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The Effects Of Strength and Plyometric Training on The Development of The Explosive Power of U-17 Youth Volleyball Players In Amhara Region Ethiopia

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THE EFFECTS OF STRENGTH AND PLYOMETRIC TRAINING ON THE DEVELOPMENT OF THE EXPLOSIVE POWER OF U-17 YOUTH VOLLEYBALL PLAYERS IN AMHARA REGION ETHIOPIA

BY:

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JUNE, 2024

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The Effects of Strength and Plyometric Training on the Development of the Explosive Power of U-17 Youth Volleyball Players in Amhara Region

BY

Astatkie Bogale Kebede

A Dissertation Submitted to Bahir Dar University Sport Academy, in Partial Fulfilment of the Requirements for the Doctor of Philosophy in Volleyball Coaching

Principal Advisor's: Dr. Aemiro Asmamaw (Assoc. Professor)

Co-Advisor: Dr. Belayneh Cheklie (Assistant Professor)

JUNE, 2024

Bahir Dar, Ethiopia

DECLARATION

I hereby declare that this Ph.D. dissertation entitled "THE EFFECTS OF STRENGTH AND PLYOMETRIC TRAINING ON THE DEVELOPMENT OF THE EXPLOSIVE POWER OF U-17 YOUTH VOLLEYBALL PLAYERS IN AMHARA REGION " was carried out by me for the degree of Doctor of Philosophy in Volleyball Coaching under the guidance and supervision of Dr. Aemiro Asmamaw (Associate Professor) University of Gondar and Dr. Belayneh Cheklie (Assistant Professor), Bahir Dar University. Wherever contributions of others are involved, every effort is made to indicate this clearly, with due reference to the literature, and acknowledgement of collaborative research and discussions.

Name ________________

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Approval of Dissertation

I hereby certify that I have supervised, read, and evaluated this thesis/dissertation titled“The Effects of Strength and Plyometric Training on the Development of the Explosive Power of U-17 Youth Volleyball Players in Amhara Region” by Astatkie Bogale prepared under my guidance. I recommend the dissertation be submitted for oral defence.

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Approval of Dissertation for Defence Result

As members of the board of examiners, we examined this dissertation entitled The Effects of Strength and Plyometric Training on the Development of the Explosive Power of U-17 Youth Volleyball Players in Amhara Region" by Astatkie Bogale. We hereby certify that the dissertation is accepted for fulfilling the requirements for the award of the degree of Doctor of Philosophy in Volleyball Coaching**.**

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Abstract

The purpose of this study was to examine the effects of plyometric and strength training interventions on the explosive power output of male volleyball trainees. A total of 68 project players participated in the study and were randomly allocated into four groups. The first group participated in plyometric training, the second and third groups took part in strength and combined training respectively. The fourth group, the control group, had participated only in the usual volleyball training program. The training session was conducted 3 times per week for 90 minutes, and the entire training intervention lasts for 12 weeks. To reveal the effect of each of the three training interventions in improving the explosive power of young players, the researcher measured the spike jump (m), block jump (m), standing broad jump (m), pull-up (rep) and sit-up (rep). The outcomes show a significant difference between the four groups (Pre vs. Post), and the combined group scored the most prominent result of all the other groups. The current study indicated that 12 weeks of involvement training meaningfully enriched explosive power of young volleyball players. Thus, it is concluded that a 12-weeks Plyometric and Strength Training intervention with a range of exercise intensity from 60% to 90% can positively impact the explosive power of the lower legs and thus boost the vertical jumping abilities.

Keywords: Strength Training, Plyometric Training, Explosive Power, Volleyball

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Abbreviations and Acronyms

BJ – Block jump

CCEPTG - combination of core and explosive power training

CG-Control Group

EPTG - Explosive Power Training Group

ICTG -Isometric Core Training Group

PG-Plyometric Group

SG-Strength Group

SJ- Spike Jump

ST+PG- Strength and Plyometric (Combined) Group

CHAPTER ONE

1. INTRODUCTION

1.1 Background of the Study

The new offense and defence players' roles brought about a need for an intensive study of volleyball abilities, especially the ability of the leg muscles to produce explosive type strength, which in volleyball lingo is referred to as the vertical jump. Due to the specific growth and for the development of young volleyball players, any vertical jump training must be approached with caution.

A volleyball match can last five sets, which means that an athlete can perform 250–300 trials dominated by explosive leg muscle strength (Stojanovi1, and Kostic, 2002).

Of the total number of actions, jumps take up around 50–60%, high-speed movements and changes of direction in space about 30%, and falls about 15%. (Kostic, 2002). The average height of a modern-day volleyball player is greater compared to the one from earlier periods, and is between 195 and 200 centimetres (Ercolessi, 1999). The average extent of a receiver's vertical jump in a spike, a spiker's or a middle blocker's is between 345 and 355 centimetres, and in a block from 320 to 335 centimetres (Ercolessi, 1999). The spike and block actions are dominated by the corresponding explosive type strength, which is referred to as the player's vertical jump, which is usually the key to winning points.

The major muscle groups utilized while hitting, blocking, passing, setting, and moving during a volleyball game or training drill were studied to determine the movement patterns (Gadken, 1999). To generate a larger force while jumping, the glutes, hamstrings, quadriceps, and calves work jointly to produce the power essential to lift the body up (Scates, et al. 2003).

Considering the fact that the height of volleyball players cannot be changed during the course of training, the height within reach during a spike or block (the vertical jump) can be increased by sports training. One of the fundamental goals of volleyball training is to "build" explosive type strength "into" not only the biochemical structure, but also many other structures of volleyball techniques (Kostic, 1995).

The idea of explosive kinds of strength is linked with the reactive ability of the neuromuscular apparatus (Verhoanski, 1979). In the definition of explosive type strength, Zatziorski introduced the concept of reversible strength, a strength which consists of two phases: the eccentric phase (the stretch) and the concentric phase (the shortening). The concentric stage is added to the preceding muscle stretch in the shortest time possible (Zatziorsky, 1995).

In the theory of strength training, the specific training for the increase of explosive type strength is referred to as "plyometric training" and the training method is called the "plyometric method". Plyometrics is a speed-strength workout, a mixture of strength and speed (Marullo, 1999).

The fundamental principle of the plyometric method lies in the speed of the shift from and to the eccentric and concentric muscle contractions. The key to this lies in the time needed for one muscle to shift from a state of flexibility (the stretch) into a state of shortening (the return to its original position). This points to the fundamental principle of strength and plyometric training: the measurement, the extent of the stretch (the degree), determines the use of the strength that allows flexibility and the transformation of eccentric and concentric energy into energy used to move muscles (Kostic, 1999).

By using the strength and plyometric training method, volleyball players may injure themselves, unless the requirements regarding the basic technique structures of the depth jump are met (the anatomic, dynamic, rhythmic, etc., as found in Kostić, 2000). One of the major requirements for using the plyometric training method is a basic strength training. Young volleyball players do not require a high basic strength level. Once we have stabilized the basic strength, the next problem is the eccentric strength of the leg muscles. It is quite limiting, especially during any training consisting of high volume and increased force exercises. Without the adequate eccentric muscle strength, a high speed shift from the eccentric to the concentric mode proves to be ineffective. If the amortization phase lasts a long time, and if the movements are slow, the shift from eccentric to concentric muscle movement, the eccentric strength levels will not be adequate, and the training itself should be reduced in volume and intensity (Kostić, 1999).

The amount of strength exercised varies depending on the drills. Olympic style lifts never exceed 6 repetitions in some programs due to the fact that performing more than 6 repetitions may place the athlete at risk for injury (Gadeken, 1999).According to Gadeken, (1999), the use of free weights and superior and inferior body ballistic training is vital in increasing strength and power.

The accurate realization of the drills requests to be monitored regularly during the shift, apart from the level of the athlete, When the speed and strength exercise method is being used with beginners, it is very important that they adopt the appropriate depth jump procedure, which they will soon get better at with the intensity of the exercises. Jumps represent a constant exchange between the forces of production and reduction, leading to the merging of these forces by means of all three joints of the lower extremities (Kosti, 1999).

The maximal height of the depth jump is often cited as an important criterion for the proper jump technique (Schmidtbleicher, & Gollhofer, 1985). It needs to correspond to the height at which one's heels do not touch the ground prior to take-off during the depth jump. The concept of "border height" from which one jumps into "the depth" (Schmidtbleicher, 1984) has been accepted as the logical depth jump height in the research of Bosco, & Pitter, (1982) and Letzler, & Letzler (1990).

Volleyball needs anaerobic conditioning due to the short and explosive movements and high power outputs. Games may last a long period of time, but the game plays are not continuous with numerous breaks through the game (Scates, et al., 2003). Precise volleyball exercises are essential to raise the body's efforts and development. Overload training must be stimulus-based, which means that the weights, speed, height, and duration must be higher than usual to have a direct impact on body resistance, strength, and conditioning. (Black, 1995).

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As Marques, et al. (2009) indicated, there are variations in the muscular strength and power characteristics of volleyball athletes according to the place they are playing. Outside hitters have an important variation in maximal bench press strength, parallel squat, and throwing distances compared to setters and liberos. The setters and liberos have less body strength. Outer hitter skills and exercises are unlike those of a setter or libero. While the setter focuses on sound set passes, the outer hitter will focus on block jumps, backpedal for 4 m, fast spike approaches and spike jumps, each accomplished in a short period of time (Hendrick, 2007).

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1.2 Statement of the Problem

One of the primary training goals for any volleyball player or coach is to increase the explosive power of the athletes (Baechle, & Earle, (2000)). Incorporating strength and plyometrics training into a training program could become a helpful tool in increasing the vertical jumps of those volleyball players. Coaches, athletic trainers, and strength and conditioning coaches know about plyometrics and that doing strength and plyometric exercises can help increase the explosive power of an athlete, but not many know how to safely and effectively add them into their off-season training programs (Baechle, & Earle, 2000).

Although strength and plyometrics are the sole conditions necessary for volleyball players, their significance is paramount. And with no doubt, they are given to the volleyball players by trainers, but the level of adequacy varies. The researcher wants to argue here that the Ethiopian U-17 The players throughout their history have not secured the essential dose of training to become physically fit; that is, the players have not developed the necessary strength that help them to stand out as strong competitors.

As far as the understanding of the researcher is concerned for many years the majority of volleyball sport clubs in Amhara region filled with players coming from other regions of Ethiopia. This indicated that there is a deficit in volleyball successors in the region.

As the weakness of the Ethiopian U-17 volleyball players is seen by their continuous poor performance, there is a felt need to upgrade their qualities by developing their strength and plyometrics.

Numerous research studies shows controversial issue in the effects of strength and plyometric trainings on vertical jump skills development, for instance the study conducted by (Cetin & Ozdol, 2012); Abebaw, 2019) confirmed that strength training has significant effect on muscular endurance performance of players. On the contrary, studies conducted by (Bishop, Mackinnon, Michael & McEniery, 1999) investigated that strength training has no significant effect on muscular power performance of players.

A research conducted by (Ramin, Zahra & Alireza, 2014); (Abebaw, 2019); (Jozsi, Campbell & Evans, 1999) confirmed that strength training has significant effect on explosive power of players. On the opposite, the study conducted by Charles (1967) investigated that strength training has no significant effect on explosive power of players. Thus the researcher wants to proof which issues are correct and applicable for designated region and subjects.

Performance differences among Amhara youth male volleyball project trainees are not well registered. Therefore, PE teachers and coaches may have difficulty in developing programs to improve volleyball performance, especially during their years of competition.

In both the theoretical and practical aspects of training volleyball players, there are several models for developing the explosive type strength of leg muscles, such as the Chu, model, 1991).The fundamental goal of this experimental research is to investigate the effectiveness of plyometric and strength exercises in the development of explosive type strength for U-17 project volleyball trainees.

The study examines differences in performance based on individual player skill abilities. It also provides a means to test the effectiveness of various training *programs designed to address performance deficits. The lack of information available to* U-17 male volleyball project trainees across explosive power and makes comparison of performance indicators among athletes very difficult. So the researcher need to conduct this research in order to adverse the prevailing problems.

1.3 Objectives of the Study

1.3.1 General Objective

The general objective of the study was to investigate the effects of strength and plyometric training on the development of the explosive power of **U-17** male volleyball players.

1.3.2. Specific Objectives

1. To examine the effectiveness of strength and plyometric trainings used to develop explosive power.
   (a)*. to examine the effect of strength training on explosive power development of U17 volleyball players)*
   (b)*. to examine the effect of plyometric training on explosive power development of U17 volleyball players)*

2. To investigate the different strength and plyometric training methods that suit the demands of project players.

3. To find out the relationship b/n strength and plyometric trainings in developing explosive power.

1.4. Research Hypothesis

1. Null hypothesis (H_0): There would be no significant improvement in explosive power performance outcome measures in plyometric and strength training program among experimental and control groups.

2. There would be no strength and plyometric training methods that suit the demands of project players.

3. There would be no relationship between strength and plyometric trainings in developing explosive power.

1.5 The Significance of the Study

The study would help to provide information about explosive power quality made by project players, training coaches, PE teachers, and professionals on how to test, plan, and re-evaluate specific training program to fill the gap and improve project players' performance.

In certain sports, it is very important to be faster or more powerful in today's set up; coaches are required to search for an efficient and successful method in the least amount of time to optimize explosive power improvement. This study helps the coaches to implement a time-efficient training regime. The development of a new form of training assists in recognizing modifications in program patterns for developing power in individuals, and due to the lack of a scientific basis for training programs in Ethiopia, this study is a beginning to change this situation.

It would also serve as reference material for other researchers.

1.6. Delimitation of the Study

Within the framework of this study, the influence of the coaches on the implementation of the training program could not be controlled with the provision of facilities and services and related matters. Nevertheless, the training program was monitored closely in every training session. Even though the training program was affected by different factors, no attempt was made to control for the food intake of the subjects during the period of the study. No effort was also made to control for any psychological, socio-cultural or other correlates believed to play a role in the relationship between training and motor abilities. The study was also limited to objective assessment of players on the block jump (BJ), the spike jump (SJ), the standing linear jump (SBJ), (AAHPER test item), pull ups for boys (AAHPER test item), bent knee sit ups (AAHPER test item). The study was carried out at youth training sites in Amhara regional state's west Gojjam, south Gondar, and east Gojjam zones. Trainees who were aged 15–16 years ± 6 months were included. Those who had health problems were not included in the study.

1.7. Limitation of the Study

Since it is challenging to control extraneous variables entirely, the influence of some extraneous variables, such as lifestyle, daily routine work, diet (the subjects were only given orientation), and metrological variations, such as air temperature and atmospheric pressure during testing, were not well or fully controlled. The players' psychological makeup and associated variables were uncontrolled. This investigation was limited by inadequate facilities and scientific measurement instruments.

Some of the difficulties at the study period were:

1. Getting the actual project cites data was very difficult. Even their age was not appropriate at the time of data gathering. The researcher kept one year till their age become under 17 year old.
2. The data gathering process extended and also disturbed due to the above mentioned problem and the occurrence of COVID-19 all over the world.
3. Some players were under injury as a result of training.

1.8 Theoretical Frame work

1.8.1 Increasing explosive power

There have been many different methods and training techniques utilized in various research studies investigating the development of explosive power. Resistance training is a common term for many different types and variations of exercises using variable resistances that overload the musculature to provide a training effect (Lyttle, 1994). Plyometrics are training techniques that utilize the stretch shortening cycle (**SSC**) to produce energy for dynamic muscle contractions and are said to be vital to the optimal development of muscular power. Other forms of training commonly used to develop explosive power include various combinations of resistance training and plyometrics (Adams, et al. (1987), Blakey, & Southard, (1987) and Maneval, et al (1987), short sprints, towing sleds, maximum vertical jumping, medicine ball drills, and others.

In his article on power development, Lyttle, (1994), explains the various techniques used to develop explosive power, all of which are utilized in various studies:

1) Plyometrics and combined weights

2) Plyometrics.

3) Mixed methods for the optimization of power output

1.8.2 Plyometric and Combined Weights

Complex training combines resistance training and plyometric exercises that are biomechanically similar in nature to sports movements and are contained in the same training session (Libby, 2006).

Newton, et al (1999) investigated the effects of ballistic training on the vertical jump in highly trained elite volleyball players during preseason preparation. Sixteen male players participated in the study. They were randomly divided into control and experimental groups after completing a series of tests which consisted of the standing vertical jump and reach, and the jump and reach from a three-step approach. The vertical jump test was performed on a plyometric power system and force plate to measure power, force, and velocity during jumping. Athletes were required to complete volleyball on-court training together with a resistance training program. The treatment group needed to accomplish 8 weeks of squat jump training on top of the training program mentioned earlier. The control group carried out squat and leg press exercises at 6 RM. The results illustrated a significant improvement of 3.1% in the standing vertical jump and reach and 5.1% in the jump and reach in the three-step approach. It was also concluded that an increase in overall force output during jumping and an increase in the rate of force development resulted in increased jump height.

1.8.3 Plyometric Conditioning

Plyometric is the main part of the most physical activities, including running, jumping, hopping, and throwing, which is observed in children's games. Plyometric training is an extremely successful method of transforming strength into power (Reezer, et al., 2003). As with most types of exercise, plyometric exercises range from those that are easy to perform to those that are extremely difficult to perform.

