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EFFECTS OF PLYOMETRIC TRAINING ON SHOOTING PERFORMANCE AND SOME SELECTED PHYSICAL FITNESS QUALITIES IN CASE OF ADET TOWN HANDBALL PROJECT

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A THESIS SUBMITTED TO SPORT ACADEMY, BAHIR DAR UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTERS OF SCIENCE IN HANDBALL COACHING.

ADVISOR

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JULY, 2020

BAHIR DAR

Certificate

Bahir Dar University

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Approval of Thesis for defense

I hereby certify that I have supervised, read, and evaluated this thesis titled **"Effects of Plyometric Training on Shooting Performance and Some Selected Physical Fitness Qualities in Case of Adet Town Handball Project Players"** by **Yordanos Chalie** prepared under my guidance. I recommend the thesis be submitted for oral defense.

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Advisor's name	Signature	Date

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Approval of Thesis for defense result

We hereby certify that we have examined this thesis entitled **"Effects of Plyometric Training on Shooting Performance and Some Selected Physical Fitness Qualities in Case of Adet Town Handball Project Players"** by **Yordanos Chalie**. We recommend that the thesis be approved for the degree of "Masters of science in Handball Coaching".

Board of Examiners

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External examiner's Name	Signature	Date
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Internal examiner's Name	Signature	Date
_____	_____	_____
Chair person's Name	Signature	Date

DECLARATION

I, Yordanos Chalie, hereby declare that the material contained within this research now submitted to the Sport Academy of Bahir Dar University in partial fulfillment for the award of Degree of Master of Science in Handball Coaching is entirely my own work. I have followed all ethical principles of scholars in the preparation, data collection, data analysis and completion of this thesis. All information in this thesis has been obtained and presented in accordance with academic rules and ethical conduct and fully cited and referenced all material has been acknowledged . All scholarly matter that is included in the thesis has been given recognition through citation. I affirm that I have cited and referenced all sources used in this document. Every serious effort has been made to avoid any plagiarism in the preparation of this thesis. It has not previously formed for the award of any degree or diploma of any university to the best of my knowledge and belief.

Student's Name: Yordanos Chalie

Signature: ----------

Date: ----------

DEDICATION

I dedicate this thesis document to my favorite parents and beloved two uncles. Furthermore, the researcher unlimited his dedications to sport participants who supply still a member of advice all the way through in my life to achieve in this step**.**

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LIST OF ABBREVIATIONS

ANRS	Amhara National Regional state
CG	Control group
EG	Experimental group
MD	Mean Difference
N	Number
POT	Post Test
PT	Pre Test
SD	Standard Deviation
SPSS	Statistical Package for Social Sciences
SSC	Stretch shortening cycle
THF	Turkish Handball Federation

ABSTRACT

Handball is a fast body contact Olympic team sport that requires running, jumping, sprinting, throwing, repeated sprinting, faking, hitting, blocking and pushing. The purpose of this study was to investigate the effect of plyometric training on shooting performance and some selected physical fitness qualities. The study employed Experimental research design. Twenty male subjects with the age of (EG=18.6±1.34, CG=18.9±1.37years), height (EG=1.621 ±0.08, CG=1.61±0.07cm,) weight (EG=60.4±5.46, CG=58.6±4.71kg), training experience (2.4±0.69, CG=2.5±0.70years) from Adet town handball project participating players were randomly assigned into two equal groups. Both the experimental group (EG, n=10) and control group (CG, n=10) participated in the regular handball training, but only EG performed additional plyometric training for 12 weeks, with 3 sessions per week, each lasting 50 to 60 minutes. All subjects in two groups were tested on selected physical fitness qualities and performance variables before and after the intervention. Shooting accuracy test measured for shooting performance, hexagonal obstacle test for agility, flying 30m test for speed and vertical jump test for explosive power. The data collected from the study subject was analyzed using SPSS version 23 software by paired t-test with level of significant at 0.05. The training intervention improved shooting performance in EG (p=0.000), agility (p=0.000), speed (p=0.001), explosive power (p=0.000). Thus, the results showed that plyometric training significantly improved shooting performance, agility, speed and explosive power in EG at (p<0.05). However, shooting performance in CG (p= 0.555), agility (p=0.07), speed (p=0.344) and explosive power (p=0.08). Therefore, no significant differences were found in all of the variables in CG (p>0.05). Based on the findings, twelve weeks plyometric training has positive effect on improvement of shooting performance and physical fitness qualities of handball players. Therefore, it recommended conducting plyometric training on handball players to enhance shooting performance and physical fitness qualities.

Key words: *handball, plyometric training, shooting performance, physical fitness qualities*

CHAPTER ONE
INTRODUCTION

1.1 Background of the study

Handball is a fast body contact Olympic team sport that requires running, jumping, sprinting, throwing, repeated sprinting, faking, hitting, blocking and pushing. It requires a high standard of preparation to complete sixty minutes of competitive play and to succeed. At present, the requirements for the players have changed as the game of handball has developed over the years. The amount of training and the number of matches have increased considerably and the recently introduced rule on quick throw-off and the tightening-up of the rule about passive playing have led to an increased number of attacks and intensity for players (Ronglan et al., 2006). This has contributed to increasing the dynamics and physical demands imposed on the players. With this development, there is a need to check, plan and carry out optimal physical training regimes for handball players. From this, handball players require various technical skills (e.g. shooting, passing and throwing) and physical characteristics (e.g. jumping ability, power, speed and agility) at different levels of competition (Ziv & Lidor, 2009).

On the other hand, the research work of Hakan (2018), revealed as in all sport branches, there are many factors at the heart of success in handball such as theoretical knowledge, psychological, technical and tactical characteristics. In handball, it is necessary to look at not only technical and tactical practices, but also different issues such as training and training plans and technical tests. In handball, players' changing their places as quickly as possible, meeting the ball and using the ball will not give the opponent enough time for defense. Thus, the ability of speed or speed comes to the forefront as the most important motor characteristic of handball. Likewise, Handball is a sport branch that requires powerful effort composed of defense and offensive organizations to carry out walking, passing, bouncing, shooting, block, short distance fast running (Marques et al., 2011).

Subsequently, plyometric exercises first appeared in coaching texts in the 1960s (Radcliffe & Farentinos, 1999). In plyometric exercises, the sudden lengthening and shortening of muscle

length by the contraction and stretching of muscles result in a rapid release of energy stored in the muscles, because of these exercises simultaneously enhance important abilities, i.e. power, speed and endurance. Perhaps one of the most successful methods is the one that involves plyometric exercises (Boumpa, 2005). Apart from, plyometric exercises have shown to improve jump performance in many sports. These exercises combine strength with speed of movement to produce power. Similarly, plyometric exercise involves starting, stopping, and changing movement directions that contribute to agility development. Besides that, in relation to rank plyometric method is the most frequently used method for conditioning in handball (Lehnert et al., 2009).

On the other hand, plyometric training involves exercises designed to produce fast, generate quick, and improve the functions of the nervous system as well as the purpose of improving performance in sports to powerful movements involving explosive concentric muscle contraction preceded by an eccentric muscle action (Chu, 1998). These types of explosive muscular contractions are in practical instances such as jump shot in handball. In fact, plyometric is a type of training that develops the ability of muscles to produce force at high speeds in dynamic movements; these movements involve a stretch of the muscle immediately followed by an explosive contraction of the muscle. This pattern of muscle contraction is also known as the stretch-shorten cycle (SSC). From this, motor ability, sprinting, jumping, flexibility and throwing accuracy represent physical activities that are considered as important aspects of the game and contribute to high performance of the team (Zapartidis et al., 2009b).

Plyometric movements, in which a muscle is loaded and then contracted in rapid sequence, use the strength, elasticity and innervations of muscle and surrounding of hopping, skipping, jumping and throwing activities designed to make the athlete faster going from slow muscles to fast muscles requires performing quick, “explosive” movements (Pallav, 2015). These activities must allow for minimal contact with the ground (lower body) or the hand contact surface (upper body). Plyometric is the best answer for these types of exercise needs. A lower body plyometric exercise emphasizes quick foot movements and the ability to get off the ground quickly. Upper body plyometric exercises emphasize using medicine balls to teach the muscle to respond more quickly to external forces (Salvi, 2012).

Competitive handball players are required to throw the ball with both high velocity and accuracy. Speed and accuracy have been frequently analyzed in team handball players both expert and novice levels (Rousanoglou et al., 2014). Throughout the brightness of the above clarification, the purpose of the study was to investigate the effect of plyometric training on shooting performance and some selected physical fitness qualities in case of Adet town handball project players.

1.2 Statement of the problem

Handball is intense and one of the fastest team sports, characterized by repeated jumps, sprints, changes in direction, body contact at high speed, and specific technical movement patterns occurring in response to the varying tactical situations of the game (Karcher & Buchheit, 2014). Handball players undergo various types of training to maximize their performance. A Plyometric training program has been advocated as a suitable technique for sports, which need vertical jumping ability and explosiveness improvement (Karadenizli, 2016). Generally, plyometric training is the best way to provide power / speed to react immediately during the game and to provide the player to jump higher and to improve the jumping ability of the leg muscles (Zeynep, 2013).

According to Muller, (2008) stated that, in team handball, shooting on goal is one of the most important aspects of the handball game. Shooting the ball hard is not enough to beat a good goalie; accuracy is essential. Shooting for the corners is one of the important principles of shooting. For a shot to be successful, it requires maximum ball velocity and precision as well as an element of surprise for the defensive players and goalkeeper. In handball players perform, more often repeated short sprinting with change of direction. However, plyometric drills usually involve stopping, starting, and changing directions in an explosive manner. These movements are components that can assist in developing agility (Miller et al., 2006).

For handball players, successful match performance requires several physical attributes such as speed, power, strength and agility, plus the ability to maintain performance during repeated sprints (Michalsik et al., 2013). However, derived from the researcher's observation, there was a lack of physical fitness qualities and shooting performance in case of handball project players in Adet town. The researcher has had more than 3 years' as a living place to Adet. That is why; the

researcher got the opportunity to observe a variety of aspects of their training session and training methods of Adet town handball project players. As the researcher saw it for the last three years, coaches have set fewer concentrations for player's fitness and a player is not too good at sport and executes handball skills competently and successfully. All training activities were only handball game oriented exclusive of incorporating physical fitness exercises. This attitude might arrange players developing poor fitness levels in opposition to predictable norms. In fact, players showed restriction on their physical fitness qualities and skill performance when the researcher's observation in their training program. Thus, there is a setback of physical fitness qualities and shooting performance in case of Adet town handball project players. Accordingly, the investigator believes that if the trainer gives enormous concentration to plyometric training on their training program, it would have an impact on players shooting performance and physical fitness.

Researchers have carried out many studies to investigate the effect of plyometric training on the physical demands of handball players and they have drawn different conclusions. Conroy (1998) came to conclude that plyometric training does not have a significant effect on the athletes' speed and does not decrease their time. Conroy (1998) also concluded that plyometric training did not lead to a significant difference between a control and experimental group in terms of improvement in the vertical jump. However, other research demonstrates that plyometric training has a positive effect on the vertical jump and increases it (Shahdadi, 1999), this indicates that there is a controversial research issue regarding it and this requires a comprehensive investigation.

Reaching athletic achievement is necessary and many necessary requirements to work to raise the level of athletic performance and fulfill the best achievements. This can be achieved through the best methods and ways that can achieve it. Thus, several coaches in several countries adopted plyometric training methods and they achieved advanced results in volleyball, handball, basketball, football and arena games, swimming, gymnastics and weightlifting. That is, plyometric exercises and good level of techniques work together to enable the progress in the level of achievement of various sporting events and skills (Bastosi, 1999). It is worth indicated that some important and extremely common activities in handball include: jumping and shooting over the head of the opponent into the goal (Shahdadi, 1999), the player's shooting at a speed of

more than 70 miles per hour (Amirtash, 2006) and passing the opponent around 6 and 9 meter lines of the handball court and 30 meter speed, which are effective features for elite handball players to execute counterattacks (Agha & Ghahremanloo, 2007). All of these abilities have a substantial impact on the result of a match and they are suitable predictors of successful performance in handball, which determine the winner and the loser.

Numerous studies have discovered positive effects of short-term plyometric training on jumping performance in basketball (Matavulj et al., 2001); soccer (Ramirez-Campillo et al., 2014); volleyball (Milic et al., 2008); handball (Chelly et al., 2014) and other team sport games, there is expensive tiny data around their particular impact on handball physical skills. These studies as of now appeared that plyometric training significantly improved jumping performance. However, there has been no other specific research focused on the effect of plyometric training on shooting performance and other physical requirements of handball. Thus, this study aims to bridge the gap by investigating in detail about the effects of plyometric training on shooting performance and physical fitness qualities of handball players. Therefore, the purpose of the study was to investigate effects of plyometric training on shooting performance and some selected physical fitness qualities in case of Adet town handball project players.

1.3 Objectives of the study

1.3.1 General Objective

The general objective of this study was to investigate the effect of plyometric training on shooting performance and some selected physical fitness qualities in case of Adet town handball project players.

1.3.2 Specific Objectives

In adding together to the general objective on top of investigate was existed concentrate on the subsequent specific objectives:

1. To evaluate the effect of plyometric training on shooting performance of players in Adet town handball project players.

