EFFECT OF 12 WEEKS SELECTED PLYOMETRIC TRAINING ON AGILITY, SPEED AND EXPLOSIVE POWER: THE CASE OF MALE SPORT SCIENCE STUDENTS OF AMBO UNIVERSITY; AMBO TOWN, ETHIOPIA

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FURA WAKO SEBERO

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As research advisors, we hereby certify that we have read and evaluated the thesis entitled "**Effect Of 12 Weeks Selected Plyometric Training On Agility, Speed And Explosive Power: The Case Of Male Sport Science Students of Ambo University; Ambo Town, Ethiopia**" prepared by **Fura Wako Sebero**. We recommend that the thesis can be submitted as fulfilling the thesis requirements.

DestaEnyew (PhD)	________________	________________
Major Advisor	Signature	Date
AbinetAyalew(PhD)	________________	________________
Co-Advisor	Signature	Date

As members of the Board of Examiners of the M.Sc. thesis open defense examination of **Fura Wako Sebero**, we certify that we have read, evaluated the thesis and examined the candidate. We recommended that the thesis be accepted as it fulfills the requirements for the Degree of Master of Science in **Sport Medicine.**

________________	________________	________________
Chairperson	Signature	Date
________________	________________	________________
Internal Examiner	Signature	Date
________________	________________	________________
External Examiner	Signature	Date

DEDICATION

This thesis is dedicated for my loving memory of my late grandfather SeberoBoriso, who passed away in September 2015 and to my father, Wako Sebero and mother, Martu Koroso for their undenying love.

STATEMENT OF THE AUTHOR

By my signature bellow, I declare and confirm that this thesis is my own work. I have followed all ethical and technical principles of scholarship in preparation, sample collection, laboratory investigation, data analysis and completion of this thesis. In addition, I affirm that I have cited and referenced all sources of information, knowledge and materials used in this document. Every serious effort has been made to avoid any plagiarism in the preparation and development of this thesis. This thesis has been submitted to Haramaya University in partial fulfillment of the requirements for the Degree of Master of Science in the program of **Sport Medicine** and deposited at the Library of the University to be made available to borrowers under the rules and regulations of the Library. I solemnly declare that I have not submitted this thesis to any other institution anywhere for the award of any academic Degree, Diploma Or Certificate.

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Name of Author: **Fura Wako Sebero** Signature: _____________

Place of Submission: Haramaya University, Haramaya

Date of Submission: _____________

Department : Sport Science

BIOGRAPHICAL SKETCH

The Author was born on January 01, 1988 in West Arsi zone, ShashemeneWoreda. He attended his Elementary and Secondary School education at Burka Bekumsa Elementary and Biftu Secondary School, respectively. He completed his preparatory school education at Paradise Valley Preparatory School in 2010. Then, the Author joined Ambo University in the Department of Sport Science in 2011 and graduated with Bachelor of Science (BSc) in Sport Science in 2013. After graduation he was employed there at Ambo University as Graduate Assistant in September 1, 2014. He served Ambo University for two years and then joined Haramaya University in 2016 as regular student to pursue his M.Sc. program in **Sport Medicine**.

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LIST OF ABBREVIATIONS AND ACRONYMS

CMJ	Counter movement Jumps
CNS	Central Nervous System
DQC	Data Quality Control
DJ	Depth Jumps
DTT	During Training Test
ECCP	Eccentric-Concentric Coupling Phase
HRmax	Heart-Rate Maximum
MHC	Myosin Heavy Chain
MD	Mean Difference
PoT	Post Test
PT	Pre Test
PmT	Plyometric Training
RFD	Rate Force Development
SECs	Series Elastic Components
SPSS	Statistical Package For Social Sciences
SSC	Stretch Shortening Cycle
SJ	Squat Jumps
WT	Weight Training
VL	VastusLateralis
VJ	Vertical Jumps

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ABSTRACT

Plyometric training has been a very popular training technique used by many coaches and training experts to improve speed, explosive power output, agility, explosive reactivity and eccentric muscle control in diffirent kinds of sports. The study was conducted to find out the effect of selected plyometric training on physical fitness variables(speed, agility and explosive power) of Ambo University Sport Science male students. For this study 40 subjects were selected by simple random sampling technique out of 87 total study population. The subjects of the study were participated in a supervised plyometric training program for 3 days (Tuesday, thrusday and Friday) per week and for twelve consecutive weeks for 60-65 minute per session. The physical fitness skill variables selected for the study were: Speed, Agility, Explosive power and their tests were 30 metre shuttle run, Illinois agility test and vertical jump test respectively. Tests were taken three times before,while and after training sessions as pre test, during test and post test respectively. Data were analysed by using SPSS software version 20. Comparison of mean was done by paired T-test. The results obtained in this study indicated that there was significant improvement in selected variables due to the intervention of selected plyometric training. After 12 weeks of selected plyometric training intervention subjects' agility (MD= 0.54), speed (MD= 0.55), and explosive power (MD= 2.75) were changed significantly ($p < 0.05$). This study proved that selected plyometric training was significantly important in improving the study variables in this manuscript.

Key words: *plyometric training, speed, agility and explosive power*

1. INTRODUCTION

This chapter describes the research background, statements of the problem, research questions, scope of the study, significance of the study, and objectives of the study respectively

1.1. Background of the Study

To any sport that requires powerful, propulsive movements, such as football, volleyball, sprinting, high jump, long jump, and basketball, the application of plyometric or explosive jump training is applicable (McArdle, Katch&Katch, 2001). Plyometrics has been a very popular training technique used by many coaches and training experts to improve speed, explosive power output, agility, explosive reactivity and eccentric muscle control during dynamic movements (Coetzee, 2007). Plyometric training (PT) has widely been used to enhance muscular power output, force production, velocity, and aid in injury prevention (Robinson, 2004; Potash & Chu, 2008). Plyometric training (PT) is popular among individuals involved in dynamic sports, and plyometric exercises such as jumping, hopping, skipping and bounding are executed with a goal to increase dynamic muscular performance (Impellizzeri, 2008).

PT has been applied in numerous studies, and there is a general consensus that it improves sport specific skills such as agility (Miller, 2006) and vertical jump performance, common measures of muscle power (Markovic, 2007). In various sport events rapid movements such as acceleration and deceleration of the body, changes of direction, as well as jumps are often performed and high level of dynamic muscular performance is required at all levels of training status. In investigations most players were recruited to demonstrate the effects of PT on muscular performance (Chimera, 2004; Ronnestad, 2008; Sedano Campo, 2009), and results are often conflicting. For example in division I female soccer players 6 weeks of PT either improved (Sedano Campo et al., 2009) or did not improve (Chimera et al., 2004) vertical jump height. In a different study male professionals were trained for 7 weeks and it was found that PT combined with strength training improved various dynamic measures, but not vertical jump performance (Ronnestad et al., 2008). Inconsistencies in studies can be attributed to several factors, such as gender, training status, methods of testing, different types of apparatus, and differences in duration, intensity, and the types of the exercises used in the training program (Markovic, 2007).

One problem with regard to the PT studies is that many times in short-term programs either low intensity (Rubley, 2011) or low impact (Miller et al., 2006) exercises are performed, or intensity is not reported at all (Miller et al., 2006; Ebben, 2010). In a study by Chimera et al. (2004) plyometric exercises with 30s duration or with 30 to 70 repetitions were performed continuously with a possibility of improperly inducing high fatigue in participants. Furthermore, mostly bilateral (two-leg) exercises were performed (Impellizzeri et al., 2008; Sedano Campo et al., 2009; Perez-Gomez, 2008; Chelly, 2010; Thomas, 2009), while including more intensive unilateral (single-leg jump) exercises into short-term PT programs may be beneficial with a goal of rapid strength gain. Makaruk et al. (2011) for example demonstrated that in untrained women unilateral jump training improved power and vertical jump height in a shorter period, compared with bilateral jump training. Though unilateral exercises have been extensively used by track and field athletes for decades in various age groups and levels to maximize sprint speed, jumping height and distance, and have also been used among recreationally trained participants in scientific investigation (Malisoux, 2006). Much less information is available on the effectiveness of PT in these individuals (Thomas et al., 2009), while improving dynamic muscular performance is also highly recommended for lower class teams to focus on. Finally, single-leg plyometric movements into lateral directions are rarely included in programs, or if included, maximum intensity was not required or at least was not reported by the authors (Miller et al., 2006).

plyometrics are training techniques used by athletes in all types of sports to increase strength and explosiveness (Chu, 1998). Plyometrics consists of a rapid stretching of a muscle (eccentric action) immediately followed by a concentric or shortening action of the same muscle and connective tissue (Baechle and Earle, 2000). PT has been applied in numerous studies, and there is a general consensus that it improves sport specific skills such as agility (Miller, 2006) and vertical jump performance, common measures of muscle power (Markovic, 2007).

1.2. Statement of the Problem

Plyometric training affects overall athlete's performance in different sport events. Plyometric training exercise has got effect on explosive power, muscular strength, speed and quickness, agility, neuromuscular coordination, vertical jump performance, leg strength, muscular power, increase joints range of motion and enhance skill performances of the athletes. Plyometric training is widely used in conditioning, power training (Roopchand- Martin and Lue-Chin, 2010).

Therefore, the present study was tried to answer the following research questions:

1. What is the effect of selected plyometric training on speed, agility and explosive power?
2. How can selected plyometric training affects the selected variables?
3. What is the significance and contribution of selected plyometric exercises in improving agility, speed and explosive power?

1.3. Scope of the Study

The scope of this study was only West Shoa Zone, Ambo University Sport Science male students to see changes on agility, speed and explosive power by the intervention of selected plyometric training for 12 consecutive weeks. This study was delimited itself and concentrated only on the selected plyometric exercises training which are specific to see the selected study variables.

1.4. Significance of the Study

To be effective and productive practically, Sport Science students are needed to be fit and good performer physically and mentally. If that so, selected plyometric training exercise would be a means and good intervention in order to come across the effect on physical fitness qualities agility, speed and explosive power**.** The main significance of this study was to investigate the effects of 12 weeks selected plyometric training on selected physical fitness variables; agility, speed and explosive power in the case of Ambo University Sport Science male students. Eventhough, plyometric training has been used for many years, to our knowledge there has been very few research done using a sport specific plyometric program sport science students (MesfinMengesh, 2014).Ambo University was the first to use from this research study but it does not mean that the outcome of this research is only restricted to Ambo University. It also helps other Ethiopian University sport science students. After the output of this research has been identified, then its used as an imput for students, teachers, coachs and other concerned individuals to be included or excluded from their training. Lastly the importance of the study is to aware all sport science students that selected plyometric training is the major strategy for affecting selected physical fitness variableseither positively or negatively.

1.5. Objectives of the Study

1.5.1. General Objective

The general objective of this study was to observe the effect of 12 weeks selected plyometric training on agility, speed and explosive power of Sport Science male students in the case of sport science department, Ambo University.

1.5.2. Specific Objectives

The specific objectives of the study were:

1. To identify the effect of plyometric training on speed, agility and explosive power on sport science male students.

2. To investigate and address the effect of plyometric training that contribute on up- agility, speed and explosive power.

3. To prove the significance and contribution of plyometric training exercises for the enhancement of speed, agility and explosive power.

2. RELATED LITERATURE REVIEW

In this chapter,origin and development of plyometric training, the physiology of plyometric training, models of plyometric training, speed, agility and explosive power has been delt.

2.1. Origin and development of plyometric training

Plyometrics is the term now applied to exercises that have their origins in Europe and were first known as 'jump training' (Chu, 1998: 1). It is widely accepted that plyometric training has its origin in the former Soviet Union as far as the early 1960's with the scientific formalisation of the training system, 'shock training' by Dr. Yuri Verkhoshansky (Siff, 2003). In the West, a certain mystique surrounded plyometrics in the early 1970's, as it was thought that plyometricswere responsible for the Eastern bloc countries' rapid competitiveness and growing supremacy in international track and field athletic events (Chu, 1998). The term, 'plyometrics', was first used in 1975 by American track and field coach, Fred Wilt (Chu, 1998). The development of the term is confusing; Plyo- is derived from the Greek word pleythein, which means to increase. Plio is the Greek word for "ore", while metric means "to measure". (Wilt, 1975 referenced in Voight, Draovitch&Tippett, 1995). Dr.Verkhoshansky preferred the term 'shock method' instead of the more widely used term of 'plyometric', to differentiate between the naturally occurring plyometric actions in sport and the formal discipline he devised as a training system to develop speed-strength (Siff, 2003). Plyometrics grew rapidly in popularity with coaches and athletes as exercise or drills focused on linking strength with speed of movement to produce power (Chu, 1998).

2.2. The physiology of plyometric training

Plyometric exercise are quick, powerful movements that enable a muscle to reach maximal force in the shortest possible time (Potash & Chu, 2008). This is achieved by using a prestretch, or countermovement, that involves the stretch-shortening cycle (SSC) (Wilk et al., 1993; Voight et al., 1995). The purpose of plyometric exercises is to increase the power of subsequent movements by using both the natural elastic components of muscle and tendon and the reflex (Potash & Chu, 2008). Peak performance in sport requires technical skill and power, where success is dependent upon the speed at which muscular force or power can be generated (Voight&Tippett, 2004). Power combines strength and speed (Radcliffe &Farentinos, 1999). It can be improved by increasing the amount of work or force that is produced by the muscle or by decreasing the amount of time required to produce force. The amount of time required to produce muscular force is an important variable for increasing power output. The training method which combines speed of movement with strength is plyometrics (Voight&Tippett, 2004). According to Coetzee (2007), plyometric training (PT), or the combination of PT with a sport-specific training programme, have acute and chronic training responses. The acute effects of plyometric programmes include a significant increase in the 1RM leg strength and the delayed onset of muscle soreness. Chronic improvements include increases in explosive power, flight time and maximal isotonic and isometric leg muscle strength, average leg muscle endurance, isokinetic peak torque of the legs and shoulder, range of ankle motion, speed and frequency of muscle stimulation. PT programmes also seem to significantly decrease ground contact time during sprinting activities and the amortization time during execution of plyometric exercises. Literature has also shown that aquatic plyometric programmes provide the same or more performance enhancement benefits than land plyometric programmes (Coetzee, 2007; Colado et al., 2010).

2. 3. Models of plyometric training

According to Coetzee (2007) and Potach and Chu (2008), the production of muscular power is best explained by three proposed models: mechanical, neurophysiological and the stretch-shortening cycle.

2.3.1. The mechanical model

The mechanical model explains that during an eccentric muscle action, elastic energy in the musculotendinous components is increased with a rapid stretch and then stored (Potach& Chu, 2008). Significant increases in concentric muscle production occur when immediately preceded by an eccentric contraction. This increase might be partly due to this storage of elastic potential energy, since the muscles are able to utilize the force produced by the series-elastic component (SEC) (Voight&Tippett, 2004). SEC in the muscle plays an important role in this model (Coetzee, 2007). Even though all components of the SEC (actin and myosin filaments and tendon) are stretched when a joint is loaded, the tendon is the main contributor to muscle-tendon unit length changes and the storage of elastic potential energy (Chmielewski, Myer, Kauffman & Tillman, 2006). To maximize the power output of the muscle, the eccentric muscle action must be followed immediately by a concentric muscle action (Radcliffe &Farentinos, 1999; Potach& Chu, 2008). If a concentric muscle action does not occur, or if the eccentric phase is too long or requires too great a motion about the given joint, the stored elastic energy is lost as heat, and stretch reflex is not activated (Voight&Tippett, 2004; Potach& Chu, 2008). For example, greater vertical jump height has been attained when the movement was preceded by a countermovement as opposed to a static jump (Voight&Tippett, 2004).