A plyometric exercise such as a drop jump requires a quick, reactive body movement to attain the power required for the action. Plyometric training causes muscular and neural changes that facilitate and enhance the development of rapid and powerful movements. Eccentrically loading muscles stores potential energy within the series of elastic components of the muscle. Similar in concept to a loaded spring, when released during the subsequent concentric muscle activation, this energy augments that energy generated by the contractile apparatus of the muscle fibres (Reezer, et al., 2003).

Like any other training program, there are great concerns about the efficacy and safety of plyometric training for improving motor performance especially in children. Johnson et al. suggest that plyometric training is safe for children when parents provide consent, children agree to participate, and safety guidelines are built into the intervention, Plyometric training had a large effect on improving the ability to run and jump, also on the increasing kicking distance, balance, and agility. Twice a week program for 8-10 weeks beginning at 50-60 jumps a session and increasing exercise load weekly results in the largest changes in running and jumping performance in children (Johnson, et al 2011).

In children who participated regularly in sports activities PT is suggested by means of skill improvements, especially for jumping. Kotzamanidis, et al. (2006) suggest that Plyometric exercises can improve squat jump and running velocity in pre-pubertal boys. More specifically, this program selectively influenced the maximum velocity phase, but not the acceleration phase (Kotzamanidis, et al.2006). Diallo, et al. (2001) showed that short-term plyometric training programs increase athletic performances in prepubescent boys and these improvements were maintained over a period of reduced training. The short-term plyometric program had a beneficial impact on explosive actions, such as sprinting, change of direction, and jumping.

1.8.4 Mixed methods for the optimization of power output

When examining the literature, one-dimensional training approaches that only focus on the development of strength or power do not maximize the development of power, strength,and endurance. Toji, and Kaneko, (2004a, b) and overall sports performance capacity. Thus, a mixed methods approach is suggested when attempting to maximize power productivity. Cormie P. et al. (2010), (Figure 1). The use of a mixed methods approach to optimize power-generating capacity allows for a superior increase in maximal power output and a greater transfer of training effect because of a more well-rounded development of the force-velocity relationship (Ellenbecker Ts., and Davies GJ. (2011)).Theoretically, the use of low-load high-velocity movements can impact the high-velocity area of the force velocity relationship, while heavier loads enhance the high-force portion of this relationship.

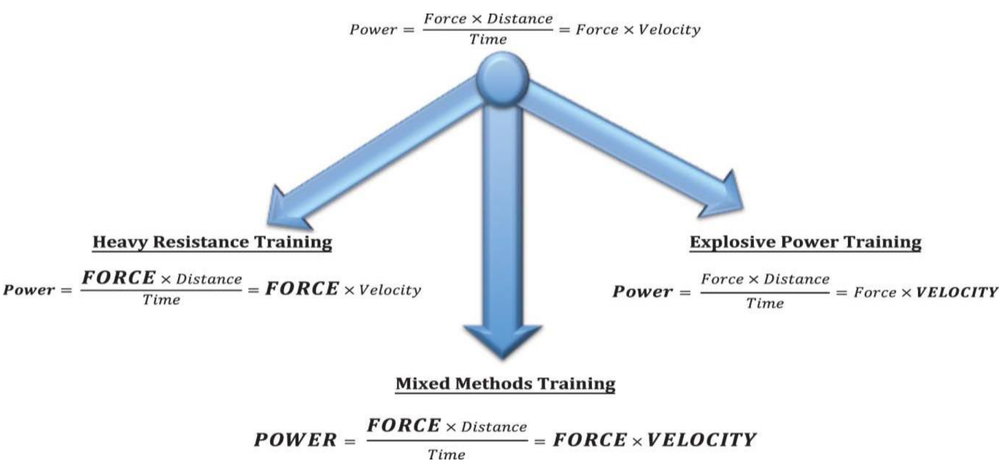

Figure-1-Training method relationship to the development of power, strength, and movement velocity, adapted from Newton and Kraemer (1994)

The first strategy for employing a varied training approach is to use a diversity of training loads. For instance, in the back squat, power improvement can take place between loads of 30–70% of 1RM, while elevated loads (75% of 1RM) would normally be engaged for strength improvement (Cormie P. et al., 2007; and Kirby, TJ. et al., 2010). Thus, if athletes were performing sets at 80–85% of 1RM for the improvement of strength, they would perform submaximal back squats as part of their warm-up, which would successfully serve to build up power-generating ability if performed "explosively."

The next power improvement strategy is to use a mixed methods approach in which different portions of the force speed arc are besieged with the use of a mixture of training exercises performed at different loading intensities. For example, unloaded jump squats, which are efficiently plyometric exercises, would mark power development of the low-force high velocity portion of the force-velocity association when performed with loads between 0 and 30% of 1RM.

1.8.5 Conceptual Model of The Study

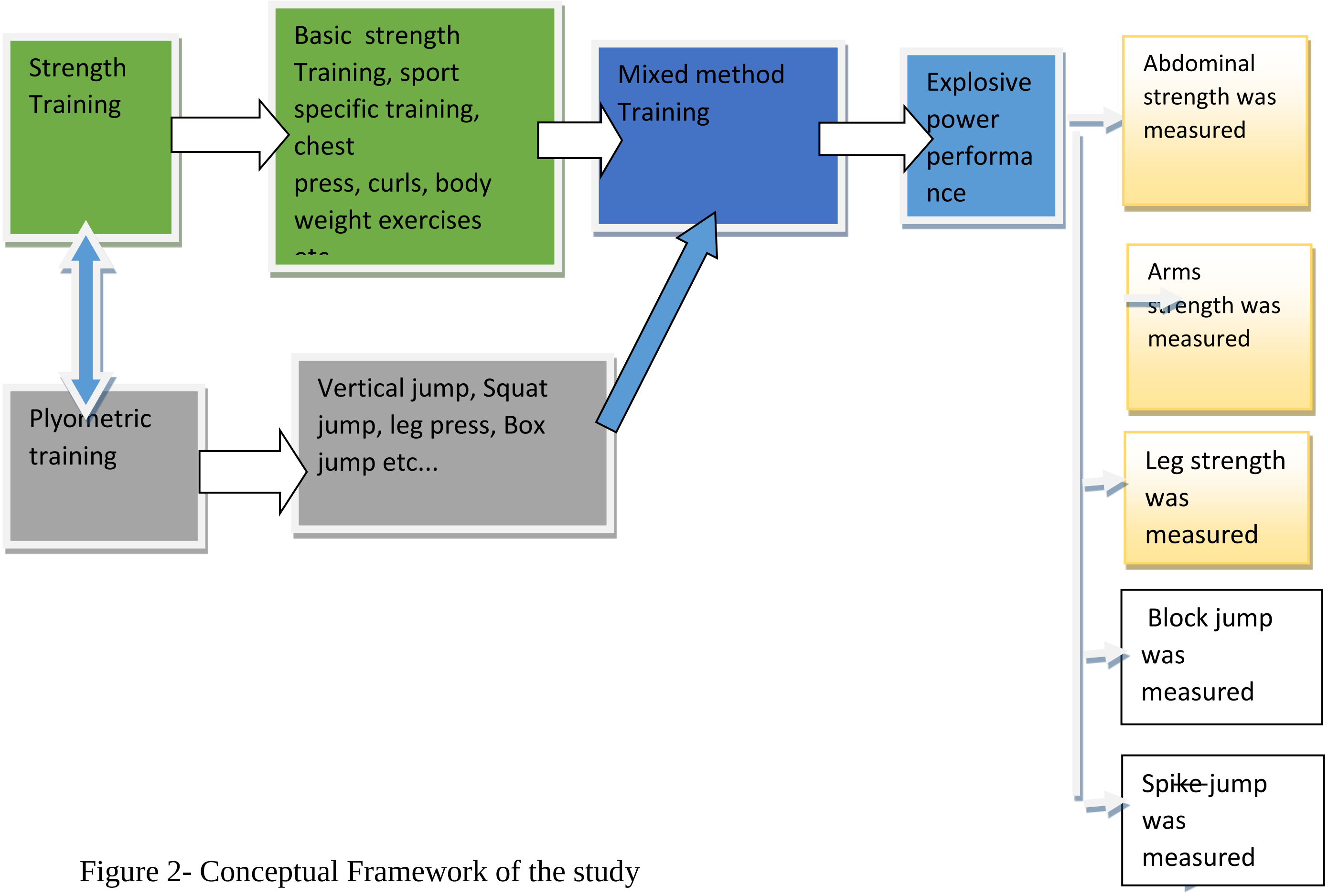

Figure 2- Conceptual Framework of the study

1.9 Organization of the Study

The study contained six chapters. The first chapter introduced the background of the study; the statement of the problem; general and specific objectives of the study; research questions; significance of the study; delimitation of the study; and operational definitions of key terms. In addition, chapter one also describes the theoretical framework of the study.

Chapter two focused on a review of related literature. It critically reviewed and evaluated relevant literature based on the research questions of the study to show the research gap in the area. Furthermore, this chapter included the theoretical framework of the study. It elaborates the historical and conceptual framework of different studies in relation to investigating youth volleyball players' explosive power development.

The third chapter discussed the methodological parts of the study. It presents the quantitative and qualitative, randomized pre-test-post-test control group design, population, sampling and participants of the study, procedures of data collection and administration of tests. Procedures and ethical considerations were considered**.** Differences in the variables (pre-test and post-test) within the groups were analysed by a dependent *univariate analysis of variance* test. Data presentation and analysis were dealt with in chapter four. The findings of the study were analysed using the test results of different variables. In the fifth chapter the results were discussed by comparing and constructing with different literatures.

Chapter six contains the conclusion, and recommendations of the study. Limitations of the study and suggestions for future research issues were included in this chapter.

1.10 Definition of terms

1) **Amortization phase-**is the time from the beginning of the eccentric action (lengthening of the muscle) to the beginning of the concentric action (shortening of the muscle) and is often referred to as the rate of eccentric action (Luebbers, et al. (2004).

2) **Concentric-**is a contraction in which the muscle fibers pull together and shorten

3) **Eccentric-**is a contraction, which occurs when the muscle lengthens under tension (McClellan, 2005).

4) **Basic Strength Training: A** method of improving muscular strength by gradually increasing the ability to resist force through the use of free weights, machines, or the person's own body weight. Trainings include keeping balance, push ups, stationary lungs, abdominal crunches, curls, body weight exercises, etc.

5) **Trainees**—individuals who are undergoing training for a volleyball game or profession.

6) **Plyometrics -**is defined as exercises that enable a muscle to reach maximum strength in as short a time as possible (McClellan, T. 2005).

7) **U-17 volleyball trainees-**project volleyball players whose age is 15–16 years ± 6 months.

8) **Explosive power**: refers to a player's ability to exert a maximal amount of vertical jump force in the shortest possible time interval.

CHAPTER TWO

2. REVIVEW OF RELATED LITERATURE

2.1 Muscular Strength Training

Strength exercise is not a recent discovery. Egyptian tombs exhibit pictures of people lifting baggage filled with sand and stone, wavering and throwing drills. These kinds of equipment were also well liked in early Germany, Scotland, and Spain. Weightlifting contests date back to the ancient Greek civilization. These actions led to the initiation of sports contests that soon became known as the modern Olympics. The pioneers of these events did not have the complex equipment that we have nowadays or the studies on exercise and physiology to support the exercises, but they did have the most significant thing — the desire to do something weighty for enjoyment, sport, and corporal health. http://thesportdigest.com/archive/article/**history-strength-training.**

Strength training in the ancient times was very simple; there was not a lot that could be changed concerning the method an exercise was done. Nowadays, the world of weightlifting is shifting all the time with new apparatus, workouts, machines, and techniques. Conditioning and everything connected with it have come far. Strength training is something that is going to obtain better. The earnings that come from it are sky-high. We, as a people, have come to realize that weight training is not only for a select few; it is for everybody. Each person wants strength training in some way or another.

2.2 Plyometric Exercise

Until the 1970's, plyometric exercises, or "jump training," did not begin to gain popularity in the United States. Jump training was used mainly in eastern European communities by the top athletes, Veroshanski, (1967) in sports like track and field, weightlifting, and gymnastics. Veroshanski was one of the first to publish a series of jumping drills. Previously, the word "plyometric" came from two Greek words: plio, meaning "more"; and metric, meaning "to measure", or more accurately, "measurable increase." The word "plyometric" was coined in 1975 by one of America’s great track coaches, Fred Wilt.

2.3 Muscular Strength

Strength is the capacity to overcome resistance or to take action against resistance (Hardayal Singh, 1991). Muscular strength is defined as the maximal contraction power of the muscles.

Muscular strength is frequently calculated with reverence to an individual set of muscles performing together. Muscular strength is experienced with the help of dynamometers and/or tension meters, which calculate the quantity of force exerted in a single endeavour by a particular set of muscles. Hand strength estimation that is reliable and appropriate provides an objective guide of overall superior body strength. The power grasp is the product of strong flexion of all the fingers' joints with the maximum intended force that the subject is competent to apply under normal bio-kinetic conditions. The contractility act of flexor and extensor muscles, as well as muscle group correlation, play an important role in the strength of the resulting grip. Several aspects influence the strength of the grip. In addition to muscle strength, hand supremacy fatigue, time of day, age, dietary status, limited motion and pain.

2.4 Intensity of Plyometric Exercise

All plyometric exercises are not equivalent in intensity. Drills like skipping, for instance, are somewhat light, whilst single-leg bounds and depth jumps are mainly forceful. A sketch should develop steadily from lesser concentration drills to more plyometric drills, particularly in a person with fewer strength exercise skills. (https://www.strength-and-power-for-volleyball.com/volleyball).

The magnitude of plyometric exercises is generally kept to a minimum also. A normal session may incorporate only two or three inferior body plyometric exercises interspersed with superior body plyometric drills if they're suitable for that sport. Proper exercise choices are essential!

For plyometric exercise to be at its most proficient, it should track a phase of maximal strength training. The purpose of plyometric is to develop the athlete's ability to apply further force more speedily. The better the athlete's capacity to produce maximal force or strength to start with, the more of it can be changed into sport-specific power (https://www.strength-and-power-for-volleyball.com/volleyball).

2.5 The Effects of Strength and Plyometric Training on the Development of the Explosive Power of Youth Volleyball Players

Vassil, and Bazanov, (2012), measured the effect of a plyometric training program on young volleyball players.

Subjects were 12–19 years old and practiced for 16 weeks. (F = 12, M = 9) Results showed that medicine ball throws (p 0.01), vertical jumps to the maximal height in 10 seconds (p 0.01), and standing long jump girl's group average changed from 194.8 13.2 cm to 203.3 13.2 cm (P > 0.05) and boys' average improvement was 240.9 16.7 cm to 248 15.5 cm (P > 0.05). Depth leap long jump girl's group average developed from 185.3 14.7 cm to 193.8 13.6 cm (P > 0.05) and the boys' average changed from 238.3 17 cm to 246.4 17.7 cm (P > 0.05). As a researcher, I want to focus on the explosive power parameters (strength and plyometric).

Martnez-López, et al. (2012), on the other hand, conducted research on the effects of electrostimulation and plyometric exercise plan mixture on jump height in teenaged athletes. The participants were 51 males (52%) and 47 females (48%). practiced for 8 weeks (2 days/week). The results demonstrated that a high-frequency (150 Hz) EMS and its simultaneous application with PT can significantly improve the three types of strength manifestations (explosive, explosive-elastic, and explosive-elastic-reactive strength).They used a combination of 150Hz EMS + PT and 85Hz EMS + PT (for groups 1 and 2). The combination of 150Hz EMS + PT: jump height (p 0.05), and the combination of 85Hz EMS + PT: no sig. difference in jump height. First, this research had limitations because the researchers used different stimulation frequencies for each group. Another drawback was the fact that two determinant variables were included in the same study group. So I need to conduct my research by using proper measureable variables for study participants.

Likewise, Faigenbaum, et al. (2007) studied a short-term plyometric and resistance training plan (six weeks) on fitness performance in boys aged 12 to 15 years. (PRT, n = 13) or resistance training only (RT, n = 14). The result showed that PRT compared to RT: long jump (p 0.05), medicine ball toss (p 0.05), agility (p 0.05), and shuttle run time (p 0.05). A group which could participate only in resistance training was not included. Their research focused on comparing the effects of six weeks of resistance and plyometric training with resistance training and static stretching. There were no baseline differences in physical or performance measures between groups. It was concluded that the group that performed resistance training and plyometric training performed more physical conditioning than the group that performed resistance training and static stretching. The researcher need to see more results by extending the intervention period.

As stated by Michal etal. (2009), on changes in speed and strength in female volleyball players during and after a plyometric training plan. The plan was applied to a group of female youth volleyball players (n = 11) twice a week for an eight week time. Actual level of explosive power and loco motor velocity was evaluated ahead, during and after the intervention was finished. The levels were determined by: the standing vertical jump, the vertical jump with an approach and the shuttle run for 6 × 6 m. There were positive average change values of test scores through the time of investigation, however the dynamics of the changes in the explosive power and the velocity were dissimilar. Result showed important changes in the volleyball players' motor predispositions ($p < .05$). It be concluded that plyometric trainings are effective tools in the improvement of explosive power and velocity in adolescent athletes. The researcher want to examine explosive power development by using combined resistance and plyometric training techniques.