2. To determine the effect of plyometric training on agility of players in Adet town handball project players.
3. To measure the effect of plyometric training on the speed of players in Adet town handball project players.
4. To examine the effect of plyometric training on explosive power of players in Adet town handball project players.

1.4 Hypotheses

The study has tried to test the following hypotheses.

1. **$H_{1.1}$:** plyometric training would have a significant effect on shooting performance of handball players.
2. **$H_{0.1}$:** plyometric training would have no significant effect on shooting performance of handball players.
3. **$H_{1.2}$:** Plyometric training would have a significant effect on the agility of handball players.
4. **$H_{0.2}$:** plyometric training would have no significant effect on the agility of handball players.
5. **$H_{1.3}$:** Plyometric training would have a significant effect on the speed of handball players.
6. **$H_{0.3}$:** plyometric training would have no significant effect on the speed of handball players.
7. **$H_{1.4}$:** Plyometric training would have a significant effect on the explosive power of handball players.
8. **$H_{0.4}$:** plyometric training would have no significant effect on the explosive power of handball players.

1.5 Significances of the Study

The study proposes to indicate the high importance for a variety of reasons. First, it provides greater insight to the concerned body for the effect of plyometric training on shooting performance and some selected physical fitness qualities of handball players. Second, facilitate better shooting performance, agility, speed and explosive power of handball players. Third, convince and motivate players to take part in plyometric training to raise the fitness qualities and handball skills. Fourth, afford coaches to recognize additional about the effect of plyometric training and the attitude of the preferred fitness qualities and handball skills. Fifth, to offer full information for players who contribute in a plyometric training program to build up shooting performance, agility, speed and explosive power. Sixth, express an outstanding consequence performance upgrading in physical fitness qualities and skills of handball players. Seventh, hand out as commence and generate an occasion for handball coaches and players to play good-looking, efficient and competently handball skills in competition. Finally, it could be provided as a springboard for the future researchers' who want to pursue further studies in similar areas.

1.6 Delimitations of the Study

This study was delimited in the following areas.

- The study was delimited to handball project players in Adet town within the age of 16 to 20 years.
- There are multitudes of variables that interfere with the successful shooting performance, agility, speed and explosive power of the player in handball projects. However, to satisfy the purposes of the current study, this study delimited to prefer dependent variables were handball shooting performance, agility, speed and explosive power. However, independent variables were encircled to plyometric training.
- Experimental group achieved plyometric training in addition to regular handball activities. However, the control group only has regular handball activities.
- The duration of the training period was restricted to three days per a week and lasted to 50 up to 60 minutes per session for three months in successive weeks adding together to standard handball training.
- The project of players was experienced with established 1-3 years.
- The study was conducted in the training season of 2019-2020 G.C.

1.7 Limitations of the Study

Throughout the conducting of this study, the following limitations are stated.

The major constraint of the study was lack of abundant literature on the issue of plyometric training on handball performance skills in Ethiopia. The investigator managed this limitation throughout revealing himself to other foreign related literatures. Furthermore, unable to control alter temperature and atmospheric pressures of the area during testing periods were the limitations encountered in this study. Other limitations of the study were living conditions, family status and personal habits of subjects. However, the researcher attempted to use all her potential and other encouraging mechanisms to finish with all the factors.

1.8 Operational Definitions of Key Terms

Adet: is a town, which is found in Amhara Regional state West Gojjam Zone, Yilmana densa woreda.

Agility: is the ability to start (or accelerate), stop (or decelerate and stabilize), and change direction quickly, while maintaining proper posture.

Explosive power: is one of the fundamental components for capable competitors, which empowers them to achieve their peak jump height.

Plyometric training: plyos", are works out based on greatest muscle constrain generation in a most limited conceivable time to progress speed and power (Markovic, 2007).

Project: is a long term that is carefully planned and structured in order to improve handball player's fitness level.

Shooting accuracy: expressed as the sum of inconstancy or irregularity of performer's development final point within the target. (Schmidt & Wrisberg, 2004).

Shooting performance: shooting a ball at the goal is the termination of an offensive phase.

Speed: is a capacity that empowers a player to move as fast as possible under the position at a given level of opposition.

Training: is a process by which an athlete prepared for the highest level of performance.

1.9 Organization of the Study

This experimental research was organized in five chapters. In the first chapter, presenting the background to this study, it incorporates a discussion about the plyometric training in relation to shooting performance, agility, speed and explosive power that was succinctly described. It also comprises the statement of the problem, general objective of the study, specific objectives, research hypotheses, significance of the study, delimitation of the study, limitation of the study, operational definitions of key terms and organization of the study also described in detail.

Chapter two concentrates on a review of related literature. In this section, relevant research works thoroughly and deeply reviewed to support and substantiate the problem and the findings of the study utmost and the missing part that needs to be fulfilled.

The third chapter of this study explains the research methods that include, the study area descriptions, research approach, research design, study population, sample and sampling techniques, source of data, data collection instrumentation, method and procedure of data collection, method of data analysis, ethical consideration were discussed in detail.

In chapter four the results obtained in the study and analysis were presented, which investigates the nature of the effect of plyometric training on shooting performance and some selected physical fitness qualities in Adet Town handball project participant players. In addition, this chapter portraits discussion of the results with the existing and past research works scrutinized in line with the present findings.

Finally, in chapter five summaries of the study presented, based on the findings, conclusions, recommendations, and directions for intervention affirmed to possible improvement for future research.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Concept of Plyometric training

Plyometrics have been used for many decades in the Russian and eastern European training of track and field athletes. Verkhoshanski, a well-known track and field coach in Russia, began the concept that he referred to as shock training or jump training. However, former Purdue University women's track coach Fred Wilt first coined the actual term plyometric in 1975. The word plyometric is actually a derivation from the Greek words plythein or plyo, which means to increase and metric, which means to measure. Consequently, the purpose of plyometric may be thought of as “to increase the measurement.” Typically, the measurement is sports performance outcomes demonstrated in testing or competition such as throwing, serving velocity, jump height or sprint speed (Davies, 2000).

Conceptually, plyometric training is characterized by the operation of the stretch-shortening cycle (SSC), which is the mechanism underlying the tissue response contractile and elastic elements and pointed out that their different length shortening behavior was vital in movements. Moreover, the power/strength produced during the initial phase of the stretch-shortening cycle positively influences neuromuscular control and joint stabilization (Mikulic, 2010). Thus, plyometrics, which is the exercise the athlete performs) also known as "jump training" or "plyos", are exercises based on maximum muscle force production in a shortest possible time to improve speed and power. Plyometric exercises involve rapid stretching (i.e. lengthening) of a muscle immediately before a rapid concentric contraction. This combined action is commonly called the stretch shortening cycle (SSC) (Hermassi et al., 2014).

A popular type of training exercise is plyometric training (Zatsiorsky, 1995). This type of training uses jumping exercises to involve the neuromuscular system in rapid force development and improved use of tissue elasticity to improve power, rate of force development, and the ability to absorb force. Besides, plyometric training is very stressful, but the stress comes from the mechanical impact demands placed on relevant tissues and the ability of the nervous system to

respond rapidly to these quickly applied forces. It is essential that the musculoskeletal system is given time to adapt to the demands of plyometric training programming.

Plyometrics are merely a part of an overall strength training and conditioning program that includes strength, speed, agility, aerobic and anaerobic training, flexibility training, and proper nutrition. Plyometrics have a purpose, which is usually described as power and speed training, but plyometrics are not a panacea (Lindstedt, 2003). Plyometrics, virtually all of the things required during athletic events involve one's ability to exert force in a rapid manner. This ability to exert force can be in the form of jumping, hopping, and changes of direction. Improving one's ability to exert force in a rapid manner can have a positive influence on sports performance. Prior to improving one's ability to exert force rapidly, it is important that athletes can absorb force during various movements. Improving absorption of force involves an adequate strength base, and strong and elastic connective tissue.

Plyometric training considered to enhance the muscle's ability to utilize SSC. SSC is an eccentric contraction (where the muscle and tendon lengthens under contraction), which is immediately followed by a concentric contraction (Asadi et al., 2016). Use of SSC during plyometric exercises enables the muscle-tendon unit to produce the maximum amount of force in the shortest time possible. Due to this, and the fact that SSC is an integral part of athletic actions, it is important to include plyometric exercises into an athlete's training plan (Requena & Cronin, 2012).

Plyometric training is defined as a quick, powerful movement involving an eccentric contraction followed immediately by an explosive concentric contraction (Verhoshanski, 1983). This is accomplished through the stretch-shortening cycle or an eccentric-concentric coupling phase. The eccentric concentric coupling phase is also referred to as the integrated performance paradigm (which states that in order to move with precision, forces must be loaded (eccentrically), stabilized (isometrically), and then unloaded/accelerated (concentrically). Plyometric exercise stimulates the body's proprioceptive and elastic properties to generate maximum force output in a minimum amount of time (Brady, 1992).

Plyometric training is an effective mode of training as it enhances motor learning and neuromuscular efficiency promoting the excitability, sensitivity, and reactivity of the

neuromuscular system to increase the rate of force production (power), motor-unit recruitment, firing frequency (rate coding), and synchronization (Jack, 2013). All movement patterns that occur during functional activities involve a series of repetitive stretch shortening cycles. Besides that, the neuromuscular system must react quickly and efficiently following an eccentric muscle action to produce a concentric contraction and impart the necessary force (or acceleration) in the appropriate direction. Therefore, specific functional exercises that emphasize a rapid change in direction utilized to prepare each athlete for the functional demands of a specific activity. This training provides the opportunity to train specific movement patterns in a biomechanically correct manner at a more functionally appropriate speed. This provides functional strengthening of the muscle, tendon, and ligaments specific to the demands of everyday activities and sports. Apart from this, the ultimate goal of plyometric training is to improve the reaction time of the muscle action spectrum (eccentric deceleration, isometric stabilization, and concentric acceleration). From this, the speed of muscular exertion is limited by neuromuscular coordination. This means that the body will move most effectively and efficiently within a range of speed that the nervous system has programmed to allow. This training improves both neuromuscular efficiency and the range of speeds set by the central nervous system. From that, optimum reactive performance of any activity depends on the speed at which muscular forces can be generated (Wilkerson, 2004). The mode of plyometric training is determined by the general part(s) of the body that are performing the given exercise. For example, a depth jump is a lower body plyometric exercise, whereas a medicine ball chest pass is an upper body exercise (Potach, 2000).

2.2 Training fitness

Athletes prepare to achieve a specific goal through structured and focused training. As the intent of training is to increase the athlete's skills and work capacity to optimize athletic performance. That is training undertaken across a long period and involves many physiological, psychological, and sociological variables. During this time, training is progressively. Throughout training, human physiological and psychological functions are modeled to meet demanding tasks (Bompa & Gregoryhaff, 2009). Training is a process of preparing an individual for any event. Usually in sports, we use the term sports training to denote a well planned training program, preparing players for attaining the highest level of sports performance. However, nowadays individuals

who take up physical activity do so either for health and fitness or for competing in sports at different levels. Hence, sport training involves physical, technical, Intellectual, psychological and moral preparation of sports persons through physical training (Dibakar & Ezhilmaran, 2016).

Sport training is a process of athletic improvement, which is conducted based on scientific principles through systematic development of mental and physical efficiency, capacity and motivation, enables athletes to produce outstanding and record breaking athletic performance (Harre, 1982).

2.3 Variables of training

The efficiency of a physical training program results from the manipulations of volume (duration, distance, repetitions, or volume load), intensity (load, velocity, or power output), and density (frequency), which are key variables in training. These variables should manipulate according to the functional, physiological, and psychological requirements of the training goal or competition. Thus, when designing the training plan, the coach must first decide which variable to emphasize to meet the performance objective. The manipulations of these variables will establish distinct training-induced outcomes that can significantly affect the athlete's performance (Bompa & Gregoryhaff, 2009).

Intensity: - Exercise intensity is a measure of "how hard is the exercise and is related to the power output. The exercise intensity lies somewhere on a continuum between rest (basal metabolic rate) and maximal effort, which coincides with the maximal oxygen uptake for that activity. Exercise intensity can be monitored by measuring sub maximal oxygen consumption (Daniels, 1985), heart rate (Lambert et al., 1998), blood lactate (Swart, 2004), the weight lifted during the exercise (Sweet et al., 2004), or the perception of effort (Foster et al., 2001). Training intensity is the major training stimulus that influences adaptation and performance. Athletes advised to incorporate high intensity training into their training programs after they have developed a sufficient base (Laursen & Jenkins, 2002). If too much high intensity training is carried out the athlete will be at risk of developing symptoms of fatigue associated with over reaching (Meeusen et al., 2006) and overtraining or will increase the risk of getting injured (Noakes, 2001).

The intensity of plyometric drills typically classified as low, medium, or high. When the athlete reaches high-intensity levels, volume should decrease. The intensity of plyometric drills for the lower extremities related to foot contacts, direction of jump, speed and jump height (Namrata, 2014).

Volume: - Volume of training under prescription of training volume may lead to not achieving the desired improvements in strength and muscle performance, and over prescription of training volume may lead to overtraining and overuse injuries. As a result, the optimal number of sets remains an extreme (Wolfe et al., 2004).

Lower body plyometric volume typically expressed as the number of foot contacts, whereas Upper body plyometric volume expressed as throws of the medicine ball or distance jumped. Adolescent athletes should perform low-impact plyometric training once weekly to increase lower-body power resulting in increased vertical jump and kicking distance (Kisnerwilk, 1993).