2.3.2. The neurophysiological model

The neurophysiological model involves the potentiation (force-velocity characteristics of the contractile components change with a stretch) of the concentric muscle action by use of the myotatic or stretch reflex. The stretch reflex is the body's involuntary response to an external stimulus that stretches the muscle (Potash & Chu, 2008). Muscle spindles are amongst the special receptors that play a permanent role in the appearance of the myostatic stretch reflex. These proprioceptive organs are sensitive to the rate and magnitude of a stretch (McArdle et al., 2001). During plyometric exercise, or when the muscle is rapidly stretched, the stimulated muscle spindles cause a reflexive muscle action. The more rapidly the load is applied to the muscle, the greater the firing frequency of the spindle and resultant reflexive muscle contraction (Voight&Tippett, 2004). This reflexive response increases the activity of the agonist muscle, and increases the amount of force for the resultant concentric muscle action (Potash & Chu, 2008). The rapid lengthening phase in the stretch-shortening cycle produces a more powerful subsequent movement. This is due to a higher active muscle state (greater potential energy) being reached before the concentric, shortening action, and the stretch-induced evocation of segmental reflexes that potentiate subsequent muscle activation (McArdle et al., 2001).

2.3.3. Stretch-shortening cycle model

The repeated sequence of eccentric (lengthening) contractions followed by a concentric, explosive, powerful muscular contraction is known as the stretch- shortening cycle (SSC) (Komi, 2003). The SSC uses the energy-storing capacity, the SEC and stimulation of the stretch reflex to facilitate a maximal increase in muscle recruitment over a minimal amount of time (Potach& Chu, 2008). An effective SSC can only be achieved if the following basic conditions are met: first, a timed preactivation of the muscles before the eccentric phase occurs; secondly, a short and fast eccentric phase; and finally, an immediate transition (minimal delay) from the eccentric to the concentric phase (Komi, 2003).

The SSC involves three distinct phases: the eccentric or loading phase, amortization or coupling phase, and the concentric or unloading phase. Phase One, the eccentric phase, involves preloading the agonist muscle group(s). Eccentric loading will place load upon the elastic components of the muscle fibers(Voight&Tippett, 2004). The SEC stores elastic energy and muscle spindles are stimulated. As the muscle spindles are stretched, they send a signal to the ventral root of the spinal cord via the Type 1a afferent nerve fibers. Phase Two, the amortization phase, is the electromechanical delay between the first (eccentric) phase and third (concentric) phase where alpha motor neurons then transmit signals to the agonist muscle group. Muscles must switch from overcoming work to acceleration in the opposite direction. The shorter the amortization phase, the greater the amount of force production (Voight&Tippett, 2004; Potach& Chu, 2008). Phase Three, the concentric phase, is the body's response to the eccentric and amortization phases. When the alpha neurons stimulate the agonist muscles, they produce a reflexive concentric muscle action (Potach& Chu, 2008). Most of the force that is produced comes from the fiber filaments sliding over each other (Voight&Tippett, 2004). The stored elastic energy in the SEC during the eccentric phase is used to increase the force of the subsequent isolated concentric muscle action (Potach& Chu, 2008). Plyometric exercises stimulate proprioceptive feedback to fine-tune for specific muscle-activation patterns. These exercises utilize the SSC, train the neuromuscular system by exposing it to increased strength loads and improve the stretch reflex (Wilk et al., 1993). Increased speed of the stretch reflex and increased intensity of the subsequent muscle contraction will amount to better recruitment of additional motor- units. The force-velocity relationship postulates that the faster a muscle is loaded or lengthened eccentrically, the greater the resultant force output will be (Voight&Tippett, 2004).

2.4. Speed

Speed is a quality that is always in high demand in sports. A major aspect of the job of strength and conditioning coach is the development and enhancement of the speed of players (Cissik, 2004; Young & Pryor, 2001). Kreighbaum and Barthels (1996) define speed as how fast a body is moving or the distance that is covered divided by the time it takes to cover that distance. From a biomechanical perspective speed is only a state of motion without regards to the direction. In order to be most accurate in terms of a sport setting, this project is concerned with velocity. Velocity encompasses both the speed and the direction that a body is moving (Kreighbaum&Barthels, 1996). Drawing a distinction between speed and velocity is important in the sports setting because it is important for athletes to move in the right direction on the playing field to ensure that the speed is useful in the sport.

2.4.1. The Components of Speed

There are two main factors in running speed, stride length and stride frequency (Cissik, 2004; Cissik, 2005; Lee &Ferrigno, 2005). For every athlete there is a unique balance between these two factors that will allow the athlete to run at the fastest speed possible. When training for speed development, a strength and conditioning coach attempts to manipulate stride length and frequency to develop an athlete's greatest speed potential. Stride frequency is the number of steps an athlete takes per minute or the number of strides taken over a certain distance. Stride length relates to the distance an athlete covers in one stride length, from the center of mass (Lee &Ferrigno, 2005). Optimal stride length at maximum speed is normally 2.3 to 2.5 times an athlete's leg length (Lee &Ferrigno, 2005). Optimal stride length is important because many athletes will over stride, and this leads to less force production (Baechle& Earle, 2000). There is a braking action of the legs which greatly decreases the rate of force production into the ground for forward propulsion. Athletes typically develop their optimal stride length through proper coaching of technique and improvements in strength and power, (Lee &Ferrigno, 2005).

2.4.2. Running Terms and Definitions

Running is not a single movement, but is a sequence of movements that make human locomotion and high speeds possible (Blazevich, 2000; Cissik, 2004). In order for there to be a thorough understanding of speed, there needs to be an explanation of the different components or phases that occur in an athlete when running. The first phase in running is the swing phase. During the swing phase hip extension occurs which allows the foot to be contacting the ground and thus being able to apply force backwards into the ground to propel the athlete forward (Blazevich, 2000). The athlete drives the foot down to the ground by the hip extensors. The ankle is undergoing dorsiflexion with the big toe pointed up towards the knee; this position allows for more storage of elastic energy to help maximize propulsion (Cissik, 2004). The second phase in running is the recovery phase. During this phase hip flexion occurs which brings the leg forward and prepares it for the next swing phase (Blazevich, 2000). When the foot leaves the ground, the athlete dorsiflexes the ankle and flexes the knee and quickly brings the heel up towards the hips. As the heel is recovered, the leg will begin to swing forward. The athlete's arms are swung in opposition to the legs to maintain balance and provide additional forward momentum (Cissik, 2004). There are a few other terms that are important in running. Foot-ground contact refers to the time at which the foot is striking the ground during running (Blazevich, 2000). The support leg is the leg that is striking the ground, which means it is supporting the body (Blazevich, 2000).

2.4.3. The Basic Speed Model

When looking at speed, there are two distinct phases that strength and conditioning coach may train in different ways. The first phase of the basic model is the acceleration phase. Acceleration involves a particular mechanics that involve a falling and recovery action with each movement affected by the previous movement (McFarlane, 1993). Within the acceleration phase there are two subphases, the pure acceleration phase and the transition phase. The pure acceleration phase is approximately the first meters of the run while the athlete is gaining speed. The transition phase last from 15-30 meters. During the transition phase the running mechanics change from a falling and recovery type of action to a more upright posture with a longer leg cycle. Maximum velocity phase runs from 30 meters up to 60 meters approximately where the athlete is moving at their fastest speed possible.

2.4.4. Training for Running Speed

The components of running speed are stride length and stride frequency. In order to increase speed, the strength and conditioning coach must learn to alter the components of speed to reach the maximum speed possible. First, the different training for stride frequency methods will be explained. Stride frequency is trained in a number of ways. First, an increase in overall body strength tends to evoke greater rates of stride frequency. The increase in muscular force capacity allows an athlete to recover their legs more quickly and thus have higher rate of leg turnover. Another way to increase stride frequency is sound running technique. Sound running technique allows for efficient movements which means higher rate of turnover and thus more contacts with the ground (Blazevich, 2000, Cissik, 2004, McFarlane, 1993). Increasing the number of contacts with the ground is important because that is the only time that the athlete is then, and only then, producing locomotive energy (Lee &Ferrigno, 2005). The over speed training allows athletes to learn to relax while running at a speed that is faster than their normal, unassisted speed (Cissik, 2005, Lee

&Ferrigno, 2005). One point of caution in order to avoid injury is to ensure that athletes are very familiar with proper technique and are adequately warmed up (Baechle& Earle, 2000, Lee &Ferrigno, 2005). The other variable that a coach can manipulate to improve speed is to increase stride length. Once again, an increase in overall body strength will correspond with an increase in stride length (Klinzing, 1992, p. 49). By being stronger an athlete is able to apply more force to the ground and reduce ground contact time (Blazevich, 2000). An increase application of force to the ground means that the athlete can travel further per stride. Proper sprinting technique is important when striving to improve stride length as well. Proper mechanics ensures that maximum force is directed into the ground and translated into horizontal distance. Within proper technique, there are three main components: posture, arm action, and leg action. Posture relates to the lean of the body during the run and how it changes through the different phases of running. The acceleration phase will create more forward body lean because of the need for the athlete to overcome the body's inertia. Body lean is usually around 45 degrees in acceleration but will straighten out to about 80 degrees as top speed is reached (Baechle& Earle, 2000).

A key evaluative tool for determining good running posture is to be able to draw a straight line from the ankle of the support leg through the knee, hip, torso, and head when the leg is fully extended (Lee &Ferrigno, 2005). The arm action component of running technique refers to the velocity and range of motion of the athlete's arms. The hands should be loose and the arms should swing at the shoulder with a ninety degree bend at the elbow. The hand should move from shoulder height to slightly behind the hips (Klinzing, 1992). The arm swing helps to counteract the rotational forces that the athlete can generate with their legs. The leg forces are immense, and thus vigorous and coordinated arm movements are absolutely necessary to keep the body in proper alignment. While arm movement is important in all phases of running, it is of critical importance in the initial acceleration phase (Lee &Ferrigno, 2005). The leg action component of running technique looks at the relationship between the hips and legs relative to the torso and the ground. In order to create the most force into the ground to accelerate and run at maximum velocity, there needs to be a coordinated extension of the hip, knee, and ankle. Additionally there needs to be proper recovery mechanics to ensure that optimal stride frequency and stride length are being achieved (Lee &Ferrigno, 2005). Strength training for stride length improvements can occur through a number of mediums. Classic strength training is probably the most common form of training for improved stride length (Sheppard, 2003), but the use of weighted pants and vests, parachutes and harnesses, and uphill running all provide resistance to build strength and foot contact power (Cissik, 2005; Lee &Ferrigno, 2003; McFarlane, 1993; Zatsiorsky, 2006). There is some caution to resisted run training because too heavy of loads can impair good running mechanics, which would hinder the goal of speed development (Baechle& Earle, 2000; Lee &Ferrigno, 2005).

2.4.5. Coaching and Training Speed Mechanics

There are a variety of modalities that strength and conditioning coaches use to train for speed development. Strength training is extremely popular in the strength and conditioning field for improving speed. Exercise selection is particularly important from a specificity standpoint because the lifts should have similar mechanical components as actual sprinting (Zatsiorsky, 2006, p. 112). Once again however, there needs to be a distinction between lifting for improved acceleration and lifting for improved maximum velocity. The overlying principle in choosing lifts based on their mechanical properties is that there will be increased synchronization of the peripheral nervous system, improved gross coordination, and increased training of the proprioceptive stabilizing mechanisms (Sheppard, 2003; Zatsiorsky, 2006).

When examining training for acceleration there are a few key components of the movement that need to be addressed. Sheppard (2003) explains that, "During acceleration athletes tend to be moving forward and upward in the sagittal plane with a low center of gravity, with the center of mass ahead of the legs (forward lean)" (p.28). The resulting body position means that the knee joint angle is in a higher degree of flexion compared with the joint angle during the maximum velocity phase (Sheppard, 2003). Lifts that mimic the appropriate joint angles are (Sheppard, 2003; Zatsiorsky, 2003 Muscle groups that are overlooked in acceleration are the hip extensors that provide the explosiveness out of the lower position. Exercises that are selected should involve high levels of force being generated in the lower extremity, but the load is supported through the torso with the spinal extensors (Sheppard, 2003). Some examples of appropriate exercises are the (Sheppard, 2003; Zatsiorsky, 2006).Running is a total body movement and that means the upper body must be strong as well. Sheppard (2003) points out that the chest, shoulders, and upper back muscles play a role in creating propulsive forces upward and forward to help generate lift along with forward momentum.

Sheppard (2003) suggests that exercises such as the close-grip bench press and some pulling movements may decrease the time it takes for an athlete to make his or her initial step. The mechanics used in maximum velocity area of top speed have significant differences when compared to the mechanics used during acceleration. The pumping action of the arms helps to create lift while the back extensors, hip extensors, and plantar flexors provide leg-extension forces. The hip flexor muscles drive the leg up and forward to create the reaching with the leg during each stride. Zatsiorsky (2006) suggests that selecting lifts that allow strength to develop at the weakest points of an athlete's strength curve will yield the best results.

Additionally, using the proper body position to most closely reflect the demands of the athletic movement is important to ensure that the strength that is being developed is specific to an athlete's needs (Zatsiorsky, 2006). Coaches should select lifts that focus on extension and flexion at the hips for the greatest specificity (Sheppard, 2003). Some lifts to consider are (Sheppard, 2003; Zatsiorsky, 2006): Strength training is an important component of any speed program and will be a large determinant of the success of the Cal Poly athletes. However, plyometrics and jump training have become increasingly popular in recent year and therefore it is imperative that this training modality be addressed in this project. Leaders in USA Weightlifting suggest that plyometrics have a high carryover to starting and acceleration during sprinting. Also, they suggest that plyometrics can improve cutting maneuvers, lateral quickness, and many other sports skills where explosiveness and changes in direction are necessary (USA Weightlifting, 2003).

Plyometrics are defined as, "a quick, powerful movement that involves the stretch-shortening cycle" (Baechle& Earle, 2000, p. 428). The purpose of plyometric exercises is to increase the power of these quick and powerful movements by enhancing the natural elastic components of the muscle tendon complex, as well as the stretch reflex (Baechle& Earle, 2000; Zatsiorsky, 2006). Plyometric training is similar to any other kind of resistance training in that it involves a periodization of intensities from low to high as athletes improve their performance and ability (Baechle& Earle, 2000; Zatsiorsky, 2006). Just as loads, frequency, and intensity varies with resistance training, so does plyometric training. Many of the plyometric movements that strength and conditioning staff use in the summer programs of Cal Poly athletes will be complexed. Complexed means that the plyometric exercise will follow an exercise or be part of a superset for a particular exercise.

Complexing is not as common because often it is better to perform plyometrics as a single workout for a day (Baechle& Earle, 2000, p. 436), but due to time and staff constraints a complex system is more effective and efficient. Resistance training and plyometrics will be an important part of the speed development program for Cal Poly. While strength training does play an important role in the development of speed, there are some other coaching points related to how to conduct speed training sessions that need to emphasis. The following list of guidelines is useful in designing and

2.5 Agility

Agility is often defined as “a rapid whole-body movement with change of velocity or direction in response to a stimulus” (Sheppard and Young, 2006). This can take many forms, from simple footwork actions to moving the entire body in the opposite direction while running at a high speed. Thus, agility has a speed component, but it is not the most important component of this ability. The basic definition of agility is too simplistic, as it is now thought to be much more complex and involving not only speed, but also balance, coordination and the ability to react to a change of the environment (Plisk, 2008). Furthermore, acceleration and deceleration involved in the change of direction movements, which in turn underpin agility performance, are therefore specific qualities and should be trained as such (Jeffreys, 2006). Sheppard and Young (2006) also claim that agility represents an independent physical ability and therefore, its development requires a high degree of neuro-muscular specificity. Perceptual components, which form their fundament and include the anticipation and decision-making processes, also play an important role in their development (Young et al., 2002). However, when testing agility, one has to take into consideration sudden changes of direction of movement, accelerations and fast stops. Specifically, agility in team sports does not comprise only the ability of changing the direction of movement, but also the capability to anticipate the movement of the opponent, read and react to specific game situations (Sheppard and Young, 2006).