2.6 Exercising for Explosive Power

A logical-structured volleyball training plan can enhance explosive power, straight-up jump height, endurance, and velocity and agility in the region of the court. For instance, practicing spikes won't build up the physical qualities essential to play to the athlete's complete potential (Gabbett, et al., 2006). Volleyball players have special lower body power and carry out well in the vertical jump trial (Smith et al., 1992). Power in the legs is required to jump explosively off the floor so as to spike, block, set and dive.

Volleyball needs explosive actions with the sequential use of muscles in a specific order. Cross, 1993). Olympic lifts strengthen muscles at the same speed and in the same order as in volleyball (Cross, 1993). Hence, this plan will include the use of Olympic lifts (snatch, clean, and jerk). Vertical jumping in volleyball is typically performed from a fixed standing position or a two-step move toward (Black, 1995).However, a lot of upward and side movements of the upper limb are required for blocking and spiking. Superior body and abdominal (trunk) strength has also been revealed to be a causative aspect of vertical jump performance (Bobbert et al., 1994).

Strength in the superior body, mainly the arms and shoulders, helps to raise the strength all over the trunk area, which creates firm posture to aid maximised jumping skills. Hence, this plan is t includes various exercises for the upper body in order to strengthen all the muscles involved in upright jumping. Other exercises (bench press, push press, and core conditioning) are incorporated into the plan, though they do not particularly develop vertical jumping. These exercises are incorporated to preserve muscular balance and improve the strength base.

Although this program is mainly designed to develop the vertical jump, it would also be adequate in increasing upper and lower body strength and power. This program also consists of some plyometric activities for both upper and lower limbs. Speed specificity is a key concern when scheming resistance training programs for vertical jumps. It shows that training adaptations (e.g., increased strength or power) are maximal at or near the training velocity (Pereira and Gomes, 2003).

However, there exists a contradictory assumption that the intent to move a barbell, one's own body, or any other thing explosively is more significant than the real movement velocity in determining speed-specific responses of the neuromuscular system to resistance training (Behm, and Sale, 1993). Plyometric training has been revealed to be one of the most successful methods for developing explosive power (Fleck and Kraemer, 2004). A broad variety of athletes can benefit from power training, mainly if it follows or coincides with a strength training program. In order for plyometric training to be at its most effective, it should track a phase of maximal strength training (Baechle, et al., 2000). The intention of plyometric is to develop the athlete's ability to apply more force more rapidly.

Rationally, then, the better the athlete's capacity to produce maximal force or strength to begin with, the more of it can be changed into sport-specific power. Weighted vertical jumps are incorporated into this program for its fame, along with training specialists, and for its verified profit in many studies. Baker, et al. (2001) discovered that maximal power was achieved during weighted squat jumps with a 48–63% 1RM squat. Furthermore, Wilson, et al. (1993) concluded that weighted jumps improved counter-movement and non-counter-movement vertical jump heights more than the usual resistance training and plyometric exercises.

Likewise, Newton et al. (1997) demonstrated that ballistic jump squat training against 30, 60, and 80% 1RM enhanced the vertical jump performance of the best volleyball players significantly more than squat and leg press training with 6RM loads. Subjects in both groups also accomplished the usual on-court volleyball practice, which involved a great volume of jumping activities.

2.7 The Training Advantages of Plyometric Exercises

The latent and speculative training benefits of plyometric exercises for the superior and inferior extremities contain, but are not restricted to the following concepts: capacity to boost average power and speed; improved peak force and speed of acceleration; increased time for force improvement; energy storeroom in the SEC; the skill for heightened levels of muscle activation; and the skill to stir up stretch reflexes (Saez de Villarreal, et al, 2010).

Via desensitizing the GTO (the Golgi tendon organ), plyometric exercises permit muscles to produce force by having the musculoskeletal system endure enlarged workloads without the GTO firing. Plyometrics raise neuromuscular harmony by training the nervous system and making movements more automatic during activity (training effect). This is recognized as reinforcing a motor pattern and creating automation of activity, which develops neural efficiency and increases neuromuscular performance. The increase in performance frequently occurs without a concomitant rise in morphological changes within the muscle (Ellenbecker, T and Davies, 2011). This training result of the neural system predominates in the first six to eight.

Weeks of any training program, and then following several additional weeks, hypertrophic changes of the muscles begin to occur (Moritani, and DeVries,1979).

2.8 Periodization Program and Training Components

Periodized training, in essence, is a training program that changes the exercise session at regular intervals of time (Wathen, 1993, Fleck, and Kraemer, 1996,Davies, 1997). For a full review of periodization training readers should refer to the paper by Lorenz as a part of this special issue. The plyometric program should use the principles of progression and overload. This can be accomplished by manipulating the volume dosage (reps, sets, weight, etc.) of many different variables. The quality of the work is more important with plyometrics than the quantity of the work. In order to recruit the fast twitch fibers, the intensity of the work should be performed at high levels of intensity 80-100% maximum volitional contraction (MVC).

Additionally the rate of the muscle stretch is more important than the length of the stretch. During the training session, if the quality of the movement performance deteriorates and is not able to be performed correctly, then the athlete is probably experiencing fatigue and the plyometric portion of the exercise session should be terminated. Based on the rest, recovery and reparative phase following high intensity resistive plyometric exercises, there should be increased recovery time when compared to other types of exercise. Although no evidence exists regarding the optimum rest period between high intensity plyometric workouts, the authors recommend 48-72 hours between sessions.

2.9 Muscle Physiology

Muscles are our only musculoskeletal structures that have the ability to lengthen and contract. In this way, they possess a unique ability to impart dynamic activity to the body (Potteriger, et al.1999). Each muscle is comprised of extrafusal and intrafusal muscle fibers. Extrafusal fibers contain myofibrils, the elements that contract, relax and elongate the muscles (McClellan, 2005). Intrafusal fibers, also called muscles spindles, are the main stretch receptors in the muscles.

During plyometric exercises, the muscle spindles are stimulated by a rapid stretch, causing a reflexive muscle action (Chimera, al, 2004).Both extrafusal and intrafusal muscle fibers play an important role in the muscle contractions that are initiated during the plyometric exercise. McClellan, (2005). Muscle contractions can be generated by the body and are used during all movement, including sports activities (McClellan, 2005). The muscle contractions that are involved during these movements are eccentric, isometric, and concentric contractions. Lengthening of the muscle under tension is an eccentric contraction, and is used to help decelerate the body. When there is no change in the muscle, yet tension is applied and an isometric, or static contraction occurs, which activates when the body comes to a halt (Howard, .2004). Concentric contraction occurs when the muscle shortens to produce force, which results in the acceleration of the limb segments and/or body (McClellan, 2005).

Vertical jump performance is determined by five factors,1 the strength of the muscles of the lower body, the rate at which the muscles can develop force, and the speed with which the muscles can contract and still maintain force output. The ability to utilize the stretch-shortening Cycle to maximize the jump height, and finally the degree of coordination and skill in performing the movements (Holcomb, et al. 1996).

2.10 Stretch-Shortening Cycle

The goal of training with plyometric is to increase the rate of the stretch shortening cycle (SSC), as well as the power behind it, so that the stored elastic energy transfers more rapidly to the next explosive movement (Rimmer, & Sleivert, 2000). This means the volleyball player will spend as little time as possible on the floor between jumps while elevating as high as possible during both jumps (Baechle, Earle, 2000). Plyometric is a type of training that develops the ability of muscles to produce force at high speeds (power) in dynamic movements (Bompa, T.O. 1998). These movements involve an eccentric lengthening or stretch of the muscle immediately followed by an explosive contraction of the muscle (Luebbers, et al.2004). During a plyometric movement, the muscles rapidly switch from the eccentric phase to the concentric phase (Powers, 1996). This SSC decreases the time of the amortization phase, which is the time from the beginning of the eccentric action to the beginning of the concentric action, and that in turn allows for greater than normal power production (Umberger, 1998). The shorter the amortization phase, the more powerful the contraction will be (Potteriger, et al1999). Plyometrics teach muscles to quickly switch from eccentric to concentric movements (Starzynski, and Sozanski, 1995). The muscles' stored elastic energy and stretch reflex response are essentially exploited in this manner, permitting more work to be done by the muscle during the concentric phase of movement (Kroon, 2001). Training programs that have utilized plyometric exercises have been shown to positively affect performance in power-related movements such as jumping and speed (Allerheiligen, & Rogers, and 1995). Also, with plyometric training, the nervous system is conditioned to react more quickly to the SSC (Holcomb, et al., 1998).

According to Kramer and Newton, most jumping and power activities involve a counter movement (wind-up, back swing, crouch) during which the muscles involved are first stretched rapidly and then shortened to accelerate the limb or body. It is also called a plyometric contraction (Powers, 1996). The faster the muscle is stretched, the greater the amount of force it will produce. An example would be an elastic rubber band. The more you pull the elastic back, the faster it returns to its original length and the further it will fly. Muscles react the same way during the stretch reflex (Smith,1996).

This SSC has been demonstrated to enhance power performance to a greater extent than concentric training alone (Faigenbaum, 2000). The faster the muscle is stretched, the greater the amount of force it will produce. Plyometric exercises that involve stretching an active muscle prior to its shortening have been shown to enhance performance during the concentric phase of muscular contraction (Umberger, 1998).

Sports that require jumping, throwing, or sprinting rely heavily on the strength-speed or power of the athlete (Baker, 1996). Plyometrics are used to improve power output and increase explosiveness by training the muscles to do more work in a shorter amount of time in these activities, (Umberger, 1998).

2.11 Mechanics of Jumping

Vertical jump ability is critical for success in volleyball. Jumping ability exercises are very dynamic (Hedrick, & Anderson, 1996). These exercises mobilize all muscle groups and organize their actions. They are a functional result of speed and strength, and demand good coordination (Faigenbaum, 2000). Jumping is utilized during the jump set, jump serve, blocking and spiking movements in volleyball (Holcomb, et al. 1998). The ability to jump high and reach maximum height quickly creates a successful volleyball player. This requires an ability to generate power in a very short time (Holcomb, et al. (1998). Exercises like plyometrics are able to link strength with speed of movement to produce power very effectively (Chu, 1998).

Athletes feel that jumping is something that they just do and they do not need training for it, when actually jumping up vertically is a skill that can be taught to them (Howard, 2004). When one examines the vertical jump, they can see that as an athlete jumps in the air, that jump is preceded by a counter-movement. It is during this countermovement that the center of gravity takes over, causing the athlete to drop rapidly (McClellan, 2005).

The vertical jump can be analysed in three different phases; the preparatory phase, take off phase, and landing phase (Faigenbaum, & Chu, 2001). When looking at the vertical jump, the starting position (preparatory phase) is the flexed position. In this position, the hips, knees, and ankles are simultaneously flexed, as well as the trunk. Here, the muscles are actually being stretched (eccentric contraction), stimulating the stretch receptors (muscle spindles) to increase here. McClellan, (2005). As the athlete moves into the take-off phase and the body extends, the muscles quickly contract to produce a greater amount of force (concentric phase). The take-off velocity ultimately determines the jump height. Holcomb, et al. (1996). The necessary force to take off is facilitated by the "stretch". As the body is pulled down by the centre of gravity in the landing phase, the body returns to the flexed deceleration position, placing an eccentric contraction again on the muscle to absorb the force that is placed on the limbs. Howard, (2004).

The arm swing during the take-off phase is an important component that assists the vertical jump. During the starting position, the arms are extended back, and then as the body moves into extension, the arms swing upward into flexion. Past this point, they are only able to decelerate, which allows the body to begin to lift off, Holcomb, et al. (1998). For maximum force development, the athlete would want to have their arms extended and straight to increase lever length. The use of the arms has been shown to have a significant effect on peak force in jumping. Kroon (2001) found that the arms contribute an average of 10% to the take-off velocity during a vertical jump, Hedrick and Anderson (1996)

Although both anticipation and practice will help the athlete reach their vertical jump height, it is the strength of muscles and coordination that will produce a good vertical jump height. Smith, (1996). To maximize jump height, the athlete must coordinate a head-to-toe effort. This provides a good reason for including plyometric exercises in the overall training program (Potteriger, 1999).

2.12 Jump Height

Multiple authors have demonstrated that plyometric training programs can increase maximal vertical jump height (Baker, 1996; 10:131–136). These studies included various jump training programs ranging from six to 24 weeks, including pre-pubertal, pubertal, and adult athletes. A variety of jump training tests have been measured to evaluate improved vertical jump height, including squat jumps, split squat jumps, bounding, countermovement jumps with and without arm swings, and drop jumps (Canavan, and Vescovi, 2004; 36(9):1589–1593). More advanced techniques include tuck jumps, depth jumps, and single leg hops. To achieve improved jump heights, training has been anywhere from one to five sessions per week or tallied as total training sessions from six to more than 25 sessions. The volume of jump training has ranged from 400–1700 jumps. Despite the large variety of variables that have been manipulated within these studies, improved vertical jump performance is a consistent outcome after plyometric training (Carvalho, et al., 2014; 41:125–132).

2.13 Progression of Plyometric Training

There are many components to a plyometric training program. One important component is the progression in the training program. When thinking of progression with plyometric training exercises, you should consider intensity, volume, recovery, and detraining effects. These progressions are all interrelated; the higher the intensity, the lower the volume, the longer the rest period (Baechle,. & Earle, 2000).

Intensity is the effort that is put forth in performing an exercise. In plyometrics, intensity is controlled by the type of exercise being performed, where as in weight training it is the amount of weight lifted (McClellan, 2005).

Intensity is also dependent on the rate of the stretch shortening cycle (movement from eccentric to concentric contractions) (Beal, 1998). Plyometric exercises range from simple tasks like hip-twist ankle hops to highly complex and stressful exercises such as depth jumps (Chu, 1998). These plyometric exercises are classified by the degrees of intensity that are used (Beal, 1998).

Volume is thought of as the number of foot contacts and/or distance that the athlete performs. The number of foot contacts will depend on the intensity of the exercises, skill level, body weight, and time of year (offseason, pre-season, and in-season) (Beal, 1998). The volume of specific jumps will vary as the intensity of the exercise program increases. A plyometric exercise program will have a higher volume of jumps when starting out at a low intensity level (Beal, 1998).

As the athlete progresses and increases the intensity in the exercise program, the volume of specific jumps will decrease (Beal, 1998).

2.13 Considerations for Training

There are some limitations when working with middle and high school aged athletes. Programs for these athletes are less common and offer unique challenges. Physical and emotional maturity levels vary widely in this age group. Howard, (2004). Some adolescents are more mature and more physically developed than their counterparts who are still immature and less developed. Also, athletes in middle and high school often have a busy schedule that involves participation in multiple sports activities (Howard, (2004)). This can pose a problem when trying to start an off-season program.

Plyometric have been criticized for having a greater risk of injury than other methods due to the increased forces of landing and immediate rebounding (Faigenbaum, & Chu, 2001). Many factors should be taken into consideration when starting a plyometric training program. The factors include age, sex, strength gains, landing surfaces, and progression of exercises (Beal, 1998).

The age at which you start a plyometric training program is debated by coaches, athletic trainers, and strength and conditioning coaches alike. Due to the high intensity of some plyometric drills and the potential risk of injury to growth plates, Allerheiligen and Holcomb both recommend that athletes under the age of 16 years old should not perform plyometrics of shock intensity levels (Beal, 1998). They feel depth jumps and other high-intensity exercises should not be performed until the epiphyseal plates are closed (Baechle, & Earle, 2000). However, plyometric are a natural part of most movements, as evidenced by the jumping, hopping, and skipping movements typically seen on any school playground (Baechle, & Earle, 2000). With qualified coaching and age-appropriate instruction, plyometric training can be a safe, effective, and fun method of conditioning for young adolescents (Faigenbaum, 2000). Adolescents should develop an adequate baseline of strength before participating in a plyometric training program, or they should simply begin plyometric training with lower intensity exercises and gradually progress to higher intensity exercises over time (Chu, D 1998).

Neuromuscular adaptations are another factor in which plyometric are seen to prevent injuries. (Wilkerson, et al., 2004). Wilk et al. suggest that muscular performance gains after plyometric training are attributed to these neural adaptations rather than to morphologic changes. Smith, (1996). For this reason, plyometric training may enhance neuromuscular function and prevent knee injuries by increasing dynamic stability. Smith, (1996).Neuromuscular adaptations are believed to enhance dynamic knee stability and performance.

2.14 Force Improvement Pace

The pace of force improvement or "explosive muscle strength" expresses the time at which force is described through a sporting movement (Aagaard, et al., and McBride, et al., 1999). The rate of force development is determined from the slope of the force time curve, (Viitasalo,1981), (Figure 2). The slope can be determined in several ways, such as the peak rate of force development in a 20-millisecond sampling window or between specified time bands, such as the slope between 0 and 200 milliseconds.