Frequency: - Training frequency refers to the number of training sessions in a defined period. Training frequency may vary depending on the sport, level of performance of the athlete, and stage of training cycle (Smith, 2003).

Plyometrics should not perform more than two to three times per week unless you are alternating days of upper and lower body plyometric drills. Off-season plyometric routines performed twice per week. In season, one session per week is appropriate for most sports. Track and field athletes may perform two to three times per week (Namrata, 2014).

Duration:-This refers to the time or amount of the exercise session. This is sometimes confused with the volume of training, which quantifies training over a period and combines duration and frequency (Smith, 2003). Athletes competing at the international level need to train for approximately 1000 hours per year (Bompa, 1999).

Rest and recovery

Rest and recovery are important, often neglected principles of training. Factors that need to consider during the recovery process after a training session are as follow:

1. Age**: -** Athletes older than 25 years need longer recovery periods than younger athletes (Bompa, 1999).

2. Environmental conditions: - Training and competing in the heat imposes more physiological stress on the athlete and requires a longer recovery period (Noakes, 2001).

3. Type of activity: - Training and competition that induces muscle damage requires longer recovery periods than activities that cause fatigue but no muscle damage or soreness. Even within a specific sport the demands on the players vary depending on their playing position (Takarada, 2003). Ideally, the recovery for each player should customize. It recommended that players are monitored using subjective and objective strategies to ensure that the recovery period is customized (Lambert & Borresen, 2006). A practical tool developed to assist coaches and athletes with monitoring recovery (Kentta & Hassmen, 1998). The work to rest ratio should be 1:5 to 1:10 to be certain that the intensity and proper execution of movement are preserved. It suggested that 1 to 5 minutes of rest needed between plyometric exercises, depending upon the intensity and volume of the workout. Recoveries between sessions recommended to 48-72 hours (Chu, 2000).

2.4 Basic principle of training

A plyometric training program should respect basic training principles including the principle of specificity (Bompa & Carrera, 2005). In planning a training program, there are some basic principles that need to be considered. They discussed under the following:

Progression

Plyometric exercise is a form of resistance training and thus must follow the principles of progressive overload a systematic increase in training frequency, volume, and intensity by various combinations. Progressive overload is an essential component of any resistance-training program whether it may be for improving muscle size, strength, or power (Winett & Carpinelli, 2001). To sustain increases in muscle development and performance one constantly needs to progress the program by gradually increasing the demands placed on the body (Rhea et al., 2003). This incorporated into a training program by manipulating any of the following training variables appropriately: increasing the frequency of training; increasing the repetitions in each

set; increasing the number of exercises; decreasing the rest periods between sets and/or exercises; increasing the load utilized; or changing the speed of movement (Kraemer & Ratamess, 2004).

Variation

There is sufficient evidence to support the concept that varying the exercises trained on a specific body part (e.g. the chest musculature) improves strength and power gains (Pearson et al., 2000). There are a few ways of doing this. Either one change the exercises trained every 2–3 weeks, or one can use two program variations on alternate training days. However, one should be cautious not to vary core exercises too much, as this might hinder progression.

Specificity

The principle of specificity states that adaptations are specific to the type of training stress. It follows that the type of training must be structured and planned in accordance with the requirements of the competition. However, this principle applied inappropriately if it assumed that all training should simply mimic the demands of competition (Young, 2006). In certain sports, the physical demands of competition can induce muscle imbalances and the risk of injury higher in many types of competition compared to training for the competition. Therefore, it is necessary to vary training and structure it so that the athlete develops a good base of fitness before attempting the more high risk, competition-specific fitness.

Overload

An athlete exposed to an overload stimulus at regular intervals for the induction of training adaptations. An overload stimulus manipulated by changing the mode of exercise, duration, frequency, intensity, and recovery period between training sessions (Bompa, 1999). Overload training stimulus imposed by altering nutrition and influencing intracellular milieu before the training session. For example, to mimic the metabolic stress in the muscles towards the end of a marathon an athlete could start the training session with a low muscle glycogen concentration. This is achieved by reducing carbohydrate intake about 24 hours before the training session. The athlete then begins the training session with lower than usual glycogen levels in the liver and muscles. After about 20–30 km of the training run, the metabolic flux will be similar to the

metabolism that occurs towards the end of a marathon. An advantage of this strategy is that a metabolic overload is imposed without the same mechanical muscle stress and damage that occurs towards the end of a marathon.

2.5 Phases of Plyometric training

Both lower extremity (LE) and upper extremity (UE) sports use the plyometric concept as part of functional movement patterns and skill when performing the sport. Plyometric training utilizes the stretch-shortening cycle (SSC) by using a lengthening movement that is quickly followed by a shortening movement (Ebben & Jensen, 2008). There are three distinct phases involved in plyometric training including the eccentric or loading phase, the amortization, or transition phase and the concentric or unloading phase (Chmielewski, 2006).

2.5.1 The Eccentric phase

The first stage of a plyometric movement classified as the eccentric phase, but it also been called the deceleration, loading, yielding, countermovement, or cocking phases (Lundin, 1985). This phase increases muscle spindle activity by pre-stretching the muscle prior to activation. Potential energy is stored in the elastic components of the muscle during this loading phase. A slower eccentric phase prevents taking optimum advantage of the myotatic stretch reflex.

2.5.2 The Amortization phase

This phase involves dynamic stabilization and is the time between the end of the eccentric contraction (the loading or deceleration phase) and the initiation of the concentric contraction (the unloading or force production phase) (Wilk, 1993). The amortization phase, sometimes referred to as the transition phase, is also referred to as the electromechanical delay between the eccentric and concentric contraction during which the muscle must switch from overcoming force to imparting force in the intended direction A prolonged amortization phase results in less-than optimum neuromuscular efficiency from a loss of elastic potential energy (Swanik, 2004). A rapid switch from an eccentric contraction to a concentric contraction leads to a more powerful response. One of the primary goals of plyometric training is to decrease the time to rebound phase.

2.5.3 The Concentric phase

The concentric phase (or unloading phase) occurs immediately after the amortization phase and involves a concentric contraction resulting in enhanced muscular performance following the eccentric phase of muscle contraction. This occurs secondary to enhanced summation and reutilization of elastic potential energy, muscle potentiating, and contribution of the myotatic stretch reflex (Rassier & Herzog, 2005).

2.6 The elastic properties of muscle

Muscles modeled with a contractile element and two elastic elements that are named according to their relationship to the contractile element one in line with (the series elastic element) and one in parallel (the parallel elastic element). When a muscle contracts, tension is not directly transmitted to the ends of the tendon and load not overcome, leading to movement. This would only happen if the connection between the contractile element and its insertion were rigid and inelastic. In reality, the contractile element develops tension, stretching the series elastic element; the degree of stretch is dependent on the load moved. After sufficient tension is generated, the tension at the ends of the muscle is sufficient to overcome the load and the load to move. When a load is applied to a joint (eccentric phase), the elastic elements stretch and store potential energy (amortization phase) prior to the contractile element contracting (concentric phase). An eccentric contraction immediately preceding a concentric contraction significantly increases the force generated concentrically because of the storage of elastic potential energy (Newton, 1999). During the loading of the muscle, the load transferred to the series elastic components and stored as elastic potential energy. The elastic elements then contribute to the overall force production by converting the stored elastic potential energy to kinetic energy, which enhances the contraction (Bosco, 1982).

The muscle's ability to use stored elastic potential energy affected by the variables of time, magnitude of stretch and velocity of stretch. Increased force generation during the concentric contraction is most effective when the preceding eccentric contraction is of short range and is performed immediately (Wilson, 1991). A simple example of the use of the energy stored in the elastic element is the basic vertical, or countermovement, jump. The initial squat (the countermovement) is the eccentric phase that stretches the elastic elements and stores elastic

energy (amortization phase). When the jump is performed (the concentric phase), the stored energy is "added" to the tension produced leading to a higher jump. The amount of stored energy used is inversely proportional to the time spent in the amortization phase. When doing a vertical jump, the longer one waits at the end of the countermovement before performing the jump, the lower the eventual jump height due to the inability to recover the stored elastic energy.

2.7 Physiology of plyometric training

Plyometric training utilizes the elastic and proprioceptive properties of a muscle to generate maximum force production by stimulating mechanoreceptors to facilitate an increase in muscle recruitment in a minimal amount of time (Wilk, 1993). Muscle spindles and Golgi tendon organs (GTOs) provide the proprioceptive basis for plyometric training. The central nervous system then uses this sensory information to influence muscle tone, motor execution, and kinesthetic awareness. Stimulation of these receptors can cause facilitation, inhibition, and modulation of both agonist and antagonist muscle activity. This enhances neuromuscular efficiency and functional strength (Astrand, 2003).

2.8 Plyometric training program and Design Guidelines

A systematic and progressive plyometric training program is a vital component of any integrated training program. As plyometric training is one of the more advanced training tools, the athlete needs proper levels of flexibility, core strength, and balance before progressing into plyometric training. Besides that, sport performance professionals must follow very specific program guidelines, proper exercise selection criteria, and detailed program variables for the best outcome and lowest risk of injury (Voight, 1992).

According to (Potach & Chu, 2000), Plyometric, like other forms of training, are usually only performed two or three times a week. Training should occur in a non-fatigued state. Therefore, these exercises should not perform after resistance training or aerobic conditioning. Ample rest between sets should be used in order to avoid turning these speed and power enhancing exercises into endurance training. Generally, rest five to ten times more than it takes you to perform the set of plyometric. Thus, if you do a set of multiple hops that takes four seconds, you should rest 20 to 40 seconds prior to the next set or exercise. Another good rule to follow is to limit your sets to no more than 10 repetitions. In fact, it is probably good to use a range of repetitions such as sets

of one, three, five, and ten repetitions in order to train explosiveness as well as power endurance across a continuum. The amount of plyometric training or volume performed in any given training session measured by the number of foot contacts. Beginners often perform approximately 80 to 100 foot contacts per session (Potach, 2000). However, half of that amount may be appropriate, particularly for children, older adults, or those who are untrained. Obviously, exercise intensity is an important consideration as well. Eighty foot contacts of a variety of line hopes, cones, and ankle hopes is dramatically less intense than 80-foot contacts of high box depth jumps, single leg jumps, pike jumps, and maximal overhead jumps and reaches. From the point of view, plyometric programs should start with low intensity exercises. Over time, moderate and eventually higher intensity exercises are incorporated for those who are healthy and fit. The program increases the volume (foot contacts) to a point and then volume eventually decreases as exercise intensity increases, in order to reduce exercise fatigue and increase adaptation to the program.

2.9 Pre consideration of plyometric training

Plyometric exercise is not inherently dangerous; however, as with all modes of exercise, injury risk is present. Injuries may occur following an accident, but they more typically occur when training procedures violated and may result from an improper program design, inadequate instruction and supervision, or inappropriate training environment. Personal trainers must understand and address these and other risk factors to improve the safety of the athletes performing plyometric exercise (Lachance, 1995).

Plyometric are a very high intensity form of training, placing substantial stress on the bones, joints, and connective tissue. While plyometrics can enhance an athlete's speed, power, and performance, it also places them at a greater risk of injury than less intense training methods. Prior to starting a program there are several variables to consider so the training sessions performed in a safe and effective manner (Namrata, 2014). A person should have an adequate base of muscle strength and endurance as well as flexibility of the muscles exercised. Criteria to begin plyometric training usually include 80% to 85% level of strength and 90% to 95% range of motion (Chu, 2000). Power squat test is a good closed chain exercise to determine whether an athlete has an adequate strength base for lower extremity plyometric. It performed with 60% of an athlete's body weight. Squat repetitions done in 5 seconds, and the depth should be knee

flexion close to nine for each repetition. Although static stretching is important in the performance of plyometrics, some ballistic stretching is demanded. Individuals must be able to perform a 30 seconds one-leg stance with eyes open and closed for proprioception and single leg half squat for strength (Tippett, 2001). For shock and high intensity lower extremity plyometric, it recommended that healthy athletes have enough leg and hip strength to be able to perform a squat with 1.5 to 2.5 times the athlete's body weight. For high intensity upper extremity plyometric, it suggested that an athlete be able to perform five clap push-ups in row (Paavo Komi, 2000).

2.10 Benefit of Plyometric Training on handball players

Plyometric training is widely known as a potential tool for improving functional sports performance. During Plyometric training, the muscles switch rapidly from an eccentric to a concentric phase of contraction. The decreased duration of the amortization phase exploits stored elastic energy and the stretch reflex, allowing a greater than normal release of power during the concentric phase of movement (Ramirez-Campillo, 2015).

A Plyometric training program has been offered as a suitable methodology for sports, which need vertical jumping ability, explosiveness and shooting ability improvement. In general, plyometric training is the excellent way to offer speed or power to react directly during the handball game. In addition, it is used to give the players to jump higher and to enhance the jumping capacity of leg muscles. This program offers functional intensification of the tendon, ligaments and muscle particularly to the everyday demand sports and activities. This plyometric training program covers a learning practice requiring an efficient design as well as application with maximum care (Surendra, 2017).