The literature search revealed nine studies that examined PT effects on agility performance (Arazi et al., 2012; Asadi, 2013; Váczi et al., 2013; Ramirez-Campillo, 2013; Ramirez-Campillo et al., 2014, 2015a; Meylan and Malatesta, 2009; Michailidis et al., 2013; Sohnlein et al., 2014). In addition, the data obtained in the present review show that there was a significant increase in agility performance in elite and amateur team sport players following

PT. Particularly, the data show that PT with 2 sessions per week have more beneficial effects over 8-12 weeks compared to shorter duration training programs (>8 weeks) in amateur players. Moreover, the combination of unilateral and bilateral jump drills seems more advantageous in improving agility performance than bilateral jump drills alone. Another aspect is that an aquatic based plyometric training program provided similar or more improvements in agility of young players than the land-based plyometric training program of the same duration. Considering that T-agility and Illinois agility tests require ~11 and ~14 s to be completed, respectively, during these tests not only the ATP-PC system, but the glycolytic energy system is also used. The latter could be the reason why improvements were smaller compared with the agility tests that require less time for execution. Overall, improvements in agility after PT can be attributed to neural adaptation, specifically to increased intermuscular coordination (Markovic and Mikulic, 2010).

The term agility can have many different definitions. Some consider agility is the ability to change direction, while others consider it is the ability to react to a stimulus in the appropriate fashion. For the purpose of this paper agility will be defined as “the ability to maintain and control correct body position while quickly changing direction through a series of movements” (Yap, Brown, & Woodman, 2000, p. 10).

2.5.1 Agility Technique

Not unlike linear running, there are technical elements to agility skills that make the skill more or less effective. Young & Farrow (2006) point out that there are technique recommendations in coaching literature, but there is little or biomechanical research that relates to the best technique used for maximizing speed during change of direction. Due to the lack of research on optimal agility technique, there will be a brief discussion of body position and how it influences the ability to change direction. In running, a forward lean is required for acceleration, while a backwards lean is required for braking. A sideward lean will produce a lateral change of direction. The change in body positions causes changes in the direction of forces being directed into the ground and this in turn allows the necessary change in direction of the athlete (Young & Farrow, 2006). Brown and Vescovi (2003) have suggested some basic of mechanics for agility. They said that the arm movements can be great contributors to the efficiency of agility movements. They also provided a step-by-step sequence of change of direction movement that is simplified, but does help to illustrate the role the arms play: To begin the change of direction the head is first rotated to face the new direction. From this point the inside arm (e.g. if an athlete plants on the right foot to cut to his or her left, the left arm becomes the inside arm) pulls in a backward direction (shoulder hyper-extension) as the outside (right) arm moves forward (shoulder flexion). This contralateral movement of the arms assists rotation of the body on the longitudinal axisand thus will help channel the movement in the new direction. Arm actions that are too far away from the body will create more resistive forces for the body to overcome and result in lower velocity of movements (as the force-velocity relationship illustrates) (p. 7). As Brown and Vescovi (2003) point out, the arm movement of an athlete can be very critical to influencing proper body mechanics and thus they recommend rapid, compact arm movements be taught and coached in order to maximize change of direction speed.

2.5.2 Agility Movements

Ian Jeffreys (October 2006) proposes a unique approach to examining and classifying the skill of agility. In the mind of Jeffreys, agility is a serial skill that has different parts and designed to achieve certain objectives that will then correlate to the execution of a skill. The first series of movements that Jeffreys identifies are the initiation movements. Jeffrey's describes initiation movements as being aimed to initiate or change movement. Initiation movements normally involve short, rapid movements that allow athletes to either start or change direction (Jeffreys, October 2006). Typical initiation movements seen in athletics can include cross-steps, first-step starts, dropsteps, and cut steps (Jeffreys, October 2006). The second classifications of movements are the transition movements. The main concern for an athlete in transition movements is keeping themselves in such a position that they are able to read and react to a stimulus. The aim of the transition movement is often focused on body position to create the optimal position for rapid reaction as opposed to being focused on maintaining maximal speed. Typical transition movements include backpedals, sideshuffles, and chop steps, and all of these are seldom done for long distances (Jeffreys, October 2006). The final classes of movements are the actualization movements. In the actualization phase of the movement the athlete will have perceived a stimulus and respond by either moving to a point in play or executing a sport skill. The actualization movements typically decide the success of the sequence in performing the skill (Jeffreys, October 2006).

2.5.3 Agility and the Central Nervous System

In order for agility skills to be the most effective, it has to become an almost automatic response to a stimulus. Brown and Ferrigno (2003) suggest that agility training may be the most effective way to elicit game-like neuromuscular demands. Agility training can resemble actual competition through intensity, duration, and recovery time (Brown &Ferrigno, 2003). To illustrate this automatic response characteristic, a brief explanation of the central nervous system (CNS) and how it functions in agility follows. When an athlete decides on a movement pattern, the CNS will determine which muscles are needed and how they are to be sequenced to properly execute the movement. Once a basic pattern is developed and put in place the CNS can then begin to make refinements and adjustments by changing the number of fibers in each muscle being used as well as the frequency with which muscles are turned on. By practicing a skill more and more times, the CNS becomes more and more refined at that movement. Improvements in the movement will cease when the feedback of the movement and the intent of the movement are in synch (Craig, 2004). A problem that occurs with agility training is the idea of anticipation. By knowing the movement pattern ahead of time the athlete can increase the synchronization of movement because of the time to plan. Therefore, it can be more effective if agility drills require responses to commands and thus removes the ability to anticipate and the CNS can become more effective at coordinating the signal and the feedback (Craig, 2004). Young and Farrow (2006) say that there is considerable research that indicates better athletes are able to produce more accurate and faster responses because of an enhanced ability to pick up anticipatory information. Typically the information an athlete needs to make decisions comes from the presence of an opponent. Young and Farrow (2006) also suggest that a training stimulus needs to be as sport-specific as possible in order to allow the athletes to use their perceptual and anticipatory skills to their advantage. The practice of planned versus unplanned movements has also gained some attention in recent years. It is not uncommon to see athletes who are great with on-field agility, but test poorly in agility fitness tests. Young and Farrow (2006) cite a study by Besier et al. that showed that unplanned movements produced greater loads on the knee joint in a cutting movement. Therefore it could be of crucial importance to include unplanned agility training to not only enhance performance, but also reduce the risk of injury.

2.5.4 Training for Agility

There is no single technique that is accepted as the best possible way to execute agility drills and skills. However, there are some recommended components that are considered fundamental for performing changes of direction in the most effective manner. The first component is visual focus. Ideally the athlete's head will be in a neutral position with the eyes looking straight ahead regardless of the movement be executed. There are exceptions to the forward head position, such as the athlete focusing on another athlete or an object. Additionally, the head should be turned and a new focus point should be found to initiate any changes in direction (Brown &Ferrigino, 2003). The second component goes back to the arm action. In order for changes in direction to be performed the fastest possible, then powerful arm movements are needed during transitions and directional changes. The arm movement is extremely important in reaccelerating to a high rate of speed after a maneuver is made. Inadequate or incorrect arm movements can result in a loss of not only speed, but also of efficiency (Brown &Ferrigno, 2003). The last component that Brown and Ferrigno addressed in agility training is recovery time. In order for the drills to be the most effective and realistic to actual competitive settings, the work to rest ratio needs to be consistent with that of the athlete's sport. This ensures adaptations are occurring that will change the appropriate energy systems and therefore make for gains that are truly sport specific.

2.5.5 Agility Strategies

There are two primary strategies or skill sets that are covered in agility training. The first strategy involves running curves. Some sports have more curve patterns in their sports such as running the bases in baseball or softball. Running curves tends to be an easier skill because the change in direction is less abrupt. The downside to curves is that they tend to be performed slower and thus the change in direction takes longer. The second strategy is called making a cut. A cut is an abrupt change in direction. Cutting tends to be faster, but there is a higher level of complexity associated with performing it. This increased speed in cutting increases the potential for injury purely because of the increased speed and forces at work (Cissik, 2007). Coaching Guidelines for Agility Coaching any skill is highly based on the skill level of the athlete. In order to be most effective in providing feedback, it is imperative that coaches understand what type of feedback is most appropriate. Jeffreys (December, 2006) proposes a pyramid model. The pyramid has a foundation level at the bottom, followed by a development level, and finally at the top is the peak level. The foundation level focuses on developing the fundamental target movement patterns for the skill or sport. Typically, the tasks are novel in nature and the greatest challenge is in conveying the general idea of the skill. The foundation level is the most important level of development because a well learned foundation will correspond to better transfer to the more advanced levels.

2.6 Explosive leg power

'Plyometric training'' is a colloquial term used to describe quick, powerful movements using a pre-stretch, or countermovement, that involves the SSC (Potach& Chu, 2008). Plyometric training (PT) is a common modality to enhance lower-extremity strength, power and stretch-shortening cycle (SSC) muscle function in healthy individuals (Markovic&Mikulic, 2010). The ability to produce force rapidly is vital to athletic performance. Increases in power output are likely to contribute to improvements in athletic performance (Potteiger et al., 1999). The transfer of these plyometric effects for athletic performance is most likely dependent upon the specificity of the plyometric exercises performed. Specific plyometric exercises can be used to train the slow or fast SSC. Examples of slow SSC plyometrics include vertical jumps and box jumps. Bounding, repeated hurdle hops, and depth jumps, typically, are regarded as fast SSC movement (Flanagan &Comyns, 2008). Athletes who require power for moving in the horizontal plane (e.g. sprinters and long jumpers) mainly engage in bounding plyometric exercises, as opposed to high jumpers, basketball or volleyball players who require power to be exerted in a vertical direction and who perform mainly vertical jump (VJ) exercises (Markovic&Mikulic, 2010). These training adaptations are in accordance with the principle of specificity (McArdle et al., 2001). In the literature appropriate plyometric training programmes have been shown to increase power output (Luebbers et al., 2003), agility (Miller, Herniman, Ricard, Cheatham & Michael, 2006), running velocity (Kotzamandisis, 2006), and also running economy (Turner, Owings &Schwane, 2003).

2.6.1 Neuromuscular changes for power development

Current literature suggests that plyometric training (PT), either alone or in combination with other typical training modalities (e.g. weight training [WT] or electromyostimulation), elicits many positive changes in the neural and musculoskeletal systems, muscle function and athletic performance of healthy individuals (Markovic&Mikulic, 2010). Markovic and

Mikulic (2010: 860) summarized as follows: “the adaptive changes in neuromuscular function due to PT are likely to be the result of: (I) an increased neural drive to the agonist muscles; (II) changes in the muscle activation strategies (i.e. improved intermuscular coordination); (III) changes in the mechanical characteristics of the muscle-tendon comple of plantar flexors; (IV) changes in muscle size and/or architecture; and (V) changes in single-fiber mechanics”. Potteiger et al. (1999) showed that a plyometric training (PT) programme could bring about significant increases in leg extensor muscle power and whole muscle fiber hypertrophy. In an eight-week, threes day per week plyometric and aerobic exercise programme, changes in muscle power output and fiber characteristics following this intervention were examined. A group of 19-physically active men aged 21.3 ± 1.8 years were randomly selected to either a plyometric-group or combination-group of PT and aerobic exercise. The PT consisted of vertical jumps (VJ), bounding, and 40- centimetres (cm) depth jumps. The aerobic exercise was performed at 70 percent (%) heart-rate maximum (HRmax) for 20-minutes immediately following the plyometric workouts. Muscle biopsy specimens were taken from the vastuslateralis (VL) muscle before and after training. Type I (slow twitch) and Type II (fast twitch) muscle fibers were identified and cross-sectional areas (CSA) calculated. Peak and average muscle power output were measured using countermovement vertical jump (CMJ). No significant differences were found between the groups following training for either peak or average power. Both groups displayed significant increases from pre-testing to post-testing for both peak and average leg extensor muscle power. The plyometric-group increased by 2.8% and 5.5%, for peak power and average power, respectively. The combination-group increased by 2.5% in peak power and 4.8% average power, respectively .VJ height improved in each group from pre-training to post-training. The plyometric-group increased peak power and average power by 2.8% and 5.5%, respectively. Each group demonstrated a significant increase in muscle fiber CSA from pre-training to post-training for Type I (plyometric- group, 4.4%; combination-group 2, 6.1%) and Type II (plyometric-group 7.8%; combination-group 2, 6.8%) fibers, with no differences between the groups. The improved CMJ and increased power output following the PT were most likely due to a combination of the enhanced motor unit recruitment patterns and increased muscle fiber CSA, caused by fiber hypertrophy in both slow twitch and fast twitch fibers.

Malisoux et al. (2006a), on the other hand, focused on the contractile properties of single fibers of VL muscle of recreationally active men (n= 8; age: 23 ± 1 year). After eight weeks of PT induced significant increases in peak force and maximal shortening velocity in the myosin heavy chain (MHC) isoforms Type I, IIa and hybrid IIa/IIxfibers, while peak powe

increased significantly in all fiber types. PT significantly increased maximal leg extensor muscle force, and VJ performance was also improved 12% ($p<0.01$) and 13% ($p<0.001$), respectively. Peak force increased 19% in Type I ($p<0.01$), 15% in Type IIa ($p<0.001$), and 16% in Type IIa/IIxfibers ($p<0.001$). Maximal shortening velocity increased 18, 29, and 22% in Type I, IIa, and hybrid IIa/IIxfibers, respectively ($p<0.001$). Single-fiber CSA increased 23% in Type I ($p <0.01$), 22% in Type IIa ($p<0.001$), and 30% in Type IIa/IIxfibers ($p<0.001$), in VL muscle following the PT-intervention.

Potteiger et al. (1999) also reported significant increases in Type I and type II fiber CSA of the VL muscle, but these effects were of lesser magnitude (6–8%). Malisouxet al. (2006b) also found a significant increase in the proportion of type IIafibers of the VL muscle. In contrast, Potteiger et al. (1999) did not observe any significant changes in fiber-type composition of the VL muscles. Contradictory to the above research, Kyröläinen et al. (2005) found that 15-weeks of maximal-effort PT performed by recreationally active men (n=23; age 24 ± 4 years) showed no significant changes in muscle fiber type or size. Plantar flexor strength did improve with significant increases in muscle activity, but not the rate of force development (RFD) and without any changes in either the muscle fiber distributions or CSA. Although no changes were found in the maximal strength or muscle activation for knee extensor muscles, the enhancements in jumping performance were due to improved joint control and increased RFD at the knee joint. In contrast, Kubo et al. (2007) showed in a 12-week comparative study of PT and WT upon untrained male participants (n=10; age: 22 ± 2 years), PT induced changes in the strength of plantar flexors, but not in that of the knee extensors. Plantar flexors showed significant hypertrophy and significant increases in maximal voluntary contraction with increased muscular activation. Studies that showed significant changes in a single fiber function (Malisoux et al., 2006a; 2006b) due to PT were also accompanied by significant improvements in the whole muscle strength and power. The noteworthy results of Malisoux et al. (2006a) suggest that PT-induced improvements in muscle function and athletic performance could be partly explained by changes in the contractile apparatus of the muscle fibers, at least in the knee extensor muscles.

