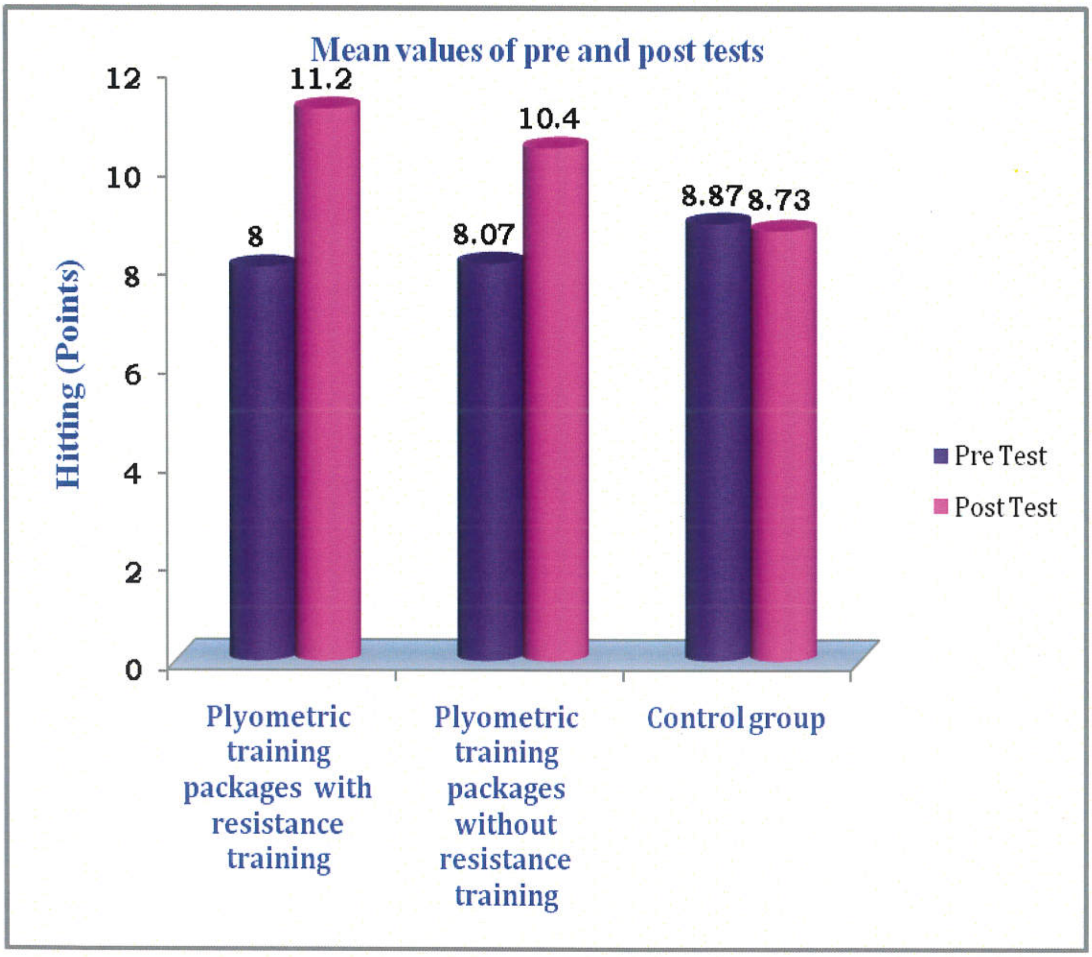

FIGURE: 23

Bar Diagram Showing the Pre and Post Test Mean Values of Plyometric Training Packages with Resistance Training (Group-I), Plyometric Training Packages without Resistance Training (Group-II) and Control Groups on Hitting