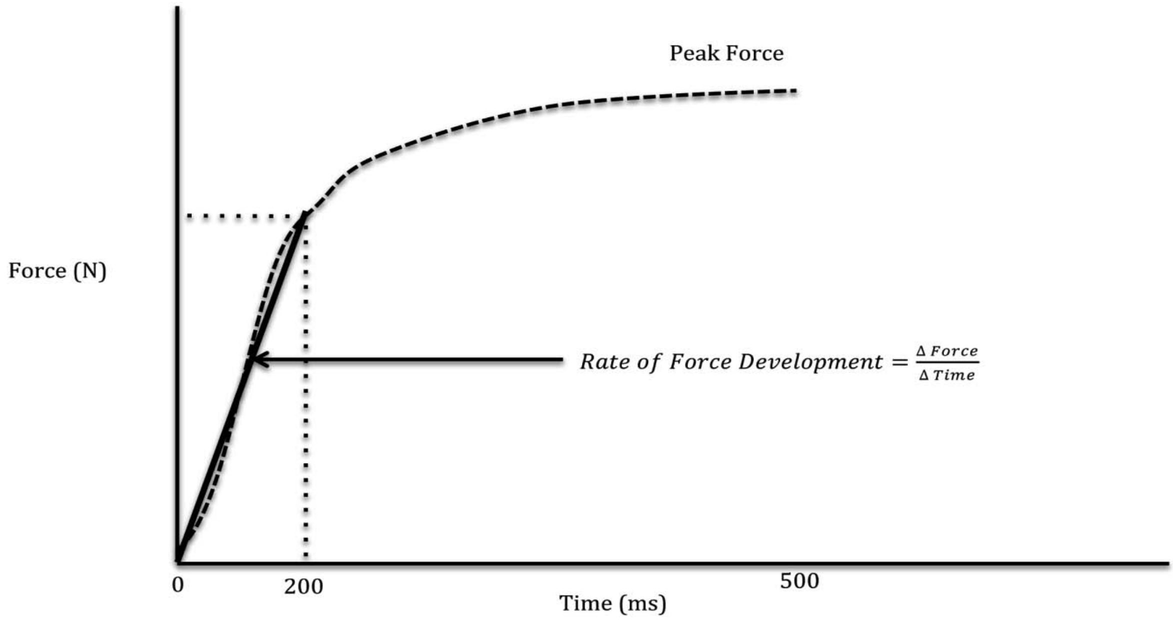

Figure 3. Isometric force-time curve. Adapted from (Haff GG, et al.1997).

2.15 Testing for Power and Assessment

Vertical jump testing is commonly used (1) to measure improvements in the vertical jump for sports in which jumping ability helps performance, and (2) as a general measure of lower body power in sports that require high levels of lower body power.(Kroon,S. 2001). The easiest way to measure vertical jump performance is to simply measure the athletes vertical jump height. There are various other tests that can help assess different components of vertical jump performance. (Howard 2004).These tests include the athlete's maximal leg strength, the maximal rate at which force can be developed, the ability of the athlete to increase power by employing the SSC during the crouch before the jump, and the athletes' ability to coordinate the movements involved in jumping (Holcomb,1996). Maximal strength can be measured through the squat or leg press. When jumping with minimal contact and maximal height, this is useful in showing the maximal force of rate development (Holcomb, 1996). When these tests are accomplished, the results can help increase the vertical jump height.

2.16 Plyometric versus Resistance Training

The primary training method for training athletes that coaches, athletic trainers and strength conditioning coaches' have used is traditional resistance training programs. Traditional training programs use high intensity training in slow velocity movements (Kroon, 2001), (Faigenbaum, 2000). Plyometric training is another method that has been used more often when training for enhancing power performance. Plyometric training requires the athletes to accelerate and decelerate their body weight rapidly during dynamic movements (Faigenbaum, (2000).

Studies have demonstrated the effectiveness of plyometric training for improving power, generally expressed as increases in vertical jump height. Kroon, (2001), (Faigenbaum, 2000). Therefore, it is suggested to be included in any program aimed at improving vertical jump ability (Starzynski, & Sozanski, 1995). Adam, et al, (1992), feels that traditional resistance training has been shown to improve vertical jump performance as well, (Faigenbaum, 2000). However Hakkinen. and Komi,(1985) feel these improvements may be limited in experienced strength- trained individuals, as does, Armstrong, et al, Kramer & William,(1997) who feel it does in athletes who have a high pre-training vertical jump ability (Faigenbaum, 2000). When plyometric drills are combined with a resistance training program, vertical jump Performance appears to be enhanced to a significantly greater extent than if each of the training programs were performed alone. (Chu, 1998), Faigenbaum, (2000). Plyometrics are not intended to be a stand-alone exercise program and should be incorporated into a well-designed overall conditioning program that also includes strength, aerobic, flexibility, and agility training Chu,(1998).

2.17 Volleyball Conditioning

A recent review by Hedrick, (2007) suggested that a training program for high-level performance in volleyball must be specific to the requirements of volleyball. Exercise should be based on movements that will take place during a game. For example, lateral movements are often performed in volleyball, whereas most strength exercises are executed in the sagittal plane, and therefore, coaches should include exercises such as lateral squats and side lunges in their training programs. Plyometric exercises, such as lateral box jumps and lateral bounds, should also be included. In addition, dumbbell training should be considered as an important part of the conditioning program because it improves balance and body control. Also, trunk training is essential because the game of volleyball requires movements such as running, twisting, and jumping, which can create strenuous forces on the back. Usually, trunk exercises are performed in the supine position. In volleyball, based on the principle of specificity, some of the exercises should be done standing up.

A strong trunk must be accompanied by a strong upper body. A strong upper body will allow for higher-velocity spikes and improved VJ and will help prevent injuries in the shoulder joint musculature, which is stressed in the game of volleyball. Lastly, training should aim at improving VJ because it is one of the most important aspects of the game. In a follow-up article (Hedrick, 2008), Hedrick presented a fully detailed conditioning program based on the abovementioned principles.

2.18 Factors Affecting Vertical Jump Ability

There are several factors which affect the ability of an athlete to successfully perform a standing vertical jump, which can be identified by physiological and other sports testing procedures.

Komi, in Kaneko, et al. 1983, states that the specific composition of muscle fibers of the individual athlete will affect the development of power. Athletes with a high percentage of Fast Twitch (FT) muscle fibers are able to develop greater amounts of explosive power. This is supported by Wilson, et al. (1993), and Sale, (1988), who also refer to several neural adaptations which affect muscular power, such as motor unit activation, motor unit synchronization, and the specificity of the movement pattern.

The initial levels of strength of the athlete and the ability to make use of a Stretch Shorten Cycle (SSC) will also affect the development of power (Clutch, et al. 1983, Duke, S. & BenEliayhu, 1992, Sale, 1988, Shorten, 1987, and Wilson, 1993). Basketball and volleyball players, for example, should be able to use a much more forceful pre-stretch for the production of an efficient S.S.C. than untrained athletes (Sale, 1988).The possible existence of two different types of S.S.C. has also been suggested by Schmidtbleicher, (1990) in Young, (1995). A long SSC and a short SSC are developed by specific types of training and are mutually exclusive of each other. The use of elastic and contractile energy for producing dynamic muscle contractions as required in maximum power sports has been well documented (Maneval, & Poole, 1987).

Other factors which have been shown to affect vertical jump performance are: effective use of the arms for increased vertical velocity (Harmen, et al 1990), trunk extension, head movements, and utilization of a countermovement to initiate the stretch shortening cycle (SSC) (Van Soest, et al 1985, and Young, 1995). These actions are a natural movement during a jump for most athletes, but they occur to different degrees between jump-trained and non-jump-trained subjects.

Upper body and abdominal (trunk) strength have also been shown to be a contributing factor to vertical jump performance. (Bobbert, & Van Soest, 1994; Cisar, & Corbelli, 1989). Strength in the upper body, particularly the arms and shoulders, helps to increase the strength throughout the trunk region, creating solid posture to help maximize jumping technique, and also to maximize power production and transferral of forces between the upper and lower body.

The fact that an arm swing is so important to vertical jumping performance may indicate that there is a technique or skill component to vertical jumping, rather than just leg power (Young, 1995). If this is true, then the development of a motor pattern for V.J. will also be a factor affecting performance in V.J. testing of athletes. In relation to the specific composition of muscle fibers, it has been suggested that athletes with a well-developed alactic or anaerobic power capacity (Conlee,. et. al. 1982, and Shorten, (1987).

CHAPTER THREE

3. RESEARCH METHODS

3.1 Research Design

Since the main objective of the study was to investigate the effects of strength and plyometric training on the development of the explosive power of U-17 male volleyball players, the researcher employed an experimental (randomized pre-test-post-tests control group) research design. It help to see either there is improvement in post-test as a result of the conducted interventions on the experimental groups. Pre-post-test designs are widely used in experimental research, primarily for the purpose of comparing groups and/or measuring change resulting from experimental treatments (Dimitrov & Rumrill, 2003).

3.2 Population and Study Area

There were twenty-nine U-17 training project sites in AMHARA region. Totally, there were 227 trainees in the region. The study areas were located in the West Gojjam, South Gondar, and East Gojjam zones. In the three zones, there were 85 project trainees in six project sites each.

3.3: The Basic Criteria for Selection

All the trainees were older than 15 and less than 17 years; they were all members of a publicly-owned project trainee; they trained volleyball for a period of 3 months; they registered as U-17 volleyball project trainees/players/in the 2011E.C. season; they had four training sessions a week during the preliminary period, and the sessions lasted from 90 to 120 minutes; they were tested at the start and at the end of the experiment; all the volleyball players were physically healthy and the data on the injured players was not used in the statistical analyses.

3.4 Sampling Techniques

By means of the randomization, the trainees were divided into 4 groups, experimental (E1, E2, E3,) volleyball players, and control group players (C).

The study used a sample of 70 players as research participants. This was determined by using Taro Yamane formula (1970). This t formula is:

$$n = \frac{N}{1+N(e)^2}$$

Where:

n = sample;

N = Population size;

e = Degree of tolerance error;

With a significance level put at 95%, the degree of error term will be 5% (i.e. 0.05).

Therefore:

$n = 85/1+85(0.05)^2$

$= 85/1+85(0.0025)$

$= 85/1+ 0.2125$

Sample size = 70.

But, due to sport injury two players were drop-out from the study and the researcher took 68 participants.

Accordingly, these 68 players were randomly divided into 4 groups, E1 n=17, E2 n=17, E3 n=17, and control group (C) n=17.

3.5. Data Gathering Instruments

A Physical Activity Readiness Questionnaire (PAR-Q) form and an informed consent form were administered to all the subjects. Subjects were required to fill up the form before they participated in his study ensured that they do not have any physical problems or diseases with their bodies. A valid measuring tape and an AAHPER test item were used to measure the height of vertical jump and strength during the study. Subjects are required to use chalk to draw on the wall. All jumping height of spike and block (m), pull up (rep), set-up (rep) and broad jump (m) data was recorded in their own record form.

3.6 Data Gathering procedures

The Variable Sample

Independent variables: Plyometric and strength trainings.

Dependent variables: Explosive power.

The process of developing and of establishing the state of the explosive power at the initial and final measuring was carried out with the use of five measuring test items which cover the area of explosive type strength. These test items were labelled in the following manner:

- the block jump (BJ)
- the spike jump (SJ)
- the standing linear(broad) jump (SLJ)
- Pull Ups (AAHPER test item)
- Bent knee sit ups (AAHPER test item)

The correctness of the first two tests will be proven by measuring the calculable features by means of proceedings dealing with factors, proceedings proving any predictable capabilities, and which will be administered by the authors of the research.

The Block Jump

The instruments: a board with a darkened background, fastened to the wall and a steel measuring tape.

The task: the examinee stands facing the wall and resting both outstretched arms next to the fixed measuring tape, so that they are on the same level. After noting the height within reach for the block jump, the examinee takes off with both feet, and touches the board with the fingers of both hands.

The evaluator should be standing near to a board, so that his head is at level with the height within reach of that jump, so as to increase the accuracy of the results. Three jumps are made. Any incorrectly performed jumps are repeated.

Marking: the height within reach for that jump is measured in centimetres, and then the height within reach is subtracted from it, and we get the height of that jump. Only the best attempts are actually will be used in the statistical analysis.

Notes*:* No double take off is allowed. The examinee can jump either barefoot or in his sneakers, but his fingers previously coated with white colour.

The Spike Jump

The instruments: a board with a darkened background, fastened to the wall and a steel measuring tape.

The task*:* the examinee stands facing the wall and resting both outstretched arms next to fixed measuring tape, so that they are on the same level. After noting the height within reach for the spike jump, the examinee takes a step back, and with a running start of just one step, takes off with both feet, and touches the board that is next to the steel measuring tape with the fingers of both hands, which will be coated with white colour. The evaluator should be standing, so that his

Head is at level with the height within reach of that jump, so as to increase the accuracy of the results. Three jumps are made. Any incorrectly performed jumps are repeated.

Marking: the height within reach for that jump is measured in centimetres, and then the height within reach is subtracted from it, and we get the height of that jump. Only the best attempts are actually will be used in the statistical analysis.

Notes: No double take off is allowed. The examinee can jump either barefoot or in his sneakers, but his fingers should previously coated with white colour.

- **The standing broad jump (SBJ):**

The instruments: a steel measuring tape and suitable court for long jump.

The task: the examinee athlete begins with both feet approximately shoulder width apart and on the starting line, Arms should be used to assist the jump, the athlete is allowed to use a countermovement (bending the hips and knees prior to jumping) for accessing elastic strength to assist in the jump, this downward countermovement prior to upward propulsion is the eccentric phase of the stretch-shortening cycle which contributes to a maximum height of the jump, the Distance travelled should be measured to the nearest half inch at the heal of the back foot, athlete should try to leap as far forward as possible in a linear direction, the best of 3 trials is recorded.

Test: Pull Ups for Boys (AAHPER test item)

Purpose: To measure arm and shoulder strength.

Facilities and equipment: A metal bar approximately 1.5 inches in diameter will be placed at a convenient height. However, for the lower age levels a door way gym bar can be used. All times it may be necessary to improvise by using such equipment as a basketball goal support or a ladder.

Procedure: The bar is adjusted to such height that the student can hang free of the floor. The student should grasp the bar with his palms facing away from his body (overhand grasp). The student should then raise his body until his chin is over the bar and then lower it again to the starting position with his arms fully extended.

Instructions: You must lift your knees or assist your pull-up by kicking. You must return to the hang position with the arms fully straight. You will not be permitted to swing or snap your way up.

Scoring: One point is scored each time the player completes a pull up. Part scores do not count, and only 1 trail is permitted unless it is obvious the player does not have a fair chance on his first trial.

Testing personnel: Researcher conducted the test and one assistant record it. (Nelson, and Johnson, 1979)

Test: **bent knee sit ups.**

Purpose: To measure abdominal muscle endurance.

Facilities and equipment: Mat will be used.

Procedure: The player lies flat on the back knees bent and feet on the floor with the heels no more than 1 foot from the buttocks. The knee angle should be no less than 90 degrees. The fingers are interlocked and placed behind the neck with the elbows touching the floor. The feet are held securely by a partner. The players then curls up to a sitting position and touch the elbows to the knees. This exercise is repeated as many times as possible in the time requirement.

Instructions: 1. Subject's fingers must remain interlocked and in contact with the back of the subject's neck at all times. 2. Subject's curl up from the starting position, but they may not push off the floor with elbow. 3. When they return to the starting position their elbows must be flat on the floor or mat.

Scoring: One point is scored for each correct sit-up. The score is the maximum number of sit-ups completed. The score is the maximum number of sit ups completed in one time continuously. Three trails were given. Best of three trails were finally score in number by

testing personnel: Researcher conducted the test and an assistant record it. (Barrow, and McGee, 1979).

3.7 Data Analysis Method

Descriptive and inferential statistics were employed for the analysis of quantitative data collected through practical tests. In the study, quantitative analytical procedures were used. A computer was used to assess and interpret the data gathered from various explosive parameter test measurements into a meaningful concept so that changes in certain physical characteristics could be compared between groups. There were descriptive data (mean ± SD) available. The estimated marginal means and standard errors were used to determine whether there was a significant difference or homogeneity between the control and experimental group pre-tests, and ANCOVA was used to compare between groups post-tests with effect sizes of strength and plyometric trainings on physical factor qualities at the 0.05 level of significance. The univariate test was used to determine whether there is a significant difference between the pre and post test results of the experimental and control group. Version 26 of the statistical package software (SPSS) was used. The univariate test is a kind of research called repeated measures test (within-subjects design), commonly used in before-after designs. And the level of significance was set at $P < 0.05$.

3.8 Validity and Reliability

3.8.1 Validity

Test validity refers to the degree to which the test measures - what it claims to measure and the extent to which inferences, conclusions, and decisions made based on test scores are appropriate and meaningful (Hamed, 2016;Haradhan, 2017&James et al., 2018).To assure the validity of the tests, the researcher adopted previously designed and applied tests by different researchers. For instance, pull ups and set up tests were used by AAHPER, spike and block jumps and broad jump were used by Pushparajan (2010), Borges TO., et al. (2017), and Ab Rahman, Z., et al. (2021). The researcher used standardized measurement tools for each test.

Before the tests were applied, all of the instruments were examined by sport science professionals from Bahir Dar University for its relevance in terms of the cultural context and norms of the country (Ethiopia).