Plyometric training (PT) exercises require a high level of eccentric force to stabilize and control the knee and hip joint. A high level of concentric quadriceps and hamstring muscle force development is also needed for perpetuation and momentum during PT movements.

To determine the effect of PT on the knee extensor and flexor muscles, Wilkerson et al. (2004) studied the neuromuscular changes in 19-university women basketball players (age: 19 ± 1.4 years). A six-week plyometric jump training programme was completed as part of their pre-season conditioning. Concentric isokinetic peak torque of the hamstrings and quadriceps were measured before and after the intervention at 60º·s-1 and 300º·s-1. The experimental group (n=11) completed stretching, isotonic WT and structured PT under the supervision of the researcher. The control-group (n=8) also participated in stretching, isotonic WT and a periodic performance of unstructured PT under the supervision of the team's basketball coaches. Data was also collected from the quadriceps and hamstring muscles during a forward lunge test, called the unilateral step-down test. Results showed a significant increase for hamstrings' peak torque at 60º·s-1 (p=0.008)

In the experimental group, while only three of the eight participants in the control-group showed an increase. The hamstrings did not show a significant increase at 300º·s-1 for the experimental group. There were no significant increases in quadriceps muscle torque at either 60º·s-1 and 300º·s-1 isokinetic test velocities. Therefore, PT increased the performance capabilities of the hamstring muscles, but not the quadriceps muscles. An improvement in the hamstring muscle strength stabilizes and controls the eccentric movement through the hip and knee whilst the body is in motion.

In the above literature, PT induced significant improvements in neuromuscular function for power development. PT appears to enhance motor unit recruitment patterns, with increases in muscle fiber hypertrophy for optimal maximal power output. PT significantly increased maximal leg extensor muscle force, with improved CMJ performance and increased RFD at the knee joint in recreationally active males. These changes were accompanied with increased muscle fiber CSA in whole muscle and in single fiber studies. PT has also significantly improved maximal shortening velocities of leg extensor muscles. Plyometric exercises can too optimize performance and assist with injury prevention by improving hamstring strength, eccentric control and stability of the pelvis and knee.

2.6.2 Vertical jumping performance

A critical physical attribute and key component for successful performance in many athletic events is explosive leg power. An excellent example of this is vertical jumping ability, athere is a strong association between increased lower body power and vertical jump (VJ) height (Potteiger et al., 1999). Some studies have shown that plyometrics training (PT) has improved VJ performance (Kubo et al., 2007; Markovic, Jukic, Milanovic&Metikos, 2007b; Thomas, French & Hayes, 2009), whereas other studies have not found any significant improvements (Sáez-Sáez De Villarreal, Gonzalez-Badillo&Izquierdo, 2008; Vescovi, Canavan&Hasson, 2008). The absence of such significant findings may be due to the difference in training programmes in terms of intensity or volume, and possibly that the training programme was not specifically designed to improve power and enhance performance. There is also the possibility that the VJ test was not sensitive enough to detect small but significant changes in power.

According to two meta-analysis studies into whether plyometric training improves VJ (Sáez-Sáez De Villarreal, Kellis, Kraemer &Zquierdo, 2009; Markovic, 2007a), and a review of physiological adaptations for PT (Markovic&Mikulic, 2010): VJ performance can be assessed using all four types of standard vertical jumps such as squat jumps (SJ), countermovement jumps (CMJ), CMJ with the arm swing (CMJA) and depth jumps (DJ). Markovic (2007a: 355) summarized: “PT provided both statistically significant and practically relevant improvement in VJ height with the collective mean effect ranging from: 4.7% for both SJ and DJ, over 7.5% for CMJA, to 8.7% for CMJ”. However in a more recent review, Markovic&Mikulic (2010: 876, 880) concluded: “PT considerably improved VJ height; upon a collective mean effect ranging from: 6.9% (range, -3.5% to +32.5%) for CMJA, over +8.1% (range, -3.7% to +39.3%) for SJ, and 9.9% (range, -0.3% to +19.3%) for CMJ, to 13.4% (range, -1.4% to +32.4%) for DJ”. The relative effects of PT are likely to be higher in fast SSC VJ (DJ) than in slow SSC VJ (CMJ and CMJA) and concentric-only VJ (SJ) (Gehri et al., 1998; Markovic&Mikulic, 2010). The landmark study by Wilson, Newton, Murphy and Humphries (1993) suggested that PT was more effective in improving VJ performance in fast SSC jumps as it enhances the ability of participants to use neural, chemo-mechanical and elastic benefits of the SSC. PT can enhance both slow and fast SSC muscle function, but these effects are specific to the type of SSC exercise used in training (Markovic&Mikulic, 2010). It was therefore more beneficial to combine different types of plyometrics than to use only one form, whereas the best combination was SJs + CMJs + DJs (Gehri et al., 1998; Sáez-Sáez De Villarreal et al., 2009). The above literature demonstrated that PT could induce significant improvements in VJ. Vertical power was significantly improved using a plyometric intervention of both DJ and CMJ plyometrics exercises. DJ training appeared to be more effective as it more closely approximated sport-specific jumping, with a greater application to sport than SJ or simple CMJ, due to neuromuscular specificity. Furthermore it would be more beneficial to combine different types of plyometrics than to use only one form, whereas the best combination was SJs + CMJs + DJs. Additionally, utilizing combination training of PT and WT could exhibit significantly better VJ performances than with PT or WT alone upon VJ height, jumping mechanical power, and flight time.

2.7. Principles of Training

Training Principles are essential for coaches and athletes who wish to gain the most from their training and avoid the “hit or miss” approach often used by less “principled” trainers.There are many different schools of thought, each with their own ideas on how to train athletes in order to increase athletic performance. So how does one know which particular program will work for any given athlete? The Training Principles are a group of components that have been scientifically proven to increase performance. They can guide coaches in ensuring that their athletes get the maximum benefits from their training regime.

2.7. 1. Overload Principle

The first principle is known as the Overload Principle, which is summed up in the following quote: “For any fitness component to improve, it must be overloaded. To obtain optimal improvement and prevent injury, overload must be individualized and progressive” (Hodge, Sleivert, McKenzie 1996). Most athletes can relate to this principle in an anecdotal fashion. They are aware that if they don’t push themselves a little bit harder in training, they won’t see any performance improvements in their chosen discipline.

The Adaptation Principle is important here because the body adjusts to this training by eliciting a number of responses to meet the requirement of the increased workload it has to do. These adaptations vary according to the type of training performed. For example, endurance training can increase blood volume, oxygen transport in the blood, and capillary density in the trained muscles (Reaburn and Jenkins 1996). Resistance training may lead to adaptations including increases in muscle fibre size, lean body mass, ligament and tendon strength, and enzyme activity of creatine phosphokinase and myokinase (McArdle, Katch, and Katch 2001).

This is why progressive overload is necessary. By continually increasing the amount of overload, the body will continue to adapt, allowing further gains to be made. There are a number of ways to ensure that this overload is achieved. The F.I.T.T. principle summarizes these well (Hodge, Sleivert, McKenzie 1996). There are four key factors which can be manipulated to achieve overload. They are:

- Frequency: The number of training sessions per week.

- Intensity: How hard the work is using a physical measurement such as heart rate, a perceived level of exertion, or a measure such as repetition maximums (e.g. 8 RM).

- Time: Measured in a number of forms depending on the type of exercise being performed. Aerobic work is often taken as the total amount of time per session as well as any applicable distances whereas with weight training volume, the number of sets and repetitions performed is often recorded. The amount of time the individual was exercised is also often measured to ensure that the targeted energy system is being used (e.g. 5–10 second exercise intervals load the short-term phosphagen anaerobic systems, 20–60 second intervals load the lactic acid anaerobic system, and intervals greater than two minutes primarily load the aerobic system).

- Type: The type of fitness components trained and the exercises performed. This is the basis of specificity.

2.7. 2. Specificity Principle

The next principle is the Specificity Principle: “The characteristics of a training load must be specific to the movement, muscles, and energy systems of the sport you are training for” (Hodge, Sleivert, McKenzie 1996). The types of specificity (Cochrane 2005) include:

- specificity of energy systems
- specificity of mode of training
- specificity of muscle groups and movement patterns
- posture specificity

This principle confers that one should aim to keep all training as sport-specific as possible, regardless of the type of fitness being trained. The only real exception to this is when injury or the potential for injury restricts the athlete from doing specific training. In this case, exercises should be kept as specific as possible while mitigating the risk of injury. Many athletes will relate to this principle when reflecting on their performances and reviewing the type of training and exercises used prior to the event.

Eugene Coleman (2002) sums this up, stating, “know what you need and train to get it. You need to lift weights to get stronger, run to get faster, and run, hit, catch, jump, and throw to become a better athlete. If you are going to spend 80% of your time jogging, you’re going to wind up practicing how to be slow.”

2.7. 3. Rest / Recovery Principle

The Rest/Recovery Principle clearly states that adequate rest is needed to maximize improvements in fitness. Consideration should be given to rest not only between daily workouts but also programmed rest/recovery weeks throughout an annual training plan. Rest does not simply mean sleeping in late and avoiding all physical activity, although at times this is an option! Instead, the focus should be on active recovery sessions involving such activities as massage, stretching, sled dragging, low intensity/low volume training sessions, and hydrotherapy. The majority of serious athletes have come across the signs and symptoms of overtraining and should be well aware of the need to monitor for these symptoms as well as plan training sessions to avoid them.

Coleman (2002) comments, “no matter how hard you work, you don’t make gains during workouts. Gains are achieved during periods of recovery. Recovery is one of the most important and most ignored principles of training.” Many trainers will attest to this after watching inexperienced athletes struggle through hours of training six days a week with very little return. These athletes could benefit by learning about the recovery principle and recognizing that more is not always better!

2.8.The Tapering Principle

The Tapering Principle is in essence a period of time when training is decreased gradually in a constant fashion to allow for peak performance at the actual event. This taper should be approximately two weeks in length just prior to competition, and by gradually decreasing the volume of training while keeping the intensity at competition level, an increase in performance of up to five percent may be gained (Hodge, Sleivert, McKenzie 1996). This concept is well-known and much used in strength sports. It is reflected in the old weightlifting saying, “There’s no point leaving your best lifts in the gym.”

2.8.1. Individualization and Ceiling Principle

The Individualization and Ceiling Principle is important when considering how to maximize an athlete’s skill enhancement and performance level. The key aspects of this principle are that athletes will benefit more when programs are planned to meet their individual needs and when the individual’s capabilities are taken into consideration. Individuals respond differently to training. Some are “high” responders and some are “low” responders. As such, programs may need adjusting to reflect the athlete’s requirements (Hodge, Sleivert, McKenzie 1996). Many athletes will relate to this having watched training partners gain tremendous performance improvements while only making slow progress themselves. This scenario may indicate that changes need to be made to both of the athletes’ programs.

This principle also considers the length of time an athlete has been training and how close they are to their individual genetic potential. Many athletes may recall the time that they put 20 kilograms on their best bench press in only two months or the year that they slashed their best 100 metre time by 1.2 seconds. These rapid gains in performance generally occur during a relatively early stage of an individual’s training. These gains slowly but surely diminish as time pushes forward. This principle considers that an athlete nearing his or her “ceiling” in one type of fitness may benefit by improving in another area of fitness. An example of this is a team-sport athlete whose speed is nearing its peak. However, with room to improve flexibility, this athlete could increase overall performance on the field as well as reduce the risk of injury. Coleman (2002) discusses developing the total athlete stating, “You cannot get away with just being strong or fast or flexible or skilled. You need the whole package—total fitness.”

2.8.2. Reversibility or Detraining Principle

The next principle is the Reversibility or Detraining Principle. Simply put, this is the “use it or lose it” principle. Most athletes who have had significant time off from training will recognize that their performance decreases if the body is not continually overloaded. This is evident in the gym when training has been neglected for any extended period. Weights that were once easy seem unusually heavy and awkward, and the pain of delayed onset muscle soreness is at an all-time high over the next week. The body has clearly reversed its adaptation of increased strength and decreased recovery times. This principle does have a positive side to it though. Detraining can allow an athlete to physically and psychologically recover from extended periods of training, allowing them to return to training with renewed enthusiasm.Obviously not all athletes can train at a high level year round. So how can they prevent the detraining effect? This is where the final principle, the Maintenance Principle, comes into the equation. To maintain gains in fitness for periods of up to three months, an athlete may manipulate the F.I.T.T principle described earlier and allow training frequency to decrease by up to two-thirds (Cochrane 2005). This principle is often used effectively by athletes whose sport involves defined seasons that don’t allow the training level achieved in the off-season to continue while competing.

So how do all of these training principles fit together? Any training program should consider all aspects of the training principles in relation to the individual athlete for whom the program is written. A periodization model should be used that divides the training year into phases to train specific types of fitness for the athlete. This plan should address the amount of overload on the athlete (using the F.I.T.T principle) and the amount of rest and recovery that the athlete requires. Both overload and rest should be adjusted to maximize the athlete’s adaptation to the training stimulus. The program should identify where and how tapering will be used to allow the athlete to perform at peak levels during his or her event. Periods of maintenance training and/or detraining may be used where applicable during the year, but their timing must be considered to be of maximum benefit to the athlete. A coach should work very closely with his or her athletes, monitoring and adjusting training as necessary. If an athlete is nearing his or her performance potential “ceiling” in one aspect of fitness, the coach may consider modifying the plan to gain further benefits from increasing other types of fitness.

2.8. Types of Exercise

Exercisesaregenerallygroupedintothreetypesdependingontheoveralleffecttheyhaveonthehumanbody:

- Aerobic exercises, suchascycling, walking, running, hiking, andplaying tennis, focus onincreasing cardiovascular endurance. Wilmore J and Knuttgen H (2003)
- Anaerobicexercises,suchasweighttraining,increaseshort-termmusclestrength.StavrinosT.,etal.(2005)
- Flexibilityexercises,suchasstretching,improvetherangeofmotionofmusclesandjoints.Spinks W., et al.(2006)

2.8.1. Aerobic Exercise

Aerobic(orcardiovascularexercise,a term attributedtothiskindofexercisebecauseofitsvariousbenefitsin cardiovascular health)referstoexercisethatinvolvesorimproves oxygen consumption by the body. (http://education.yahoo.com/reference/dictionary/entry/aerobic.)Aerobicmeans"withoxygen",and referstotheuseofoxygeninthe body's metabolic or energy generating process. (http://en.wikipedia.org/wiki/Aerobic_organism.)Manytypesofexerciseareaerobic,andby definitionareperformedatmoderatelevelsofintensityforextendedperiodsoftime.Thisintensity canvaryfrom50-80%of maximumheartrate.Runninga long distanceata moderatepaceis anaerobicexercise,but sprintingis not. Playingtennis,with nearcontinuous motion, is generally considered aerobic activity, while doubles tennis, with their brief bursts of activity punctuatedbymorefrequentbreaks,maynotbepredominantlyaerobic. Amongtherecognizedbenefitsofdoingregularaerobicexerciseare:

- **Stronger heart**:theheartmuscleisstrengthenedandenlarged,toimproveits pumpingefficiencyandreducethe restingheartrate.
- **Increaseofthetotalnumberofredbloodcells**inthebody,tofacilitatetransportofoxygenthroughoutthebody
- **Improvedbreathing**:themusclesinvolvedin respirationarestrengthened,to facilitatetheflow of airin and outof the lungs.