Plyometric training programs are often implemented during the pre-season to bring young players to an appropriate initial level of fitness. In addition, it is strongly recommended that handball coaches implement in-season plyometric training to enhance the performance of their players. It is repeated into the standard training improved parts, which are important to handball performance, particularly, the explosive actions, such as sprinting, jumping and ball throwing velocity. Apart from this, plyometric training programs can also improve the physical performance of the lower body in young handball players (Van den Tillaar et al., 2013).

Plyometric training program is the most generally used in distinctive speed force and explosive power development for various sport related activities, which need the incorporation of the greatest speed with highest force of muscle, in which this technique contribute in triumphing over or overcoming the issues that characterize force development (Benzidane, Bensikaddour & Mokrani, 2015). Plyometric training program also contributes to the enhancement of attainment, particularly in activities that employ explosive muscular contractions and plyometric training program in the short term is more efficient to the growth of strength muscle and anaerobic capacity (Sofiane, 2011).

Plyometric training of the lower extremities has been shown to increase sprinting speed or velocity. Sprinting velocity is important for sports requiring quick bursts of speed or repetitive change of direction. This is valuable for sports like soccer, handball, volleyball and tennis (Chaouachi, 2014). Plyometric training programs can increase maximal vertical jump height including various jump training programs ranging from six to 24 weeks, including pre-pubertal, pubertal, and adult athletes (Turner, 2003). Plyometric training has been an effective method for the improvement of agility, sprinting, and jumping ability and it also been reported to improve running economy, joint stability, increased joint awareness and decrease the severity of knee injuries (Watsford, 2003) and sprint times decrease (Rimmer & Sleivert, 2000).

2.11 Shooting performance in handball

For an effective shooting, the ball must go at the highest speed and aim at the target. Therefore, players must maintain these two parameters throughout the game (Manchado et al., 2013). Players must increase their chances of scoring as fast as possible to score goals (Gorostiaga, 2005). However, about shooting performance, it is thought that reaching the goal in handball should include shooting accuracy. Shooting ability depends on the speed and accuracy of the ball that the players must maintain these two parameters during the competition. As the effect of these two parameters can be reduced during the game so; the regular and planned strength, speed strength and technical training programs should be implemented (Zapartis et al, 2007).

2.11.1 Handball shooting

Shots are one of the most important elements of handball. They are vital elements that decide the scores. While shooting the muscles of the lower and upper limbs, the pelvic region and trunk are extremely engaged. One can assume that shooting is performed similarly to passing, but with a stronger action of the trunk and upper limbs. The shot power is conditioned by the distance and hand action time on a ball. The greater the distance that the hand on the ball covers in the time unit the stronger the shot will be (a ball reaches a higher velocity) performed (Janusz & Frantisek, 1997).

Shot or throw is the culmination of offense aimed at scoring a goal. This element of technique of handball play directly affects the success of the player and the team regarding the result. That is exactly the reason why many players and coaches observe the shot as the dominant element of handball play and devote it more time in the training process than other elements of the techniques devote. Opinions of handball experts differ in terms of importance of individual elements of handball technique, but they agree that shot is a relevant and important factor (Sinisa, Danijel & Tijana, 2018). In order to achieve success in handball players have to fulfill the basic aim of scoring. Apart from this accuracy and velocity of the shot, it increasingly gained significance in the result outcome of the handball game.

2.11.2 Types of handball shooting

According to (Clanton & Dwight, 1997), there are four basic shots in team handball.

1. Set shot is the most natural of all shooting actions and is simply the overhand pass thrown hard. For the set shot to be effective, it must perform quickly. In the preparation phase of movement, the player runs to get into the shooting position. The momentum created from being in motion will increase the power of the player's shot. Players attack using three steps and during the second step, the ball is brought up to head height. Elbows are flexed to 90 degrees or greater. At that time, all of the body weight should be on the back foot, upper body should be upright and shoulders perpendicular to the goal. Players should keep their head up and eyes on the goalie. In the execution phase of movement, to shoot step forward and transfer body weight from rear foot to front foot. Shoulders rotated and opened for being parallel to the goal. Player begins moving the arm forward by leading

with the elbow, then whip forearm and snap the wrist. In the follow-through phase of movement, momentum of the body continues forward and the motion of the throwing arm continues across the body. The referee awards a 7-meter throw when a fault obstructs a clear scoring opportunity.

2. Jump shot is the most used shot in team handball. Developing the ability to jump and shoot over the defense, as well as jumping inside the goal area, will make athletes a more effective scoring threat.
3. Wing shot is the jump shot performed at a difficult shooting angle.
4. Fall shot is the basic technique of the circle runner. It allows receiving the ball on the 6-meter line and shooting without using three steps.

The referee awards a 7-meter throw when a fault obstructs a clear scoring opportunity. Generally, the set shot and the fall shot are used for a 7-meter shot. The 7-meter throw is an important part of the game to go scoring (THF, 2010).

2.11.3 Shooting accuracy

Accuracy is one of the most important terms in order to reach optimum results in team handball because of being high intensity intermittent types of sport (Beyza, 2012). That is, accuracy is the distance from the desired point of impact of the projectile and the actual point of impact on the target. Success or failure depends on whether a team attains its ultimate aim, that of scoring a goal. Throwing efficiency is the key to winning or losing matches and has been the subject of various studies (Marques et al., 2007). The factors that determine throwing velocity are technique; coordination and maximum explosive power of the muscles in the upper and lower body, hence the importance of developing training methods that improve both accuracy and throwing velocity (Manchado et al., 2013. Accuracy and throwing velocity in handball are regarded as basic parameters of performance during competition (Hore, 1996).

The main objective of the competition in the game of team handball is to score the ball into the opponent's goalkeeper team from a convenient location without the presence of blocking defenders. From this point, shooting is considered as one of the most important offensive skills that play a major role in tip the team on the other. Besides that, the goal of proficiency and mastery of the fundamental skills provides an opportunity for one of the attackers to reach a

suitable place to hit the target in different ways, without potential hazard. On the other hand, the most common shooting in team handball against the goalkeeper was done by executing the upward leap (up forward) in the games. As this, two basic factors are of importance with regard to the efficiency of shots: accuracy and throwing velocity of the faster the ball is thrown at the goal, the less time defenders and goalkeeper have to save the shot (Kilani & Finch, 2001). By training, physical fitness and technique can be improved, while biomechanical variables could halt. The offensive players, however, attempt to throw a ball on goal from a position without being tackled or obstructed by the opposing defensive players. In competition, 73-75% of all throws during the game constitute jump throws, followed by the standing throw with run-up (14-18%), penalty throw (6-9%), diving throw (2-4%) and direct free throw (0-1%) (Wagner et al., 2008).

2.12 Agility in Handball

Agility is an ability to change direction accuracy and quickly while moving rapidly. It is obviously necessary for a successful handball player. The sudden change of direction, the twisting and rapid running and forward running backward are the hallmarks of quality players of agility (Bhupinder, 2013). The rate of coordination (agility) in handball dynamics has changed so suddenly that the athlete must quickly change direction, with the lowest stall and accelerate back towards where it came from. To increase braking ability rapidly to a rapid movement in the other direction, you need to train these agility movements. Rate of coordination is found in the structure of the following points and action both technical and tactical: changes in direction of the ball or without the ball, branding, passing the ball coming successively with the threat score, the movement of the fundamental position laterally, forward, and backward and attacking the opponent with the ball (Cazan et. al., 2013). Handball involves multidirectional changes of direction (Massuca et al., 2014). Athletes often perform stop-and-go changes of direction in a response to unpredictable stimuli (ball, opponent etc.) over a relatively small court (Karcher, 2014). Quick starts, stops, and changing direction fast are the fundamentals of handball performance. In the game of handball, diverting of the ball occurs very frequently, the players must be ready to receive the ball and act accordingly for that agility required (Pankaj, 2019). Agility is helpful for handball players in various aspects in a game situation during one to one

faint, group tactics, dodging, scoring the goal & it is helpful for pivot players (Singh & Deol, 2016).

2.13 Speed in handball

Speed is one of the essential components in handball to shoot and to travel from one corner to the fore court. It also depends on reaction time that a player moves to score to the opponents and in the same way, he is reacting on the return from the opponent court. Speed directly influences the capacity of handball players to exert the maximum force in the shortest possible time (Bhupinder, 2013). The value of a handball player lies to a large extent on the qualities that are trained in including speed in the scope and the basis of which currently principles and skills are required for the development of the tactical and technical content specific to the modern game handball teams practiced by the best teams in the world. Specialists in the field claim that the shares of the motive power of the handball game implies in competition and especially in the preparation, a mixture between heavy proportion of strength, resistance, speed, the suppleness and skill (Marques, 2006). Handball players are required to cover distances from 20 to 30 meters with maximal speed in the transition from defense to offense or, after a ball loss, to prevent a fast break (Hermassi et al., 2014; Ingebrigtsen et al., 2013).

Speed training in handball to aspects of running that are observed in handball: starting speed, acceleration, running lengths of between 5m and a maximum of 30m (in fast breaks), possibly combined with a change in direction for elite and sub-elite team handball players have indicated that strength, jumping abilities and maximal running speed have an impact on performance (Buchheit, 2009). As it happens in most team sports, the handball players are required to have the ability to speed off with maximum speed on distances of 20 to 25 meters and to be able to repeat these sprints several times during the game (speed - resistance, power - resistance). The ability to run and sprint repeatedly at high intensity is of paramount importance for success (Souhail, 2010). Speed consists of a number of components all of which are independent qualities: acceleration speed, maximum speed, and speed endurance. Performance in the 10-m sprint is influenced by acceleration speed, while performance in the 40-m sprint is dependent on both acceleration speed and maximum speed. Speed improved by increasing the power to weight ratio. As this, plyometric training (i.e., counter-movement jumps or loaded squat jumps) is effective for improving speed (Cronin & Hansen, 2005).

According to (Cazan et. al., 2013), in handball, game can identify the following attributes and skills specific, which must measured:

- **The starter speed**: when fighting directly to the opponent, related to the limited space and land, it is very important that the player have a quick start so as to exceed the opponent directly. This can only be achieved if at the beginning of muscular contractions, the athlete is able to generate a maximum of force, and create an initial speed high. Speed start encountered the structure following moments and share technical and tactical actions: triggering counter attack quickly re ball after the goal, debranding place open to receive the ball, crossing steering ball or without the ball, branding directly or indirectly penetration among defenders, defensive retreat after losing the ball or after a goal is scored, the input intercept the balls.
- **The rate of acceleration:** In a very short time from the start of the race, the athlete reaches the maximum speed. This time depends on the strength and rapidity of the muscle contraction, while the acceleration power depends on both the arms and legs. Speed acceleration reached in the following moments of structure and technical and tactical actions: counter, quick, throw the ball after the goal, crossing the ball or without the ball direction, branding and defensive retreat after losing the ball or after a goal scored.
- **Speed acceleration**: Speed acceleration found in the following moments of structure and technical and tactical actions: counter, quick, throw the ball after the goal, crossing the ball, without the ball direction, branding and defensive retreat after losing the ball or after a goal scored.

2.14 Explosive power in handball

Power is an important factor in handball, highlighted in game situations involving sprinting, changing of direction, jumping and physical contacts with the opponent. However, since the force actions repeated several times during the game, the power resistance has to be trained (Buchheit, 2008). Vertical jump capability is critical for success in handball. From this, jumping is utilized during the jump shot, jump attack from attack line, blocking and defending the opponent for a successful player must not only be able to jump high but must also be able to

reach that height quickly. This requires an ability to generate power in a very short time. It is a value signifying some significant and very general activities in handball namely, jumping as well as shooting over the opponent head into the target (Ghuman & Godara, 2013). Vertical jumps and hops are used to increase the explosive power of the lower extremities (Ebben, 2005).

Explosively in handball, motion translates into speed, the detention and the maximum force, so the force is likely to be mobilized and used in a very short time in a specific gesture (neutralization striker, 1 against 1) (Negrea & Cazan, 2011). It is a capacity to release the maximum force in the shortest time quickly. A power player is not only strong but generates the force quickly. The handball player makes a powerful shooting or power of legs when jumping to words for an attack and available to clear the court from the back rear court. The power is also known as the strength ability of the player is during the use of power in shooting, throwing & passing. The players are used to having fall strength in their body muscles of both lower and upper extremities (Bhupinder, 2013). Muscle power, which is a function of the interaction between force of contraction and the speed of contraction, is associated with the explosiveness of the muscle. The relationship between force and speed of contraction and the subsequent point at which peak power occurs varies between athletes (Jennings et al., 2005). A fundamental way of increasing muscle power is to increase maximal strength, particularly in untrained athletes.

CHAPTER THREE

RESEARCH METHODS

3.1 Study Area Descriptions

The study was accomplished in Adet town, in the Yilmana densa area of West Gojjam Zone, Amhara National Regional state (ANRS). The administrative center of West Gojjam Zone, Finote Selam, is also the administrative center of Yilmana densa area, located at 42km South East of Bahirdar (the regional capital). The complete Yilmana densa area is a latitude and longitude of 11°16′ N latitude and 37°29′longitude East with an altitude of 2,216 meters above sea level. Kuarit in South, Sekela in the Southwest, Mecha in the West, Bahirdar Zuria in the North, and Abay River in the East bound it (Mulugeta, 2017).

