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Effect of high Intensity Interval Training on Selected Physical Fitness Qualities and Spiking Technique of Volleyball Project Players

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**EFFECT OF HIGH INTENSITY INTERVAL TRAINING ON
SELECTED PHYSICAL FITNESS QUALITIES AND SPIKING
TECHNIQUE OF VOLLEYBALL PROJECT PLAYERS**

BY

MEKURIYAW ESHETU

JUNE, 2022

Bahir Dar

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By

Mekuriyaw Eshetu

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

ADVISOR

Chalachew Chekol (Ass. professor)

June 2022

Bahir Dar,

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Certificate

Bahir Dar University

Sport Academy

Department of Sport Science

Approval of Thesis for Defense

I hereby certify that I have supervised, read and evaluated this thesis prepared by Mekuriyaw Eshetu entitled with “Effect Of High Intensity Interval Training On Selected Physical Fitness Qualities And Spiking Technique Of Volleyball Team Players ” and recommended that it is accepted as fulfilling the thesis requirement for the Degree of Master of Science in Coaching volleyball.

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We hereby certify that we have examined this thesis entitled “Effect of High Intensity Interval Training on Selected Physical Fitness Qualities and Spiking Technique of Volleyball Team Players” by **Mekuriyaw Eshetu**. We recommend that the thesis is approved for the degree of “Masters of Science in volleyball Coaching.

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DECLARATION

I, hereby that this thesis for the partial fulfillment of the requirement for the Degree of **Master of Science in volleyball coaching** on the title “Effect of high intensity interval training on selected physical fitness qualities and spiking technique of volleyball project players” is my real original work and all sources of materials used in this thesis have been cited and acknowledged. All researchers and book writers issue that is built-in the thesis has been given credit in the course of citation. I insist that I have cited and referenced all sources used in this paper. Every serious effort has been made to avoid any plagiarism in the preparation of this thesis.

DEDICATION

I dedicate this thesis manuscript to my beloved brother **Tilahun Eshetu**, my mom **Kelemework Mekonnen** my father **Eshetu Kassaw** as well as the researcher extended his dedication to peoples who contribute even a piece of advice all the way through in my life to arrive at in this step.

Mr. Mekuriya Eshetu

Signature:-.....

Date:

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LIST OF ACRONYMS AND ABBREVIATIONS

ACSM	American college of sport medicine
ANCOVA	Analysis of covariance
CG	Control group
DF	degree of freedom
EG	Experimental group
F	ratio calculate
HIIT	High intensity interval training
M1	Mark one
MICT	Moderate intensity interval training
PAQ-R	physical activity readiness questionnaires
N	numbers of team players
POT	post test
PT	pre test
RST	Repeated sprint training
SD	standard deviation
SITS	Sprint interval training
SPSS	Statistical Package for Social Sciences
USA	United State of America
VO2max	Maximum oxygen consumption

ABSTRACT

Volleyball is highly an intermittent sport activity and it depends on the combination of active and passive phases and it requires frequent short bouts of high-intensity exercise, followed by periods of low-intensity movements. The main purpose of this study was to investigate the effect of eight weeks HIIT on selected physical fitness qualities and spiking technique of volleyball team players in Kutaber Woreda. This study followed quantitative research approach and experimental research design. To achieve the purpose of this study twenty-four male volleyball project players were selected by using comprehensive sampling and randomly assigned to either EG (N=12) or CG (N=12). The EG was performed additional HIIT for eight week, 3-days per week for a total of 45-50 minutes per session. Both groups were participated field tests before and after the intervention. Participants were measured on tests of vertical jump for explosive power; flying 30m sprint test for speed, push up for strength, SEMO agility test for agility and radar test for spiking speed. The collected data were statistically analyzed by ANCOVA to compare post tests between groups' effect sizes of independent variables on dependent variables after intervention at significance level of 0.05. The analyzed data showed that HIIT has significant improvement on the selected variables in pre-post test performance of EG ($p < 0.05$). However, CG has no improvement in all selected variables of pre and post test performance. Based on the finding of this study was concluded that EG showed significant improvement on the selected variables of volleyball players when compared to the CG. It was also concluded that the significant difference exists between HIIT group and CG on the selected variables. Consequently, it is recommended that volleyball players and coaches should include HIIT program on their training sessions for the development of physical fitness and spiking speed of volleyball team players.

Key words: agility, explosive power, HIIT, speed, spiking speed, strength, volleyball

CHAPTER ONE

INTRODUCTION

1.1 Back ground of the study

Sports and games are nowadays become a new religion in all over the world and currently a large number of sport persons are practicing in sport. Every developed and developing country is trying to become champion in this ground and for that they are developing different technologies, instruments, means and method of training. Sports activities are activities that will never lost from human life and as part of human education and progress. Volleyball is the most popular sport in the world and is performed by men and women, children and adults with different levels of expertise. Sports and games hold as a well-known place in modern life, millions of people participate in sporting activities (Magray and Jain, 2020).

Volleyball is one of the most well known team sport in all over the world which can be played both indoors and outdoors and it's as an intermittent sport, with the highest degree of regular high-intensity activity, involving explosive bursts, short body movement and numerous jumps that means it's a game of explosive power, speed, strength as well as it's a game of agility (Sheppard et al., 2007). Furthermore, the exercise periods in volleyball are comparatively short, lasting only; approximately 9 seconds on average interspersed by 12-second recovery intervals and display work to-rest ratios ranging between 1:1 and 2:2 (Sheppard et al., 2009). Success in terms of volleyball is strongly related to physical characteristics of the player that means being tall, powerful, speedy and agile and participates in the specific support of a training program.