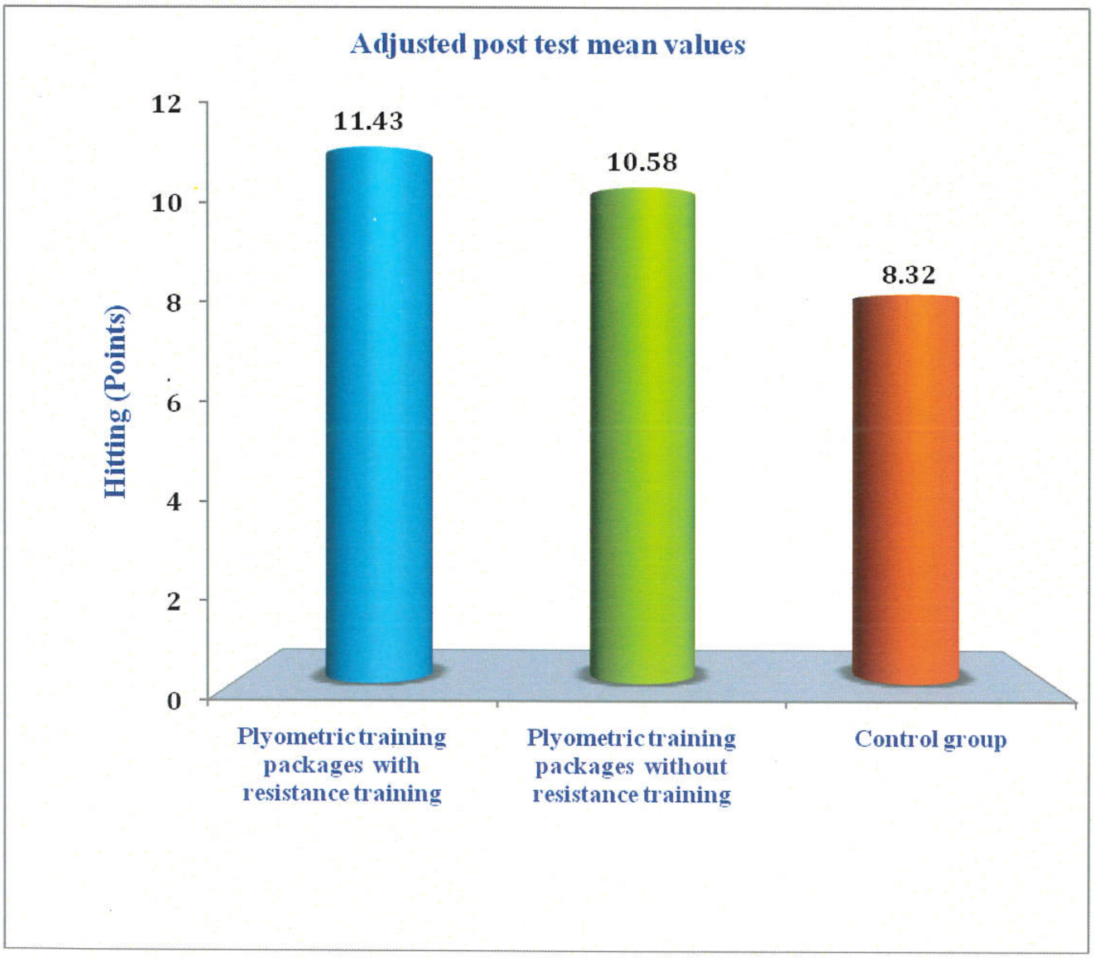

FIGURE: 24

Bar Diagram Showing the Adjusted Post Test Mean Values of Plyometric Training Packages with Resistance Training (Group-I), Plyometric Training Packages without Resistance Training (Group-II) and Control Groups on Hitting

4.2.18 DISCUSSIONS ON THE FINDINGS OF HITTING

The post hoc analysis of obtained ordered adjusted means proves that the significant differences are observed between plyometric training packages with resistance training group and plyometric training packages without resistance training group, plyometric training packages with resistance training group and control group, plyometric training packages without resistance training group and control group at 0.05 level of confidence.

The results of the study show that plyometric training packages with resistance training significantly differed on hitting when compared to plyometric training packages without resistance training and control group. Plyometric training packages without resistance training group also significantly differed on hitting when compared to plyometric training packages with resistance training and control groups. Hence it is concluded from the results, that both plyometric training packages with resistance training and plyometric training packages without resistance training are better method to improve the hitting of hockey players. Among the training, plyometric training packages with resistance training is found to be much better than plyometric training packages without resistance training in enhancing the performance of hitting of hockey players.

The findings of the present study are in agreement with the earlier studies of the following researchers:

Mallesh and Gandhi (2014) examined that there were significant differences in physical fitness variables of speed, agility and explosive power, and performance variables of sports competition dribbling, hitting and trapping between university and senior state men hockey players.

Taheri et al. (2014) stated that plyometric exercises showed more favorable effects on improving speed and performance skill and suggested to include plyometric training and resistance training for soccer players.

4.3 DISCUSSIONS ON HYPOTHESES

- The first hypothesis formulated by the investigator was that "there would be significant improvement on selected bio-motor variables due to the influence of plyometric training packages with and without resistance training". The results of the study showed that there was a significant improvement in selected bio motor variables such as speed, agility and cardio respiratory endurance by the impact of plyometric training packages with and without resistance training. Hence the formulated hypothesis of the present study is proved true for the selected bio motor variables.

- The second hypothesis formulated by the investigator was that "there would be significant improvement on selected physiological variables due to the influence of plyometric training packages with and without resistance training". The results of the study proved that there was a significant reduction in resting pulse rate and respiratory rate. Breath holding time is significantly improved by both plyometric training packages with and without resistance training. Hence the formulated hypothesis of the present study is proved true for the selected physiological variables.

- The third hypothesis formulated by the investigator was that "there would be significant improvement on selected hockey skill performance factors due to the influence plyometric training packages with and without resistance training". The results of the study proved that there was a significant improvement in the selected skill performance factors like dribbling, pushing and hitting of hockey players by the influence of plyometric training packages with and without resistance training. Hence the formulated hypothesis of the present study is proved true for the selected skill performance factors.