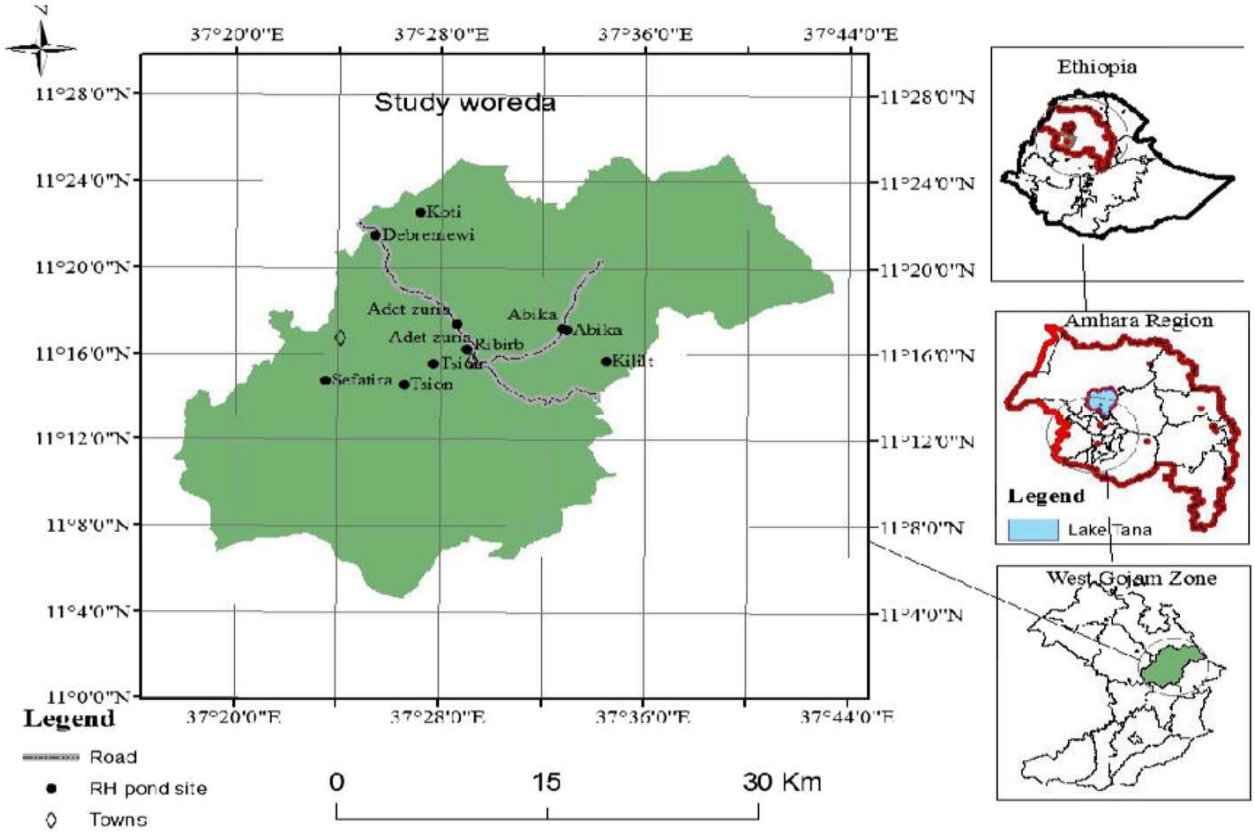

Figure 1 Map of study area

3.2 Research approach

This study points out to investigate a proposed hypothesis of the research by examining and collecting statistical data in the pattern of numbers and figures. Hence, this research undergoes quantitative as a research approach. Apart from this, the research makes use of experiments to collect data that is revised in numbers, which allows the data characterized by the use of statistical analysis.

3.3 Research design

The purpose of this study was to investigate the effect of plyometric training on shooting performance, agility, speed and explosive power in case of Adet town handball project players. Sustaining the appropriateness of the pre and post test data, the study employed experimental research design to evaluate, determine, measure and examine the effect of independent variable on the dependent variables. Besides that, the experimental research design is the better method to evaluate the cause and effect link among variables. Experimental and control groups attended standard handball training sessions. However, the experimental group was included in a detailed plyometric training program.

Table 1

Research design outline

Intervention	Plyometric training
Training weeks	12
Total duration	3 days / week
Duration/session	50-60 minute
Intensity	Low, moderate, High
Training days	Monday, Wednesday, Friday
Training time	Morning and afternoon

3.4 Population, Sample and Sampling technique

In this study, an experimental research method based on a pre-test and post-test system with a control group has been used. The participants were homogenized and randomly assigned into two groups of ten players: the experimental group (plyometric training), EG (n=10) and the control group, CG (=10). Prior to applying experimental interventions, a pre-test was administered and post-test also conducted at termination of the intervention. Within the study the investigator has used to comprehensive sampling techniques, because twenty players participated in Adet town handball project, so that the investigator has used these players as a total for experimental study purpose, Therefore, the sample population of this study incorporated every one of the handball players at Adet town handball project players. It must be prominent that the control group suffers merely standard handball training sessions identified through the trainer and experimental group was performed further plyometric training for 12 weeks, among 3 sessions per week, each imparted 50 up to 60 minutes. In this regard, plyometric training was functional, as the independent variable, to investigate their effect on the physical fitness qualities and skills of handball players, as the dependent variable.

3.5 Sources of Data

Toward achieving the study, the investigator has used primary data sources to gain enough information concerning the effect of plyometric training on handball players' shooting performance and physical fitness qualities. As a result, the primary sources of data were Adet town handball project players of pre and post test dimensions consequence in the field.

3.6 Training protocol

The designed protocol of plyometric was divided into two groups: experimental and control group. Experimental group participated in further plyometric training and the control group followed only standard handball training. The plyometric exercise-training program consisted of 12 weeks performed to a session of three days per a week. A session of plyometric training was divided in three parts: warming up, main part and cooling down. All subjects would go through a 10-minute dynamic warm-up consisting of jogging, as well as stretching at the start of each session, 35 to 45 minutes for the main part and use 5-minutes to cool down for each training session. The training lasted for 50-60 minutes each for twelve weeks. A progressive overload

principle was included into the program by increasing the number of sets of each exercise. The subjects would be instructed to perform all jumps at maximal effort (maximal height or amplitude and minimal ground contact time (Grosset, 2008). The training session was consisting of eight exercises: squat jump, tuck jump, bounding, plyometric pushups, plyometric pull-ups, lateral box jump, forward hops and medicine ball overhead throw. The training program was based on recommendations of intensity and volume. Therefore, the researcher had prepared a training session plan for experimental players. The following variables were studied in the research: performance variable: measured shooting performance and physical fitness qualities namely: agility, speed, explosive power. These data were collected two days before training and within two days of completing the twelve-week intervention.

3.7 Data collection instruments

In order to collect data of the study concerning the effect of plyometric training on shooting performance and selected physical fitness qualities throughout correct tests and measurements. From the point of view, shooting accuracy for shooting performance, hexagonal obstacle test for agility, flying 30m test for speed and vertical jump test for explosive power. Completed study also used necessary materials and equipment such as handballs, handball court, handball net, wall, ropes, cone, stopwatch, whistle, record sheets, pen, meter and other related materials used.

3.8 Procedures of test administration

The tests were selected according to the type of the training program and requirements of game performance. The players participated in two testing sessions. The first measurement (pre testing) was performed on the two days before start with the plyometric training program, the second (post testing) was done also two days after terminating the plyometric training program. The direction about the process of test-administration, rules of participation in each test item, time limit of performing each fitness factor and scoring principles were determined openly. Appropriate planning was done well in advance and the helpers were showing different trials prior to actual test administration. Since the investigator had to measure one handball skill and three physical fitness qualities i.e., shooting performance, agility, speed and explosive power. The test items were conducted strictly following standard procedure. All the test items were administered with the help of the professionally qualified personnel who were fully familiar with testing procedures. The schedule of the data collection has been prepared well in advance. The

subjects were explained the entire test items systematically prior to conducting the actual tests, in which they had to participate. They were informed that performing these tests was no way harming them in their performance; rather it would help them to know their own status of performance. Before the actual administration of the tests, the subjects were given an opportunity to participate in each of the test items, on a trial basis, if desired by the participants, so that they were well familiar with the test. Likewise, all test procedures are explained underneath.

3.9 Performance test

The detailed descriptions of the performance test conducted on the subjects are as follows:

3.9.1 Measuring shooting performance

Shooting performance was measured by using shooting accuracy

Shooting accuracy

Objective: To measure the shooting ability of accuracy for team handball players can make throws at the target in team handball.

Equipment: A marked level floor or ground with a smooth surface, a stopwatch, standard inflated handballs, rope or string, measuring tape (meter), score cards or recording sheets and pencil/Pen.

Procedure: Goal post was divided in eight parts with 50cm distance from side and ground. Five points were decided for the four corner parts, 3 points for the rest area and 0 pts for the middle part of the goal post. Each 10 players were supposed to attempt 10 shots from the 7-meter penalty line. One hundred shots were completed by all players 10 times for each of target locations from 7m shooting distance. The throw had to be completely executed with the use of the dominant arm.

Rules: Players were instructed that their feet remain in contact with the ground just behind the shooting line and for using correct techniques.

No Points will be given if

- players has not performed Three Step Jump Shoot
- The ball shoots outside the goalpost
- players has to shoot again if ball hits on the string which divides the goal post

Scoring: The score is the sum of points scored on each target.

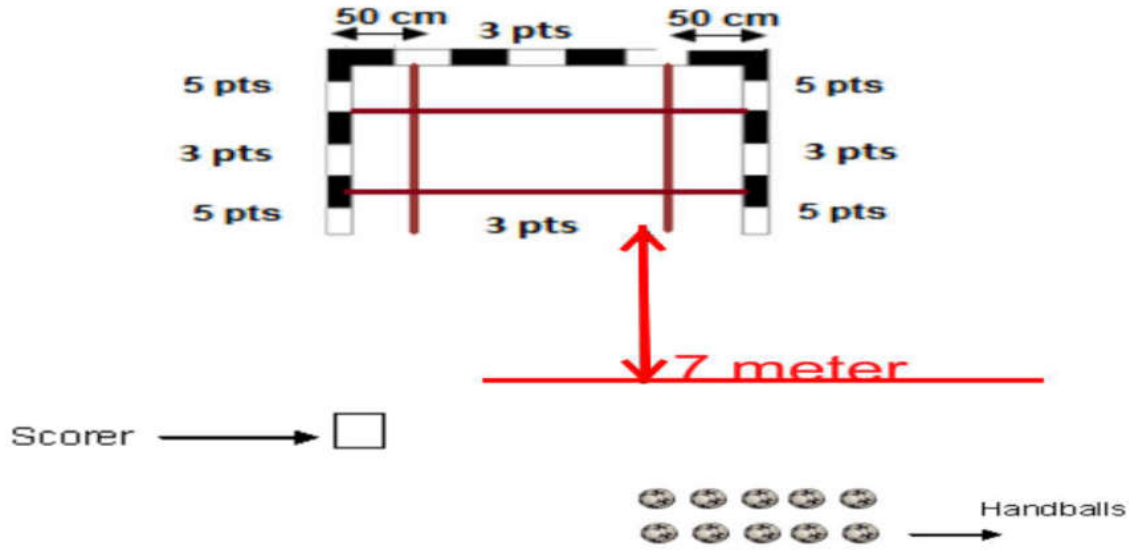

Figure 2 Shooting accuracy test

Adopted from Kangane, S.E. (2007)

3.10 Physical fitness test battery (PFTB)

The detailed descriptions of the physical fitness tests conducted on the subjects are as follows:

3.10.1 Measuring agility

Hexagonal Obstacle Test

Objective*:* - the hexagonal obstacle test is to monitor the athlete's agility.

Equipment: - 66 cm sided hexagon marked out on the floor, Stopwatch and Assistant.

Procedure: - The athlete stands in the middle of the hexagon; facing line A for all times throughout the test the athlete is to face line A. On the command GO the watch is started and the athlete jumps with both feet over line B and back to the middle, then over line C and back to the middle, then over line D and back to the middle, then over line E and back to the middle and then over line F and back to the middle. When the handball player jumps over line A and back to the middle this counts as one circuit. The athlete is to complete three circuits, on completion of three circuits the watch stopped and the time recorded the athlete rests and then repeats the test by using the correct techniques.

Rule: If you jump the wrong line or land on a line then the test is to be restarted

Scoring: On completion of the second test determine the average of the two recorded times.

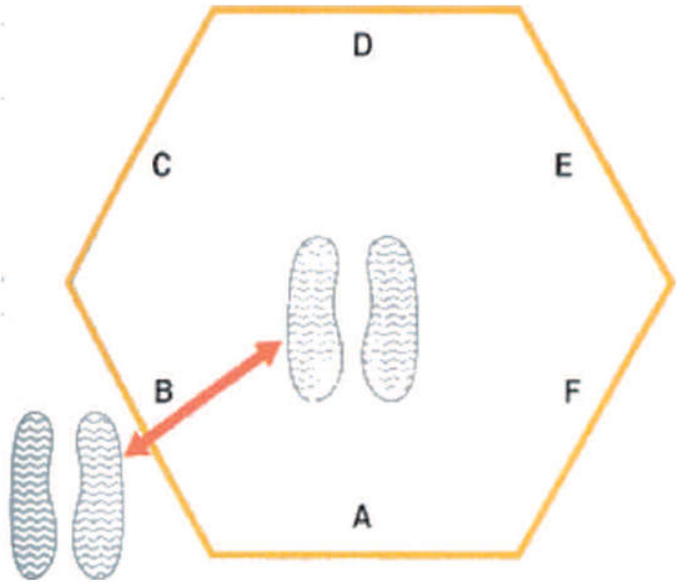

Figure 3 Hexagonal obstacle test

Adopted from Mackenzie, (1997)

3.10.2 Measuring speed

Flying 30-meter test

Objective: To monitor the development of the athlete's maximum sprint speed.