Volleyball is highly an intermittent sport activity and it depends on the combination of active (short interval exercise periods) and passive phases (rest period) and requires players to participate in frequent short bouts of high-intensity exercise, followed by periods of low-intensity movements and it's also a game that includes continuous aerobic and anaerobic loading of play with frequent explosive movements (i.e. power and speed) where trained players and it can be considered as a highly competitive game, requiring a high level of fitness, for example, volleyball players have been

shown to perform approximately 115 jumps and 85 hits in a game (Medeiros et al., 2014). Therefore, speed and leg explosive power is an important component of high-intensity performance in team sports and includes variables such as acceleration, decelerations (speed), and explosive strength capacity during directional changes (agility) and also which are important fitness performance parameters in the volleyball players. Volleyball players have been demonstrated to cover approximately 1200m and; up to 1750 m in total in a 3-set and 4-set game, respectively (Mroczek et al., 2011).

Manipulating high intensity interval training can be a prerequisite for athletes success on the development of explosive power, strength, speed and agility qualifying components of physical fitness and desirable for best athletic performance of volleyball players (Zearei, Ramezanpourb , Pakdelanc , 2013), because performances in most sports is determined by the level of athlete's physical characteristics and physical abilities of players exert marked effects on the skill of the players themselves and the tactics of team. Thus, during the pre-competitive period, intensification of the training load is a frequently used strategy aimed at preparing the athletes through physical fitness make ups will important to face the demands of a long competitive period and adapt rapidly (Raeburn,2008 and Coutts et al., 2007a).

Modern volleyball games are involved in defensive and offensive jumping activities where explosive power, speed, strength and agility are required (González, Arija and Suarez, 2011). Volleyball players require high level explosive power in order to jumps and rapidly changes of direction to be more effective during the game. Explosive power refers to individuals' ability to exercise the greatest amount of force within the shortest possible time frame. Whether in the practice of getting higher to become a better smasher or being able to jump quickly in order to provide an effective spike and block, the ability to stand off the floor rapidly and reach above the net is significant for volleyball players. Additionally, volleyball players need stronger leg power to get high in the air and explosive strength to display skills such as digging, spiking and blocking (Giminiani and Visca, 2017).

Volleyball players required strength for stability as it permits valuable transmission of power from the lower body to the upper body and containing strength variables in

HIIT programs increases muscle fibers allows the athlete to develop higher jumping power and greater power to produce force to block, spike and dig balls during a game. The more power or force they put into the ground or floor the higher the player will jump and also the more force or power they put into the ball, the faster it will go which increases the chances of a kill shot (Ojo, 2019). Strength in the muscles also helps injury prevention and force of each landing transfers through the ankles, knees, hips, and back. As the players decelerate a hit, it places stress on the posterior shoulder, requiring complimentary strength to control this rapid speed. The capacity of the neuromuscular system to produce power is critical to the performance, in sports that need changes in direction, jumps and sprints (Izquierdo, 2002).

Speed matters in volleyball in fact that players are required to move quickly in various directions throughout the game. Volleyball players require the ability to accelerate in all directions to achieve quick lateral, forward, backward, and vertical movements. Many of these are in reply to the motion of a ball, opposition players, or team-mates. Thus, volleyball is an intermittent sport that combines active and passive phases of play and requires players to participate in repeated short bouts of high-intensity work out, followed by periods of low-intensity movement (Hirko and Samson, 2017).

Agility in volleyball requires quick and usually awkward movements as players adjust your body position to the ball during play and also players to accelerate, decelerate, stabilize, and quickly change directions with proper posture with a minimal loss of control or average speed as well as to start and stop quickly (Little and Williams, 2005). Those physical fitness qualities abilities are expressed by the numerous playing abilities to perform during the games, which are important both for the attacking and defending activity of volleyball players (Sheppard et al., 2009; 2008; 2007). Due to its size of court, volleyball by nature it requires very short-distance sprints and quick and high agile movements for successful playing performance in defensive actions (Cengizel, 2020).

Spiking technique is the offensive play where a player hits the ball sharply downwards over the net and into the opponents' court, making it hard for the opposing team to recover the ball. Ball speed is one of the primary factors that contribute to successful offensive. The harder the ball is attack, the faster the ball will travel and the shorter the time opposing defender will have to successfully keep the ball in play. In the spike, the goal of spiking speed is to achieve hit speedy ball that the ball to be unpredictable and ensure diverse actions. The higher the player's spiking speed during the spike, the larger the effective field size and the steeper the ball trajectory at high ball velocity. The higher a player is able to vertically jump, the greater his/her potential for successful spiking speed to hit unpredictable ball or speedy hitting action during volleyball game (Bonnie, 2006).

Regard to this, HIIT is an important component of volleyball sports' training program, as it's a training format that allows specific preparation toward meeting the physical demands and technical skill of players' performance (Buchheit, 2019). However, the researcher got a chance to observe a variety of aspects on their training session of the players. Based on the researcher's observation, there was lack of physical fitness and technical skill execution in Kutaber Woreda volleyball project players. During researcher's observation their training status, coach has given less attention for players fitness and players are interested in playing game rather than fitness development. This trend might made players notable to develop the required fitness levels. Therefore, the researcher focused on to see the effect of eight week high intensity interval training on selected physical fitness qualities and spiking technique of volleyball project players in Kutaber Woreda.

1.2 Statement of the problem

Volleyball players require a large number of athletic abilities, such as explosive power, speed, strength, agility, and other types of physical characteristics. Thus, every volleyball player is interested to improve their physical fitness abilities. There are different types of training methods for the development of physical abilities of volleyball players. In order to be effective HIIT is basically considered as an effective, potent, practical and time efficient means to optimize volleyball players' physical fitness and technical skill development (Buchheit, et al., 2011). Considerable

in somewhat researches have been done abroad in the effect of HIIT on physical fitness qualities related to volleyball sport. However, as per the knowledge of the researcher during a comprehensive review of literature there were no published researches that conducted in Ethiopia to investigate the effect HIIT on the selected variables of volleyball players.