3.8.2 Reliability

As stated by Haradhan (2017); Heale & Twycross (2015),&James et al. (2018)test reliability refers to the degree to which a test is consistent and stable in measuring what it is intended to measure. Reliability will depend upon how strictly the test is conducted and the individual's level of motivation to perform the test. In this study, the test reliability was approved by using the test-retest method.

The average results showed a high degree of reliability coefficient for both physical fitness tests of explosive power ($r = 0.915$, $P < 0.05$).

The researcher attempted to mitigate other factors that might have influenced the test results at the time of intervention and the test administration; such as the dressing of players, diet time before exercise and tests, weather (the time of day the trainings were given and tests were conducted), and experience of trainers and testers by providing training on the detailed process of the intervention training and tests.

All tests were properly recorded with recording instruments (record sheet, video, and photo).

3.8 Ethical Consideration

The researcher got ethical approval from the Bahir Dar University research ethical committee. Youth's volleyball projects under Ethiopian volleyball Federation were contacted and informed about the present research topic, objective and purpose of the study. All of the subjects were successfully pass a physical exam and complete a Physical Activity Readiness Questionnaire (PAR-Q) form in which they were screened for any possible injury or illness. The subjects received all the necessary information about the study's procedures in oral and written form.

CHAPTER FOUR

4. RESULTS

The purpose of the current study was to investigate the effects of strength and plyometric training on the development of the explosive power of u-17 youth volleyball players in Amhara region. So, the result of the findings presented below.

Table1: Descriptive Statistics summery of Broad jump performance

Dependent Variable: Broad jump post			
Type of training given	Mean	Std. Deviation	N
Plyometric	2.39	.21	17
Strength	1.99	.29	17
Strength and plyometric	2.38	.13	17
None	1.98	.31	17
Total	2.23	.29	68

The broad jump performance score for the plyometric group is 2.39 + 0.21m. In this regard, the strength and the plyometric groups achieved a mean performance score of 1.99+ 0.29 and 2.38+ 0.13m, respectively.

The control group, which did not receive strength or plyometric training, had a mean performance score of 1.98m+0.31m. The St+P groups had a higher mean score than the control group (table 1).

Table2: Tests of Between-Subjects Effects

Dependent Variable: Broad jump post(Ancova)						
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3.994[a]	4	.999	33.562	.000	.681
Intercept	.126	1	.126	4.230	.044	.063
Broad jump pre	1.413	1	1.413	47.509	.000	.430
Type of training	.253	3	.084	2.833	.045	.119
Error	1.874	63	.030			
Total	344.695	68				
Corrected Total	5.868	67				

a. R Squared = .681 (Adjusted R Squared = .660)

F (3, 63) =47.509, P.001, nP2 = 0.430 was used to test how different the three groups are based on their performance gain or development. This result indicates that the performance of young volleyball players increases for each parametric factor. The result of each group has a significant difference between subjects. (Table 2).

The tests between subjects effects show that all of the factors have no significant values greater than 0.05; there is no performance difference between groups. Lack of nutrition, poor training conditions, poor talent identification, and other factors could be to blame.

Table3: Estimated

Dependent Variable: Broad jump post				
Type of training given	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Plyometric	2.288[a]	.043	2.202	2.374
Strength	2.158[a]	.052	2.053	2.263
Strength and plyometric	2.294[a]	.038	2.219	2.369
None	2.111[a]	.053	2.005	2.217

a. Covariates appearing in the model are evaluated at the following values: Broad jump pre = 2.10.

The above table (3) shows the estimated marginal means and standard errors of performance results at the factor of plyometric, strength, and combined training. This table is important to explore the possible interaction effect among those three factors.

A plyometric group is expected to perform 2.288m, while the St+pG scores are 2.294 m, ST, 2.158m, and the CG gains are 2.111 m.

Table4: Pairwise Comparisons

Dependent Variable: Broad jump post						
(I) Type of training given	(J) Type of training given	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
Plyometric	Strength	.130	.073	.478	-.069	.329
	Strength and plyometric	-.006	.054	1.000	-.152	.141
	None	.177	.072	.100	-.019	.374
Strength	Plyometric	-.130	.073	.478	-.329	.069
	Strength and plyometric	-.136	.069	.327	-.325	.053
	None	.047	.068	1.000	-.139	.233
Strength and plyometric	Plyometric	.006	.054	1.000	-.141	.152
	Strength	.136	.069	.327	-.053	.325
	None	.183	.069	.058	-.004	.370
None	plyometric	-.177	.072	.100	-.374	.019
	Strength	-.047	.068	1.000	-.233	.139
	Strength and plyometric	-.183	.069	.058	-.370	.004

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

The above table (4) displays the comparison of each training type given to the trainees. We can understand from the result that there is no significant difference between b/n/each training type p-value > 0.05. The reason may be food culture, psychological factors, lack of training materials, etc.

Table 5: Univariate Tests

Dependent Variable: Broad jump pots						
	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Contrast	.253	3	.084	2.833	.045	.119
Error	1.874	63	.030			

The F tests the effect of Type of training given. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

The output for the F measures provides statistics for b/n subject effects for different training types. The statistics show a measure of the linear relationship between different training models and performance. Types of training and performance are statistically significant. The F statistic (3, 63) =2.833 p =.05, nP2 = 0.119 was associated with player performance. This allows us to reject the null hypothesis that there is no linear relationship between training and performance. By rejecting the null hypothesis, we can conclude that there is a positive relationship between the two variables, indicating that as the number of training days increases, the performance of players also increases. Check with the original

Table6: Descriptive Statistics

Dependent Variable: Standing reach (spike) post			
Type of training given	Mean	Std. Deviation	N
Plyometric	2.18	.08	17
Strength	2.13	.07	17
Strength and plyometric	2.23	.07	17
None	2.16	.08	17
Total	2.18	.08	68

The performance result of PG shows 2.18± 0.08m (table 6). Likewise, the strength, ST and PGs scored 2.13 ± 0.07m, and 2.23 ± 0.07m, respectively. The none group (CG) achieved 2.16 ± 0.08m. There is no performance difference between all groups. This indicates the age and physical structure of players are proportional.

Table7: Tests of Between-Subjects Effects

Dependent Variable: Standing reach /spike /post/						
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	.445[a]	4	.111	321.791	.000	.953
Intercept	.001	1	.001	1.779	.187	.027
Standing reach pre	.351	1	.351	1014.267	.000	.942
Type of training	.001	3	.000	.675	.571	.031
Error	.022	63	.000			
Total	323.979	68				
Corrected Total	.467	67				

a. R Squared = .953 (Adjusted R Squared = .950)

Ancova test was carried out to test how different the three groups were depending on their standing reach, spike, and gain. Three groups are statistically significant (3.63) =1014.267, P.001, nP2 = 0.942.

Table8: Estimates

Dependent Variable: Standing reach /spike/ post				
Type of training given	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Plyometric	2.179[a]	.004	2.170	2.188
Strength	2.178[a]	.005	2.167	2.188
Strength and plyometric	2.186[a]	.004	2.178	2.194
None	2.179[a]	.005	2.168	2.189

a. Covariates appearing in the model are evaluated at the following values: Standing reach pre = 2.1796.

Table 8 shows the estimated marginal means and standard errors of performance results for different training parameters. The table helps us to find out the interaction effect between these training types. A PG achieves 2.179m, while ST+P Gs achieve 2.186m and SG achieves 2.178m.

Table9: Pairwise Comparisons

Dependent Variable: Standing reach /spike/post						
(I) Type of training given	(J) Type of training given	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
Plyometric	strength	.002	.007	1.000	-.017	.020
	Strength and plyometric	-.007	.006	1.000	-.023	.010
	None	.001	.007	1.000	-.018	.019
Strength	plyometric	-.002	.007	1.000	-.020	.017
	Strength and plyometric	-.008	.007	1.000	-.027	.010
	None	-.001	.007	1.000	-.021	.019
Strength and plyometric	plyometric	.007	.006	1.000	-.010	.023
	strength	.008	.007	1.000	-.010	.027
	None	.007	.007	1.000	-.012	.026
None	plyometric	-.001	.007	1.000	-.019	.018
	strength	.001	.007	1.000	-.019	.021
	Strength and plyometric	-.007	.007	1.000	-.026	.012

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

The tests among groups show that all of the training types have no significant value (p >0.05); there is no performance difference between groups.

Table 10: Univariate Tests

Dependent Variable: Standing reach post						
	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Contrast	.001	3	.000	.675	.571	.031
Error	.022	63	.000			

The F tests the effect of Type of training given. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

The statistics show linear relationships between different training models and the performance result is statistically insignificant. The F statistic (3, 63) =0.675, P-value > 0.05, nP2 = 0.031, does not correlate with subject performance. This enables us to reject the alternative hypothesis that there is a linear relationship between different training types and performance. By rejecting alternative hypotheses, we can conclude that there is no positive relationship between training variables and performance, indicating that as the number of training sessions increases, the performance of players won't increase.

Table 11: Descriptive Statistics

Dependent Variable: Spike jump post			
Type of training given	Mean	Std. Deviation	N
Plyometric	2.52	.11	17
Strength	2.49	.11	17
Strength and plyometric	2.78	.09	17
None	2.57	.08	17
Total	2.61	.15	68

The plyometric group attains 2.52 ± 0.11m, (Table11). On the other hand, the strength group accomplishes 2.49± 0.11m. While the plyometric + strength group achieves 2.78± 0.09m,

The Cg gets 2.57 ±0.08m. The ST+PGs had a higher mean score than all other groups. The CG also achieves more than PG. The reason behind the result of CG might be that this group has better talent identification, experience, etc. in this particular activity.

Table12: Ancova Tests of Between-Subjects Effects

Dependent Variable: Spike jump post						
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1.373[a]	4	.343	88.851	.000	.851
Intercept	.046	1	.046	11.896	.001	.161
Spike jump pre	.351	1	.351	90.804	.000	.594
Type of training	.803	3	.268	69.316	.000	.770
Error	.240	62	.004			
Total	459.225	67				
Corrected Total	1.613	66				

a. R Squared = .851 (Adjusted R Squared = .842)

A test was carried out based on their performance progress, F statistic (3, 63) =90.804, p < 0.001, nP2 =0.594. This shows that the performance of players increases for each specific training model.

Table13: Estimates

Dependent Variable: Spike jump post				
Type of training given	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Plyometric	2.501[a]	.015	2.470	2.531
Strength	2.537[a]	.017	2.502	2.572
Strength and plyometric	2.758[a]	.013	2.732	2.784
None	2.573[a]	.018	2.537	2.609

a. Covariates appearing in the model are evaluated at the following values: Spike jump pre = 2.5697.

The above table13 displays the model estimated marginal means and standard errors of trainings gained at the factor of plyometric, strength, plyometric and strength training methods.

The plyometric group appears to execute 2.501m, whereas the ST+PGs behaves to attain 2.758m. The STG achieves 2.537m, less than the CG (2.573).The ST+PG has better result than the rest of the groups.

Table 14: Pairwise Comparisons

Dependent Variable: Spike jump post						
(I) Type of training given	(J) Type of training given	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
Plyometric	Strength	-.037	.023	.734	-.100	.027
	Strength and plyometric	-.258*	.020	.000	-.311	-.204
	None	-.073*	.023	.018	-.137	-.009
Strength	Plyometric	.037	.023	.734	-.027	.100
	Strength and plyometric	-.221*	.022	.000	-.281	-.161
	None	-.036	.025	.920	-.104	.032
Strength and plyometric	Plyometric	.258*	.020	.000	.204	.311
	Strength	.221*	.022	.000	.161	.281
	None	.185*	.022	.000	.125	.245
None	Plyometric	.073*	.023	.018	.009	.137
	Strength	.036	.025	.920	-.032	.104
	Strength and plyometric	-.185*	.022	.000	-.245	-.125

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

When we compare the ST+PG with the ST, P, and the CG, it has a significant difference $P < 0.001$. The ST, P, and CGs groups

There is no significant difference between subjects. It suggests that the combined training method is important in developing Players' explosive power performance.

Table15: Univariate Tests

Dependent Variable: Spike jump post						
	Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Contrast	.803	3	.268	69.316	.000	.770
Error	.240	62	.004			

The F tests the effect of Type of training given. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

The statistics on table 15 indicate the measure of the linear relationship between different training methods and the performance of players. The three training methods and the achievement of subjects are statistically significant. The F statistic (3, 63) =69.316, P-value < 0.001, nP2=0.770. This shows that for every specific training, there is an improvement in the performance of players.

Table 16: Descriptive Statistics

Dependent Variable: Standing reach bloke post			
Type of training given	Mean	Std. Deviation	N
Plyometric	2.17	.09	17
Strength	2.13	.09	17
Strength and plyometric	2.17	.06	17
None	2.14	.08	17
Total	2.16	.08	68

The standing block jump mean performance score for the P-G is 2.17±0.09m, Table 16). The STG and the ST+PG attain 2.13 ±0.09, and 2.17m, while the CG scored 2.14 +0.08. The output value of players is similar. This shows that there are homogenous groups among the subjects. Because of that, the result of standing block/reach/is similar in each group.

Table17: Tests of Between-Subjects Effects (Ancova)

Dependent Variable: Standing reach block post						
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	.388[a]	4	.097	178.199	.000	.919
Intercept	.001	1	.001	2.744	.103	.042
Standing reach block pre	.368	1	.368	677.774	.000	.915
Type of training	.021	3	.007	12.824	.000	.379
Error	.034	63	.001			
Total	316.647	68				
Corrected Total	.422	67				

a. R Squared = .919 (Adjusted R Squared = .914)

F (3.63) =677.774m, p< 0.001, nP2 = 0.919, Ancova test was used to determine the difference between groups based on their performance development. The statistics revealed that the performance increases for each specific training model. There are significant differences between subjects.

Table 18: Estimates

Dependent Variable: Standing reach block post				
Type of training given	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Plyometric	2.173[a]	.006	2.162	2.184
Strength	2.164[a]	.006	2.151	2.177
Strength and plyometric	2.132[a]	.005	2.122	2.142
None	2.172[a]	.007	2.158	2.186

The above table 18 includes the estimated marginal means and standard errors of performance at the factor of different training given. These statistics are important to assess the predominant interaction effect among the three factors. The expected performance of PG is 2.173m. The ST scored 2.164m. In addition, the ST, PG, and CG gain 2.132 and 2.172 points, respectivey.

Table 19: Pairwise Comparisons

Dependent Variable: Standing reach block post/table 4

(I) Type of training given	(J) Type of training given	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
Plyometric	Strength	.010	.008	1.000	-.013	.032
	Strength and plyometric	.042*	.008	.000	.022	.062
	None	.001	.009	1.000	-.022	.025
Strength	Plyometric	-.010	.008	1.000	-.032	.013
	Strength and plyometric	.032*	.008	.001	.010	.055
	None	-.008	.009	1.000	-.033	.017
Strength and plyometric	Plyometric	-.042*	.008	.000	-.062	-.022
	Strength	-.032*	.008	.001	-.055	-.010
	None	-.041*	.009	.000	-.064	-.017
None	plyometric	-.001	.009	1.000	-.025	.022
	strength	.008	.009	1.000	-.017	.033
	Strength and plyometric	.041*	.009	.000	.017	.064

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Adjustment for multiple comparisons: Bonferroni.

The tests between subjects show that the plyometric, ST+PG, the ST and the none factors have no significant difference with each other, except the ST+PG, which has a significant difference (P< 0.001).

Table 20: Univariate Tests

Dependent Variable: Standing reach block post						
	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Contrast	.021	3	.007	12.824	.000	.379
Error	.034	63	.001			

The F tests the effect of Type of training given. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

The above table 21 shows the output for the F measures and provides the statistics for b/n subject effects of different types of training. It shows that the measure of linear relationship between training models and performance is statistically significant. The F statistics (3, 63) =12.824m, P< 0.001, nP2 = 0.379 were related to player performance. This allows us to reject the null hypothesis that there is no linear relationship between training and performance. By rejecting the H_0 hypothesis, we can come to understand that there is a positive linear relationship between the variables, indicating that as the number of training sessions increases, so does the performance of players.

Table 21: Descriptive Statistics

Dependent Variable: Block jump post			
Type of training given	Mean	Std. Deviation	N
Plyometric	2.59	.12	17
Strength	2.45	.11	17
Strength and plyometric	2.73	.09	17
None	2.58	.10	17
Total	2.61	.15	68

The block jump score for the PG is 2.59±0.12m, while the ST+PG attains 2.73±0.09. The strength group executes 2.457 ± 0.11m. Likewise, CG gains 2.58±0.10. The combined group had a higher mean score than all of the other groups.

Table 22: Tests of Between-Subjects Effects (Ancova)

Dependent Variable: Block jump post						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1.263[a]	4	.316	119.015	.000	.883
Intercept	.011	1	.011	3.981	.050	.059
Block jump pre	.518	1	.518	195.168	.000	.756
Type of training	.500	3	.167	62.890	.000	.750
Error	.167	63	.003			
Total	464.548	68				
Corrected Total	1.430	67				

a. R Squared = .883 (Adjusted R Squared = .876)

Ancova was carried out to test how different the three groups were depending on their performance achievement. F (3, 63) =195.168, p 0.001, nP2 = 0.756m. This shows that the performance of players increases for each specific exercise.