Equipments: Flat non-slip surface, Cones, Stopwatch and Assistant

Procedure: This test requires the athlete to sprint 60 meters. The athlete conducts a warm-up for 10 minutes .The assistant marks out a 60-metre straight section (AC) with cones and places a cone at the 30-meter point (B). From a sprint start with appropriate start commands (on your marks, set, "GO") from the assistant the athlete sprints the 60m .The assistant starts the stopwatch on the command "GO" The assistant records the time the athlete's torso crosses the 30-metre point (B) and the 60-metre point (C). The test comprises of 3 x 60m runs from a standing start and with a full recovery between each run

Scoring: To determine the athletes flying 30m time subtract the time for the first 30m from the time for the whole 60m.

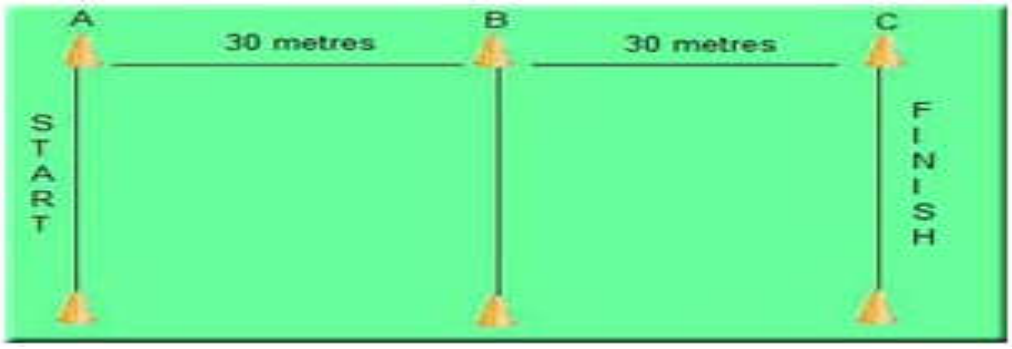

Figure 4 Flying 30-meter test

Adopted from Mackenzie, (1997)

3.10.3 Measuring Explosive power

Power was measured using vertical jump test

Vertical Jump Test

Objective: To measure the explosive power of the leg in vertical jump height jumped.

Equipments: - Measuring tape or marked wall, chalk for marking wall, score sheet, pencil.

Procedure: The player chalks the end of his fingertips, Stands side onto the wall, keeping both feet remaining on the ground, reaches up as high as possible with one hand and marks the wall with the tips of the fingers (M1). From a static position jumps as high as possible and marks the wall with the chalk on his fingertips (M2), the assistant measures and records the distance between M1 and M2. The player performed three trials. The assistant calculated and recorded the highest jump from the three trials.

Scoring: The jump height is usually recorded as a distance score in centimeter to the best of three trials as the score.

Figure 5 Vertical jump test

Adopted from Mackenzie, (1997)

3.11 Method of data analysis

After the subjects of the experimental and control group were tested on selected handball skills prior and immediately after the treatment (plyometric training), Data processing and statistical evaluations were completed using SPSS version 23. Descriptive statistics (mean ±SD) were presented. Paired sample t-test was applied for differences between pre and post- test conditions in terms of shooting performance, agility, speed and explosive power. The data analyzed level of significance in all parameters were fixed at ($p<0.05$). Depending on the data results and discussion, brief conclusions and recommendations were listed.

3.12 Reliability and Validity of Tests

Based on the nature of the variables (i.e. Physical Fitness and Handball Skill) the researcher collected proper equipment to conduct all the tests. To get reliable and valid results from the tests the equipment was in detail checked and their purposeful status was verified to ensure accuracy in data collection. The reliability and validity of the test was interpreted by using statistical technique, effective and necessary equipments', players and establishing technical standards

respectively. Because, tests the reliability and honesty of a test. The validity of the test standards improved by number of measurements in the testing procedure with the assistance of the professionally qualified person. Therefore, all reliable statistical techniques and materials as well as players and valid standard measurements were used in this research.

3.13 Ethical considerations

The study was in agreement with the ethical issue related to the research. Therefore, the study was conducted based on the universal rules, codes of conduct and policies concerning research ethics. It protects the privacy of study subjects and makes security and confidentiality of the information that had been given to the study and any risk harm due to participation. In addition, the written consent document that included a description of the testing and training procedures were given and informed the players. Before beginning the research, the researcher obtained permission from the trainer, woreda sport office and all the players had obvious information about the aim of the study, the performance benefits and the possible risks of participation in this study was explained to the players.

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1. Introduction

This section discussed analysis of the data collected from the subjects of the study through different skill and fitness tests. The purpose of this study was to investigate the effect of plyometric training on shooting performance, agility, speed and explosive power in case of Adet town handball project players. All of the subjects played on the Adet town handball project. The subjects were grouped randomly into EG (N= 10) and CG (N = 10). The group received all the necessary information about the study's procedures in verbal and written form. Then the plyometric training was given for the experimental group for three days per a week in addition to their standard handball related activities for 12 weeks. Pre-test and post-tests were taken from both experimental and control groups before and after 12 weeks of plyometric training intervention and the scores were recorded. Both groups underwent measurements of their shooting accuracy for shooting performance, hexagonal obstacle for agility, flying 30 meter for speed and vertical jump test for explosive power before and after the training program and the scores were recorded. The collected data analyzed by paired t- test using SPSS version 23.

4.2 Results of the Study

Table 2

Demographic characteristics of study participants

Group	N	Sex	Age (year)	Height(cm)	Weight(kg)	Training experience(year)
			Mean ± S.D	Mean ± S.D	Mean ±S.D	Mean ± S.D
Experimental group	10	Male	18.6±1.34	1.621 ±0.08	60.4±5.46	2.4±0.69
Control group	10	Male	18.9±1.37	1.61±0.07	58.6±4.71	2.5±0.70

Based on the above table, the descriptive characteristics of twenty study subjects from Adet town handball project players age were (EG= 18.6±1.34, CG= 18.9±1.37); height (EG=1.621 ±0.08, CG= 1.61±0.07); weight (EG= 60.4±5.46, CG= 58.6±4.471) and training experience (EG=2.4±0.69, CG=2.5±0.70). As shown in the table, (Mean ±S.D) value of control group, age and training experience (sport age) greater than participants of experimental group. However, in the height and weight of control group participants less than experimental group subjects.

Table 3

Descriptive Statistics of performance variable

Performance Variable	EG		CG	
	Mean ±Std. deviation		Mean ±Std .deviation	
	PT	POT	PT	POT
Shooting performance	31.5000±2.79881	33.2000±2.48551	32.6000±2.01108	32.8000±1.87380

Key: - EG=Experimental group, CG= Control group, PT= pre test, POT= post test,

According to the data existing in the table (3), the pre and post test result of shooting performance from experimental and control groups. The pre test score of EG found to be 31.5000 ± 2.79881 and the post -test score of EG found (33.2000 ± 2.48551). However, the pretest score of CG were 32.6000±2.01108 and the post test result of CG found to be 32.8000±1.87380. Therefore, this indicates that the mean value of EG from pre to post test improved by 1.7 to contribute plyometric training and in CG there is extremely close related from pre to post test were not intervention with plyometric training.

Table 4

Paired sample t-test results of performance variable for the two groups of pre and post test.

Performance variable	subjects	MD	SD	df	sig. (2- tailed)
Shooting performance	EG PT-POT	-1.70000	0.48305	9	0.000
	CG PT-POT	-0.20000	1.03280	9	0.555

Key: EG=Experimental group, CG= Control group, PT= pre test, POT= post test, MD= mean difference, df= degree of freedom, SD= standard deviation

According to the data obtainable in table 4, from pre to post test result of shooting performance for the EG showed a statistically significant difference (MD= -1.70000, SD=0.48305, p= 0.000), $p<0.05$, significant at 0.05. However, no significant difference was observed in CG between pre and post testing (MD= -0.20000, SD=1.03280, p=0.555). The results suggest that the practical training protocol caused a significant enhancement in shooting performance in the experimental group.

Table 5

Descriptive Statistics of physical fitness quality variables in both groups of pre and post test.

Fitness variables	EG		CG	
	Mean ±Std. deviation		Mean ±Std. deviation	
	PT	POT	PT	POT
Agility	29.9000±2.96086	27.1000± 3.28126	21.5000±2.27303	22.9000±2.02485
Speed	5.1070±0.30959	4.8760±0.36975	5.3120±0.33182	54.6290±156.13620
Explosive power	0.8059±0.07531	0.9330±0.11719	0.7810 ±0.04864	0.8040±0.05038

Key: EG=Experimental group, CG= Control group, PT= pre test, POT= post test,

According to the data available in table 5, on agility, the pre and post test results of experimental and control groups. The pre test score of EG was found to be 29.9000 ± 2.96086 and the post test result of EG was found to be 27.1000 ± 3.28126. Therefore, the mean value of EG was an enormous difference from pre to post increased by 2.8. Similarly the pre test score of CG were 21.5000±2.27303 and the post test score of CG found to be 22.9000±2.02485. Therefore, the mean values of CG were cloth related from pre to post test.

As presented, the table (5) also indicates that the pre and post test result of speed from experimental and control groups. The pre test score of EG was found to be 5.1070 ±0.30959 and the post test score of EG found to be 4.8760±0.36975, where as the pre test score of CG found to be 5.3120±0.33182 and the post test score of CG found to be 54.6290 ±156.13620. Apart from this, after 12 week plyometric training given to EG, the mean score of speed for EG has increased by 0.231 from pre to post test. However, the mean score of speed for CG has a great decrease of speed performance by 49.317 from pre to post tests.

The above table also shows the analyzed data of explosive power. The pre test score of EG were found to be 0.8059±0.07531 and the post test score of the EG were 0.9330±0.11719. Whereas, the pre test score of CG found to be 0.7810±0.04864 and the post test score of CG found to be 0.8040±0.05038. Therefore, to intend 12 week plyometric training given for the experimental group, the mean score of explosive power for the experimental group has a higher jumper and power by 0.1271 from pre to post than the control group. Mean value difference between pre and post tests of the groups were discussed as follows.

Table 6

Paired sample t-test results of physical fitness quality variables for both groups of pre and post test.

Fitness variables	subjects	MD	SD	df	sig. (2- tailed)
Agility	EG PT-POT	2.80000	1.31656	9	0.000
	CG PT-POT	-1.40000	1.26491	9	0.07
Speed	EG PT-POT	0.23100	0.15044	9	0.001
	CG PT-POT	-49.31700	167.29490	9	0.344
Explosive power	EG PT-POT	-0.12800	0.06233	9	0.000
	CG PT-POT	-0.02300	0.02163	9	0.08

Key: EG=Experimental group, CG= Control group, PT= pre t test, POT= post test, MD= mean difference, df= degree of freedom, SD = standard deviation.

The above table reveals that the test of significance differences of the experimental and control groups of pre and post test results. According to the data presented in the table (6), the pre and post test result of agility showed a statistically significant difference in EG (MD=2.80000, SD=1.31656, p=0.000, p<0.05). However, no significant difference was observed in CG (MD= -1.40000, SD= 1.26491, p=0.07, p>0.05). This specifies that the group members who established a plyometric training program (experimental group) significantly improved players' agility than the control group who had participated without a plyometric training program.

The above table (6) exposes the test of significance differences of the two groups (EG and CG) of pre and post test results. According to the data shown in the table, the pre and post test result of speed showed a statistically significant difference in EG (MD=0.23100, SD=0.15044,

p=0.001, p<0.05). However, no significant difference was observed in CG (MD=-49.31700, SD= 167.29490, p=0.344, p>0.05).

The above table also shows that EG significantly improved explosive power (MD= -0.12800, SD=0.06233, p=0.000, p<0.05). However, no significant difference was observed in CG (MD= -0.02300, SD=0.02163, p=0.08, p>0.05). This designates that the group members who received a plyometric training program (experimental group) were significantly better performers in explosive power than the control group who had participated without intervention training.

4.3 Discussions

The purpose of present study was to investigate the effect of plyometric training on shooting performance and selected physical fitness qualities in case of Adet town handball project players. Two groups were included, plyometric training group and control group. The subjects participated throughout the testing period and cooperated for the success of collection of necessary data. The experimental or training group participated in a 12-week training program performing the selected plyometric training designed to the handball players, while the control group did not participate in this program. Apart from this, plyometric training showed improvements in shooting performance and selected physical fitness qualities. The findings of this study in each quality discussed as follows.