According to (Andy, 2012) and (Will and Yannis, 2004), sporting performance is results from the combination of numerous factors, which interact with one another. Many of Ethiopian athletes including volleyball players and sport performance is complicated phenomenon from others in various aspects including their genetic predisposition, altitudes, the associations between somatotype and physical fitness based on those factors different researchers have also attracted scientific interest to made research by using different study area because this factors have been proposed to explain the extraordinary success. But, this makes it hard to know how effectively HIIT would actually work as an exercise strategy in Ethiopia and based on researcher point of view during the observation of different projects in South Wollo zone this training method has been known theoretically not practically specifically for physical fitness and technical skill development of volleyball players.

The previous studies have shown different results on the effect of HIIT on agility. For instance, (Fajrin et al., 2018) conducted a research on the effect of HIIT on agility and researchers concluded that HIIT have significant effect on agility. On the other hand, (Sadi, 2022) investigated the effect of HIIT on agility performance of male volleyball players in university teams and concluded that the effects of HIIT have no significant effect on agility. Those researches conducted on the effect of HIIT on agility of volleyball players were controversial each other.

Studies are recommended HIIT which improves explosive power, speed, strength and agility. For instance, A research conducted by Nelson, Jim and Arumugam (2020) conducted a study on effect of HIIT on explosive power college volleyball players. The researchers concluded that HIIT has significant effect on explosive power of volleyball players. Similarly, Fajrin et al (2018) conducted on the effect of HIIT on increasing explosive power. The results showed there is significant change in the selected variables. On the other hand, a research conducted by Rômulo Vasconcelos,

et al., (2020). This conclusion suggests that six weeks of high-intensity training was no significant effect to increase on performance of vertical jump height (explosive power).

Similarly, study shows controversial issue in the effects of HIIT on strength, for instance the study conducted by Saravanan and Manju, (2021), conducted on the impact of drill based HIIT on physical fitness variables of volleyball players. The result showed significant improvement on muscular strength of HIIT. On contrary, Jaime Della Corte, et al (2019) conducted study on the effect of HIIT on strength performance but, on the basis of the data obtained in this study has no significant effect on strength performance. This was additional motivation of researcher to investigate the effect of HIIT on selected physical fitness qualities of volleyball players. This is the other inspiration of researcher to investigate the effect of HIIT on spiking.

1.3 Objective of the study

1.3.1 General objective

The general objective of this study was to investigate the effect of high intensity interval training on some selected physical fitness qualities and spiking technique of volleyball project players in Kutaber Woreda.

1.3.2 Specific objective

In addition to the general objective investigator address the following specific objectives

1. To identify the effect of HIIT on explosive power of volleyball project players in Kutaber Woreda.
2. To examine the effect of HIIT on speed of volleyball project players in Kutaber Woreda.
3. To identify the effect of HIIT on agility of volleyball project players in Kutaber Woreda.
4. To find out the effect of HIIT on strength of volleyball project players in Kutaber Woreda.

5. Determine effects of HIIT on spiking speed of volleyball project players in Kutaber Woreda.

1.4 Hypotheses

This research was focused on the following basic research hypothesis

H_{0.1}: High intensity interval training might have significance effect on explosive power of volleyball project players.

H_{0.2}: High intensity interval training might have significance effect on speed of volleyball project players.

H_{0.3}: High intensity interval training might have significance effect on strength of volleyball project players.

H_{0.4}: High intensity interval training might have significance effect on agility of volleyball project players.

H_{0.5}: High intensity interval training might have significance effect on spiking technique i.e. spiking speed of volleyball project players.

1.5 Significance of the Study

- ✚ This study was conducted with the aspirations of increasing the knowledge of how HIIT programs can influence on physical fitness and spiking speed of volleyball players in relation to participation /engagement/ of the eight week training.
- ✚ Also this study may inspire and encourages volleyball team players to engage in HIIT program.
- ✚ Additionally, coaches and physical education teachers could obtain useful information from this research to train their athletes by apply this training method as a guideline.
- ✚ Give a clear picture to the sports coaches on the specific exercises to be included in the training schedule for the improvement of the selected physical fitness variables.
- ✚ Finally, the findings of this research would be pave further ways and means to explore similar researches on framing suitable training methods which would influence specific physical fitness variables of volleyball players.

1.6 Delimitation of the study

Some delimitation was taken into consideration during this study

- ✚ This research was delimited to Kutaber Worda volleyball project players. Because, ideally the researcher study area resolve relates to future coaching practice and researcher has a potential to contribute to the achievement of the project by supporting and provides a comfortable training environment through materials as a coaching staff member and this area makes studying less stressful.
- ✚ This study was limited to 24 volleyball players (all of the payers in Alansha volleyball project) because, the study area does not contain other age categories and the age of the subjects include under this study were between 17 to 19 years.
- ✚ The training was confined to HIIT and duration of the experimental period was limit to 8 weeks and the training was conducted three days per week for 45-50 minute.
- ✚ The intervention period of this study was from March up to May and it conducted in the year of 2021- 2022 G.C.
- ✚ Finally, researcher selected among several physical fitness and technique of volleyball variables researcher only chose explosive power, speed, strength, agility and spiking speed of volleyball technique of volleyball players.

1.7 Operational definitions of key terms

Active Recovery: in recovery period, volleyball players continue to move by shaking out legs or arms to help the body by pumping blood and oxygen back fatigued muscles to normal after intensive exercise.

Agility: is the ability of volleyball players to stop, start and change the direction of their body parts rapidly under their own control.

Exercise intensity is simply defined as the amount of volleyball players' energy that required for the execution of performance during the physical exercise per unit of time.

Explosive Power is an ability of volleyball players to transfer their explosive energy into power with in short period of time

High intensity interval training is an exercise of short but intense bursts of energy of the players followed either active or passive rest during activity.