- The fourth hypothesis formulated by the investigator was that "there would be significant differences among the experimental groups on the selected bio motor, physiological variables and hockey skill performance factors of women hockey players". The results of the study showed that the plyometric training packages with resistance training was found to be more effective than plyometric training packages without resistance training in improving the selected bio motor (agility), physiological (breath holding time, resting pulse rate and respiratory rate) variables and skill performance factors (dribbling, pushing and hitting).

- The results further proved that the insignificant difference was existed on bio motor (speed and cardio respiratory endurance) variables between plyometric training packages with resistance training and plyometric training packages without resistance training groups. Hence the researcher's fourth hypothesis was proved true and accepted with respect to agility, resting pulse rate, respiratory rate, dribbling, pushing and hitting.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

CHAPTER – V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 SUMMARY

Training is the main component and the basic form of preparing the athlete for higher level of performance. It is systematically planned preparation with the help of the exercise, which realized the main factors of influencing athlete's progress. The content of training includes the physical, technical, tactical and psychological preparation of the sportsman. Through systematic training the athlete's fitness level and his acquisition of vital knowledge and skills are improved.

The improvement of motor fitness includes improvement of general health and organic functions as well as increasing the strength and stability of the muscle-skeletal system. Further, techniques of training and improvement of tactical efficiency play a vital role in the training process.

Hockey is a game, calls for strenuous, continuous and thrilling action. The skills involved are simple, natural and yet are highly stimulating and satisfying to any child. These skills are Dribbling, Pushing, Hitting, Flicking, Scooping, Tackling, Dodging, Stopping and Passing.

The investigator being a hockey player, coach, selector, and observer was motivated to find out the influence of plyometric training packages with and without resistance training on selected bio motor, physiological variables and skill performance factors among women hockey players.

The purpose of the present study was to find out the influence of plyometric training packages with and without resistance training on selected bio-motor, physiological variables and skill performance factors among women hockey players. To execute this investigation the research scholar employed random sample of forty five women hockey players among the hockey players who had represented from various affiliated colleges of Periyar University at inter-collegiate hockey tournaments at Salem, Tamil Nadu, India during the year 2012-2013. Their age was range between 18 to 21 years. The selected subjects were randomly assigned into two experimental groups such as plyometric training packages with resistance training (Group I), plyometric training packages without resistance training (Group II) and control group (Group III) of fifteen (n = 15) each. The experimental groups were subjected to their respective training programmes for a period of twelve weeks and three sessions in a week in addition to their regular activities and academic schedule. However, control group was not exposed to any specific training but they took part in their regular schedule. The subjects were free to withdraw their consent in case of feeling any discomfort during the period of their participation but there was no drop out in this study.

For the feasibility of the present investigation, the scholar has selected the following variables as criterion variables, i.e. Bio-motor variables - Speed, Agility, Cardio Respiratory Endurance; Physiological variables - Breath Holding Time, Resting Pulse Rate, Respiratory Rate; Skill performance factors - Dribbling, Pushing and Hitting. All the groups were tested on the selected criterion variables prior to and immediately after the training programme for a period of 12 weeks. The data on speed was assessed by 50 meters dash, agility was assessed by Illinois agility test, cardio respiratory endurance by Cooper's 12 minutes run/walk, breath holding time was estimated by the time of holding the breath, resting pulse rate and respiratory rate by manual method, hockey skill performance factors such as dribbling, pushing and hitting was assessed by standard field hockey tests. Pre test data were collected two days before the training programme and post test data were collected immediately after the training period.

The collected data before and after the experimentation of the treatments were analyzed by dependent 't' test and Analysis of Covariance (ANCOVA) to assess the post training significance. The level of significance of 'f' ratio obtained by the analysis of covariance was fixed at 0.05 level of confidence, which was considered to be more appropriate in view of the fact that very high sophisticated equipments were not used for more stringent level of significance. Whenever the obtained "f" value for adjusted post test mean was found to be significant, the Scheffe's test was applied as post hoc test to determine the paired mean differences, if any.

5.2 CONCLUSIONS

From the analysis of the data, the following conclusions were drawn.