Table 23: Estimates

Dependent Variable: Block jump post				
Type of training given	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Plyometric	2.576[a]	.012	2.552	2.601
Strength	2.519[a]	.015	2.490	2.548
Strength and plyometric	2.724[a]	.011	2.703	2.745
None	2.538[a]	.015	2.507	2.568

a. Covariates appearing in the model are evaluated at the following values: Block jump pre = 2.5271.

Table 24 shows the estimated marginal means and standard errors at training parameters. The statistics are important in examining the interaction of these three factors.

The expected result of PG is 2.576m, whereas the STG achieves 2.519m. And the ST+STG attains 2.724m, while the CG scores 2.538m.

Table 24: Pairwise Comparisons

Dependent Variable: Block jump post

(I) Type of training given	(J) Type of training given	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
Plyometric	strength	.058*	.019	.025	.005	.110
	Strength and plyometric	-.147*	.016	.000	-.191	-.103
	None	.039	.019	.296	-.014	.091
Strength	plyometric	-.058*	.019	.025	-.110	-.005
	Strength and plyometric	-.205*	.018	.000	-.254	-.155
	None	-.019	.022	1.000	-.078	.041
Strength and plyometric	plyometric	.147*	.016	.000	.103	.191
	strength	.205*	.018	.000	.155	.254
	None	.186*	.018	.000	.136	.236
None	plyometric	-.039	.019	.296	-.091	.014
	strength	.019	.022	1.000	-.041	.078
	Strength and plyometric	-.186*	.018	.000	-.236	-.136

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

The test b/n subjects indicates that there is no significant difference among subjects except the ST+PG, for which the p-value is < 0.001.

Table25: Univariate Tests

Dependent Variable: Blockj ump post						
	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Contrast	.500	3	.167	62.890	.000	.750
Error	.167	63	.003			

The F tests the effect of Type of training given. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

The above table26 shows the repeated measures of training factors and performance of young players. The F statistic (3, 63) = 62.890, P-value< 0.001, nP2 = 0.750, associated with the performance level of Players.

This enables us to reject the null hypothesis that there is no relationship between the training factors and the performance of subjects. Therefore, we can come to the conclusion that, as the time of training factors increases, the performance of players also increases.

Table 26: Descriptive Statistics

Dependent Variable: pullup post			
Type of training given	Mean	Std. Deviation	N
Plyometric	10.06	2.78	17
Strength	8.43	4.47	17
Strength and plyometric	18.21	3.15	17
None	10.00	4.31	17
Total	12.59	5.49	68

The pull-up performance of PG is 10.06± 2.78, the STG 8.43± 4.47, the combined group18.21± 3.15, and the CG 10+ 4.31, respectively. The CG, PG, and the combined group had a higher mean score tha the strength group. The STG has weaker upper-body strength than the rest of the groups.

Table 27: Tests of Between-Subjects Effects /Ancova/

Dependent Variable: pullup post						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1616.606[a]	4	404.151	63.359	.000	.801
Intercept	115.623	1	115.623	18.126	.000	.223
Pull up pre	420.467	1	420.467	65.916	.000	.511
Type of training	907.149	3	302.383	47.404	.000	.693
Error	401.865	63	6.379			
Total	12794.000	68				
Corrected Total	2018.471	67				

a. R Squared = .801 (Adjusted R Squared = .788)

Ancova was carried out to test the difference between the three groups relying on their performance improvement. F (3, 63) = 65.916, P 0.001, nP2=0.511. This indicates that the performance of trainees increases for each specific factor.

Table 28:Estimates covariates

Dependent Variable: pullup post				
Type of training given	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Plyometric	15.080[a]	.859	13.364	16.796
Strength	7.705[a]	.681	6.345	9.066
Strength and plyometric	15.828[a]	.593	14.643	17.014
None	8.068[a]	.767	6.535	9.600

a. Covariates appearing in the model are evaluated at the following values: Pull-up pre = 7.69.

The above table displays the estimated marginal means and standard errors of players' performance results at the factor of plyometric strength and combined training. The data in the table enables us to find out the possible interaction effects among the three factors. The PG assumes to perform 15.080, while the combined group attains 15.828. At the same time, the ST and CG scores were 7.705 and 8.068, respectively. A higher performance is seen in the combined group.

Table 29: Pairwise Comparisons

Dependent Variable: pullup post

(I) Type of training given	(J) Type of training given	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
Plyometric	strength	7.375*	1.145	.000	4.255	10.494
	Strength and plyometric	-.749	1.205	1.000	-4.031	2.534
	None	7.012*	1.273	.000	3.545	10.479
Strength	plyometric	-7.375*	1.145	.000	-10.494	-4.255
	Strength and plyometric	-8.123*	.874	.000	-10.503	-5.744
	None	-.362	1.005	1.000	-3.099	2.374
Strength and plyometric	plyometric	.749	1.205	1.000	-2.534	4.031
	strength	8.123*	.874	.000	5.744	10.503
	None	7.761*	.895	.000	5.324	10.198
None	plyometric	-7.012*	1.273	.000	-10.479	-3.545
	strength	.362	1.005	1.000	-2.374	3.099
	Strength and plyometric	-7.761*	.895	.000	-10.198	-5.324

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

The results of tests on b/n subjects are shown in the table above. When we compare the performance of PG with STG, it has a significant difference, p = 0.001. There is no performance difference between PG and combined group P > 0.05 (0.001). The CG also has significant differences with the PG.

The STG has a significant difference. P- 0. 001 for ST+PG. However, there is no statistically significant difference between the CG and STG P 0.001.The combined group differs significantly from the CG and STG (P 0.001).

The CG differs significantly from the PG and combined groups (p 0.001). However, there is no difference with the STG p 0.001. So we can conclude that the PG + strength group scored higher than the rest of the groups.

Table 30: Univariate Tests /pairwise comparison/

Dependent Variable: pullup post

	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Contrast	907.149	3	302.383	47.404	.000	.693
Error	401.865	63	6.379			

The F tests the effect of Type of training given. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

The F tests show the effect of training given. The test is based on linearly independent pair-wise comparisons among the estimated marginal means. The types of training given are statistically significant. The F statistic (3, 63) =47.404P-0.001, $nP^{2=}$0.693 relates to the performance of trainees. This permits us to reject the null hypothesis that there is no linear relationship between the types of training given and performance level. And by rejecting the null hypothesis, we can infer that there is a positive relationship between the two variables, showing that as the training schedule increases, the performance of trainees also increases.

Table 31: Descriptive Statistics

Dependent Variable: Sit –up post

Type of training given	Mean	Std. Deviation	N
Plyometric	32.22	6.30	17
Strength	24.00	6.87	17
Strength and plyometric	47.75	6.78	17
None	13.58	2.99	17
Total	32.72	14.11	68

The PG gains a mean performance score of 32.22 ± 6.30, while the combined group (ST+PG) attains a mean performance score of 47.75 ± 6.78. In this regard, STG and CG achieve 24.00 ± 6.87 and 13.58 ± 2.99 performance, respectively. The most prominent score is gained by the combined group. The lowest score is taken by the CG.

Table 32: Ancova/Tests of Between-Subjects Effects

Dependent Variable: Sit-up post						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	11363.682[a]	4	2840.920	91.036	.000	.853
Intercept	1344.288	1	1344.288	43.077	.000	.406
Sit-up pre	478.518	1	478.518	15.334	.000	.196
Type of training	6333.546	3	2111.182	67.652	.000	.763
Error	1966.009	63	31.206			
Total	86133.000	68				
Corrected Total	13329.691	67				

a. R Squared = .853 (Adjusted R Squared = .843)

Ancova was carried out in order to know whether there is a difference between these three groups depending on their performance progress. F (3, 63) = 15.334 p 0.001, nP2 = 0.196. This shows that the performance subject increases for each specific training factor. The result of each group has a significant difference between subjects.

Table 33: Estimates

Dependent Variable: Sit-up post

Type of training given	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Plyometric	38.115[a]	2.000	34.119	42.111
Strength	22.167[a]	1.565	19.040	25.293
Strength and plyometric	42.315[a]	1.796	38.725	45.905
None	17.753[a]	1.932	13.891	21.614

a. Covariates appearing in the model are evaluated at the following values: Sit-up pre = 20.69.

The above table indicates the estimated marginal means and standard error of performance The PG performs 31.115. On the other hand, STG gains 22.167, while the combined group attains 42.3175. The CG accomplishes17.753, so, the higher score is achieved by STG+PG. Also the lowest score goes to CG.

Table 34: Pairwise Comparisons

Dependent Variable: Sit-up post

(I) Type of training given	(J) Type of training given	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
Plyometric	strength	15.949*	2.803	.000	8.313	23.584
	Strength and plyometric	-4.200	3.377	1.000	-13.398	4.999
	None	20.363*	2.128	.000	14.566	26.159
Strength	plyometric	-15.949*	2.803	.000	-23.584	-8.313
	Strength and plyometric	-20.148*	2.092	.000	-25.846	-14.450
	None	4.414	2.679	.627	-2.885	11.713
Strength and plyometric	Plyometric	4.200	3.377	1.000	-4.999	13.398
	Strength	20.148*	2.092	.000	14.450	25.846
	None	24.562*	3.149	.000	15.984	33.141
None	Plyometric	-20.363*	2.128	.000	-26.159	-14.566
	Strength	-4.414	2.679	.627	-11.713	2.885
	Strength and plyometric	-24.562*	3.149	.000	-33.141	-15.984

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

The tests between subjects show that there is a significant mean performance difference between b/n subjects. When we compare the PG with STG and CG, it has an insignificant performance difference with the combined group. When we see the comparisons of the STG with PG and the combined group, it has a significant difference. But there is no significant difference between the STG and CG; the P-value is > 0.05. The combined group has a significant difference with the STG and CG; the p-value is < 0.05/0.001.

Table 35: Univariate Tests

Dependent Variable: Sit-up post						
	Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Contrast	6333.546	3	2111.182	67.652	.000	.763
Error	1966.009	63	31.206			

The F tests the effect of Type of training given. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

The above table indicates the repeated measures of training factors and the performance of trainees. The F statistics (3, 63) =67.652, p-value 0.001, nP2=0.763, which coincides with the performance of the players. This helps us to reject the null hypothesis and accept the hypothesis that there is significant improvement in explosive power performance outcome measures in strength and plyometric training among the control and experimental groups.

Table 36: Pairwise Comparisons

Dependent Variable: Weight post

(I) Type of training given	(J) Type of training given	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
Plyometric	Strength	.826	.619	1.000	-.861	2.513
	Strength and plyometric	.210	.461	1.000	-1.046	1.467
	None	2.701*	.559	.000	1.180	4.223
Strength	Plyometric	-.826	.619	1.000	-2.513	.861
	Strength and plyometric	-.615	.550	1.000	-2.115	.884
	None	1.876*	.606	.018	.224	3.527
Strength and plyometric	Plyometric	-.210	.461	1.000	-1.467	1.046
	Strength	.615	.550	1.000	-.884	2.115
	None	2.491*	.516	.000	1.085	3.897
None	Plyometric	-2.701*	.559	.000	-4.223	-1.180
	Strength	-1.876*	.606	.018	-3.527	-.224
	Strength and plyometric	-2.491*	.516	.000	-3.897	-1.085

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

There is no significant difference between the three experimental groups P-value > 0.05 (0.001).However, there is a significant difference between the non-experimental and experimental groups, with a P-value of < 0.001.

Table 37: Univariate Tests

Dependent Variable: Weight post

	Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Contrast	60.443	3	20.148	9.547	.000	.313
Error	132.951	63	2.110			

The F tests the effect of Type of training given. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

The F tests show the effect of training given. The test depends on a linearly independent pair-wise comparison among the estimated marginal means. The types of training given are statistically significant. The trainee performance was associated with the F statistic (3, 63) =9.457, P < 0.001, nP2 = 0.313. Thus, we can reject the null hypothesis that there is no linear relationship between the types of training given and the performance of trainees.

Here we can deduce that there is a positive relationship between the two variables, indicating that as the type of training given increases, the performance of players also increases.

CHAPTER FIVE

5. DISCUSSION AND IMPLICATIONS

The general objective of the study was to investigate the effects of strength and plyometric training on the development of the explosive power of **U-17** male volleyball players. In order to determine how much progress the groups made during the twelve-week experimental treatment in terms of the used variables, a univariate analysis of variance of repeated measures (ANCOVA) was used, which tested the differences between the initial and final state at the multivariate level. Only differences with a p 0.001 significance level are considered significant.

5.1 Examine the efficacy of plyometric and strength training in developing explosive power.

5.1.1 Broad jump

We can spot that by using the set of plyometric and strength exercises for the development of explosive power in the case of the experimental group, an increase in broad jumping was noted. In addition, an increase was seen for the control group as well, but the increase was significantly greater for the participants of the experimental ST+PG (combined group) than for the control group of volleyball players. In this regard, the mean performance score for the plyometric group is 2.39 ± 0.21m. The strength training group, and ST+PG achieved a mean performance score of 1.99± 0.29 and 2.38± 0.13m, respectively. The control group had a mean performance score of 1.98m±0.31m, P-value < .001.

Similarly, the objectives of this research align with those of Milic, et al. (2008) and Çımenlı, , et al. (2016), who discovered a significant increase in horizontal jump performance following the plyometric training intervention. However, another study did not show significant differences in this regard (Idrizovic, (2018), and the study carried out by Gjinovci et al. (2017), presented only a small effect of plyometric training on horizontal jump performance.

The above authors also confirmed the importance of plyometric exercise to improving the broad jump ability of athletes as follows:

The benefits of plyometric on horizontal jump were observed in both sexes and across the ages. Standing long jump Gjinovci, et al (2017), Idrizovic, et al **(**2018), Sheikh, et al (2018)]**,** depth leap long jump Idrizovic, et al (2018)**,** triple standing jump Sheikh, et al (2018), and unilateral jumps with either no steps or one step taken Myer, et al (2006) were used as tests. In the standing long jump, meaningful improvements of 7.6% were observed in senior female players after 12 weeks of plyometric training Gjinovci et al (2017), a 7.6% improvement was observed in under-16 players after six weeks of training Myer, et al (2006)**,** and a 3.6% improvement was seen in 12- to 19-year-old players after 16 weeks of training Idrizovic, (2018 et al).Thus, twelve week strength and plyometric trainings intervention are important for explosive power development of young volleyball (U-17) players.

5.1.2 Spike jump

Regarding jump spiking, the statistical analysis indicates that the plyometric group attains 2.52 $\pm$ 0.11m (Table1). On the other hand, the strength group accomplishes 2.49$\pm$ 0.11m. While the plyometric + strength group achieves 2.78$\pm$ 0.09m, The CG gets 2.57 $\pm$ 0.08m. The ST+PGs (Combined groups) had a higher mean score than all other groups. This finding is associated with the fact that the combination of strength and plyometric exercises is shown to be more beneficial for vertical jump improvement than either individually (Kukric et al., 2012; Kyrolainen, 2005).

The nova test of spike jump indicates that F statistic (3, 63) =90.804, p 0.001, nP2 $^{=}$0.594, which shows the performance of players increases for each specific training model. On the contrary, the work of some researchers is parallel to the above results. According to the researcher’s understanding, the majority of training studies conducted did not assess other variables that may have been influenced by the training program. In a 7-week training study, Adams, (1984), measured vertical jump ability via the Sergeant jump and did not assess changes in positive energy or the effects on elastic energy. Brown, et al. (1986) evaluated the participants of their 12-week training study on a special platform but presented only vertical jump height means and did not discuss changes in positive energy or the effects of elastic energy. In their two-part training study, Clutch, et al. (1983), measured vertical jump ability on a timing platform and on a special apparatus attached to a basketball backboard. Again, they took no measurements of the effects of the training program on positive energy production or elastic energy utilization.

The three (strength, plyometric, and combined) training methods were found to be statistically significant (p-value 0.001) to develop the spike jump ability and explosive power of athletes. This issue is supported by Harman EA, et al. (1 990), Samson J, et al. (1976), and Sawula , (1991), who confirmed that, during the game, the volleyball players performed several different types of jumping movements, differentiated by execution and height of the jump reached. The jump height, in most cases, relates to the speed of movement preceding the jump. It was also found that the various jump movements require different properties of strength (Young, et al. 1995). Based on this information, the greater improvement in my studies was the explosive power. With the spike jump The researcher supposed that it could be because of the greater similarity of the movement structure of the performed plyometric exercises with the "spiking" jump.

5.1.3 The Block jump

The block jump score for the PG is 2.59±0.12m, while the ST+PG attains 2.73±0.09. The strength group executes 2.46 ± 0.11m. Likewise, CG gains 2.62±0.15. The combined group had a higher mean score than all of the other groups.

The eventual aim of scheming and working on any sports exercise plan is to develop the physical and physiological performance of trainees. In nature, the trainees embody their own inherent performance, which they obtain hereditarily from their families to do the sports activities. However, the main issue here is organizing and carrying out scientific-based preparation programs that are critical with the over status of trainees in order to nurture their innate talent and capability. Studies observed the effects of combined (plyometric and strength) training on the performance of vertical jump (explosive power) in athletes. For example, studies by Hoffman et al. (2005) and Markovic, (2007) confirm that the players need a minimum of 2 weeks to adapt to the increased load and to achieve improvement. My result does differ from that of other studies, such as by Shaji and Isha, (2 009), where maximal vertical jump has shown an increase of 4.8 cm. It was similar to that in the studies conducted by Lehnert, et al. (2009), where the improvement in the height was about 4.9 cm. In their experiment, Faigenbaum et al. (2007) achieved an increase in vertical jump of about 3.4 cm.