Interval training: the players that performing brief exercise bout that involves periods of intense work and recovery that varies on the intensity and duration of each part.

Speed: is the ability of volleyball players to perform rapid and successive movements over a short period of time during a competition or training.

Spike – It is one of the attacks from of volleyball players that usually, above the height of the net performed with the intent to send the ball straight to the floor of the opponent.

Strength: is the force or tension of volleyball player muscle group that can exert force to transfer force from lower body to upper body part during volleyball game.

1.8 Organization of the study

This study has consists of six chapters. The first chapter deals with the back ground of the study, statement of the problem, hypothesis, objectives, significance, delimitation, limitation of the study and definitions of terms used in the study. The second chapter deals with the review of related literature, and the third chapter deals with the research design and methodology of the study. The fourth chapter deals with presentation and analysis, fifth chapter deals discussion and implication, and the last chapter deals with the summary of the findings, conclusion and recommendations of the study.

CHAPTER TWO

REVIEW RELATED LITERATURE

2.1 History of Interval Training

The basic concept of interval training has existed for a number of years in one form or another. In the 1930s the known German coach, Woldemar Gerschler, with the formalization of a structured method of interval training. The term high-intensity interval training (HIIT), that was popularized in the 1990s, professional athletes have been utilizing some form of interval training since the 1950s. Some sports traits were utilizing a fundamental form of interval training, from the 1920s, before the term was coined. There are a variety of alternative terms for interval training, including: Old interval training (1920s to 1990s): That includes repetition training, intermittent training, non-exhaustive or exhaustive intermittent training, non-steady state work or workout; and interval workout and the other types are 'New' interval training (1990s to present): HIIT, high-intensity aerobic interval training, short-term intensity training; high-intensity intermittent exercise (HIIE); vo2max intervals; tabata method, tabata protocol, steady state intervals; short work-to-rest ratio intervals (Wilmore and Costill, 2012).

2.2 Basic concepts of volleyball game and HIIT

Volleyball is an intermittent sport activity that involves complex movements in continuous development. In a five-round or set match, a total of 250-300 high-power physical movements are required. Volleyball sport is depending on; short interval exercise periods and rest period can be defined as its basic interval sports activities. In volleyball, which is interval sport, a match can last for 2-2.5 hours. Volleyball sport can be defined as it's one of the types of high intensity interval sport consisting of short periods of loading and resting periods. There are four basic movements specific to volleyball at the time of training and competition period: i.e. jumping, spiking, blocking and fall (floor defense) therefore, in order to be physically fit and technically powerful, speedy, strong and agile HIIT is basic and fundamental training method (Baltacı et al., 2003). Volleyball sport is also a game that includes continuous aerobic and anaerobic loading. Therefore, it may be higher cognitive process that it requires

high muscular strength and good fitness ability. HIIT is the repetition of several exercise series at certain intervals. The feature of HIIT is the regular exchange of work and rest or severe and low load circuits. High-intensity interval studies provide more efficient use of aerobic and anaerobic energy systems. It was found that these exercises (i.e. physical fitness training) increased the oxygen intake and the activeness of mitochondrial enzymes producing energy in the players' skeletal muscles. Hence, the rehabilitation of anaerobic energy sources, which are completed by using aerobic energy sources, is enhanced. HIIT is very important in terms of explosive power, strength, speed and agility development for sports branches where load intensity such as, volleyball, handball and basketball is unstable during competition (Karacaoğlu, 2015).

During a volleyball match, players perform different types of physical activities such as the various sprints, jumps; speed plays and high-intensity court movement and players require the ability to perform these physical activities characterized by repeated maximal efforts with limited recovery during the match (Sheppard, et al., 2007). Although volleyball is not an endurance sport but, it necessarily an optimum level of aerobic capacity is crucial for the ability to maintain an elevated intensity of work to play (Lidor, 2010). HIIT therefore becomes a good time-efficient strategy to develop physical fitness levels during training adaptation similar to competition.

2.3 An Overview of High Intensity Interval Training

Basically, achievement of an athlete is always depends on how he/she practices, what is practised and what its purpose, selection of training methods and the right kind of exercise would influence the success of the exercise itself. HIIT is one of the methods and the right kind of exercise because it is very effective and efficient way to improve the desired of physical components of volleyball sports (Miramonti et al., 2015). High intensity interval programs now a day have become highly well-informed methods of training for athletic performance enhancement and it can be applied to a variety of sports and exercises, for example volleyball, handball, football and others.

It's usually defined as physical exercise consisting of repeated bouts of high- intensity activity and it performed above the lactate threshold (a perceived effort of "hard" or greater) or hypercritical speed/power, interspersed by periods of low intensity

exercise or complete rest (Buchheit, Martin, Laursen, Paul.,2019). HIIT can be described as repeated bursts of relatively intense exercise followed by periods of rest or low-intensity exercise (Gillen and Gibala, 2013). For example, mountain climber followed by a jogging is interval training a set of burpees followed by walking. Most commonly, HIIT sessions are performed an intensity of at least 80% of VO₂max or higher, but can be done using different modes or intensities of exercise (Boutcher, 2011). HIIT provides high level of fitness and health endorsement in less time per week than the suggested exercises guidelines (Heinrich, Patel, O'Neil, Heinrich, 2014). HIIT is one fundamental training method for volleyball players in order to changes of explosive power, speed, strength, agility fitness of the athletes throughout intensive short term bouts of effort with time for rest.