- Twelve weeks of systematic plyometric training packages with and without resistance training positively influences the selected bio motor variables (speed, agility and cardio respiratory endurance) of hockey players. It is further observed on comparison that the plyometric training packages with resistance training is found to be superior to plyometric training packages without resistance training in improving the selected bio-motor variables.
- Plyometric training packages with and without resistance training of twelve weeks significantly altered the physiological performance of hockey players (breath holding time, resting pulse rate and respiratory rate). The comparison between the two modes of training revealed that plyometric training packages with resistance training have considerable impact in reducing the respiratory rate and resting pulse rate and improving the breath holding time of women hockey players.
- Although significant changes have been observed after twelve weeks of plyometric training packages with and without resistance training in the selected skill performance factors (dribbling, pushing and hitting), it is noticed that plyometric training packages with resistance training is found to be highly effective in enhancing the skill performance factors of women hockey players.
- Therefore, it is concluded from the findings of the study that the regular and systematic practice of both plyometric training packages with and without resistance training would bring positive changes on the selected bio motor, physiological variables and skill performance factors of women hockey players. However, it is further concluded that the plyometric training packages with resistance training is found to be more effective in producing significant changes on the selected criterion variables of women hockey players.

5.3 RECOMMENDATIONS

Based on the findings of the present investigation the following recommendations were drawn.

- ❖ The coaches and athletes may take necessary steps to improve the bio motor, physiological and skill performance factors by including the plyometric exercises with resistance training in their training schedule.
- ❖ Similar studies may be conducted on state and Inter university level women players for better evaluation.
- ❖ Similar studies may be framed on men players at state, national and university levels.
- ❖ Same study may be conducted on highly skilled players of various games.

BIBLIOGRAPHY

BIBLIOGRAPHY

BOOKS

Baechle Thomas. R. (1994), ***Essentials of Strength Training and Conditio,*** Champaign: Human Kinetics.

Bloomfield.J, et al., (1994), ***"Applied Anatomy and Biomechanics in Sports",*** Melbourne : Blackwell Scientific Publications.

Clayne R.Jensen and A. Garth Fisher (1972), ***Scientific Basis of Athletic Conditioning,*** Philadelphia: Lea and Febiger.

Close, Nancy Allison (1973), ***Measurement in Physical Education,*** W.B. Saunders.

Dan Wathen (1994), "Periodisation: Concepts and Application" as cited by Thomas R. Baechle., ***Essentials of Strength Training and Conditioning,*** Champaign: Human Kinetics, P.460.

David Whitaker, (1986), ***Coaching Hockey,*** Ram Bury Marlborough: Rowood press, P.52.

Davies, Phil (2006), ***The Soccer Exercise Library,*** Sporting Excellence Ltd.

Don Cash Seaton et al (1983), ***Physical Education Hand Book,*** Englewood Cliffs: Prentice Hall International.

Edward L. Fox and Donald K. Mathews, ***The Physiological Basic of Physical Education and Athletics (3rd ed),*** (Philadelphia: Mosby College Publishing, 1981), p.184.

Gambetta, Vern (1988), "Plyometric - myth and misconceptions", ***Sports Coach,*** 20: 4 Summer.

Ganong, W.F., (1997), ***Review of Medical Physiology*** (24 ed.), Appleton and Lange: Stanford, Connecticut, p.619.

Horst Wein, (1973), ***The Science of Hockey,*** New Delhi, S.Chand & Company Limted, p.25, p.55.

Ion Taylor (1988), ***Taylor on Hockey,*** London: Mc Donald Publishers.

Johnson, Barry L and Jack K Nelson (1974), ***"Practical Measurement for Evaluation in Physical Education",*** Delhi: Surjeet Publication, p.140.

Mathew Donald, K (1978), ***Measurement in physical education*** (5th ed.); Philadelphia: W.B Saunders Company.

Matveyev.L (1981), ***Fundamentals of Sports Training,*** Moscow: Progress Publishers.

Morehouse, Lawrence E. and Augustus T., Millar (1976) ***"Physiology of Exercise"*** Saint Louis: the C.V. Mosby Company, P.P. 69.

Mosby (2009), ***Medical Dictionary,*** The New York Times Company 8th edition.

Pickering, R.J, (1965), ***"Strength Training Gorthe Athletic",*** England Sesser printers Limited, p.10.

Ribben B. Fresh, ***"Psychological Concepts Applied to Physical Education and Coaching",*** California: Wesley publishing company, 1971.

Seaton Don Cash, (1983), ***Physical Education Hand Book,*** Englewood Cliffs: Prentice Hall International.

Singh Hardayal (1985), "***Sports Training General.Therph and Methods***", India Patiala: Phulkia press.p.3.

Singh, Hardayal (1991), ***Science of Sports Training,*** New Delhi, D.V.S. Publications.

Singh. H.D, (2001), ***Textbook of Human Physiology,*** 6th ed. New Delhi: Published by S.Chand & Company.

Strukie, P.J., (1981), Basic physiology,New York:Springer-Verleg Inc., p.286.

Suresh (2003), ***"Physical Activity Among Adolescent in Taiwan",*** Delhi; Sports Publications.

Wein Horst (1981), ***The Advanced Science of Hockey***, Pelham book lid London: 20.

William, (1994), ***Fitness for College and Life,*** 4th ed. Philadelphia: Mosby.

JOURNALS

Ada L, Dorsch S, Canning C G (2006), "Strengthening Interventions Increase Strength and Improve Activity after Stroke: A Systematic Review", ***Australian Journal of Physiotherapy***, 52(4):241-248.