- **Improvedmusclehealth**:Aerobicexercisestimulatesthegrowthoftinybloodvessels(capillaries)inmuscles.This helpsourbodiesmoreefficientlydeliveroxygentomuscles,canimproveoverallcirculationandreducebloodpressure andremoveirritatingmetabolicwasteproductssuchaslacticacidfromthemuscles.
- **Weightloss**:Combinedwithahealthydietandappropriatestrengthtraining,aerobicexercisemayhelploseweight.
- **Disease reduction**:Extraweightisacontributingfactortoconditionssuchasheartdisease,highbloodpressure, stroke,diabetesandsome forms of cancer.As weightlossoccurs,theriskof developingthese diseasesdecreases.Lowimpact aerobicexercises, suchasswimming, cyclingandpoolexercises,canhelpkeepfitinthosewhohave arthritis,withoutputtingexcessivestressonjoints.
- **Improvedimmunesystem**:Peoplewhoexerciseregularlyarelesssusceptibletominorviralillnessessuchascolds andflu.Itispossiblethataerobicexercisehelpsactivateyourimmunesystemandpreparesittofightoffinfection.
- **Improvedmentalhealth**:Regularaerobicexercisereleasesendorphins,ourbodies'naturalpainkillers.Endorphins alsoreducestress,depressionandanxiety.
- **Increasedstamina**:Exercisemaymakeusfeeltiredintheshortterm,i.e.,duringandrightaftertheactivity,butover thelongtermitwillincreasestaminaandreducefatigue.(http://en.wikipedia.org/wiki/Aerobic_organism.)

2.8.2. Anaerobic Exercise

Anaerobicexerciseisthetypeofexercisethatenhancespowerandbuildsmusclemass.Musclestrainedunderanaerobic conditionsdevelopdifferently,leadingto greaterperformancein shortduration,high intensityactivities,whichlastupto about2 minutes. (http://www.asmi.org/sportsmed/Performance/anaerobic.html.) The most commonformof anaerobicexerciseis strengthexercise.Strengthexerciseis theuseof resistanceto muscular contractiontobuildthestrength,anaerobicenduranceandsizeofskeletalmuscles.Therearemany differentmethodsof strengthtraining,themostcommonofwhichareweightandresistanceexercise.Thesetwotypesof exerciseusegravity (through weight stacks, plates or dumbells) or machines to oppose muscle contraction, and the terms can be used interchangeably.

3. MATERIALS AND METHODS

Under this chapter, description of the study area, sources of data, definition of variables, research design, sample and sampling techniques, inclusive and exclusive criteria, methods and procedures of data collection, fitness test analysis, training protocol, methods of data analysis, data quality control were stated.

3.1. Description of the Study Area

Ambo University is one of the higher public academic institutions in Ethiopia. Geographically Ambo University is located in west shoa Ambo town. Ambo (also known as HagereHiwot is a spa town and separate Woreda in central Ethiopia located in the West Shoa Zone of the Oromia Regional state, west of Addis Ababa about 112 km and the town has a latitude and longitude of 8°59′N and 37°51′E respectively and an elevation of 2101 meters above sea level. The average annual temperature is 17.5 °C in Ambo. Ambo is known for its mineral water, which is bottled outside of town; it is reportedly the most popular brand in Ethiopia. Nearby attractions include Mount Wenchi to the south with its crater lake, Guder and Huluka Falls. Ambo is also the location of a research station of the Ethiopian Institute of Agricultural Research; initiated in 1977, this station hosts research in protecting major crops in Ethiopia. The town's market day is Saturday. The town has an estimated total population of 260, 193 of whom 131, 922 are men and 128, 271 are women (wekipedia). Map of study site is included in appendix**M.**

3.2. Definition of Variables

Agility: - ability to change direction quickly and accurately.

Dependent variables: - agility, speed and explosive power.

Independent variables: - selected plyometric training.

Plyometrics training: - specialized method of conditioning designed to enable a muscle to reach maximal force in the shortest possible time and characterized by quick, powerful, explosive type movements. Plyometric training is often a staple of sport-specific strength and conditioning programs.

Speed: - the ability to cover distance within short possible time

Stride frequency: - refers to the number of strides that are taken in a given time or for a given distance (Lee &Ferrigno, 2005).

Stride length: - is the distance covered per stride when measured from the center of mass (Lee &Ferrigno, 2005).

3.3. Sources of Data

The researcher used primary and secondary data sources. Primary data were from pre- during- and post-test measurements at field and gym according to the scheduled training program for 12 weeks where as secondary data has been obtained from different sources like books, journals, and Internet sources to get relevant and sufficient information regarding the study.

3.4. Research Design

This research study was experimental type for 12 weeks to see the effects of selected plyometric training exercises agility, speed and explosive power of the selected subjects in Ambo University Sport Science male students. For this study 40 male subjects were selected by random sampling technique for participating in 12 weeks selected plyometric training. The training program has been given to the subjects for 12 weeks and 3 days per week for 60-65 minutes per session. Pre-test has been given to all subjects to check their initial level before giving them any forms of plyometric trainings. At the middle of the training period (six weeks) the second test (during test) has been taken to check the effect and progression of ongoing training; then lastly after 12 weeks the post-test has been taken to observe the difference among the three tests.

3.5. Sample and Sampling Techniques

The total number of study population was 87 male Sport Science students. In order to select the samples for this experimental study, simple random sampling techniques was used. The number of samples for this study were 40 sport science male students with the age group ranging from 21-25. Their health condition and physical readiness questionnaire was prepared for identifying their health status and to know how much they are interested to engage in the training.

3.6. Inclusive and Exclusive Criteria

subjects who fulfilled the health history and physical readiness questionnaire requirements were selected and participated in this study. 40 Ambo University Sport Science male students who were free from any forms of acute or chronic disease and not having current physical and mental injury were included whereas the subjects contrary to the above criteria were excluded from the study politely.

3.7. Methods and Procedures of Data Collection

Quantitative data were collected through the selected appropriate physical fitness tests with the appropriate measurement of selected variables. Physical fitness tests used for this study variables were Illinois agility test (seconds) to measure agility, vertical jump test (centimeters) to measure explosive power and lastly 30 meter shuttle run (seconds) were given to measure speed. The data were recorded by the three data recorders who have been trained and oriented with how to collect data of pre-test, during test and post test after training has been completed. The researcher has used the soccer field, athletics track and gymnasium as study site. Cones, stopwatch, chalk or marker, football, whistles, table, bench, camera, laptop, mobile, treadmill, bicycle ride and ropes for skipping were some of the materials and facilities used in the training session as well as during the tests.

3.7.1. Fitness Test Analysis

The following fitness tests were used for the selected study variables before training(pre-test), while training (duing test) and after training (post test).

3.7.1.1. Illinois Agility test- The Illinois agility test is commonly used test for agility in sports. This test was done on a flat non-slip surface. Marking cones, stopwatch, and whistles was used while testing. The length of the course is 10 meters and the width (distance between the start and finish points) is 5 meters. Four cones were used to mark the start, finish and the two turning points. Another four cones were placed down the center an equal distance apart. Each cone in the center was spaced 3.3 meters apart. Subjects were leid down on their front (head to the start line) and placed hands by their shoulders. On the 'Go' command the stopwatch was started and the subjects were ready as quickly as possible and run around the course in the direction indicated, without knocking the cones, to the finish line. As soon as the subjects cross the finish line the timing was stopped. Three trials were given to the participants and finally, the highest scores was recorded (Ashok,2008).

3.7.1.2. Vertical Jump- Vertical jump was used to examine the subjects muscular power particularly lower muscles. The participants stand side on to a wall and reaches up with the hand closest to the wall. Keeping the feet flat on the ground, the points of the finger tips was marked or recorded. This was called as standing reach height. The students then stands away from the wall, and jumps vertically as high as possible using both arms and legs to assists in projecting the body upwards. The jumping technique can or cannot use a countermovement. Attempt to touch the wall at the highest point of the jump with chalk. The difference in distance b/n the standing reaches height and the jump height is the score. The best of three attempts was recorded (Ashok, 2008).

3.7.1.3. 30 Meter AccelerationTest-The objective of this test was to monitor the development of the athlete's ability to effectively and efficiently accelerate from a standing start or from starting blocks to maximum speed. Required resources to undertake this test is 30m marked section on the straight field, stop watch. The test comprised of 3 x 30m runs from a standing start or from starting blocks and with a full recovery between each run. On the "GO" command the subjects run quickly with speed from starting line and the assistants started the stop watch. When the subjects passed the finishing line the assistants stopped the stopwatch and record the time for the participants to complete the 30m. Three trials were given to the subject and the highest was recorded (Ashok, 2008).

3.8. Training protocol

The training program was carried out for 12 weeks for three times a week (Tuesday, thrisday and Friday). The session begun with 8-10 minute general and specific warming up period, followed by main workout for 50-55 minutes of low to moderate intensity selected plyometric exercises; then the session last up with 6-8 minute cooling down activities. For the first six weeks and then, the selectedvplyometric exercises increased to high intensity exercises slowly for the last six weeks. The training program was scheduled for the participants and the exercises training were given by the researcher and his assistants. The type of exercises done and training days are described in (**Appendix J**). A plyometric training program has been progressed gradually from lower intensity drills to more advanced plyometric exercises particularly in an individual with less strength training experience. Low intensity plyometric training exercises can be performed with a HRmax of 40% - 60% consisting of the following plyometric training exercises; squat jumps, jump to box and lateral jump to box. Moderate intensity plyometric training exercises consists of about 60% - 70% HRmax. It includes the following exercises; split squat jumps, trunk jumps, lateral box push offs, bounding, bounding with rings, box drills with rings, lateral hurdle jumps. However, high intensity plyometric workout may consist of about 70% - 85% HRmax and high intensity plyometric exercises includes zigzag hops, single leg trunk jump, single leg lateral hops and depth jumps (Chandler and Brown, 2008). Progressive overload principles will be incorporated into the program by increasing the number of sets of each exercise. The subjects will be instructed to perform all jumps at maximal effort (maximal height or amplitude and minimal ground contact time. (Grosset, Piscione, Lambertz, and Pérot 2008)

3.9. Methods of Data Analysis

The data collected through physical fitness tests were analyzed,interpreted and tabulated in to meaningful ideas using manually as well as by SPSS version 20 software to compare the selected physical fitness observed in the participants. Paired T-test was used to observe the difference from pre to during to post test results. The level of significance was 0.05%.

3.10. Data Quality Control

To insure data quality, all the tests, procedures, collection of data and handling information was carried out in accordance with standard protocols and fine measurements. The researcher used assistant to collect the data. To avoid errors, training were given for the assistance data collector on how to use and record data collecting instruments and measurements during data collection. Only standardized materials were used to keep the quality of the data. Additionally, all the above mentioned tests will be recorded with photograph. Finally, the data was coded and fed to software twice with different persons to avoid error in data feeding.

3.11. Research Ethics

The study was dealt with the ethical issues related to the investigation. It was protected the privacy of research subjects and can make guarantees and confidentiality of the information that was given to the study, and risk of harm due to participation. Participation of subjects in this study is purely a voluntary activity and their right not to participate and can resign at any time were respected. Therefore, the study was conducted all actions based on the university rule, code of conduct and policies concerning research ethics. Since subjects were volunteers and if they are refraining for the situations, not ready or not feel comfort they have got right to exclude theirselves at any time they want. Ethical approval were obtained from Institutional Research Ethics Review Committee (IRERC) of Haramaya University College of health science. The protocols was approved by the university guide lines and written consent was given and inform the concerned bodies

4. RESULTS AND DISCUSSIONS

In this chapter, overview and results of plyometric training on study variables have been tabulated and supported with bar graph with their interpretation and discussion.

4.1. Overview

This chapter deals with the analysis of data collected from the samples under study. The purpose of this study was to find out the effects 12 weeks selected plyometric training on agility, speed and explosive power. To achieve the purpose of the study 40 Ambo University Sport Science male students were selected by simple random technique. The variables selected for this study were: agility, speed, explosive power, and Pre, during and post tests were conducted for all 40 subjects and the scores were recorded. The collected data were analyzed by paired T-test. The results for each fitness variable are tabulated, supported with bar graph and discussed below.

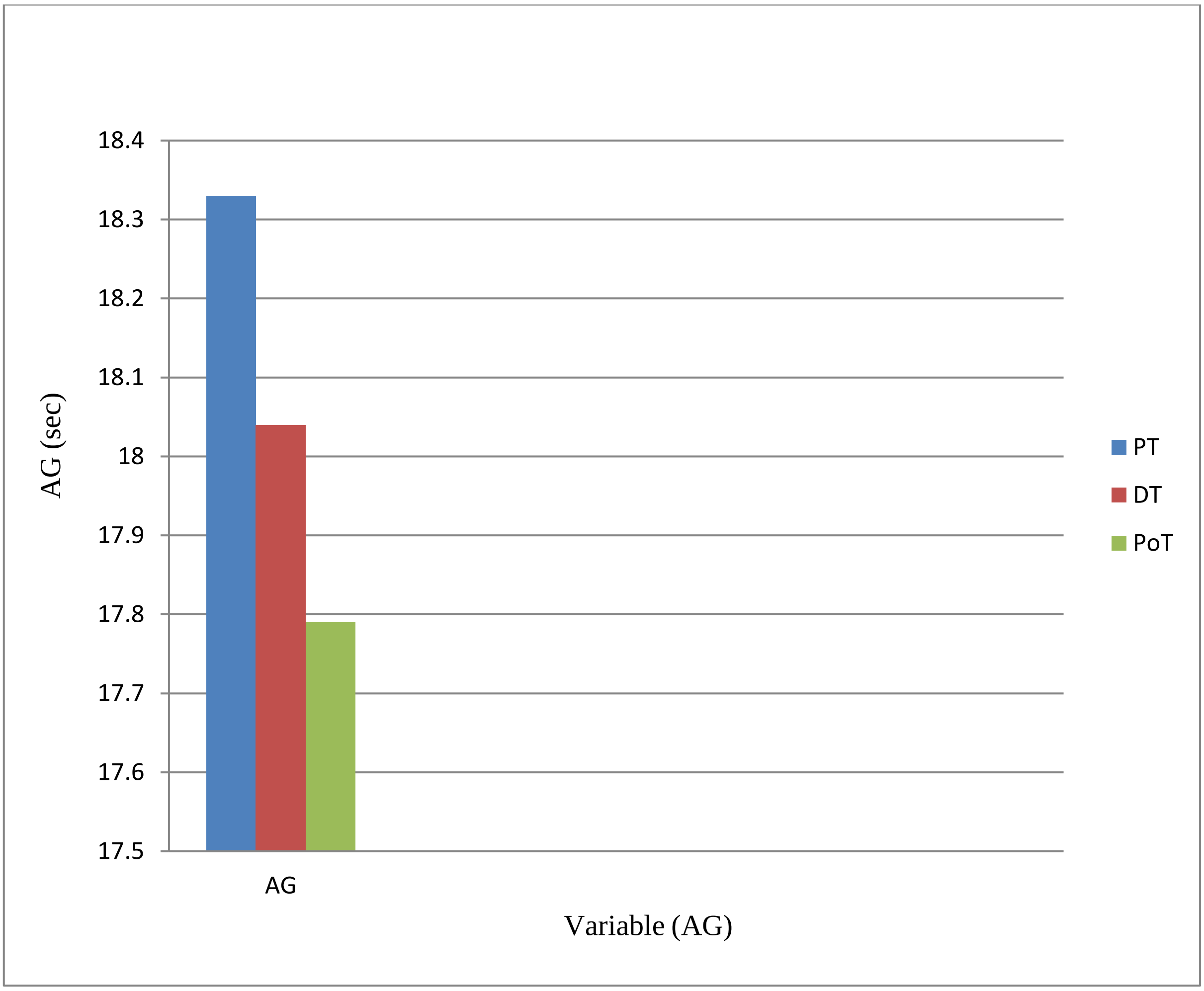
4.2. Results of plyometric training on study variables

Table 1. Mean andstandard deviation values of Agility of the study subjects (sec).