The goal in HIIT is to complete each interval at an intensity that is greater than the anaerobic threshold (Laursen and Jenkins, 2002). The anaerobic threshold is reached when an activity requires energy faster than is aerobically produced, so the body uses a quicker anaerobic process for energy. HIIT also known as high-intensity intermittent exercise (HIIE), is a short, intense workout type of cardiovascular exercise usually lasting from 4-30minutes; applying alternate exercise periods between high and low intensity exercise or between high intensity anaerobic exercise and short periods of rest (Shiraev, 2012).The primary aim of HIIT in volleyball sport is to improve , cardiovascular fitness, speed, explosive power, strength, agility, glucose metabolism, and fat burning (Talanian et al., 2006). So, in this context the fundamental characteristics of HIIT are that exercise should be brief, infrequent, and intense to the development of athletic performance especially for volleyball athletes. HIIT is recently planned as an effective training method to minimize the interference phenomenon and improve the player's overall physical fitness level, physiological function and skill performance of volleyball players (Silva, Nassis and Rebelo, 2015).

Modern volleyball players should become faster, stronger and have a better physical condition resulted of a year-round training and skills development that make the strength, power and fitness become higher. For most populations this can be very taxing and may lead to nausea, however, modifying HIIT makes this type of training more feasible for different athletic performance, while it's still remaining time-efficient compared to other types of training (Gillen and Gibala, 2013). There are

many different ways HIIT can be modified for example; containing of 10 sets of one minute whole body bouts at about 80-90% of VO₂max, with one minute of recovery between each bout (Gillen and Gibala, 2013). The total 10 minutes of vigorous exercise and 25 minutes of total exercise including a warm-up, recovery periods between bouts, and a cool-down, making it still relatively time-efficient.

There are different types of exercise containing under high intensity interval training such as: mountain climber, high knee, spiking jump at the net, push up, dips, jumping jacks, burpees, air squat, running, or skipping rope is the most common form of exercise to develop power, speed, strength, agility, physiological function and skill performance of volleyball players (Gillen and Gibala, 2013). One study had subjects train using eight sets of 20 seconds of a single exercise (burpees, jumping jacks, mountain climbers, or squat thrusts) with 10 seconds of rest between each bout four times a week for four weeks. It consumes lesser time, permits individuals to perform higher volume of high intensity efforts, and has beneficial effect on aerobic capacity in order to develop the players' explosiveness, strength, speed and agility much more time is spent in active or passive recovery than in actual exercise. However, a single bout of HIIT performed at a strenuous intensity with a low resting period likely results in decreased enjoyment, and thus, adequate resting intervals between high-intensity sessions are vital in preventing negative affective responses for long-term exercise maintenance. By keeping everything varied during a workout, your training session remains considerably more interesting (Porcari, Bryant and Comana, 2015).

2.3.1 Different forms of high intensity Interval Training

There are different forms of HIIT such as, Tabata, cardio HIIT, full-body HIIT, HIIT with weights, and HIIT for runners. This refers to exercise sessions that are relatively short in length, less than 30 minutes including warm up and cool down, but require very intense bouts (Gillen and Gibala, 2013). The five main HIIT formats tend to involve long intervals, short intervals, as well as repeated sprints of short, long durations and game-based HIIT (Buchheit et al., 2019). Interval training is based on 5 variables: intensity and length of work-time, intensity and length of rest-time, and training total volume. HIIT can be classified according to the length of work intervals: long HIIT (3-15 min), moderate (1-3min) or short (10s-1 min) (Guiraud et al., 2012).

Researchers use variety period of time for work and rest in HIIT for example, Tabata protocol is one of the most known and this protocol consists of 20 seconds of maximum intensity exercise followed by 10sec of rest, repeated 8 times (Tabata et al, .1996). However, there exist several forms with different period of time for work and rest. Kelly, King, Goerlach and Nimmo (2013), used 10 × 1 minute HIIT bouts followed by 1 min rest, (Boutcher, 2011), used 8 s HIIT bouts followed by 12 s very low intensity, (Lau et al.,2014) used 15 s intensive works with rest in ratio 1:1, (Gibala, 2007) used 4-7x 30 s HIIT bouts followed by 4 minute rest. Basically for the main goal of aerobic power, anaerobic systems and directed to neuromuscular adaptation and metabolic development HIIT of short intervals, with efforts lasting less than 1 min at intensities comparable to maximal aerobic power up to 120% of maximal aerobic power, and work-to-rest ratios of 1:1, 2:1 or 3:1 typically needed in volleyball sports.

Table 1: HIIT duration of workout, rest between set, repetitions, and mode of rest

Total duration	Duration per set	Rest b/n set	Energy	Rep	Mode of rest	% of Max. HR
30-60 minutes	1minute	1minute	Aerobic	10	Active	
	2minutes	1minute	and	5	Active	80-90%
	4 minutes	3 minutes	Anaerobic	3-4	Active	

Adopted from (Gillen and Gibala. 2014) and (Gibala, et al, 2012)

2.4 Benefits of High Intensity Interval Training

HIIT can be associated with a high degree of physical effort, fatigue, and acute discomfort, when applied properly with adequate recovery; it clearly has been shown to elicit rapid improvements in various aspects of physical fitness performance of volleyball players (Laursen and Buchheit, 2019). Therefore, HIIT is considered a time efficient training strategy to induce rapid adaptation in skeletal muscle and physical fitness performance that are comparable to traditional continuous endurance training

(Gibala et al., 2006). Due to its time-saving nature and the induced physiological adaptations of HIIT has been ranked first in 2018 (Thompson, 2018) and third in 2019 in Worldwide Fitness Trends (Thompson, 2019). Growing evidence-based research shows that HIIT programs ranging from 5 days to 12 months are effective in improving VO₂max, aerobic and anaerobic capacity and over all fitness components (Atakan, et al., 2021). These HIIT program have been exposed to guide to similar health and performance benefits despite less time interval.