Milic, et al. (2008) investigated the 2-foot block jump and performance increased by 3.53 cm. It can be assumed that the difference between results is affected mostly by the length of the PT application, performed exercises, and especially the intensity of execution.

The analysis for the Univariate test summarized below in Table 3 indicates that there is significant upgrading of the experimental group on the entire variables of study. In addition to this, the outcome is also explained as the Univariate Covariate tests be applied to evaluate the significance progress of explosive power (vertical jump) Blok jump test of EG and CG after the EG has fulfilled their training program. The mean value of test outcome also shows that the entire variables of this study of EG significantly improved over the CG, with the exception of the strength experimental group, which performs worse than the CG, which strengthens the Covariate tests results.

5.1.4 Sit-up

The researcher used the sit-up as an indicator variable measure of volley players' vertical jump (explosive power). This issue was also supported by Kim, et al. (2013), deep abdominal muscle strengthening exercises on respiratory function and lumbar stability.

The researcher indicates the estimated marginal mean and standard error of performance as follows: The PG (plyometric training group) performs at 31.12. On the other hand, STG (strength training group) gains 22.17, while the combined group attains 42.32. The CG (control group) accomplishes 17.75, so the higher score is achieved by ST+PG (combined training group). Also, the lowest score goes to CG (control group).

My study objective coincides with the work of the preceding authors. Likewise, Ashok and Suresh, (2020), studied the effects of Isometric Core Training, Explosive Power Training, and Their Combination on Leg Explosive Power of Collegiate Male Handball Players and found the following results. Thus, the isolated core training group, the explosive power training group, and the combination of core and explosive power training groups significantly improved their leg explosive power from pre-test to post test. The leg explosive power increased in the ICTG (Isometric Core Training group) from pre-test (34.20 + 2.26) to post test (37.15 + 2.10); the EPTG (Explosive Power Training group) from pre-test (33.85 + 2.10) to post test (39.40 + 2.45); the CCEPTG (combination of core and explosive power training) groups from pre-test (34.05 + 2.41) to post test (42.00 + 2.59); and there was no change in the control group from pre-test (33.65 + 2.47) to post test (33.95 + 2.76). The leg explosive power significantly showed improvement from pre-test to post test in the three treatment groups, and there were no changes in the control group. The present study demonstrated that an increase in leg explosive power of 8.62%, 16.39%, 23.35%, and 0.9% was estimated with the vertical jump test for the isolated core training group. Explosive power training group, a combination of core and explosive power training groups, and a control group, respectively. The combination of core and explosive power training groups significantly improved leg explosive power by 23.35% better than the EPTG (16.39%), ICTG (8.62%), and control group (0.89%).

The ANOVA test result indicates whether there is a difference in performance progress between these three groups; F (3, 63) =15.334 p- 0.001, nP2 = 0.196. This shows that the performance of subjects increases for each specific training factor. The result of each group has a significant difference between subjects. Therefore, sit-up is an important variable for developing the explosive power of volley players.

5.1.5 Pull-up

It will be beneficial for coaches and athletes to know which parts/joints/of the body should be focused on during their workout exercises to have the most effective training results. Our arm movements have their own role in vertical jumping activity. The researcher found the following statistical results: Hence, the mean pull-up performance of PG is 10.06± 2.775, the STG 8.43± 4,467, the combined group 18.21± 3.148, and the CG 10+ 4.306, respectively. The CG, PG, and combined groups had a higher mean score than the strength group. The STG has weaker upper-body strength than the rest of the groups. The above result is supported by different authors. For example, the effects of arm swings on jump performance have been studied for a few decades. Payne, et al. (1968), Shetty, & Etnyre, (1989), and Harman, et al. (1990) demonstrated that arm swing can increase GRF (ground reaction force) in the latter half of the propulsive phase, resulting in increased net ground reaction impulse. Centre of mass (CM) position and vertical velocity at take-off can be raised, which increases jump height. This kind of "transmission of force" theory was proposed by (Payne, et al. in 1996) and repeated by (Dapena, in 1993).

The F tests show the effect of training given. The test is based on linearly independent pair-wise comparisons among the estimated marginal means. The types of training given are statistically significant. The F statistic (3, 63) =47.404P-0.001, $nP^{2=}0.693$ relates to the performance of trainees. This permits us to reject the null hypothesis that there is no linear relationship between the types of training given and performance level. And by rejecting the null hypothesis, we can infer that there is a positive relationship between the two variables, showing that as the training schedule increases, the performance of trainees also increases. Therefore, pull-ups are an essential factor for developing the explosive power of volleyball players.

5.1.6 Explosive Leg Power

To observe the significance of the exercise, the researcher has given 12 weeks of intervention training for the EGs. Therefore, the summary outcome of /block jump/on table 3 indicates that the training has had a statistically significant change on the explosive power of the volleyball players, and this is assured since the p-value 0.001). In addition, the Univariate Covariates test obtained in table 3 also supported that there was statistically significant development in the comparison of EGs and CGs in the post-test than in the equivalent pre-test. Hence, since the p-value

The level of this variable, which is 0.00, is less than the level of significance. The 12 weeks of ST and PL training had a significant effect on increasing the explosive power of volleyball athletes.

This confirms earlier theories by Hoffman JR et al. (2005) and Markovic (2007) that the players need a minimum of 2 weeks to adapt to the increased load and to achieve improvement. It was similar to that in the studies conducted by Lehnert, et al. (2009). Where the improvement in height was about 4.9 cm. In their experiment, Faigenbaum, et al. (2007), achieved an increase in vertical jump of about 3.4 cm. Milic, et al. (2008) investigated the 2-foot block jump and performance increased by 3.53 cm. It can be assumed that the difference between results is affected by the length of performed exercises and especially the intensity of execution.

5.2 Identifying the different strength and plyometric training methods that suit the demands of the project players.

In terms of pairwise comparison between groups on spike jump activity/table4/indicates that the ST+PG with the ST, P, and the CG has a significant difference P 0.001. The ST, P, and CGs groups have no significant difference between subjects. It indicates that the combined training method is prominent in developing the explosive power performance of players. The researcher's findings coincide with the following concepts: Research suggests that the effectiveness of training to enhance sprinting and jumping performance may be influenced by maturation in young boys. (Moran, et al., 2017, Moran, et al., 2017). Lloyd et al. (2014) reported that pre-pubertal boys benefited more from plyometric training, while adolescents responded more favourably to a combined plyometric and traditional strength training stimulus (Lloyd et al. 2014).

The broad jump performance test result on table (4) shows the estimated marginal means and standard errors of performance results at the factor of plyometric, strength, and combined training. This table is important to explore the possible interaction effect among those three factors. A plyometric group is expected to perform 2.29m, while the St+pG scores are 2.29m, the STG (strength training group) is 2.16m, and the CG (Control group) gains are 2.11respectively. The STG+PG (Combined showed better results than other groups. "The plyometric training regime (method) causes muscular and neural changes that facilitate and enhance the development of rapid and powerful movements1 and is ranked among the most frequently used methods for special conditioning in volleyball (Harmandeep, et al.,2015)," according to the researcher findings. The plyometric and STG+PG (combined training groups) performances were nearly identical (2.29m and 2.29m, respectively). The two components of training are very suitable and important in developing the explosive power of volleyball players. The researcher's opinion is supported by previous research. For example, Chu, (1991) emphasizes the importance of combined strength training and plyometric training and suggests that strength training is "the ideal counterpart to plyometric training."

Besides**,** when the researcher analyses the relationship of training methods with the output of explosive power of U-volleyball players, the jump spike test (table 5) resembles as follows. Then

These statistics indicate a measure of the linear relationship between different training methods and the performance of players. The three training methods and the achievement of subjects are statistically significant. The F spastic (3, 63) =12.824, P-value 0.001, nP2=0.379. This shows that for every specific training, there is an improvement in the performance of players. Therefore, the two training methods are the most appropriate for training the explosive power of young volleyball players.

5.3 Examine the relationship between strength and plyometric training in the development of explosive power.

Previous studies tried to investigate the importance of strength and plyometric training. For instance, Chu (1991) emphasizes the importance of combined strength and plyometric training and suggests that strength training is "the ideal counterpart to plyometric training." Other researchers confirmed that plyometric training improves strength, power output, coordination, and athletic performance.

The researcher’s different statistical results support the above research findings. For example, the descriptive statistics mentioned on table 11 shows this fact.

The plyometric group attains 2.52 ± 0.11m, (spike jump Table 11). On the other hand, the strength group accomplishes 2.49± 0.11m. While the plyometric +strength group achieves 2.78± 0.09m, The Cg gets 2.57 ±0.08m. The ST+PGs had a higher mean score than all other groups. The CG also achieves more than PG. The reason behind the result of CG might be that this group has better talent identification, experience, etc. In this particular activity, Many authors also confirmed the relationship between plyometric and strength training in developing the explosive power of volleyball players.

Both plyometric and strength training are recognized as important components of fitness programs and are safe methods for improving explosive actions in young players (Lesinski, et al., 2016, and Saez et al., 2015). Systematic strength training can be used to elicit increases in maximum strength and muscle hypertrophy (Lloyd, et al., 2014), whereas plyometric training can enhance the functionality of the stretch-shortening cycle (SSC) and muscle power capacity (Lloyd, et al., 2016).

Besides, this study has allowed researchers to see the effectiveness of plyometric and strength training, which proved a great improvement in the tested variables such as (Sj, Bj, Broad jump, Sit-up, Pull-up) and this is going in the same direction as the work. Strength and plyometric exercises combined have been shown to be more beneficial for vertical jump improvement than either alone (Kukric, et al., 2012; Kyrolainen, 2005).

CHAPTER SIX

6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

When organising a training programme to maximise power, several factors need to be taken into account. The phenomena of explosive power performance is complex and reflects a variety of training elements.

According to the findings, the current study showed that 12 weeks of involvement training meaningfully enriched explosive power (vertical jump) on the performance of young volleyball players.

In general, there was a statistically significant difference between the EGs and the CG group in regard to explosive power performance in the pre-test and post-test totals of the performance of Amhara region male volleyball U-17 project players who accomplished plyometric and strength training exercises. Thus, the researcher has proved that a 12-week PT (polyometric training) and ST (strength training) intervention (with the range of exercise intensity from 60% to 90%) impacts the increase in explosive power of the lower legs and thus boosts the vertical jumping abilities.

Merging a number of components into one training session seems to be a safe training method in this age group. The current study on PT and ST training provides important information about how to coach youth volleyball players, with implications for the design of training schedules. Strength and conditioning professionals, particularly in volleyball, should focus on offering combined training as a portion of a special preparation package.

6.2 Recommendations

Based on the major findings and conclusions of the study, the following points were recommended as follows:

Strength and plyometric training were essential training methods in improving the explosive power performance of volleyball athletes from Amhara region project training centres.

Thus, carefully chosen physical ability training approaches are recommended to volleyball players in order to improve Explosive power performance. In many other sports and human cultures, it is needed to do further research in the area of explosive power performance and diverse kind of training modalities . The suggested training methods comprising the strength and plyometric trainings should be a part of physical fitness training program of volleyball players, since they are very important on advancing volley players' physical and skill ability.

Therefore, it is extremely estimated from volleyball sport professionals and associated fields to direct and train on the prominence and worth of designated training packages to attain physically and technically fit players. Coaches should focus on selected physical exercises which in turn produce future elite volleyball players. Awareness program about importance of explosive power should be given to volleyball customers using different Medias.

Likewise, young volleyball coaches are counselled to hold combined plyometric and strength training in their training schedules with understanding to preserving, and improving, physical growth in a prime fast style. Besides, important nutrients, sport wears, and training materials should be available to project trainees.

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Appendix A: 12 week strength training program

Week 1. Training one and two, intensity 60%

1A) Prisoner Squats 1B) Pushups 1C) Chin-ups (or negatives) 2A) Lateral Step-ups (Each Leg 2B) Dips (or Negatives) 2C) Inverted Row	2 sets of 10 Reps 2 sets of 10 repetitions; 2 sets;10Reps 2 sets of 10 repetitions 2 sets of 10 repetitions 2sets 10 repetitions(hold 30-60 seconds)

Week 2.training three and four, intensity 70%

1A)) Split Squats 1B)) Pushup Wall Walk 1C) Inverted Row 2A) Lateral Squats 2B) Pull-ups (or Negatives) 2C) Volleyball Pushups (1 Ball)	2 sets of 10 repetitions 2 sets of 3 repetitions; 2 sets; 10 repetitions 2 sets of 10repetitions 2 sets of 8 repetitions 2 sets of 10 repetitions

Week 3. training five – six, intensity 80%

3A) 135 degree squats 3B) Crawling (Forward and Backwards) 1A) Split Squat (Foot on Bench) 1B) Volleyball Pushups (2 Ball) 1C) Neutral Grip Pull-ups (or Negatives) 2A) Crossover Step-ups (Each Leg)	3 sets of 8 repetitions 3 sets of 45 seconds 3 sets 8 repetitions 3 sets of 10 repetitions 3 sets of 10 repetitions 3 sets of 10 repetitions

Week 1. Training seven and eight, intensity 90%

2B) Rotational Pushups (Each Side) 2B) Inverted Row 1A) Forward Lunges 1B) Pushup Wall Walk 1C) Pull-ups (or Negatives 2A) Lateral Lunges	4 sets of 10 repetitions 3 sets of 10 repetitions 3 sets; of 8 repetitions 3 sets of 3 repetitions 3 sets of 8 repetitions 3 sets of 8 repetitions

Week 5.Training 9 and 10, intensity 90%

2C) Volleyball Pushups (Feet on Ball) 3A) 135 Degree Lunges 3B) Lateral Wall Sit Sit ups Pushups Split squat	4 sets of 8 repetitions 3 sets of 10 repetitions; 3 sets; 45 seconds 3 sets of 12 repetitions 3 sets of 10 repetitions 3 sets of 8 repetitions

Week 6. Training 11 and 12, intensity 90%

2C) Volleyball Pushups (Feet on Ball) 3A) 135 Degree Lunges 3B) Lateral Wall Sit Sit ups Pushups Split squat	4 sets of 8 repetitions 3 sets of 10 repetitions; 3 sets; 45 seconds 3 sets of 12 repetitions 3 sets of 10 repetitions 3 sets of 8 repetitions

Week 7. Training 13 and 14, intensity 80%

3A) 135 degree squats 3B) Crawling (Forward and Backwards) 1A) Split Squat (Foot on Bench) 1B) Volleyball Pushups (2 Ball) 1C) Neutral Grip Pull-ups (or Negatives) 2A) Crossover Step-ups (Each Leg)	3 sets of 8 repetitions 3 sets of 45 seconds 3 sets 8 repetitions 3 sets of 10 repetitions 3 sets of 10 repetitions 3 sets of 10 repetitions

Week 8. Training 15 and 16, intensity 70%

1A)) Split Squats 1B)) Pushup Wall Walk 1C) Inverted Row 2A) Lateral Squats 2B) Pull-ups (or Negatives) 2C) Volleyball Pushups (1 Ball)	3 sets of 10 repetitions 3 sets of 3 repetitions; 3 sets; 10 repetitions 3 sets of 10repetitions 3 sets of 8 repetitions 3 sets of 10 repetitions

Week 9. Training 17 and 18, intensity 90%

2C) Volleyball Pushups (Feet on Ball) 3A) 135 Degree Lunges 3B) Lateral Wall Sit Sit ups Pushups Split squat	4 sets of 8 repetitions 3 sets of 10 repetitions; 3 sets; 45 seconds 3 sets of 12 repetitions 3 sets of 10 repetitions 3 sets of 8 repetitions

Week 10. Training 19 and 20, intensity 80%

3A) 135 degree squats 3B) Crawling (Forward and Backwards) 1A) Split Squat (Foot on Bench) 1B) Volleyball Pushups (2 Ball) 1C) Neutral Grip Pull-ups (or Negatives) 2A) Crossover Step-ups (Each Leg)	3 sets of 8 repetitions 3 sets of 45 seconds 3 sets 8 repetitions 3 sets of 10 repetitions 3 sets of 10 repetitions 3 sets of 10 repetitions

Week 11. Training 21 and 22, intensity 90%

2C) Volleyball Pushups (Feet on Ball) 3A) 135 Degree Lunges 3B) Lateral Wall Sit Sit ups Pushups Split squat	4 sets of 8 repetitions 3 sets of 10 repetitions; 3 sets; 45 seconds 3 sets of 12 repetitions 3 sets of 10 repetitions 3 sets of 8 repetitions

Week 12. Training 23 and 24, intensity 90%

2B) Rotational Pushups (Each Side) 2B) Inverted Row 1A) Forward Lunges 1B) Pushup Wall Walk 1C) Pull-ups (or Negatives 2A) Lateral Lunges	4 sets of 10 repetitions 3 sets of 10 repetitions 3 sets; of 8 repetitions 3 sets of 3 repetitions 3 sets of 8 repetitions 3 sets of 8 repetitions

Appendix B: Plyometric exercises

The Content of the Training Model for the Development of the Vertical Jump

For the purposes of this research, the set of the special model for the development of the vertical jump at the university age level consisted of five exercises which will use to increase the explosive type strength by means of the plyometric (reversible-Zaciorski) method.