		Mean± standard deviation			
Variable	N	PT	DTT	PoT	MD
AG	40	18.33±0.67	18.04±0.67	17.79±0.69	0.54

Values = Mean ± SD, AG = Agility, PT = Pre Test, DTT = During Training Test, PoT = Post Test.

Fig. 1. Figure showing the mean comparison of Agility test results of the study subjects among pre, during and post tests.



AG = Agility, PT = Pre Test, DTT = During Training Test, PoT = Post Test, MD = Mean Difference.

According to the above table 1 and figure 1, the agility performance was increased from pre training test to post training test. The mean value of agility before training was 18.33 and

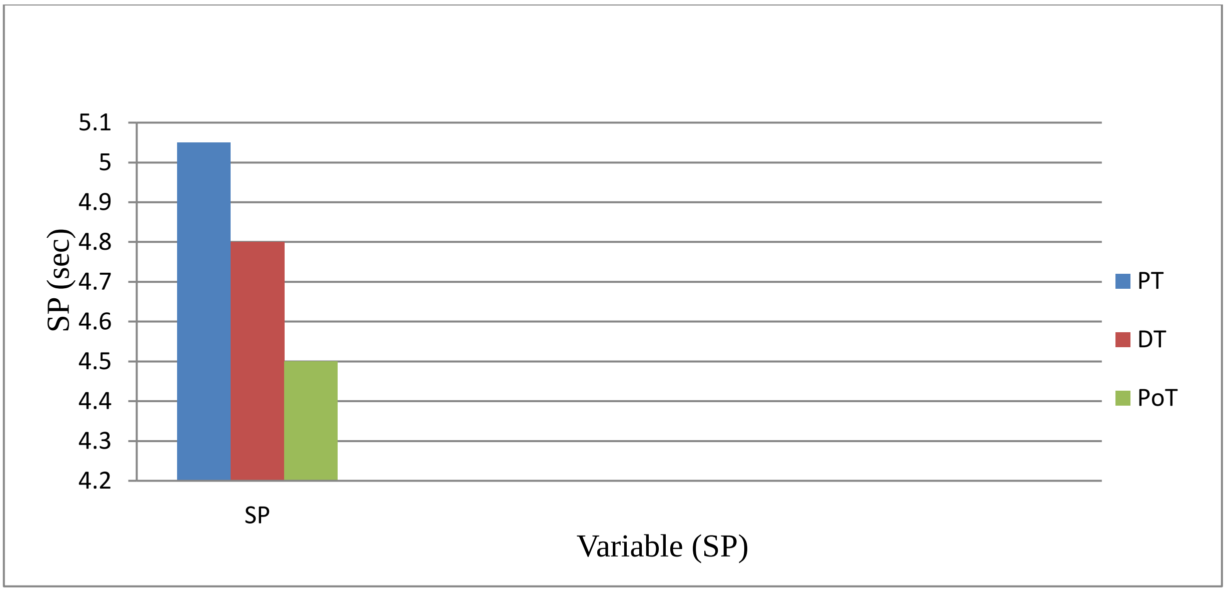
17.79 after the training program with a mean difference of 0.54. Considering the outcome of the agility test it was obvious that the agility of study subjects was significantly raised in the post test due to the intervention of 12 weeks selected plyometric training.

Table 2. Mean andstandard deviation values of Speed of the study subjects (sec).

		Mean± standard deviation			
Variable	N	PT	DT	PoT	MD
SP	40	5.05±0.36	4.80±0.40	4.5±0.43	0.55

values = mean ± SD, SP = Speed, PT = Pre Test, DTT = During Training Test, PoT = Post Test, MD = Mean Difference.

Fig. 2. Showing the mean comparison of Speed test results of the study subjects among pre, during and post tests.



SP= Speed, PT = Pre Test, DTT = During Training Test, PoT = Post Test, MD = Mean Difference.

Table 2 and **fig 1**. showed that, the speed, of participants changed after posttraining. The mean difference showed that there was an improvement in speed after plyometric training. According to the above statistical data the speed of participants was 5.05 before training and this was improved to 4.5 Sec after progressive endurance training with a mean value difference of 0.55.

Table 3. Mean andstandard deviation values of Vertical Jump of the study subjects (Cm).

	Mean± standard deviation				
Variable	N	PT	DT	PoT	MD
VJ	40	46.87±6.53	48.00±6.49	49.62±6.46	2.75

Values are Mean ± SD, VJ =Vertical Jump, PT = Pre Test, DTT = During Training Test, PoT = Post Test,MD = Mean Difference.

Fig. 3. Showing the mean comparison of Explosive Power test results of the study subjects among pre, during and post tests.

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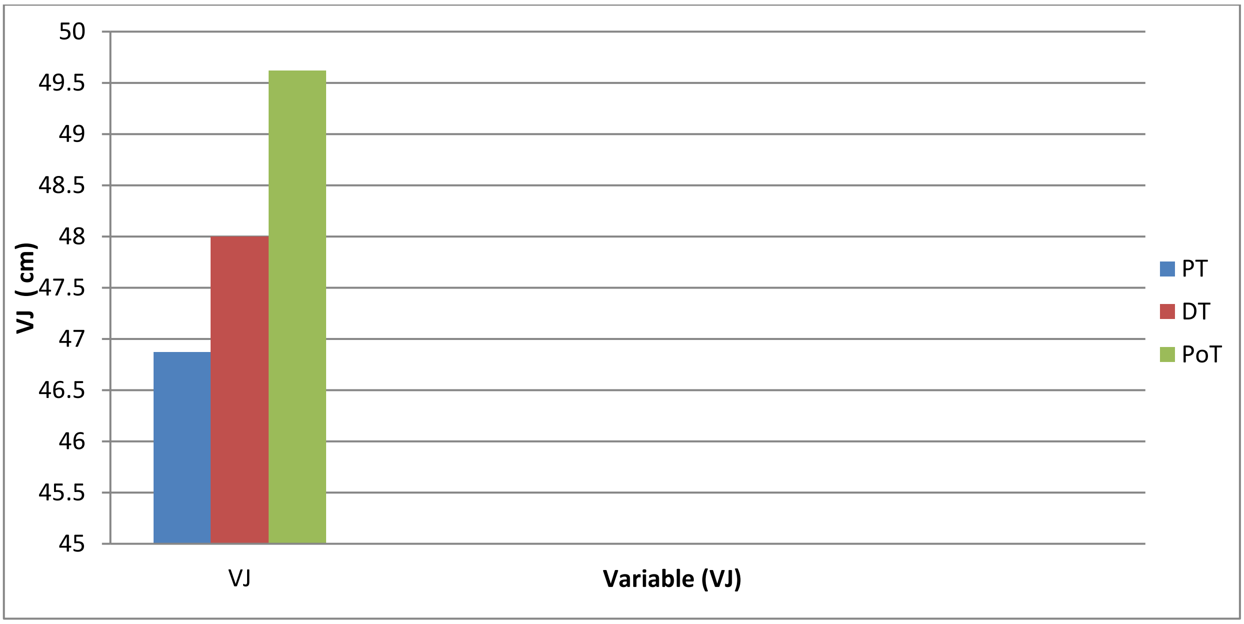

VJ =Vertical Jump. PT = Pre Test, DTT = During Training Test, PoT = Post Test,MD = Mean Difference

As it is shown above on **Table 3**and **Figure 3**, Plyometric training also significantly improved the explosive jumping ability of the subjects. The above table indicated that, the mean value difference of explosive power was improved by 2.75 Cm. This improvement was due to the plyometric training they participated in. The results showed that twelve weeks of Plyometric training had significant effects on increasing explosive power.

Table 4: The mean difference values and significance levels of pre, during and post test result of subject in all variables i.e., Agility, Speed and Vertical jump.

Variables	Parameter(A)	Parameters(B)	MD (A-B)	SIG
Agility	PoT (17.79)	PT (18.33)	-0.54	.000
		DTT (18.04)	-0.25	.000
Speed	PoT (4.5)	PT (5.05)	0.55	.000
		DTT (4.80)	-0.3	.000
Vertical Jump	PoT (49.62)	PT (46.87)	2.75	.000
		DTT (48.00)	1.62	.000

PT = Pre Test, DDT = During Training test, PoT = Post Test

According to the above table indication, three study variables pre, during and post training results has been stated with their mean diffirence and significance level. Agility pre, during and post training test was 18.33, 18.04 and 17.79 respectively with a mean diffirence of -0.25 and –0.54 from pre to during and pre to post training tests respectively which shows improvement with a significance level of .000. Speed pre, during and post training test was recorded as 5.05, 4.80 and 4.5respectively with a mean diffirence of -0.3and 0.55from pre to during and pre to post training tests respectively which shows improvement with a significance level of .000. Vertical Jump pre, during and post training test was recorded as 46.87, 48.00 and 49.62 respectively with a mean diffirence of 1.62 and 2.75 from pre to during and pre to post training tests respectively which shows improvement with a significance level of .000.

Generally, all study variables has shown positive changes which is encouraging due to the intervention of 12 weeks selected plyometric exercises training.

4.3. Discussionsof Results on Study Variables

Today, plyometric training has become a training technique which is used by the players within every kind of sports in order to increase general force and explosive force. Plyometric includes quick tension of a muscle (eccentric move) and then a concentric tension of the same muscle or the soft issue and is used to produce more power (Miller, Herniman, Ricard, Cheatham & Michael, 2006). Quadriceps, gastrocnemius, hamstring muscles are used as explosive power for jumping, kicking and turning. For this reason, it should be improved (Ateş, 2007).

Saunders et al in 2006 performed a study on "Short-term plyometric training improves Running economy in highly trained middle and long distance runners". Short-term plyometric training showed no significant difference in cardio respiratory measures or VO2max in plyometric group. But result showed improvement in Running economy, with likely mechanisms residing in the muscle, or alternatively by improving running mechanics. The results showed that eight weeks of plyometric training had significant effects on speed records reduction. These results were consistent with Mohebi et al (2012) but did not match with Hosseini et al (2011). A number of factors such as muscle length, strength, age, gender, temperature, body shape, force and flexibility can have profound impacts on speed (Mokhtari P, Rostami R, J motion, 2003, 24, 57.). Probably plyometric exercises led to speed improvements by affecting muscle length, force, muscle temperature, strength and flexibility during the eight weeks.
Results of this study are consistent with further studies regarding the effect of plyometric training on agility. In line with this study are Miller et al (2006), Parson and Jones (1998) and Shaji et al (2009). No studies in contrast with this result about agility were found. Most of agility movements require prompt transfer into and out of the muscle in leg extensors (the cycle performance stretch-shortening). It has been suggested that plyometric training through increased time the leg's muscle contacts with the ground output power and efficiency will reduce; hence, there is a positive impact on the agility (Marcovic, 2007).

Overall, improvements in agility after PT can be attributed to neural adaptation, specifically to increased intermuscular coordination (Markovic and Mikulic, 2010). The present study was designed to investigate the effect of plyometric training on agility, speed and explosive power on male sport science students. The results showed that eight weeks of plyometric training had significant effects on agility records reduction. The results were consistent with Bal et al (2011) but did not match with Alemaglu et al (2012). Plyometric training affects muscle spindles, Golgi-tendon, tendons, joints, balance and body position controlling (Miller GM , Herniman JJ, Ricard DM, J Sports Sci Med, 2006, 5, 465.). Maybe neuromuscular adaptations caused by plyometric exercises affects muscle spindles, Golgitendon, tendons, joints, balance and body position controlling favorably and this led to agility improvement in these athletes.

These results were consistent with Shahidi et al (2009) but did not match with Lamontage et al (2011). Nerves adaptation improves strength in the first 3-4 weeks of Plyometric training. Muscle hypertrophy creates an increase in the size and function of muscle fibers after 8-12 weeks of Plyometric exercise (Johnson S, Sburns S, Azevedo K, Int J ExercSci, 2013, 6, 1330]. Probably neural adaptations and hypertrophy caused by resistance exercises, improved explosive power in these subjects.

GoranMarkovic et al in 2007 had done a meta-analytical review on “Does plyometric training improve vertical jump height?” The result of the study showed that Plyometric training provides both statistically significant and practically relevant improvement in vertical jump height. It also suggest that the effects of PT are likely to be higher in slow stretch-shortening cycle (SSC) vertical jumps (countermovement jumps and countermovement jumps with arm swing) rather than in either concentric (Squat Jump) or fast SSC jumps (drop jumps). Johnson et al had done a Systematic Review on “Plyometric Training Programs for Young Children”. The current evidence suggests that a 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. An alternative program for children who do not have the capability or tolerance for a twice a week program would be a low-intensity program for a longer duration. The research suggests that plyometric training is safe for children when parents provide consent, children agree to participate, and safety guidelines are built into the intervention.

These findings show similarity with the positive effects of the plyometric exercises on the strength parameters. In many studies it was demonstrated that plyometric exercises are very beneficial methods. Especially when plyometric exercises are combined with weight exercises, they become more superior (Ebben 2002). It was shown that plyometric exercises applied to different specialties has improved the jumping performance (Baktaal 2008), speediness (Miller et al. 2006), the strength of upper and lower extremity (Ateş 2007), and the anaerobic strength (Sağıroğlu 2008).

Plyometric exercises in the present time have become an exercise technique that is used by all sportsmen for all sports to increase the general force and the explosive force. Plyometric includes the rapid stretching of the muscle (eccentric movement) and the subsequent concentric contraction of the same muscle or the soft tissue. The elastic energy stored in the muscle is used to produce a force greater than the force produced by a single concentric movement (Miller et al.2006)

This study showed that plyometric circuit exercises have an effect on the 30-meter speed run and reduce its time. This result was in accordance with the study that showed because of plyometric circuit exercise, the speed of converting outward contractions into inward contractions increases, and the created tension in the muscle increases as does the production power of the muscle, therefore reducing the duration of the speed run (Faigenbaum*et al.*, 2007; Meylen and Malatesta, 2009; Sedano Campo *et al.,* 2011). A study examined the effects of plyometric training on agility (Miller *et al*., 2006). Subjects showed significant improvements in the Illinois agility test scores after six-weeks of training. The present study also found significant improvements in Agility Scores.

Agility is an important factor in optimizing performance during a match. During a game, the players have to receive or intercept a pass, stop suddenly, change direction and then sprint to another position on the field (McArdle *et al*., 2007). This study indicated that twelve-weeks of training can improve agility and possibly performance during competition. An experimental study conducted on the effects of plyometric and resisted jump-training on speed and explosive power of young athletes showed the greatest amount of change in vertical jump (Fatouros*et al*., 2000). Physiological responses to physical training, including plyometric have been well studied by many investigators. It may be expected to positively influence many physical and biochemical functions. In a previous study plyometric training has been shown to be one of the most effective methods for improving explosive power and other physical fitness parameters. A wide variety of athletes can benefit from power training particularly if it follows or coincides with a strength training programme (Potteiger*et al*., 1999). A wide variety of training studies shows that plyometric can improve performance in vertical jumping, long jumping, sprinting and sprint cycling. Just one or two types of plyometric exercise completed 1 to 3 times a week for 6 to 12 weeks can significantlyimprove physical fitness parameters (Blackey and Southard, 1987). In accordance with these findings, the present study proved that plyometric training significantly improved selected physical fitness variables on female soccer players. A study aimed to know the effect of plyometric training on developing the explosive power of the two legs and its relation to the performance of the players. Most of the studies about plyometric training on the muscular power, had reported higher functioning after these kinds of training. The outcome of the present study is in line with Markovic et al (2007), Shaji et al (2009), Adams et al (1992), and Luebbers and Potteiger (2003), whom investigated the differences of plyometric protocols on participants' power, and reported increased results following the training.