High intensity interval exercise also enables spending longer activity time at high targeted intensities of >80% VO₂max and maximum heart rate, named to as the “red zone” “In addition to being time saving compared with continuous aerobic training, HIIT has been shown to have advantages in terms of cardio-respiratory aerobic capacity (e.g., increased maximal oxygen consumption). This phenomenon is attributed to increases in the heart’s pumping capacity and in the mitochondrial activity (Buchheit, 2013). Increased aerobic capacity is related to improving fitness benefits such as, functional capacity, muscle power, strength, speed, agility and develop overall physical fitness quality on performance of volleyball players.

HIIT is a favourite form of training among athletes that is used to further improvement of their level of physical fitness, physiological function as well as technical skill from its already elevated state. However, HIIT has also aroused considerable interest among amateurs (Bartlett, et al., 2011). Basically high intensity interval training is performed through repeated maximum efforts with alternating rest breaks. According to (Kimm et al., 2006), one of the main advantages of this form of training is its short duration and the variety of exercises, which prevents the sessions from becoming monotonous. (Bartlett, et al., 2011 and Jung et al., 2014) and those researchers suggest that HIIT workouts are more enjoyable and attractive form of training compared to others for the development of physical fitness level of sports person especially for volleyball players. According to different researchers, this training method is became an effective and safe tool for increased conditioning in both athletes and non-athletes.

Moreover, HIIT is adaptability for people of all physical fitness levels and could be performed on all exercise modes (e.g. walking, swimming, exercise/workout classes)

(ACSM, 2011). One of the important factors as to why HIIT offers is an alternative method to exercise when there is a limited amount of time (Gibala and McGee, 2008). Increases in resting muscle glycogen content are important because skeletal muscle primarily relies on glycogen in order to perform high-power outputs for a greater period of time (Burgomaster et al., 2007). Additionally, in terms of performance, HIIT training has been linked to increased muscular and cardiovascular strength, explosiveness, speed, agility in both untrained persons and athletes (Gibala, Little and Hawley, 2012).

2.5 Effects of HIIT on the selected physical fitness qualities of players

2.5.1 Effect of High Intensity Interval Training on Explosive Power

Volleyball can be defined as an explosive movement in which periods of intense activity i.e. when the ball is in play are continuously alternated with others of relative rest and recovery i.e. when the ball is out of play, and in which the duration of the game is not initially determined. This sport is requiring a fast, intense and effective response from the athlete (Sozen, 2012). The power of the arm and leg muscles, in particular, plays a significant role in supporting spiking skills one of the vital skills needed to be a good offensive volleyball player. This obviously indicates that volleyball players need a large explosive power in the extremities when they need to make jumps and smash/blocking/ with high speed (Mannan and Johnson, 2015).

The concept of explosive power is the most essential factor determining performance in volleyball players. The force is the basis of power skilfulness, but it is one of the two elements that make up the power and speed. Volleyball requires a high level of physical condition, such as speed, agility, strength, power in the lower body, and core body region. Volleyball is a sport with a high anaerobic and aerobic demands in the lower body part because of the need of power and the movement of quickly jump to spiking and blocking action. To perform activities of daily living efficiently and to maximize sporting performance capabilities one needs the muscles and joints of the body to function optimally (Bangsbo et al., 2012).

The ability to effectively generate muscle power is believed to be an essential component of athletic and sporting performance and as a result has been extensively

researched (Cronin and Slievert 2005). practically, there are two ways of intervening for developing muscle power): first by training to develop the force component (i.e. strength); and second by training the speed component, which reduces the time period over which the work is performed it is strongly related to both peak power output and sports performance by using HIIT(ACSM 2002). To develop high-speed movement ability optimally, one should train specifically using high-speed movements (Hedrick 2002). HIIT has its own positive effects on explosive power and muscle strength. Power is the most important and basic aspect in sports performance. Victorious sporting performance at elite levels of contest often depends heavily on the explosive leg power of the athletes concerned. Team sports like volleyball require high level of explosive power. Explosive power or vertical jump comes from the improvement of speed strength and pure strength. Vertical and horizontal jumping, in its many different forms, requires high levels of explosive power Gray, 2016 and Atakan, et al., 2021.

It is known that while vertical jumping is a vital task in volleyball, the test of performance in jumping has been subjected to validity and reliability (Sattler, et al., 2012). The assessments of the explosive power were measured in volleyball due to the nature of explosive movements that are associated with performance in the ability to jump. Tests with vertical jumps were recommended to educated guess the explosive capacity on players of volleyball in their performance of rhythmic movements (Hoffman and Kang, 2002).

Saravanan and Pushpa (2021), A HIIT profile for performance variables of collegiate volleyball players. In short effect of regular HIIT on speed and explosive power of volleyball players. The study was contained 40 male volleyball players aged between 17 to 25 years. Subjects were divided into two groups randomly named as EG and CG. All the subjects were tested on selected variables, before and after the HIIT program. In order to find out the significant improvement data was analyzed using paired' test. It was observed that there was a significant improvement in the HIIT group as compared to CG in speed and leg explosive power.

2.5.2 Effect of high intensity interval training on speed

Speed or sprint activity is a fundamental component in various sports, predominantly volleyball game. Sprinting is an explosive movement that can directly boost human muscle strength and is usually used as a testing exercise, both for individual and team games. In short, sprinting can be an effective training method for the development of leg extensor strength and power (Markovic, Jukic, Milanovic and Metikos, 2007). The aim of HIIT is to enhance individuals' rapid force production capabilities (i.e. speed strength). This is a very important factor in many sports, since most of the movements performed in sports allow a very short time period to produce strength, for example spiking time in volleyball game is less than one second (Mero et al. 1992). Power and speed training requires that a movement is performed with a relative high rate of force development. Power training can lead to improvements in strength production over time, but also to improvements in maximal force production (Cormie et al. 2011). Also, power training seems to produce hypertrophy in type II muscle fibers (Shepherd, 2013). Nevertheless, usually HIIT is training modalities to experience even greater adaptations, and more sport-like overall physical performance of volleyball players.