The first purpose of this study was to evaluate the effect of plyometric training on shooting performance of players in Adet town handball project players. To do this, paired sample t-test computed and the results of paired sample t-test demonstrated that EG significantly improved shooting performance and shooting accuracy (p<0.05). However, the CG indicated that no significant improvement on shooting performance was observed in between pre and post-testing. This result shows that Adet town handball project players shooting performance was improved on the experiment. In relation to this, the data which has been found from the present study is incompatible with research findings such as; Saidi(2017) argued that the specific drills with plyometric training group had less significantly improved on shooting performance school level handball players due to the effect of specific drills with plyometric training program. The control group did not improve on selected shooting performance variables. However, the present study is consistent with the findings of; Muller (2008) conducted on effects of differential training and

variable training on the quality parameters of handball players. The result revealed that from pre to post test for intervention with a plyometric training, shooting performance of handball players significantly improved in EG ($p<0.05$). However, in the control group there was no significant improvement between pre test and post test results. Hence, the researcher accepted hypothesis H1.1 and rejected H0.1 at 0.05 level of confidence.

The second purpose of this study was to determine the effect of plyometric training on agility of players in Adet town handball project players. To perform this, paired sample t-test computed and the results of paired sample t-test demonstrated that EG significantly improved agility at ($p<0.05$). However, the CG indicated that no significant improvement on agility was observed in between pre- and post-testing. This result shows that Adet town handball project players' agility was improved on the experiment. In relation to this, the present study according with the findings of, Miller et al. (2006) conducted on effects of plyometric training program on improving agility of handball players. The result on the pre and post test of agility showed significant improvement in EG ($p<0.05$). However, in the control group there was no significant improvement between pre test and post test results. The increase of the rate of this score in EG was one pointer of the development of the player's agility. The reason at the back of these alter plyometric training was employed. Hence, the researcher accepted hypothesis H1.2 and rejected H0.2 at 0.05 level of confidence.

The third purpose of this study was to measure the effect of plyometric training on speed of players in Adet town handball project players. To carry out this, paired sample t-test computed and the results of paired sample t-test displayed that EG significantly improved speed at ($p<0.05$). However, the CG indicated that no significant improvement on speed was observed in between pre- and post-testing. This result shows that Adet town handball project players speed was improved on the experiment. In relation to this, the current finding of speed is inconsistent with the finding of; Conroy (1998) conducted on plyometric training and its effects on speed, strength and power of handball athletes. The result revealed between pre and post test of speed showed significant improvement in EG ($p<0.05$). However, in the control group there was no significant improvement between pre test and post test. On the other hand, this result is consistent with the findings of; Faigenbaum et al. (2007) conducted on effects of a short-term plyometric and resistance-training program and fitness performance of boys aged 12 to 15 years.

However, in the control group there was no significant improvement between pre test and post test. Hence, the researcher accepted hypothesis H1.3 and rejected H0.3 at 0.05 level of confidence.

Consequently, in plyometric training, the speed of converting outward contractions into inward contractions increases, and the created tension in the muscle increases, as does the production power of the muscle, therefore reducing the duration of the speed run. Improvements in doing other sports are partly attributed to outward-oriented training programs and the use of the elasticity feature of muscles (Radcliffe and Farentinos, 1999). On the other hand, since in plyometric training the muscles first encounter outward contractions and then immediately inward contractions, and with the shortening of this phase, stronger inward contractions can be created.

The fourth purpose of this study was to examine the effect of plyometric training on explosive power of players in Adet town handball project players. To do this, paired sample t-test computed and the results of paired sample t-test expressed that EG significantly improved explosive power at ($p<0.05$). However, the CG indicated that no significant improvement on explosive power was observed in between pre- and post-testing. This result shows that Adet town handball project player's explosive power was improved on the experiment. In relation to this, the findings of the current research are consistent with Shahdadi (1999) conducted on the effect of plyometric training on the explosive power and change of momentum of handball players. The result on the pre and post test of explosive power showed significant improvement in EG ($p<0.05$). However, in CG there was no significant difference between pre and post test. Similarly, the finding of the present study is not in agreement with Conroy (1998) conducted on plyometric training and its effects on speed, strength, and power of handball players. The probable reason for the increase in the amount of the explosive power is that in plyometric training, the muscles first encounter outward contractions, followed immediately by inward contractions, which result in developing explosive movement (Gaeini & Rajabi, 2003). When the muscles are stretched during plyometric training, they cause elastic potential energy, which is similar to the contracted energy stored in a compressed spring or a drawn arc. Therefore, when this energy is released the amount of contraction created by the muscle cords increases (Boumpa, 2005) and causes an increase in the explosive power. It seems that it develops during the vertical

jump, because in these exercises these jumps are done repeatedly. The raising of the rate of this score in EG was one indicator of the improvement of the player's explosive power. The reason behind this change was intervention to plyometric training. Hence, the researcher accepted hypothesis H1.4 and rejected H0.4 at 0.05 level of confidence.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

The research was conducted with the main purpose of investigating the effect of plyometric training on shooting performance and some selected physical fitness qualities in case of Adet town handball project players. For this purpose, the researcher used the existing literature in order to make a decision about the focus of the study and methodologies. In order to attain the principal objective of the study, the following specific research objectives were formulated.

- To evaluate the effect of plyometric training on shooting performance of players in Adet town handball project players.
- To determine the effect of plyometric training on agility of players in Adet town handball project players.
- To measure the effect of plyometric training on the speed of players in Adet town handball project players.
- To examine the effect of plyometric training on explosive power of players in Adet town handball project players.

Depending on the beyond specific objectives, the hypotheses were prepared. In the present research, study subjects were divided into two groups, an experimental (plyometric training group) and a control group, 10 experimental group (age 18.6±1.34, height 1.621 ±0.08, weight 60.4±5.46 and training experience 2.4±0.69) and 10 control group (age 18.9±1.37, height 1.61±0.07, weight 58.6±4.71 and training experience 2.5±0.70). Twenty players of the handball project in Adet town participated in the present research. Before and after the training the pre and post test score of (shooting accuracy test for shooting performance, hexagonal obstacle test (HOT) for agility, flying 30 meter test for speed and vertical jump test for explosive power) were recorded. The experimental group lasted to 50-60 minutes plyometric training; 3 days a week, for 12 weeks were conducted on the experimental group in addition to their standard handball training. However, the control group did not perform the selected plyometric training program. In order to investigate the effects of 12 week

plyometric training of the shooting performance, agility, speed and explosive power of handball players , paired sample t- test was used for an appropriate and relevant statistical method of analysis to pre and post test for both groups. Fitness qualities had been achieved by means of physical fitness test battery (PFTB) administration of tests. Consequently, the following main findings were investigated.

1. On the basis of findings from the table 4, it was revealed that there was significant improvement in shooting performance. Experimental groups had shown improvement as of the plyometric training, shooting performance was improved better in EG. In CG, no significant change was found in pre to post test.

2. The finding of this study indicated that there was a significant improvement of agility performance in EG than CG since plyometric training. Experimental groups show increased agility with the consequence of plyometric training but no significant improvement was found in CG.

3. The finding of this study showed speed performance was significantly improved in EG after participating in plyometric training. In CG, no significant change between pre to post test was observed.

4. The findings also revealed that explosive power performance was significantly improved in EG for the reason that of 12 weeks of plyometric training. In CG, no significant change was observed.

5.2 Conclusion

By using the experimental research design and based on the results of research and discussion that described in the previous chapter, it can put concluded as follows:

1. There is a significant effect of plyometric training on shooting performance of handball players.
2. There is a significant effect of plyometric training on agility of handball players
3. There is a significant effect of plyometric training on speed of handball players
4. There is a significant effect of plyometric training on explosive power of handball players.

In general, the key finding of this study was handball skill and selected physical fitness qualities such as; shooting performance, agility, speed and explosive power had significant alteration in handball players on the intervention of plyometric training program.

5.3 Recommendations

Based on the results of the research it can be submitted recommendations as follows:

- The present investigation indicates that 12 weeks of plyometric training using shooting accuracy, hexagonal obstacle, flying 30 meter, and vertical jump had a substantial impact on several parameters important to handball performance, including shooting performance, agility, speed and explosive power. Furthermore, the data suggest that such an intervention is implemented within the training regimen without adversely affecting other aspects of performance. Thus, handball coaches should be encouraged to incorporate plyometric training into the training schedule of their teams, as a simple and practical method of enhancing their playing ability and then the goal of the exercise achieved.
- In handball, agility is one of the important aspects that influence the player's skills. Hence, the plyometric training would improve the playing ability by giving much more training by increasing the agility. Not only speed and strength are very essential in the game of handball but also power is an important component for handball players. Hence, this type of training may be given to players who need to improve their power.
- From the findings to conclude that, plyometric training is helpful in improving shooting performance, agility, speed and explosive power in handball players. So this training method is recommended to handball players for improving fitness qualities and skilled performances.
- Plyometric training is the most frequently used method for conditioning in handball. Therefore, it would seem highly prudent to implement plyometric training programs in handball training and in team sports abroad, due to its effect on performance.
- The plyometric training program should be a part of physical preparation of handball players and it is necessary to raise the awareness of the trainers with the importance of plyometric training in the direction of the skill, because of their significant influence on raising the level of the player physically and skillfully.

- By its nature handball requires several physical attributes such as speed, power, strength and agility, plus the ability to maintain performance during repeated sprints and to maximize their performance players undergo various types of training. Therefore, in order to succeed: players, coaches, technical committee's and administrators should give plyometric training as well as different types of training.
- When applying the plyometric training method, you need to select the loads according to what suits the players' levels.
- Further studies should be conducted in the same area on different samples in terms of age and training experience. Moreover, this research is used as an input and experiment of research results if choosing similar problems as the object of research**.**

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APPENDICES

Appendix 1: Profile of participants

A. Experimental Group

No	Age (year)	Height (cm)	Weight (kg)	Training experience (year)
1	19	1.55	58	3
2	16	1.49	54	2
3	17	1.52	56	1
4	19	1.66	59	3
5	18	1.64	57	2
6	20	1.69	65	2
7	20	1.55	60	3
8	18	1.69	59	3
9	19	1.67	63	2
10	20	1.75	73	3

B. Control group

No	Age (year)	Height (cm)	Weight (kg)	Training experience (year)
1	20	1.62	54	3
2	19	1.53	53	3
3	17	1.49	56	2
4	16	1.51	51	2
5	20	1.65	64	2
6	19	1.66	61	3
7	20	1.70	64	3
8	19	1.68	62	1
9	20	1.67	60	3
10	19	1.61	61	3

Appendix 2: Demographic characteristics of study participants

Group	N	Sex	Age (year)	Height(cm)	Weight(kg)	Training experience(sport year)
			Mean ± S.D	Mean ± S.D	Mean ±S.D	Mean ± S.D
Experimental group	10	Male	18.6±1.34	1.621 ±0.08	60.4±5.46	2.4±0.69
Control group	10	Male	18.9±1.37	1.61±0.07	58.6±4.71	2.5±0.70

Appendix 3: Pre and Post test result of shooting accuracy for Experimental Group

No	Shooting performance	
	Shooting accuracy	
	7m	
	Pre test	post test
1	30	32
2	29	31
3	28	30
4	27	29
5	32	34
6	33	35
7	34	35
8	35	36
9	33	35
10	34	35

Appendix 4: Pre and Post test result of shooting accuracy for Control Group

No	Shooting performance	
	Shooting accuracy	
	7m	
	Pre test	post test
1	34	35
2	32	33
3	34	35
4	30	31
5	29	30
6	33	34
7	34	33
8	35	34
9	34	33
10	31	30

Appendix 5: Pre and Post test result of physical fitness qualities for Experimental Group players

		Physical fitness qualities				
		Agility Hexagonal obstacle test(second)	Speed flying 30 meter test (second)		explosive power vertical jump test (centimeter)	
No	Pre	Post	Pre	Post	Pre	post
1	30.00	28.00	5.39	5.18	0.88	0.99
2	34	30	5.04	4.65	0.86	1.02
3	33	31	4.93	4.49	0.76	0.89
4	32	29	4.88	4.46	0.67	0.79
5	30	30	5.52	5.34	0.76	0.88
6	25	22	5.65	5.45	0.73	0.83
7	26	23	4.93	4.72	0.84	0.92
8	28	25	4.96	5.01	0.85	0.95
9	29	24	5.1	4.99	0.79	0.86
10	32	29	4.68	4.47	0.91	1.2

Appendix 6: Pre and Post test result of physical fitness variables for Control Group players

	Physical fitness qualities					
	Agility Hexagonal obstacle test (second)		Speed flying 30 meter test (second)		explosive power vertical jump test (centimeter)	
No	Pre	Post	Pre	Post	Pre	post
1	20.00	22.00	5.56	5.4	0.76	0.79
2	19	21	5.37	5.16	0.77	0.81
3	21	23	5.14	5.06	0.83	0.85
4	23	25	4.86	4.99	0.75	0.80
5	18	20	5.76	5.64	0.89	0.92
6	20	22	5.89	5.59	0.8	0.78
7	22	24	5.14	5.09	0.78	0.81
8	25	27	5.11	5.06	0.75	0.78
9	23	22	5.02	5.1	0.76	0.75
10	24	23	5.27	5.19	0.72	0.75

Appendix 7: Pictures during shooting performance (shooting accuracy test)

Appendix 8: pictures during agility (hexagonal obstacle test)

Appendix 9: Pictures during explosive power (vertical jump test)