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1. Summary

The purpose of this study was to find out the effects of 12 weeks selected plyometric training on Agility, Speed and Explosive power variables of Ambo University Sport Science male students. To achieve the purpose of the study, 40 subjects were selected from Ambo University Sport Science male students by simple random technique.The study was focused on experimental study within 12 weeks of selected plyometric training exercises. The selected physical fitness variables were speed (30-m acceleration test), agility (Illinois agility test), explosive power (vertical jump). Tests were taken from the participants at pre, during and post training programs. For this study simple random sampling techniques were used and the study subjects engaged in to well design physical exercise training program for 12 weeks, three times per week for 60-65 minute duration in low, moderate and high intensity of exercise. Each session was divided again in to warming up, main part and cooling down phase. The researcher selected different types of physical exercise which he provided for the students in 12 weeks of training programs. In 12 weeks of training the students performed each selected physical exercises 3 times in the same interval and conditions with only changed intensity from low-moderate-high intensity training. For the first 6 weeks of training the subjects were trained with low and moderate intensity and then the intensity were changed to moderate and high for the last 6 weeks of training. These selected physical exercise trainings were agility exercises, speed training and explosive power training. Before the training program, the pre physical fitness tests for each variable were taken and followed with during training test after 6 weeks to check progression. At the end 12 weeks of training program the post test was taken from the participants. Paired sample T-test was used to find out the significant difference ($p \leq 0.05$) between the post training result and pre training result of each variable. In all cases, 0.05 level of confidence was fixed to test, which was considered as appropriate. The result observed in this study showed significant improvements in selected physical fitness variables. After analyzing the pre-post mean difference of each variable, the study showed that physical fitness improved significantly. This was due to the effect of selected plyometric training program they were engaged in.

5.2. Conclusions

According to the results, the following conclusions were made.

- Selected plyometric training exercises were effective in increasing agility,explosive power and reducing sprint time in male sport science students. Plyometric Training can be safely introduced to improve vertical jump ability, speed, power and reduce chances of sports specific injury.
- Plyometric training program has shown significant improvement on speed performance of Ambo University sport science male students.
- The program also improved agility in relation to time shown reduction when comparing post training with pre training test.
- Explosive power of the University sport science male students has shown positive Changes which is encouraging.

5.3. Recommendations

Based on the major findings and conclusions of the study, the following points were made as recommendations.

- Plyometric training exercises were effective in increasing agility performance, explosive power and reducing sprint time in male sport science students. Therefore, plyometric training methods are recommended to male sport science students for improving speed, agility and explosive power.
- It is highly expected from sport professionals of Ambo University and related fields to guide and train on the importance and value of plyometric training programs to achieve the physical fitness.
- Considering the importance of Selected plyometric training exercises program on improving agility, speed and explosive power variables; sport science teachers of should make the exercise as part of their practical class for their students regularly.

- Male Sport science students of Ambo University need to participate in regular Selected plyometric training exercises program to promote their agility, speed and explosive power.
- Since plyometric training program is proved that it is beneficial and easy to manage; So,coaches and sport science teachers could be encouraged to use in their training session to produce well qualified sport science male students.
- Selected Plyometric training exercises ought to be included in all trainings that involve the advancement of physical fitness qualities.
- Efforts might be taken to popularize the benefits of plyometric training exercises to Ambo University male sport scince students, which, in turn would make the nation to produce skillful and physically fit generation.
- Further research on effect of Selected plyometric training exercises program ought to be conducted for further understanding of plyometric training.

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7. APPENDICES

APPENDIX - A

Information Record Form

The questionnaire prepared for researching entitled “The Effect of 12 Weeks selected plyometric training in improving agility, speed and explosive power in case of male sport science students in Ambo University”. So, you are kindly requested to give appropriate information for the following questions regarding to your health status. The information will be kept strictly confidential.

Thank you!

I. Participants Information

Name_____________________________ Telephone number____________________

Sex______________________________ Your typical food_____________________

Age_____________________________ Time gap between meals________________

Weight (kg) _____________________ Height (m)_____________________________

Emergency contact information

Name_______________________________Address____________________________

Relationship_______________________ Telephone number____________________

II. Personal health history (Answer Yes or No and description if it is necessary)

Is this your first visit to the exercise program? _________________________If not, please give a brief description of why, when and what _______________________

____.

Have you ever been treated for your internal organs? If yes, when and give details of problems____.

Have you ever appeared irregular heart beat on your heart? If yes, when and give details____.

Have you ever fainted or had concussion? ________________________If yes kindly write when and how you fainted out_______________________________.

Do you have any allergies? If yes, kindly list them__________________________.

Are you currently undergoing any medical treatment or under observation? __________.

Have you fallen sick in the past 6 months? ________________. If yes, please write the problems____.

Have you had any injuries in the past 5 years? ________________________If yes please write the problems ____.

Have you ever had a major surgery performed on you in the last year? _____________. If yes when and write the problems________________________.

Does your family have a history of any genetic disease? ________________If yes please write the problems ____.

Do you have any of the following diseases?

Asthma_____________________ Cancer__________________

Heart disease_________________ Stroke___________________

Diabetes_____________________ Skin infection_____________

Would you expect that this exercise program service will addressed satisfactory?

I have read and understand the form and have given accurate information in regard to my health.

Signed (participant)___________________Date_______________________

Signed (examiner) ____________________Date_______________________

Thank you for taking your time to respond!

APPENDIX - B

Participant Information Sheet and Informed Consent Form

My name is Fura Wako. I am working as a researcher for the study conducted in Ambo University on the effects of 12 weeks selected plyometric training on agility, speed and explosive power in the case of Ambo university sport science male students for my master's degree at Haramaya University, the College of Natural and computational science.

Research title: Effects of 12 weeks selected plyometric training on agility, speed and explosive power in the case of Ambo university sport science male students.

Purpose of the study: The results of this study can contribute significant role for Ambo University community especially for students, players and coaches to construct training program which is suited for them thereby improving the physical fitness status. Moreover, the aim of this study is to fulfill master's degree of sport medicine for the investigator and desire to examine the effect of 12 weeks selected plyometric training on agility, speed and explosive power of sport science male students in Ambo University.

Procedure and duration: There are a total of three physical fitness variables to be tested on you before, during and after the training programs are given to you. Participation in the study will not exceed 65 minutes per session and 3 days per week for training. The experiment of the study period will take 12 weeks. So, I kindly request you to follow exercise training to come up with the intended findings.

Risks and benefits: The risks of this research study are very minimal. While administering the tests and during training session you may experience localized muscle fatigue in your muscles. You might also feel some muscle soreness during and after the session of the exercise tests and training but it's not expected unusual risks as a direct result of this study. If any unexpected physical injury occurs, appropriate first aid will be provided, but no financial compensations will be given. There will be no costs for participating in the research on part of you. Soap and packed water will be given to you during the training session. Also when you are participating in this exercise programme you will improve your physical fitness and soccer skills. Hopefully, this will give a clear picture of plyometric training exercise. **Confidentiality:** The information obtained about you will be kept in confidence, although you are free to release it to your own physician. There will be no information that will identify you in particular. The information will be used only for scientific purposes without identifying you as an individual. No references will be made in data analysis/ written discussion that could link subjects to the research.

Rights: Your participation in this research study is voluntary. You may discontinue at any time from the study if you choose to do so and this will not label you for any loss of benefits which you otherwise are entitled.

Contact address: If there are any questions any time about the study or the procedures, please **contact**: Fura Wako (+251925255294 or +251947166141, **Email-** furawak7@gmail.com), Dr.DestaEnyew (+251938310940), Dr.AbinetAyalew (+251911827322) and any problem and complain can be addressed to Institutional research Ethics Review Committee (IRERC) office phone (0256661899). P.O.Box 235, Harar

Declaration of informed voluntary consent: I have read the subjects information sheet and have clearly understood the purpose of the research, the procedures, the risks and benefits, issues of confidentiality, the rights of participating and the contact address for any queries. I have been given the opportunity to ask questions for things that may have been unclear. I was informed that I have the right to withdraw from the study at any time. Therefore, I declare my voluntary consent to participate in this study with my initials (signature) as indicated below.

Signature of subjects: _________________ Signature of data collector: ______________

APPENDIX - C
Record Sheet 0f Variables for Study Subjects

No.	Serial code of subjects	Agility(Illin ois agility test)	Speed(30 meter shuttle run)	Explosive power(vertical jump)
1	S1			
2	S2			
3	S3			
4	S4			
5	S5			
6	S6			
7	S7			
8	S8			
9	S9			
10	10			
11	S11			
12	S12			
13	S13			
14	S14			
15	S15			
16	S16			
17	S17			
18	S18			
19	S19			
20	S20			
21	S21			
22	S22			
23	S23			
24	S24			
25	S25			
26	S26			
27	S27			
28	S28			
29	S29			
30	S30			
31	S31			
32	S32			
33	S33			
34	S34			
35	S35			
36	S36			
37	S37			
38	S38			
39	S39			
40	S40			

APPENDIX - D

Raw data for Agility, Speed and Explosive Power of 40 study subjects of pre test

SN	Serial code of subjects	Agility(Illinois agility test)	Speed(30 m shuttle run)	Explosive power(vertical jump)
1	S1	18.37	5.23	46.5
2	S2	18.66	5.24	51
3	S3	18.49	4.86	50
4	S4	18.1	5.27	40
5	S5	18.95	5.65	42.166
6	S6	18.41	5.57	36.5
7	S7	18.53	5.34	46
8	S8	18.08	5.2	43.83
9	S9	18.1	5.05	51.16
10	10	19.15	5.08	35.5
11	S11	16.94	5.1	43.833
12	S12	17.42	5.61	53.3
13	S13	17.62	5.36	58.666
14	S14	18.65	5.39	43.33
15	S15	18.60	5.34	43
16	S16	18.82	5.39	49.33
17	S17	16.88	5.60	49.66
18	S18	17.58	5.53	45.33
19	S19	18.74	5.55	46
20	S20	18.01	5.71	41.13
21	S21	18.61	4.65	43.33
22	S22	18.2	5.13	54
23	S23	17.41	4.78	50
24	S24	17.32	4.71	49.16
25	S25	17.43	4.98	46.16
26	S26	18.95	4.83	32.33
27	S27	19.87	5.42	31.5
28	S28	18.72	4.87	49.5
29	S29	18.05	4.71	46.8
30	S30	17.92	4.35	52
31	S31	17.81	4.39	54.83
32	S32	19.01	4.78	56
33	S33	19.05	4.81	41
34	S34	19.01	4.66	57.33
35	S35	18.01	4.98	56.83
36	S36	18.99	4.61	51.33
37	S37	18.09	4.79	41.66
38	S38	19.81	5.26	45
39	S39	18.96	4.69	53
40	S40	18.03	4.53	46.33

APPENDIX - E

Raw data for Agility, Speed and Explosive Power of 40 study subjects during test

S N	Serial code of subjects	Agility(Illinois agility test)	Speed(30 meter shuttle run)	Explosive power(vertical jump)
1	S1	18.11	5.11	47.7
2	S2	18.31	5.1	52.2
3	S3	18.22	4.66	51
4	S4	17.88	5.1	41.8
5	S5	18.61	5.33	43.1
6	S6	18.10	5.22	38
7	S7	18.20	5.18	47.5
8	S8	17.8	4.93	45
9	S9	17.88	4.99	53
10	10	18.90	4.97	37
11	S11	16.75	4.91	45
12	S12	17.12	5.41	54.6
13	S13	17.33	5.12	59.2
14	S14	18.21	5.19	44.1
15	S15	18.29	5.11	45
16	S16	18.48	5.21	51.3
17	S17	16.45	5.39	52
18	S18	17.27	5.24	47
19	S19	18.31	5.34	48.1
20	S20	17.77	5.42	42
21	S21	18.33	4.45	44
22	S22	17.71	4.88	54.4
23	S23	17.11	4.47	51
24	S24	17.00	4.33	50
25	S25	17.11	4.49	47
26	S26	18.63	4.45	33
27	S27	19.54	5.11	32
28	S28	18.21	4.47	50
29	S29	17.83	4.39	47.5
30	S30	17.66	4.11	53.3
31	S31	17.44	4.09	55.8
32	S32	18.75	4.48	57.2
33	S33	18.92	4.44	43
34	S34	18.93	4.39	58
35	S35	17.88	4.77	57
36	S36	18.80	4.41	52
37	S37	17.89	4.43	42
38	S38	19.44	5.01	46.3
39	S39	18.77	4.34	54.7
40	S40	17.91	4.22	47.3

APPENDIX - F

Raw data for Agility, Speed and Explosive Power of 40 study subjects of post test

SN	Serial code of subjects	Agility(Illinois agility test)	Speed(30 meter shuttle run)	Explosive power(vertical jump)
1	S1	18.5	5.6	48.2
2	S2	18.27	4.9	53.5
3	S3	18.17	4.45	53
4	S4	17.80	5	43
5	S5	18.45	5.22	44.8
6	S6	18.01	5.11	39.7
7	S7	18.00	5.01	49
8	S8	17.3	4.7	47.1
9	S9	17.44	4.75	55.2
10	10	18.50	4.68	39
11	S11	16.33	4.71	46
12	S12	17.00	5.17	56
13	S13	17.11	4.9	61
14	S14	18.01	5.01	45.1
15	S15	18.12	5	46.9
16	S16	18.1	5	52
17	S17	16.13	5.12	53.4
18	S18	17.01	5.02	49.2
19	S19	18.00	5.13	50
20	S20	17.31	5.19	43
21	S21	18.03	4.16	45.5
22	S22	17.21	4.66	56
23	S23	16.92	4.21	53.1
24	S24	17.00	4.11	52.3
25	S25	17.09	4.22	49
26	S26	18.41	4.27	34
27	S27	19.14	4.93	35
28	S28	18.11	4.18	52.1
29	S29	17.44	4.10	49.5
30	S30	17.39	4.02	55
31	S31	17.18	4	56
32	S32	18.37	4.25	58
33	S33	18.49	4.26	44
34	S34	18.54	4.18	60
35	S35	17.59	4.37	59.3
36	S36	18.45	4.21	54
37	S37	17.50	4.19	44.4
38	S38	19.10	4.8	47
39	S39	18.35	4.11	56
40	S40	17.47	4.12	49.8

APPENDIX - G

Anthropometric Measurements of study subjects

S N	Serial code of subjects	Age	Height	Weight
1	S1	22	162	58
2	S2	24.5	158	60
3	S3	23	161	61
4	S4	24	160	62
5	S5	25	159	60
6	S6	22.5	165	63
7	S7	23	170	64
8	S8	23	163	60
9	S9	25	166	59
10	10	26	155	65
11	S11	23.5	159	60
12	S12	24.6	160	62.3
13	S13	25	164	62.4
14	S14	22.5	168	60
15	S15	24	163	59
16	S16	23.6	160	60.1
17	S17	23	165	62
18	S18	24	166	64.5
19	S19	25	160	65.5
20	S20	23.5	158	63
21	S21	24	163	64
22	S22	25	170	61.5
23	S23	24.2	164	65
24	S24	23	166	58
25	S25	22.5	168	57
26	S26	23	170	60
27	S27	25	164	58
28	S28	24.5	159	61
29	S29	24	161	63.5
30	S30	24	163	64
31	S31	24	167	62
32	S32	25	166	63.5
33	S33	23.5	159	60
34	S34	23	162	62
35	S35	24	165	61
36	S36	25	168	60.5
37	S37	24.5	160	61.5
38	S38	23	161	64
39	S39	25	162	63
40	S40	22	160	65

APPENDIX - H

Description of Study Subjects

The total number of sport science is 215. Total number of males is 87 and the rest are females. Since the targated group is males; therefore, 40 study samples were selected from sport science students by simple random techniques. Since my study population was 87 and 40 study samples has been selected because the researcher believe that it could best represent rhe whole study population. Additionally, research is guided with priorly planned time and Therefore, this research is focused only on male sex group only since, the study is an experimental and if both sexes are included time, finance and resources are not sufficient.