Speed in movements of forward, backward, and lateral positions is important in many sports. It refers to the point in which athletes can speed up no more and have reached their highest rate of movement. In general sports, what is referred to as speed is in fact acceleration because athletes infrequently reach maximum speed during competition. The type of foot speed needed in volleyball is characterized by the athlete being able to quickly get from point A to point B. This rarely entails taking more than three or four steps in any one direction, so long-distance sprint-speed training is not very functional for the volleyball players. Leg muscle power is interconnected to the ability of an athlete to exert maximum strength and speed in the shortest potential time (Bompa, 2019).

Kadir and Ali (2021), Effect of eight-week HIIT on speed and agility U19 soccer players. The subjects randomly assigned into two as the EG and CG. In the study, the soccer players forming the EG attended a HIIT program three days a week for eight weeks, in addition to their regular training. The players of the CG continued their

usual training schedule. It has been observed that 8-week HIIT is statistically significant in the speed of soccer players.

Elumalai, et al., (2019), Effects of HIIT on Speed among U 16 Hockey Players. The sample includes 40 male players aged 14 to 16 years old. The respondents were divided into two groups, TG (HIIT training) and CG (skill training). The intervention program was conducted for eight weeks. The paired sample t-test analysis between pre and post tests showed significant differences after performing HIIT training in speed ($t = (19) = 3.313$, $p = 0.004$, ($p < 0.05$). Fajrin et al., (2018) this study focused on the effect of HIIT on increasing explosive power, speed, and agility. The data analyses were using the t-test (paired sample t-test). After being given the treatment for 6 weeks, the results showed there is significant change in the selected variables.

Jim and Arumugam (2020), those researchers were focused on the effect of HIIT on Explosive Power and Speed among College Volleyball Players. The selected subjects divided into two groups. EG underwent HIIT and CG acted as control. The EG was subjected to the HIIT program for alternative three days for up to 6 weeks period. The experimental design selected for this study was pre and post test randomized design. The data were collected from each subject before and immediately after the intervention period. The collected data were statistically analyzed by using dependent 't' test and analysis of covariance (ANCOVA). It was concluded that the results of the study that the HIIT group showed significant improvement in explosive power and speed when compared to the control group.

2.5.3 Effect of high intensity interval training on strength

Volleyball players required high level of strength fitness for stability as it permits valuable transmission of power from the lower body to the upper body and containing strength variables in HIIT programs increases muscle fibers allows the athlete to develop higher jumping power and greater power to produce force to block, spike and dig balls during a game. The more force they put into the ground the higher the player will jump. During volleyball game strength is moreover vital for volleyball player's stability. As a result of the strength development, the growth of the muscle fibers can usually be stimulated through intensive training programs (Ojo, 2019).

Saravanan and Manju, (2021), this study were focused on the impact of drill based HIIT on physical fitness variables of volleyball players. All the participants were separated into two equal groups with 20 subjects each. Group-I underwent drill based HIIT for a period of 16 weeks and group-II acted as control who participate in their usual training. The fitness variables muscular strength and cardio respiratory endurance were selected as dependent variables. Muscular strength was assessed by modified sit-ups and the unit of measurement in counts. Pre post-test random grouping design was used for this study. The data were collected before and after the training period of 16 weeks and the data collected were statically analyzed by 't' test, which was used to find out the significant improvement on selected variables from the base line to post. The result muscular strength of drill based HIIT group was showed 3.8 significant improvements compared to the pre test results.

2.5.4 Effect of high intensity interval training on agility

Agility is an important physical fitness component of high-intensity team sports performance that includes variables like acceleration, decelerations, and explosive strength capacity during directional changes (Bangsbo and Mohr, 2012) all of which are important parameters in competitive volleyball games. Physically, speed in high intensity interval training theory is to move a part or all of the body at great speed with the help of its members. Although the aerobic energy system is utilized intensively in netball, it is a team sport that requires anaerobic capacity components such as speed, agility, and acceleration in the game (Hazır, et al., 2009).

Agility in volleyball requires quick and sometimes awkward movements of the body position to adjust the ball during play. Volleyball is a game that involves tremendous lateral movement and the capability to move with fast feet throughout volleyball matches. Speed and agility involves moving the body very rapidly, as fast as possible, but in agility skill we add the quality of changing direction that is very essential in volleyball sport games (Horicka, Hianik and Simonek, 2014). Therefore, volleyball players need to be able to move from side to side and at a variety of angles effectively and quickly in order to be successful. Purkhu, Krustrup, and Mohr, (2016), HIIT improves exercise performance in elite women volleyball players during a competitive season (n = 25, age, 19 ± 5 years). They were randomized into a HIIT (n

= 13) group and a control (n = 12) group. In addition to the usual training and games, HIT performed 6–10 3×30-seconds all-out running intervals separated by 3-minute recovery periods 3 times per week during a 4-week in-season period whereas CG only completed the team training sessions and games. Agility performance improved in HIT post intervention compared with pre intervention period.

Chandu and Johnson (2021), the effects of HIIT on agility among inter collegiate badminton players. 30 badminton players were selected as subjects. The selected subjects were divided into two groups of (n=15). The EG was HIIT group, and a CG. Initial test on shuttle run test was conducted for all the groups and the performance was recorded for these groups. The EG was administered for 8 weeks training. The CG was not given any treatment. After eight weeks the final test was taken from both groups. The result of the study was HIIT group was significant improvement in compared to the control group.