Mutiple Box-to-Box Squat Jumps (Fig. 1)

Equiment: A row of boxes (all the same height, dependet on ability).

Start: Stand in a deep-squat position with feet shoulder-width apart at the end of the row of boxes.

Action: Jump to the first box, landin softly in a squat position. Maintaaining the squat position, jump off the box on the oder side and immediately onto and off of the followind boxes. Keep hands on the hips, or behind the head.

Fig. 1. Mutiple Box-to-Box Squat Jumps

Depth Jump (Fig. 2)

Equipment: A box (variety heights).

Start: Stand on the box, toes close to the front edge.

Action: Step from the box and drop to land on both feet. Try to anticipate the landing and spring up as quickly as you can. Keep the body from "settling" on the landing, and make the ground contact as short as possible.

Fig. 2. Depth Jump

30-60-90-Second Box Drill (Fig. 3)

Equipment: A box 30 cm high, 50 cm wide and 70 cm deep.

Start: Stand at the side of the box with feet shoulder-width apart.

Action: Jump onto the box, back to the ground on the other side, then back on to the box. Continue to jump across the top of the box for an allotted time, with each touch on top of the box counting as one. Use the following guidelines: 30 touches in 30 seconds- Start of training, 60 touches in 60 seconds- Middle of training and 90 touches in 90 seconds- End of training.

Fig. 3. 30-60-90-Second Box Drill

Split Squat Jump (Fig. 4)

Equipment: None.

Start: Spread the feet far apart, front to back, and bend the front leg 90 degrees at the hip and 90 degrees at the knee.

Action: Jump up; using arms to help lift, hold the split-squat position. Land in the same position and immediately repeat the jump.

Fig. 4. Split Squat Jump

Rim Jumps (Fig. 5)

Equipment: None.

Start: Spread the feet far apart, front to back, and bend the front leg 90 degrees at the hip and 90 degrees at the knee.

Action: Jump up; using arms to help lift, hold the split-squat position. Land in the Same position and immediately repeat the jump.

Fig. 5. Rim Jumps

Determining the correct amount of strain to be put on each volleyball player would be carried out on an individual basis. In designing individual programs, the principle state that the amount of strain during the first week should be 60% of the maximum, during the second 70%, the third 80%, the fourth 90%, the fifth 70%, the sixth 80%, the seventh 90% and during the eighth, 100%.

Week 1. Training one and two, intensity 60%

Multiple Box-to-Box Squat Jumps	2 sets of 4 boxes, box height 40 cm
Depth Jump	2 sets of 8 repetitions; box height 50 cm
30-Second Box Drill	2 sets; box height 30 cm
Split Squat Jump	2 sets of 8 repetitions
Rim Jumps	2 sets of 7 repetitions
High lung twist	2sets 7 repetitions(hold 30-60 seconds)

Week 2. Training three and four, intensity 70%

Multiple Box-to-Box Squat Jumps	2 sets of 4 boxes, box height 50 cm
Depth Jump	2 sets of 10 repetitions; box height 60 cm
30-Second Box Drill	2 sets; box height 40 cm
Split Squat Jump	2 sets of 9 repetitions
Rim Jumps	2 sets of 8 repetitions
Pull ups	2 sets of 8 repetitions

Week 3. Training five – six, intensity 80%

Multiple Box-to-Box Squat	3 sets of 4 boxes, box height 50 cm
Jumps	3 sets of 10 repetitions; box height 70 cm
Depth Jump	3 sets; box height 40 cm
30-Second Box Drill	3 sets of 10 repetitions
Split Squat Jump	3 sets of 9 repetitions
Rim Jumps	
Kettle bell swing	3 sets of 8 repetitions

Week 4. Training eight and nine, intensity 90%

Multiple Box-to-Box Squat Jumps	4 sets of 4 boxes, box height 60 cm
Depth Jump	3 sets of 10 repetitions;box height 80 cm
60-Second Box Drill	3 sets; box height 30 cm
Split Squat Jump	3 sets of 12 repetitions
Rim Jumps	3 sets of 11 repetitions
Wall block jump	3 sets of 10 repetitions

Week 5. Training 10 and 11, intensity 70%

Multiple Box-to-Box Squat Jumps Depth Jump 60-Second Box Drill Split Squat Jump Rim Jumps Inverted row	3 sets of 4 boxes, box height 40 cm 3 sets of 10 repetitions; box height 60 cm 3 sets; box height 40 cm 3 sets of 9 repetitions 3 sets of 8 repetitions 3stes of 10 repetitions

Week 6. Training 12 – 14, intensity 80%

Multiple Box-to-Box Squat Jumps Depth Jump 30-Second Box Drill Split Squat Jump Rim Jumps Ankle hops	3 sets of 4 boxes, box height 50 cm 3 sets of 10 repetitions; box height 70 cm 3 sets; box height 50 cm 3 sets of 10 repetitions 3 sets of 9 repetitions 3 sets of 8 repetitions

Week 7. Training 15 – 17, intensity 90%

Multiple Box-to-Box Squat Jumps Depth Jump 90-Second Box Drill Split Squat Jump Rim Jumps Push ups	3 sets of 4 boxes, box height 60 cm 3 sets of 10 repetitions; box height 80 cm 3 sets; box height 40 cm 3 sets of 11 repetitions 3 sets of 11 repetitions 3 sets of 12 repetitions

Week 8. Training 18 and 19, intensity 100%

Multiple Box-to-Box Squat Jumps Depth Jump 90-Second Box Drill Split Squat Jump Rim Jumps Goblet squat	4 sets of 4 boxes, box height 60 cm 3 sets of 10 repetitions; box height 90 cm 3 sets; box height 50 cm 3 sets of 13 repetitions 3 sets of 12 repetitions 3setes of 14 repetitions

Week 9. Training 18 and 19, intensity 100%

Multiple Box-to-Box Squat Jumps	4 sets of 4 boxes, box height 60 cm
Depth Jump	3 sets of 10 repetitions; box height 90 cm
90-Second Box Drill	3 sets; box height 50 cm
Split Squat Jump	3 sets of 13 repetitions
Rim Jumps	3 sets of 12 repetitions
Stair hops /both feet/	3setes of 14 repetitions

Week 10. Training 18 and 19, intensity 100%

Multiple Box-to-Box Squat Jumps	4 sets of 4 boxes, box height 60 cm
Depth Jump	3 sets of 10 repetitions; box height 90 cm
90-Second Box Drill	3 sets; box height 50 cm
Split Squat Jump	3 sets of 13 repetitions
Rim Jumps	3 sets of 12 repetitions
Static lungs	2setes of 15 repetitions

Week 11. Training 18 and 19, intensity 100%

Multiple Box-to-Box Squat Jumps	4 sets of 4 boxes, box height 60 cm
Depth Jump	3 sets of 10 repetitions; box height 90 cm
90-Second Box Drill	3 sets; box height 50 cm
Split Squat Jump	3 sets of 13 repetitions
Rim Jumps	3 sets of 12 repetitions
Front squats	3setes of 10 repetitions

Week 12. Training 18 and 19, intensity 100%

Multiple Box-to-Box Squat Jumps	4 sets of 4 boxes, box height 60 cm
Depth Jump	3 sets of 10 repetitions; box height 90 cm
90-Second Box Drill	3 sets; box height 50 cm
Split Squat Jump	3 sets of 13 repetitions
Rim Jumps	3 sets of 12 repetitions
Front squats	3setes of 10 repetitions

Appendix C: Combined Plyometric and Strength Exercise

Week 1. (17.8.2003- 23.8.2003), training one and two, intensity 60%

Mutiple Box-to-Box Squat Jumps	2 sets of 4 boxis, boxheight 40 cm
Depth Jump	2 sets of 8 repetitions; boxheight 50 cm
30-Second Box Drill	2 sets; boxheight 30 cm
1A) Prisoner Squats	2 sets of 10 Reps
1B) Pushups	2 sets of 10 repetitions;
1C) Chin-ups (or negatives	2 sets;10Reps

Week 2. (17.8.2003- 23.8.2003), training 3 and 4, intensity 60%

Split Squat Jump	2 sets of 8 repetitions
Rim Jumps	2 sets of 7 repetitions
High lung twist	2sets 7 repetitions(hold 30-60 seconds)
2A) Lateral Step-ups (Each Leg	2 sets of 10 repetitions
2B) Dips (or Negatives)	2 sets of 10 repetitions
2C) Inverted Row	2sets 10 repetitions(hold 30-60 seconds

Week 3. (24.8.2003- 30.8.2003), training 5 and 6, intensity 70%

Mutiple Box-to-Box Squat Jumps	2 sets of 4 boxes, box height 50 cm
Depth Jump	2 sets of 10 repetitions; box height 60 cm
30-Second Box Drill	2 sets; box height 40 cm
1A)) Split Squats	2 sets of 10 repetitions
1B)) Pushup Wall Walk	2 sets of 3 repetitions;
1C) Inverted Row	2 sets; 10 repetitions

Week 4. (24.8.2003- 30.8.2003), training 7 and 8, intensity 70%

Split Squat Jump	2 sets of 9 repetitions
Rim Jumps	2 sets of 8 repetitions
Pull ups	2 sets of 8 repetitions
2A) Lateral Squats	2 sets of 10repetitions
2B) Pull-ups (or Negatives)	2 sets of 8 repetitions
2C) Volleyball Pushups (1 Ball)	2 sets of 10 repetitions

Week 5. (31.8.2003- 6.9.2003), training 9 – 10, intensity 80%

Mutiple Box-to-Box Squat Jumps	3 sets of 4 boxis, boxheight 50 cm
Depth Jump	3 sets of 10 repetitions; boxheight 70 cm
30-Second Box Drill	3 sets; boxheight 40 cm
3A) 135 degree squats	3 sets of 8 repetitions
3B) Crawling (Forward and Backwards)	3 sets of 45 seconds
1A) Split Squat (Foot on Bench	3 sets 8 repetitions

Week 6. (31.8.2003- 6.9.2003), training 11– 12, intensity 80%

Split Squat Jump	3 sets of 10 repetitions
Rim Jumps	3 sets of 9 repetitions
Kettle bell swing	3 sets of 8 repetitions
1B) Volleyball Pushups (2 Ball)	3 sets of 10 repetitions
1C) Neutral Grip Pull-ups (or Negatives)	3 sets of 10 repetitions
2A) Crossover Step-ups (Each Leg	3 sets of 10 repetitions

Week 7. (7.9.2003- 13.9.2003), training 13 and 14, intensity 90%

Mutiple Box-to-Box Squat Jumps	4 sets of 4 box is, box height 60 cm
Depth Jump	3 sets of 10 repetitions; box height 80 cm
60-Second Box Drill	3 sets; box height 30 cm
2B) Rotational Pushups (Each Side)	4 sets of 10 repetitions
2B) Inverted Row	3 sets of 10 repetitions
1A) Forward Lunges	3 sets; of 8 repetitions

Week 8. (7.9.2003- 13.9.2003), training 15 and 16, intensity 90%

Split Squat Jump	3 sets of 12 repetitions
Rim Jumps	3 sets of 11 repetitions
Wall block jump	3 sets of 10 repetitions
1B) Pushup Wall Walk	3 sets of 3 repetitions
1C) Pull-ups (or Negatives	3 sets of 8 repetitions
2A) Lateral Lunges	3 sets of 8 repetitions

Week 9. (14.9.2003- 20.9.2003), training 17 and 18, intensity 70%

Multiple Box-to-Box Squat Jumps	3 sets of 4 box is, box height 40 cm
Depth Jump	3 sets of 10 repetitions; box height 60 cm
60-Second Box Drill	3 sets; box height 40 cm
2C) Volleyball Pushups (Feet on Ball)	4 sets of 8 repetitions
3A) 135 Degree Lunges	3 sets of 10 repetitions;
3B) Lateral Wall Sit	3 sets; 45 seconds

Week 10. (14.9.2003- 20.9.2003), training 19 and 20, intensity 70%

Split Squat Jump	3 sets of 9 repetitions
Rim Jumps	3 sets of 8 repetitions
Inverted row Sit ups	3stes of 10 repetitions
Sit ups	3 sets of 12 repetitions
Pushups	3 sets of 10 repetitions
Split squat	3 sets of 8 repetitions

Week 11. (21.9.2003- 27.9.2003), training 21 – 22, intensity 80%

Multiple Box-to-Box Squat Jumps	3 sets of 4 box is, box height 50 cm
Depth Jump	3 sets of 10 repetitions; box height 70 cm
30-Second Box Drill	3 sets; box height 50 cm
2C) Volleyball Pushups (Feet on Ball)	4 sets of 8 repetitions
3A) 135 Degree Lunges	3 sets of 10 repetitions;
3B) Lateral Wall Sit	3 sets; 45 seconds

Week 12. (21.9.2003- 27.9.2003), training 23– 24, intensity 80%

Split Squat Jump	3 sets of 10 repetitions
Rim Jumps	3 sets of 9 repetitions
Ankle hops	3 sets of 8 repetitions
Sit ups	3 sets of 12 repetitions
Pushups	3 sets of 10 repetitions
Split squat	3 sets of 8 repetitions

Appendix D: PAR-Q (Physical Activity Readiness Questionnaire) for Safe Exercise

If you haven't been active recently, or are looking to add a new or more intense exercise to your current routine, the PAR-Q can help you decide if you are ready to exercise safely, or if you might need a trip to your physician to make sure you don't push beyond your own limit.

The PAR-Q, or physical activity readiness questionnaire, is a simple self-screening tool that can and should be used by anyone who is planning to start an exercise program and make it stick.

It is typically used by fitness trainers or coaches to determine the safety or possible risk of exercising for an individual based on their health history, and current symptoms and risk factors. It also can help a trainer design an ideal exercise prescription for a client based on these results.

The PAR-Q was created by the British Columbia Ministry of Health and the Multidisciplinary Board on Exercise. This form has been adopted directly from the ACSM Standards and Guidelines for Health and Fitness Facilities. Although there are now a variety of PAR-Q questionnaires and other health self-directed screening assessments in use in various facilities, and on the web, the basic questions from the original questionnaire haven't changed a great deal. All the questions are designed to help uncover any potential health risks associated with exercise. The questions aim to uncover heart, circulatory, balance, medication, emotional, and joint problems that could make exercise difficult, or even dangerous for some people.

The most serious potential risk of intense exercise is that of a heart attack or other sudden cardiac event in someone with undiagnosed heart conditions.

Take the Physical Activity Readiness Questionnaire

Being physically active is very safe for most people. Some people, however, should check with their doctors before they increase their current level of activity. The PAR-Q has been designed to identify the small number of adults for whom physical activity may be inappropriate or those who should have medical advice concerning the type of activity most suitable for them.

Answer yes or no to the following questions:

1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
2. Do you feel pain in your chest when you do physical activity?
3. In the past month, have you had chest pain when you were not doing physical activity?
4. Do you lose your balance because of dizziness or do you ever lose consciousness?
5. Do you have a bone or joint problem that could be made worse by a change in your physical activity?
6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?

7. Do you know of any other reason why you should not do physical activity?

If you answered yes:

If you answered yes to one or more questions, are older than age 17 and have been inactive or are concerned about your health, consult a physician before taking a fitness test or substantially increasing your physical activity. You should ask for a medical clearance along with information about specific exercise limitations you may have.

In most cases, you will still be able to do any type of activity you want as long as you adhere to some guidelines.

If you answered no:

If you answered no to all the PAR-Q questions, you can be reasonably sure that you can exercise safely and have a low risk of having any medical complications from exercise.

It is still important to start slowing and increase gradually. It may also be helpful to have a fitness assessment with a personal trainer or coach in order to determine where to begin.

When to delay the start of an exercise program:

- If you are not feeling well because of a temporary illness, such as a cold or a fever, wait until you feel better to begin exercising.
- If you are or may be pregnant, talk with your doctor before you start becoming more active.

Keep in mind, that if your health changes, so that you then answer "YES" to any of the above questions, tell your fitness or health professional, and ask whether you should change your physical activity plan.

PARTICIPANT DECLARATION If you are less than the legal age required for consent or require the assent of a care provider, your parent, guardian or care provider must also sign this form.

I, the undersigned, have read, understood to my full satisfaction and completed this questionnaire. I acknowledge that this physical activity clearance is valid for a maximum of 3 months from the date it is completed and becomes invalid if my condition changes. I also acknowledge that the community/fitness centre may retain a copy of this form for records. In these instances, it will maintain the confidentiality of the same, complying with applicable law.

NAME ____

SIGNATURE ________________________ DATE__________________

SIGNATURE OF PARENT/GUARDIAN/CARE PROVIDER ____

WITNESS _____________________________________ DATE __________________________

Appendix E: Pre and post test data recording sheet

No	Name of players	Age	Height (m)	Weight (kg)	Broad jump	Spike Jump	Spike Jump	Standing Block	Jump Block	Pull -up	Sit-up
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											

Name and signature of coach ------------------------------------ Date: ---------------------------

Name and signature of data collector -------------------------- Date: ---------------------------