Adams TM, (1984) "An investigation of selected plyometric training exercises on muscular leg strength and power", ***Track field Quarterly Review***, 84-36.

Adibpour Nahid, Hojatolah Nik Bakht and Naser Behpour(2012), "Comparison of the Effect of Plyometric and Weight Training Programs on Vertical Jumps in Female Basketball Players", ***World Journal of Sport Sciences.*** 7 (2): 99-104.

Amrinder Singh, Gaur Sakshi, Sandhu Jaspal Singh (2014), "Effect of Plyometric training on sand versus grass on muscle soreness and selected sport specific performance variables in hockey plyers", ***J.Hum.Sport Exerc***. 9(1), pp.59-67

Andres D.Lyttle et.al(1996), "Enhancing Performance Maximal Power Versus Combined Weights and Plyometrics Training", ***Journal of Strength and Conditioning Research,*** 10(3), 173-179.

Annadurai.R and S. Rajaram(2013), "Combination of squat and plyometric Training programme on the development of power production and skill Performance of inter collegiate Men volleyball players", ***International Journal of Physical Education, Health & Sports Sciences,*** 2: 1, March.

Asaithambi.T, S. Sundararajan and I. John Parthiban (2014), "Effect of different intensities of plyometric exercises on Explosive power of collegiate athletes", ***Star Phy.Edn,*** Vol.2 Issue1. 04.

Avery d., Faigenmbanum, jams E.Mc forland (2007) "Effects of a short-term plyometric and resistance training programme on fitness", ***Journals of Sports Science and Medicine***, 6, 519 – 525.

Bandyopadhyay Sagarika, Sentu Mitra and Arup Gayen (2013), ***"Effects of plyometric training and resistance training on specific speed of basketball players"***, Paripex Indian journal of research, 2(7): 249 – 251.

Buvanendiran.P (Jaffna) and R. Barathiraj (2013), Effect of Plyometric Training on Explosive Power of Basketball Players, ***Indian Streams Research Journal,*** Volume-3, Issue-8, Sept-2013.

Campillo Ramirez R, Alvarez C, Henriquez-Olguin C, Baez EB, Martinez C, Andrade DC, Izquierdo M (2014), "Effects of plyometric training on endurance and explosive strength performance in competitive middle - and long-distance runners", ***J Strength Cond Res,*** Jan;28(1):97-104.

Carlos Balsalobre – Fernandez, Carlos MTejero – Gonazalez, Juan del Campo Ve cino, Dionisio Alonso-Curiel (2013) "The Effects of Maximal power training cycle on the strength, Maximum Power, vertical jump Height and acceleration of High – level 400 – meters hurdles", ***Journal of Human Kinetics,*** Volume 36, 119 – 126.

Chatzinikolaou A., Fatouros IG., Gourgoulis V., Avloniti A., Jamurtas AZ., Nikolaidis MG., Douroudos I., Michailidis Y., Beneka A., Malliou P., Tofas T., Georgiadis I., Mandalidis D., Taxildaris K., (2010) "Time course of changes in performance and inflammatory responses after acute plyometric exercise", ***Journal of Strength Conditioning Research*** , 24(5):1398-98.

Christopher J. MacDonald, Hugh S. Lamont, John C. Garner, and Katie Jackson, (2013), "A comparison of the effects of six weeks of traditional resistance training, plyometric training, and complex training on measures of power", ***Journal of Trainology***, 2:13-18.

Christou Marios, Ilias Smilios, Konstantinos Sotiropoulos, Konstantinos Volaklis, Theofilos Pilianidis, Savvas P Tokmakidis(2006), "Effects of Resistance Training on the Physical Capacities of Adolescent Soccer Players", ***Journal of Strength and Conditioning Research,*** Nov: 20(4):783-91.

Devaraju.K (2014), "Effect of plyometric training on explosive strength Among kabaddi players", ***Star Phy. Edn.***, Vol.2 Issue 2. 07.

Devaraju.K (2014), "Impact of plyometric training on selected physical fitness variables among ball badminton players", ***International Journal of Advanced Research in Engineering and Technology (IJARET),*** Volume 5, Issue 1.

Fagan C.D. and P.K. Doyle Baker(2000), "The Effects of Maximum Strength and Power Training Combined with Plyometrics on Athletic Performance", ***Medicine and Science in Sports and* Exercise,** 32(5), Supplements Abstract 659.

Faigenbaum A D, R L Loud, J O'Connell, S Glover, J O'Connell, W L Westcott(2001), "Effects of different Resistance Training Protocols on Upper-Body Strength and Endurance Development in Children", ***Journal of Strength Conditioning and Research,*** Nov; 15(4):459-65.