Sex and Age: for this study only male sex groups will be included and their age groups range from 21-25. According to the questionnaire filled by the subjects on information record sheet individuals on the behalf of age 21-25 have been selected.

Three months of training schedule (February, March and April)

In the periodization of training schedule, 3 months or 12 weeks will be selected. In the selection the investigator depending on exercise program that includes monthly, weekly plan and training lesson/unit (jakl, p.2008). According to jakl 8 to 12 weeks of training program is essential to maximise individuals' abilities. Based on this idea the researcher will use 3 months purposively

Training days per week

The researcher will use three days per week (Tuesday, Thursday and Friday) and at six week will take the second test during the training. In the selection of training days the investigator fixed the days based on the rule and regulation of the university.

Duration of time for each session

The duration of exercise time for each session for this study is from 60-65 minutes.

APPENDIX - I

Training Schedules of 3 Months

The main objective of this training schedule is to improve agility, speed and explosive power of sport science students. Training schedule is a time period arranged with its availability of exercise type and duration, frequency, intensity and recovery time

Frequency is the repetition of each exercises per session and its mentioned in the table below.

Intensity is the amount of effort that will be invested in the training session of this program. In this study the researcher will use low, moderate and high intensity. For six weeks the researcher uses mixed low and moderate intensity then the last six weeks will be the mix of moderate and high intensity.

Heart Rate can be used to measure the intensity of cardio respiratory training and it's measured as beats per minute (taking pulse at the wrist or neck) and workload is used to define the intensity of selected plyometric training.

There are several ways to measure exercise intensity

1 measures the amount of oxygen consumed by the body as an activity is performed. It's expressed as the percentage of maximum oxygen consumption, or %-vo2max

2 the greater the intensity of the activity being performed, the higher heart rate will be and it's expressed as the percentage of maximum heart rate or %-MHR

Measuring heart rate is a method most often used to evaluate intensity in everyday life or the level of exercise in physical training.Low, moderate and high levels of exercise intensity, as measured by heart rate is defined as follows.

- Low is about 40-54% MHR
- Moderate is 55-69% MHR
- High is equal to or greater than 70% MHR(WIKEPEDIA)

The training schedule of this study in shown below in the following tables.

APPENDIX - J

Training Schedule for Three Months

Table 1. First Month Training Schedule (Febreury, 2017)

Weeks	Days and Time	Types of Selected Exercise	Duration (Min)	Frequency	Intensity	Recovery
1 and 2	Tuesday 4:00-5:05 PM	**Warming up** ABC drills Squat jump Lateral jump to box Split squat jumps Tuck jum **Cooling down and stretching**	10 10 10 13 15 10 6	- 3x3 2x8 2x5 2x5 3x8 -	Low Mod	5 min
	Thursday 4:00-5:05 PM	**Warming up** Jump to box Squat jump Lateral box push offs Two-Foot Ankle Hop **Cooling down exercises**	10 10 10 10 10 6	- 3x3 2x8 2x5 2x5 -	Low Mod	5 min
	Friday 4:00-5:05 PM	**Warming up** Lateral jump to box Jump to box Box drills with rings Bounding **Cooling down exercises**	10 12 15 13 15 6	- 3x3 2x8 2x5 2x5 -	Low Mod	5 min
3 and 4	Tuesday 4:00-5:05 PM	**Warming up** Two-Foot Ankle Hop Double-Leg Tuck Jump Split Squat Jump Single-Leg Tuck Jump Pike Jump **Cooling down exercises**	10 10 10 10 10 6	- 3x3 2x8 2x5 3x8 -	Low Mod	5 min
	Thursday 4:00-5:20 PM	**Warming up** Double-Leg Vertical Jump Jump Over Barrier Single-Leg Vertical Jump Double-Leg Hop Double-Leg Zigzag Hop **Cooling down exercises**	10 10 10 10 10 10 6	- 3x3 2x8 2x5 2x5 3x8 -	Low Mod	5 min
	Friday 4:00-5:05 PM	**Warming up** Jump Jump Over Barrier Single-Leg Vertical Double-Leg Hop Double-Leg Zigzag Hop **Cooling down exercises**	10 10 10 10 10 10 6	- 3x3 2x8 2x5 2x5 3x8 -	Low Mod	5 min

The above training schedule was performed every week of the month of February, 2017

Table 2. Second Month Training Schedule (March, 2017)

Weeks	**days and time**	**types of selected exercise**	**Duration (min)**	**frequency**	**Intensity**	**recovery**
5 and 6	Tuesday 4:00-5:05 AM	**Warming up** ABC drills Squat jump Lateral jump to box Split squat jumps Tuck jump **Cooling down exercises**	10 10 10 10 10 8 6	- 3x3 2x8 2x5 2x5 3x8 -	Low Mod	3 min
	Thursday 4:00-5:05 AM	**Warming up** Jump to box Squat jump Split squat jumps Lateral box push offs Two-Foot Ankle Hop **Cooling down exercises**	10 10 7 10 10 10 6	- 3x3 2x8 2x5 2x5 -	Mod. high	3 min
	Friday 4:00-5:05 AM	**Warming up** Lateral jump to box Jump to box Box drills with rings Bounding Squat jump **Cooling down exercises**	10 10 8 10 10 10 6	- 3x3 2x8 2x5 2x5 -	Mod. High	3 min
7 and 8	Tuesday 4:00-5:05 AM	**Warming up** Double-Leg Tuck Jump Split Squat Jump Single-Leg Tuck Jump Pike Jump **Cooling down exercises**	10 13 10 10 10 7	- 3x3 2x8 2x5 3x8 -	Mod. High	3 min
	Thursday 4:00-5:05 AM	**Warming up period** Jump Jump Over Barrier Single-Leg Vertical Jump Double-Leg Hop **Cooling down exercises**	10 10 8 10 10 10 6	- 3x3 2x8 2x5 2x5 3x8 -	Mod. High	3 min
	Friday 4:00-5:05 AM	**Warming up period** Jump Jump Over Barrier Single-Leg Vertical Jump Double-Leg Hop **Cooling down exercises**	10 10 8 10 10 10 6	- 3x3 2x8 2x5 2x5 3x8 -	Mod. high	3 min

The above training schedule was performed every week of the month of March, 2017

Table 3. Third Month Training Schedule (April ,2017)

Weeks	days and time	types of selected exercise	Duration (min)	Frequency	Intensity	recovery
9 and 10	Tuesday 4:00-5:05 PM	**Warming up period** ABC drills Squat jump Lateral jump to box Split squat jumps Tuck jump **Cooling down exercises**	10 10 8 10 10 10 5	- 3x3 2x8 2x5 2x5 3x8 -	Mod. High	3 min
	Thursday 4:00-5:05 PM	**Warming up period** Jump to box Squat jump Lateral box push offs Two-Foot Ankle Hop **Cooling down exercises**	15 10 15 13 10 5	- 3x3 2x8 2x5 2x5 -	Mod. High	3 min
	Friday 4:00-5:05 PM	**Warming up period** Lateral jump to box Jump to box Box drills with rings Bounding **Cooling down exercises**	10 10 10 8 10 10 5	- 3x3 2x8 2x5 2x5 -	Mod. High	5 min
11 and 12	Tuesday 4:00-5:05 PM	**Warming up period** Double-Leg Tuck Jump Split Squat Jump Single-Leg Tuck Jump Pike jump **Cooling down exercises**	10 10 10 10 10 5	- 3x3 2x8 2x5 3x8 -	Mod. High	3 min
	Thursday 4:00-5:05 PM	**Warming up period** Jump Jump Over Barrier Single-Leg Vertical Jump Double-Leg Hop **Cooling down exercises**	10 10 10 7 10 10 5	- 3x3 2x8 2x5 2x5 3x8 -	Mod. High	3 min
	Friday 4:00-5:05 PM	**Warming up period** Jump Over Barrier Single-Leg Vertical Jump Double-Leg Hop Double-Leg Zigzag Hop **Cooling down exercises**	10 10 10 10 10 7 5	- 3x3 2x8 2x5 2x5 3x8 -	Mod. high	3 min

The above training schedule was performed every week of the month of April, 2017

APPENDIX - K

Paired sample T-test results of each parameter(agility, speed and explosive power)

Table 1:.Paired sample T-test results of agility parameter.

Agility Parameters	Paired Differences						t	Df	Sig. (2-tailed)
	Mean values	Mean Difference	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
PT – DDT	18.33-18.04	.29000	.09677	.01530	.25905	.32095	18.954	39	.000
PT-PoT	18.33-17.79	.55025	.18052	.02854	.49252	.60798	19.278	39	.000
DDT-Pot	18.04-17.79	.26025	.17571	.02778	.20405	.31645	9.367	39	.000

Table 2.Paired sample T-test results of Speed parameter.

Speed Parameters	Paired Differences						t	df	Sig. (2-tailed)
	Mean values	Mean Difference	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
PT - DDT	5.05-4.80	.25075	.13537	.02140	.20746	.29404	11.715	39	.000
PT-PoT	5.05-4.5	.43425	.19044	.03011	.37335	.49515	14.422	39	.000
DDT-Pot	4.80-4.5	.18350	.12429	.01965	.14375	.22325	9.337	39	.000

Table 3: Paired sample T-test results of Explosive Power.

Vertical jump Parameters	Paired Differences						t	df	Sig. (2-tailed)
	Mean values	Mean Difference	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
PT – DDT	46.87-48.00	-1.12825	.54675	.08645	-1.30311	-.95339	-13.051	39	.000
PT-PoT	46.87-49.62	-2.75325	.71988	.11382	-2.98348	-2.52302	-24.189	39	.000
DDT-Pot	48.00-49.62	-1.62500	.61425	.09712	-1.82145	-1.42855	-16.732	39	.000

APPENDIX - L

Physical Characteristics of Subjects

Antropomotric charactersitcs	N	Minimum	Maximum	Mean	Std. Error	Std. Deviation
Age	40	22.00	25.00	23.8725	.15434	.97612
Height	40	155.00	170.00	163.1000	.60320	3.81495
Weight	40	57.00	65.50	61.3975	.36069	2.28119

APPENDIX - M

Normative Data For 30m Shuttle Run, Illinois agility test and vertical jumping.

Table 1 .Normative Data for 30m Shuttle Run.

Gender	Excellent	Abve Average	Average	Below Average	Poor
Male	<4.0	4.2-4	4.4-4.3	4.6-4.5	>4.6

Source:Topendsports, 2011;Brain Mac,2011

Table 2 .Normative Data for Illinois Agility Test

Gender	Excellent	Abve Average	Average	Below Average	Poor
Male	<15.2	15.2-16.1	16.2-18.1	18.2-18.3	>18.3

Source:Topendsports, 2011;Brain Mac,2011

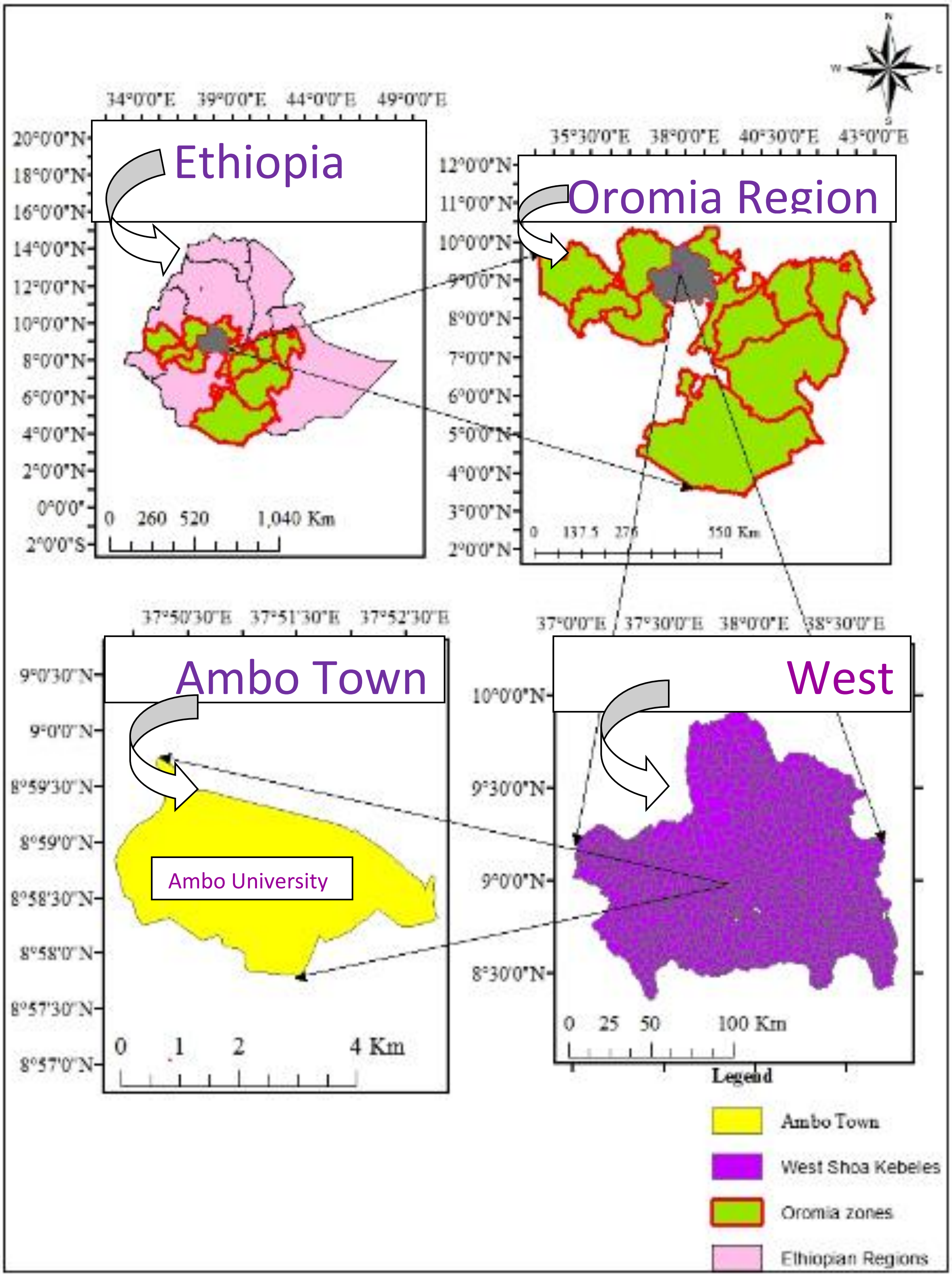
Table 3. Normative Data for Vertical Jumping

Gender	Excellent	Very good	Abve Average	Average	Below Average	Poor
Male(Cm)	70	61-70	51-60	41-50	31-40	21-30

Source:Topendsports, 2011;Brain Mac,2011

APPENDIX - M

Fig 1. Map of the Study Site



Source: Geographical information system(ARC GIS) version 10.1