Appendix 10: Twelve-Week plyometric training Program for Experimental Group

Day	JANUARY Week – 1	Set	Rep.	Intensity	Time	Recovery time (active rest)
Monday (afternoon)	**Warming up exercise** Movement of hands and leg, warming up with small sided games, warming up with ball and stretching exercise.			Moderate	10'	
	Main part			High	35'	1 minutes b/n each sets
	Squat jump	3	6			
	Plyometric pushups	3	10			
	Bounding	2	8			
	Medicine ball overhead throw	2	8			
	Cooling down Static stretching at the ending of the session. Lower and upper body stretching.			Low	5'	

Wednesday (morning)	**Warming up exercise** Movement of hands and leg, warming up with small sided games, warming up with ball and stretching exercise **Main part** Lateral box jump Tuck jump Plyometric pull ups Forward hops **Cooling down** Static stretching at the end of the session. Lower and upper body stretching	 2 3 2 3 	 8 10 6 8 	Moderate High Low	10' 35' 5'	 1 minutes b/n each sets
Friday (after noon)	**Warming up exercise** Movement of hands and leg, warming up with small sided games, warming up with ball and stretching exercise **main part** plyometric pushups forward hops medicine ball overhead throw squat jump **cooling down** Static stretching at the end of the session. Lower and upper body stretching	 2 3 2 3 	 10 8 7 8 	Moderate High Low	10' 35' 5'	 1 minutes b/n each sets

Week -2

Monday (afternoon)	**Warming up exercise** Movement of hands and leg, Warming up with small-sided games, warming up with ball and stretching exercise.			Moderate	10'	
	main part			High		
	plyometric pull-ups	3	6		35'	
	tuck jump	3	8			1 minutes b/n each sets
	lateral box jump	2	10			
	bounding	3	8			
	cooling down Static stretching at the end of the session. Lower and upper body stretching			Low	5'	

Wednesday (morning)	**Warming up exercise** Movement of hands and leg, warming up with small sided games, warming up with ball and stretching exercise **main part** Squat jump Medicine ball overhead throw Plyometric pushups Forward hops **cooling down** Static stretching at the end of the session. Lower and upper body stretching.	 2 3 2 3	 10 8 10 10	Moderate High Low	10' 35' 5'	 1 minutes b/n each sets

Friday (afternoon)	**Warming up exercise** Movement of hands and leg, warming up with small sided games, warming up with ball and stretching exercise **main part** bounding medicine ball overhead throw lateral box jump plyometric pushups **cooling down** Static stretching at the end of the session. Lower and upper body stretching	 3 2 3 2	 8 10 9 10	Moderate High Low	10' 35' 5'	 1 minutes b/n each sets

Week -3

Monday((afternoon)	**Warming up exercise** Movement of hands and leg, Warming up with small-sided games, warming up with ball and stretching exercise. **main part** tuck jump forward hops plyometric pull-ups squat jump	 3 3 2 2	 8 7 10 9	Moderate High	10' 35'	 1 minutes b/n each sets

	cooling down Static stretching at the end of the session. Lower and upper body stretching			Low	5’	

Wednesday (morning)	**Warming up exercise** Movement of hands and leg, warming up with small sided games, warming up with ball and stretching exercise **main part** lateral box jump plyo pull ups forward hops medicine ball overhead throw **cooling down** Static stretching at the end of the session. Lower and upper body stretching	 3 3 2 3	 8 7 10 9	Moderate High Low	10’ 35’ 5’	 1 minutes b/n each sets

Friday (afternoon)	**Warming up exercise** Movement of hands and leg, warming up with small sided games, warming up with ball and stretching exercise **main part** bounding tuck jump squat jump plyometric pull ups **cooling down** Static stretching at the end of the session. Lower and upper body stretching	 2 3 2 3	 10 9 8 8	Moderate High Low	10' 35' 5'	 1 minutes b/n each sets

Week -4

Monday (afternoon)	**Warming up exercise** Movement of hands and leg, warming up with training games, warming up with ball and stretching exercise.			Moderate	10'	
	main part			High	35'	1
	squat jump	2	12			minutes
	lateral box jump	3	10			b/n
	medicine ball overhead throw	3	12			each
	plyometric pushups	2	10			sets
	Cooling down Static stretching at the end of the session. Lower and upper body stretching.			Low	5'	

				Moderate	10'	
Wednesday (morning)	**Warming up exercise** Movement of hands and leg, warming up with training games, warming up with ball and stretching exercise.			High	35'	1 minutes b/n each sets
	main part					
	plyometric pull-ups	3	9			
	forward hops	2	10			
	bounding	3	10			
	tuck jump	2	12			
	cooling down			Low		
	players perform rehydrate Lower and upper stretching activities at the end of the session.				5'	

Friday (afternoon)	**Warming up exercise** Jogging ,warm up runs and Stretching exercises **main part** squat jump tuck jump bounding medicine ball overhead throw **cooling down** players perform rehydrate Lower and upper stretching activities at the end of the session.	 3 3 3 3	 9 10 8 12	Moderate High Low	10' 35' 5'	 1 minutes b/n each sets

FEBRUARY

Week – 5

Monday (afternoon)	**Warming up exercise** Jogging ,warm up runs and Stretching exercises **main part** plyometric pull ups plyometric pushups lateral box jump forward hops **cooling down** players perform rehydrate lower and upper starching activities at the end of the session.	 4 3 3 3	 7 9 8 8	Moderate High Low	10' 40' 5'	 1 minutes b/n each sets

Wednesday (morning)	**Warming up exercise** Jogging, warm up runs and Stretching exercises **main part** medicine ball overhead throw bounding squat jump tuck jump **cooling down** players perform rehydrate lower and upper starching activities at the end of the session.	 3 3 4 3	 12 10 10 12	Moderate High Low	10' 40' 5'	1 minutes b/n each sets
Friday (after noon)	**Warming up exercise** Jogging ,warm up runs and Stretching exercises **main part** forward hops bounding lateral box jump plyometric pushups **cooling down** players perform rehydrate Lower and upper starching activities at the end of the session.	 4 3 4 3	 10 12 8 9	Moderate High Low	10' 40' 5'	1 minutes b/n each sets

Week -6

Monday (after noon)	**Warming up exercise** Jogging and warming up with ball, warming up with runs **main part** plyometric pull up tuck jump lateral box jump squat jump **cooling down** players perform rehydrate lower and upper stretching activities at the end of the session.	 4 3 3 4	 9 10 12 7	Moderate High Low	10' 40' 5'	 1 minutes b/n each sets
Wednesday (morning)	**Warming up exercise** Jogging and warming up with ball, warming up with runs **main part** plyometric pull up bounding medicine ball over head throw forward hops **cooling down** players perform rehydrate Lower and upper stretching activities at the end of the session.	 4 3 4 3	 7 10 9 8	Moderate High Low	10' 40' 5'	 1 minutes b/n each sets
Friday (after noon)	**Warming up exercise** Jogging and warming up with			Moderate	10'	

	ball, warming up with runs **main part** medicine ball overhead throw forward hops squat jump lateral box jump **cooling down** players perform rehydrate lower and upper stretching activities at the end of the session.	 4 4 3 3	 8 6 10 12	 High Low	 40' 5'	 1 minutes b/n each sets

Week -7

Monday (after noon)	**Warming up exercise** Jogging and warming up with ball, warming up with runs **main part** tuck jump plyometric pushups plyometric pull ups bounding **cooling down** players perform rehydrate lower and upper stretching activities at the end of the session.	 4 3 4 3	 8 10 6 5	Moderate High Low	10' 40' 5'	 1 minutes b/n each sets

Wednesday (morning)	**Warming up exercise** Jogging and warming up with ball, warming up with runs **main part** lateral box jump squat jump tuck jump bounding **cooling down** players perform rehydrate lower and upper stretching activities at the end of the session	 3 4 3 3 	 7 8 8 10 	Moderate High Low	10' 40' 5'	 1 minutes b/n each sets
Friday (afternoon)	**Warming up exercise** jogging &synchronized Movement of hands and leg, arm, stretching exercise. **main part** medicine ball over head throw plyometric pushups forward hops tuck jump **cooling down** players perform rehydrate lower and upper stretching activities at the end of the session.	 4 3 3 3 	 7 8 9 7 	Moderate High Low	10' 40' 5'	

Week -8

Monday (after noon)	**Warming up exercise** Jogging and warming up with ball warming up with runs **main part** lateral box jump plyo pull ups bounding medicine ball overhead throw **cooling down** players perform rehydrate Lower and upper stretching activities at the end of the session.	 4 3 3 4	 8 6 8 6	 Moderate High Low	10' 40' 5'	 1 minutes b/n each sets
Wednesday (morning)	**Warming up exercise** Jogging and warming up with ball, warming up with runs **main part** lateral box jump tuck jump squat jump bounding **cooling down** players perform rehydrate lower and upper stretching activities at the end of the session.	 4 3 3 3	 8 10 12 8	Moderate High Low	10' 40' 5'	 1 minutes b/n each sets
Friday (after noon)	**Warming up exercise** Jogging and warming up with ball Warming up with runs **main part**			Moderate	10'	

	medicine ball overhead throw plyometric pushups plyometric pull ups forward hops **cooling down** players perform rehydrate lower and upper stretching activities at the end of the session.	3 3 3 4	7 8 10 7	High Low	40' 5'	1 minutes b/n each sets

MARCH

Week -9

Monday (after noon)	**Warming up exercise** Jogging and warming up with ball warming up with runs **main part** tuck jump lateral box jump bounding squat jump **cooling down** players perform rehydrate lower and upper stretching activities at the end of the session.	 4 4 4 4	 12 10 8 6	Moderate High Low	 10' 45' 5'	 2 minutes b/n each sets
Wednesday (morning)	**Warming up exercise** Jogging and warming up with ball Warming up with runs **main part** lateral box jump	 4	 9	Moderate High	 10' 45'	

	plyometric push up plyometric pull up medicine ball overhead throw **cooling down** players perform rehydrate lower and upper stretching activities at the end of the session.	4 4 4	12 10 8	 Low	 5'	 2 minutes b/n each sets
Friday (after noon)	**Warming up exercise** Jogging and warming up with ball, warming up with runs **main part** tuck jump forward hops lateral box jump bounding **cooling down** players perform rehydrate lower and upper stretching activities at the end of the session.	 4 4 4 4	 12 8 10 9	Moderate High Low	10' 45' 5'	 1 minutes b/n each sets

Week -10

Monday (after noon)	**Warming up exercise** Jogging and warming up with ball, warming up with runs **main part** plyometric pull ups plyometric pushups medicine ball over head throw forward hops **cooling down** players perform rehydrate lower and upper stretching activities at the end of the session.	 4 4 4 4	 10 12 8 10	Moderate High Low	10' 45' 5'	 2minutes b/n each sets
Wednesday (morning)	**Warming up exercise** Jogging and warming up with ball warming up with runs **main part** squat jump tuck jump lateral box jump bounding **cooling down** players perform rehydrate lower and upper stretching activities at the end of the session	 4 4 4 4	 8 10 7 12	Moderate High Low	10' 45' 5'	 2minutes b/n each sets

Friday (after noon)	**Warming up exercise** Jogging and warming up with ball warming up with runs **main part** squat jump bounding forward hops medicine ball over head throw **cooling down** players perform rehydrate Lower and upper stretching activities at the end of the session**.**	 4 4 4 4	 10 10 12 12	Moderate High Low	10' 45' 5'	 2minutes b/n each sets

Week -11

Monday (afternoon)	**Warming up exercise** Jogging and warming up with ball, warming up with runs **main part** lateral box jump squat jump bounding forward hops **cooling down** players perform rehydrate lower and upper stretching activities at the end of the session	 4 4 4 4	 10 9 10 8	Moderate High Low	10' 45' 5'	 2 minutes each b/n sets

Wednesday (morning)	**Warming up exercise** Jogging and warming up with ball**,** warming up with runs **main part** bounding plyometric pushups plyometric pull ups tuck jump **cooling down** players perform rehydrate lower and upper stretching activities at the end of the session.	 4 4 4 4	 12 10 8 6	Moderate High Low	10' 45' 5'	2 minutes b/n each sets
Friday (after noon)	**Warming up exercise** Jogging and warming up with ball, warming up with runs **main part** squat jump forward hops lateral box jump medicine ball overhead throw **cooling down** players perform rehydrate lower and upper stretching activities at the end of the session.	 4 4 4 4	 8 12 7 10	Moderate High Low	10' 45' 5'	2 minutes b/n each sets

Week -12

Monday (after noon)	**Warming up Exercise** Jogging & synchronized movement of hands and leg, arm, stretching exercise **main part** bounding lateral box jump squat jump forward hops **cooling down** players perform rehydrate lower and upper stretching activities at the end of the session.	 4 4 4 4	 12 12 8 10	Moderate High Low	10' 45' 5'	 2 minutes b/n each sets
Wednesday (morning)	**Warming up exercise** Jogging and warming up with ball, warming up with runs **main part** plyometric pull ups tuck jump medicine ball overhead throw plyometric pushups **cooling down** players perform rehydrate, lower and upper stretching activities at the end of the	 4 4 4 4	 12 10 8 12	Moderate High Low	10' 45' 5'	 2 minutes b/n each sets

	session					
Friday (after noon)	**Warming up exercise** Jogging and warming up with ball, Warming up with runs **main part** forward hops squat jump bounding lateral box jump **Cooling down** Players perform light movement and static stretching at the end of the session.	 4 4 4 4	 10 6 8 7	Moderate High Low	10' 45' 5'	 2 minutes b/n each sets