Faigenbaum, A., L. Milliken, R. La Rosa Loud, B. Burak, C. Doherty, and W. Westcott (2002), "Comparison of 1 and 2 Days Per Week of Strength Training in Children", ***Research Quarterly of Exercises and Sports,*** Dec :73 (4): 416-24.

Felipe B.D. Oliveira, Anderson S.C. Oliveira, Guilherme F. Rizatto, and Benedito S. Denadai (2013), Resistance Training for Explosive and Maximal trength: "Effect on Early and Late rate of force development", ***J Sports Sci Med,*** Sep; 12(3): 402–408.

Fletcher Iain M.., (2004), "Effect of an 8-week Combined Weights and Plyometrics Training Program on Golf Drive Performance", ***The Journal of strength and conditioning Research,*** 18:1, 69–62.

Gnaneshwar. M. N and R. Gopinath (2013), "Effect of Plyometric Training Isotonic Training and Combination of Isotonic and Plyometric Training on Speed and Muscular Endurance", ***International Journal of Health, Physical Education and Computer Science in Sports,*** Volume, No.11, No.1.pp125-127.

Gokulakrishnan D., Pushparajan A (2014), "Effect of plyometric training programme and plyometric training parallel with closed kinetic chain resistance training programme on the development of selected physiological variables of adolescent students", ***International Journal of Physical Education Sports Management and Yogic Sciences,*** Volume:4, Issu:1.

Guigan Mc, Michael R, Tatasciore, Melissa, Newton, Robert U, Pettigrew and Simone (2009), "Eight Weeks of Resistance Training Can Significantly Alter Body Composition in Children Who are Overweight or Obese", ***Journal of Strength and Conditioning Research,*** 23(1) January, pp 80-85.

Haghighi Asghar, Mehrzad Moghadasi, Asghar Nikseresht, Ahmad Torkfar, Mostafa Haghighi (2012), "Effects of plyometric versus resistance training on sprint and skill performance in young soccer players", ***European Journal of Experimental Biology,*** 12.

Hakkinen K. (1993), "Changes in physical fitness profile in female volleyball players during the competitive season", ***Journal of Sports Medicine Physical Fitness,*** Sep;33 (3) : 223-32.

Hanjabam Barun and Kailashiya Jyotsna (2014), "Effects of addition of sprint, strength and agility training on cardio vascular system in young male field hockey players", ***IOSR journal of sports and physical education,*** 1(4): pp. 25 – 29.

Hoda Zeareia, Mohammad Reza Ramezanpourb, Saeid Pakdelanc (2013), "Comparison of the Effect of Plyometric and Resistance Training on Explosive Power and Speed in Female Taekwondo Players", ***J. Basic. Appl. Sci. Res.,*** 3(1): 339-343.

Jaipal and Ashok Kumar Sharma (2013), Vascular Efficiency Among Adolescents, ***International Journal of Health, Physical Education and Computer Science in Sports,*** VolumeNo.11, No.1.pp104-106.

Kar Subhabrata (2013), Effect of Short-Term Plyometric Training on Strength Performance of the Athletes, ***International Journal of Management, Economics and Social Science,*** Vol. 2 No. 2, October.

Keiner M, Sander A, Wirth K, Schmidtbleicher D (2014), "Long-term strength training effects on change-of-direction sprint performance", ***J Strength Cond Res***., 28(1): 223-31.

Khlifa R., Aouadi R., Hermassi S., Chelly S., Jlid MC., Hbacha H., Castagna C., (2010). "Effects of a Plyometric Training Program with and without Added Load on Jumping Ability in Basketball Players", ***Journal of strength and conditioning Research***, 24.

Khodajo Abdul Rahim, Asghar Nikseresht and Ebrahim Khoshnam (2014), "The effect of strength and plyometric training on anaerobic power, explosive power and strength quadriceps femoris muscle in soccer players", ***European Journal of Experimental Biology,*** 4(1):448-451.

Kubo K, Morimoto M, Komuro T, Yata H, Tsunoda N, Kanehisa H, Fukunaga T(2007), "Effects of plyometric and weight training on muscle-tendon complex and jump performance", ***Med Sci Sports Exerc***, 10:1801-10.

Kumar Rajesh and J.Prabhakar Rao(2013), "A Study on the effect of Plyometric Exercises on Performance ability and Speed among Long Jumpers of Osmania University in India", ***International Journal of Health, Physical Education and Computer Science in Sports,*** Volume No.9, No.1.pp100-103.

Lakshmikrishnan.R and Dr. K. Sivakumar (2013), "Effect of Weight Training and Plyometric Training on Strength Endurance and Leg Strength", ***International Journal of Health, Physical Education and Computer Science in Sports,*** VolumeNo.11, No.1.pp152-153.

Lemmer, Jeffrey t.; Ivey, Frederick M.; Ryan, Alice S.; Martel, Greg F.; Hurlbut, Diane E.; Metter, Jeffrey E.; Fozard, James L.; Fleg, Jerome L.; Hurley, Ben F.(2001), "Effect of Strength Training on Resting Metabolic Rate and Physical Activity; Age and Gender Comparisons", ***Medical science of Sports and Exercise,*** Apr: 33(4):532-41.

Makaruk Beata, Henryk Sozański, Hubert Makaruk Tomasz Sacewicz (2013), The Effects of Resisted Sprint Training on Speed Performance in Women, **Human Movement**, Volume 14, Issue 2.

Makaruk H., Czaplicki A., Sacewicz T., Sadowski J. (2014), "The effects of single versus repeated plyometrics on landing biomechanics and jumping performance in men", ***Biol. Sport,*** 31:9-14.

Mallesh.N and Gandhi.R, (2014), "Comparative analysis of selected physical fitness and performance variable among university and senior state men hockey players", ***Star Phy. Edn***., Vol. 2 issue 6(9), pp. 40 - 44.

McDonald CJ, Lamont HS, Garner JC (2012), "A Comparison of the Effects of 6 Weeks of Traditional Resistance Training, Plyometric Training, and Complex Training on Measures of Strength and Anthropometrics", ***Journal of Strength and Conditioning Research,*** Feb;26(2):422-31.

Miller, M.G, Hermiman J.J., Ricard M.D, Cheatham .C.C, Michel .T.J. (2006), "Effect of six weeks of plyometric training on athlete's agility", ***J Sports Sci. Med,*** 5(3): 459 – 465.

Nageswaran.A.S (2014), "An Impact of Plyometric Training Packages with and Without Resistance Training on Leg Explosive Power of Arts College Men Basketball Players", ***Indian Journal of Applied Research,*** Volume : 4, Issue : 2.

Nageswaran. A.S. (2014), "Effect of Resistance Band Training on Strength Speed and Balance among Inter Collegiate Kabaddi Players", ***Star Phy. Edn.*** Vol.2 Issue 2. 05.

Perez-Gomez J., Olmedillas H., Delgado-Guerra S., Ara I., Vicente-Rodriguez G., Ortiz RA., Chavarren J., Calbet JA., (2008) "Effects of weight lifting training combined with plyometric exercises on physical fitness, body composition, and knee extension velocity during kicking in football" ***Journal of Applied Physiology nutrition and Metabolism***, 33 (3):501- 510.

Polhemus and Burkhardt (1987) "Examined the effects of Plyometric training drills on strength gains of collegiate football players", ***Journal of Sports medicine and physical fitness,*** 41: 159-64.

Rahman Rahimi and, Naser Behpur (2005), "The Effects of Plyometric, Weight and Plyometric-Weight Training on Anaerobic Power and Muscular Strength", ***Physical Education and Sport,*** Vol. 3, No 1, pp. 81 – 91.

Rajan.C and Reddy Venkat .P (2012), "The influence of circuit training for development of endurance among university hockey players of Andhra Pradesh", ***Asian journal of physical education and computer science in sports,*** 7(1), pp, 108-110.

Raj kumar (2013), "The effect of 6 week plyometric training program on Agility of collegiate soccer players", ***International Journal of Behavioral Social and Movement Sciences,*** Vol.02,Issue01.

Ratamess NA, Kraemer WJ, Volek JS, French DN, Rubin MR, Gómez AL, Newton RU, Maresh CM (2007), "The effects of ten weeks of resistance and combined plyometric/sprint training with the Meridian Elyte athletic shoe on muscular performance in women", ***J Strength Cond. Res,*** 21(3): 882-7.

Rathod Laxmikanth L.B., (2011) "Plyometric Training for Foot Ball", ***International Journal of Health, Physical Education and Computer Science in Sports,*** Volume No.4, No.1pp 98.

Rde Baldon M, Moreira Lobato DF, Yoshimatsu AP, dos Santos AF, Francisco AL, Pereira Santiago PR, Serrão FV (2014), "Effect of plyometric training on lower limb biomechanics in females", ***Clin J Sport Med.*** 24(1):44-50.

Robert Angel and K. Murugavel (2013), Effect of plyometric resistance and sprint training on acceleration speed flight time and jump height of male basketball players, ***International Journal for Life Sciences and Educational Research,*** Vol.1(3), pp. 105 - 109, October.

Ronnestad BR, Mujika I (2014), "Optimizing strength training for running and Cycling Endurance Performance: A review", ***Scand J Med Sci. Sports.***

Rubenstein Heidi(2004), "The Effects of a Four-week Combined Plyometrics and Resistance Training Program on Shot Speed on Goal in Women's Soccer Players", ***Research Paper presented in training methods International Seminar*** at London, 22.6.2004.

Sagarika BandyopadhyaySentu Mitra, Mr. Arup Gayen(2013), "Effects of Plyometric Training and Resistance Training on Specific Speed of Basketball Players", ***International Journal of Behavioral Social and Movement Sciences,*** Volume : 2, Issue : 7.

Sankarmani. B, S.Ibrahim Sheriff, K.R.Rajeev, Jagatheesan Alagesan, (2012), "Effectiveness of Plyometrics and Weight Training in Anaerobic Power and Muscle Strength in Female Athletes", ***International Journal of Pharmaceutical Science and Health Care***, 2:2.

Shafeeq, V. A, Dhinu, M. R.; Jackson, P.; Shine Singh, J. P (2013)., Impact of isolated and combined resistance training and plyometric training on strength and power outputs, ***Brazilian Journal of Biomotricity.*** v. 7, n. 2, p.117-127.

Shallaby, Handy Kassem (2010), "The effect of plyometric exercises use on the physical and skillful performance of basketball players", ***World journal of sport science*** 3(4): 316 – 324.

Singh Dalwinder and Sukhwinder Singh (2013), "Effects of Vertical and Horizontal Plyometric Exercises on Running Speed", ***Human Movement,* 12.**

Sodhi H.S, (1995), "Study of Physical structure and performance of Tribals of Chotanagpur and North Indian players Ranging in age 14 to 16 years", ***NIS Scientific Journal,*** (18:4).

Solanikidis K., Zaferiridis A., (2008) "A effect of plyometric Tennis drills and combined training reaction lactoral and linear speed, power and strength Novice Tennis players" ***Journal of Strength conditioning Research,*** PP. 182-191.

Stone, M. H(1990), "Muscle conditioning and muscle injuries", ***Medicine and Science in Sports and Exercises.*** V. 22, p. 457-462.

Taheri Eskandar, Asghar Nikseresht and Ebrahim Khoshnam (2014), "The effect of 8 weeks of plyometric and resistance training on agility, speed and explosive power in soccer players", ***European Journal of Experimental Biology,*** 4(1): 383-386.

Tang, J. E.; Perco, J. G.; Moore, D. R(2008), "Resistance training alters the response of fed-state mixed muscle protein synthesis in young men", ***American Journal of Physiology Regulatory Integrative and Comparative Physiology,*** v. 294, p. 172-178.

Velusamy.P (2013), "Effect of Varied Methods of Resistance Training on Selected Physical Fitness Components of Inter Collegiate Male Volley Ball Players", ***International Journal of Science and Research (IJSR),*** Volume 2 Issue 7.

Vijayalakshmi.V and Jayabal .T (2013), "Effect of plyometric training with Yogic practices on selected physical and physiological variables among adolescent boys", International journal of innovative research and development 2(5) : 1559 – 1564.

Vincent, K. R., Braith, R. W., Feldman, R. A., Magyari, P. M., Cutler, R.B(2002), "Resistance Exercise and Physical Performance in Adults Aged 60 to 83", ***Journal of American Geriatric Society,*** June 50(6):1100-7.

Wilk. KE., Voight ML., Keirns MA., Gambetta V. Andrews JR, Dillman C.J. (1993) "Stretch - shortening drills for the upper extremities: theory and clinical application", **Journal of Orthopedic Sports Physical Therapy**, 17(5):225-39.

Wilson. G.J (1993), "The Optimal Training Load for the Development of Dynamic Athletic Performance", ***Medicine and Science in Sports and Exercise,*** 25: 11, p.1279-1286.

Yamamoto, Linda M, Lopez, Rebecca M, Klau, Jennifer F, Casa, Douglas J, Kraemer, William J, Maresh, Carl M(2008), "The Effects of Resistance Training on Endurance Distance Running Performance Among Highly Trained Runners: A Systematic Review", ***Journal of Strength and Conditioning Research,*** 22(6) November 2036-2044.

Zeareia Hoda, Mohammad Reza Ramezanpourb, Saeid Pakdelan (2013), "Comparison of the Effect of Plyometric and Resistance Training on Explosive Power and Speed in Female Taekwondo Players", ***J. Basic. Appl. Sci. Res.,*** 3(1) 339-343.

UNPUBLISISHED THESES

Palani.S (2010), "A comparative study of selected physical, psychological and performance variables among southern region Men hockey teams at different playfields", ***Unpublished Doctoral Thesis,*** Pondicherry University.

Reddy Sathiyanarayana(1993), "Relative Effects of Plyometric and Weight Training Followed by Plyometric Training on Power, Speed, Stride Length and Stride Frequency", ***Unpublished Doctoral Thesis*****,** Annamalai University.

WEBSITES

Retrieved Hockey History from http://www.fih.ch/en/fih/history, on 7.2.2012

Retrieved from http://www.exrx.net/Lists/PowerExercises.html on 7.5.2013

Retrieved from http://the-exercise-site.com on 18.12.2013.

Retrieved from http://www.exrx.net/Lists/PowerExercises.html on 19.8.2013

Retrieved from http://www.slideshare.net/pdhpemag/types-of-resistance-training on 27.2.2014