2.6 Method of Monitoring Intensity during HIIT

Monitoring HIIT is easy in a laboratory setting; however, for the general population that doesn't have access to the necessary equipment, it may be hard to determine a percentage of VO₂max. To determine if intensity is high enough to be considered HIIT is to look at heart rate. High intensity interval work should be done at 80% or greater of maximal heart rate, which can easily be calculated (Kravitz, 2014). General populations can also use the “talk test” as a guide. When performing high-intensity exercise, an individual should not be able to carry on a conversation or talk without great difficulty or if you can't say more than a few words without gasping for breath, you are exercising at an energetic intensity. For the recovery intervals between bouts, individuals can choose an active or inactive recovery. If choosing to do an active recovery between bouts, intensity should be at about 40%-50% of max heart rate (Kravitz, 2014). The success of this training method lies in the possibility of target and monitor training load (Buchheit et al, 2009). The intensity and duration of workout and rest intervals are the key influencing factors. But, in order to control the whole activity the coach should count and register the routine of intervals, the number of series, and between-series recovery length and intensity level account for the total work performed. This method does not require the monitoring of heart rate, speed, or

power. A coach can just instruct, “You’re running 4 × 4 min hard, with 2 min walk recovery intervals.” It’s a versatile method that can be used any where (Buchheit, et al., 2019).

2.7 Physiological Responses of HIIT

The general purpose of HIIT is to stress specific physiological systems used in sport to an equal or greater extent than that required during contest so that new levels of performance can be attained. Training at higher exercise intensities, especially with athletes and trained individuals of higher fitness levels, can improve the ability to supply energy aerobically and anaerobically to the exercising muscles. During high intensity exercise of short duration, the capacity for aerobic energy supply is critical for exercise performance. Results from (Tjonna et al., 2008) indicate that high intensity exercise increases VO_2max to a higher degree than exercise of a lower intensity.

High-intensity interval training (HIIT) has become increasingly more common in physical training preparation for team sports, as it has been shown to be a time effective method that stresses the physiological capacities common to team sport match-play (Buchheit and Laursen, 2013). HIIT is one of the best ways to increase metabolic activity for hours after the period of exercise is over. The repeated variation of oxygen concentration in working muscle and brain during work out is likely to be one of a number of critical signals responsible for the improved muscular oxidative capacities and performance improvement shown subsequent training.

HIIT including squats, push-ups, and burpees of a 12-minute workout affected the muscles power and strength more than a 40-minute aerobic training and it improves oxygen and blood flow on the heart pumps through the different body in order to deliver oxygen and nutrients to the muscles. Largely, shorter duration of HIIT program elicit lower oxygen uptake, heart rate and blood lactate concentration of the body when the total work out is matched (Tschakert et al., 2015). Varied combinations of work out-recovery durations and intensity can generate a balance or imbalance between lactate production and lactate clearance. But, the goal of HIIT is defined as increasing the training time close to maximum heart rate, as a result producing a stronger stimulus for cardiovascular health and muscle adaptations of

exercising and to improve physiological and metabolic overload by maximizing time spent performing high-intensity exercise (Buchheit, et al., 2013). During HIIT, the ability to maintain adequate overload without critical disruption of homeostasis leading to premature fatigue is controlled by either duration of interval or the duration of the recovery period (Laurent et al., 2014).

During HIIT, the ability to preserve adequate overload lacking critical disruption of homeostasis leading to early fatigue is controlled by either duration of interval or the duration of the recovery period (Laurent et al., 2014). HIIT can help in regulating musculoskeletal aspects as compared to traditional /long-established/ training. HIIT are also more successful in performance enhancement of volleyball players due to slow accumulation of lactic acid production in the exercising muscles, through delaying the onset of fatigue for substantial time. As well HIIT can increase the size and number of mitochondria in the trained muscle group and for the duration of this program the myoglobin content may sometimes increase; hence the oxygen storage capacity increases. As part of the repair process, the body will generate elevated levels of participants' growth hormone, testosterone and insulin-like growth factor-1 to repair damaged muscle proteins, which lead to increases in muscle volume and its working definition.

2.8 Principle and Guidelines of high intensity interval training

According to (Buchheit, et al., 2019) to use high intensity interval training appropriately athletes' and coaches should consider:- understand the context, including the sport, individual athlete needs and unique responses, phase of the training cycle, and the possible interference effects, define the target (desired physiological response/adaptation and, in turn, one of the six target types/, choose (one of the) appropriate HIIT formats (HIIT short intervals, HIIT long intervals, game-based HIIT, RST, and sit), manipulate the HIIT variables to shape the piece, monitor the load and its response. Perform an adequate warm up and cool down when performing HIIT and If you experience any of the following symptoms, during the training stop exercising immediately and seek medical aid like: extreme breathlessness, breathing problems such as wheezing or coughing, chest pain,

dizziness or fainting, severe muscle pain or cramps, nausea, severe pain in any muscles or joints and extreme and long-lasting fatigue after exercising.

According to the Kravitz and ACSM (2014), HIIT comprises exercising program that increase participants heart rate to 80-90% of persons maximum capacity. The underlying principle of the workout is that the shorter the duration of the exercise, the higher its level of intensity. Principles of HIIT are mainly focused on level of intensity, duration of the training, and recovery time. It involves 4 to 10 repetitions of work out (an exercise), with breaks of 1 to 3 minutes between repetitions. There is no universal specific formula for HIIT but, it depends on one's level of cardiovascular improvement still, researchers used common formula involves a 2:1 ratio of work to recovery periods, for example, 40–60 seconds of hard jump squat with 10–15 seconds of jogging or walking. Three days a week is adequate amount of HIIT program after 24 hours of rest and recovery between sessions are recommended.

When performing, HIIT researchers suggest that total exercise duration should lasting between 30 and 60 min and the duration of the set should be between 45-90 seconds for better results (range 30-150 seconds), with warm up and cool down included in that time. During planning HIIT program avoid those mistakes like planning long workouts more than 30 minute per session, forgetting about recovery because, most people would often benefit from more recovery time between intervals, so that they're able to recover well enough to generate a high level of force or intensity throughout the next work interval(Gibala and McGee, 2008).

2.9 Principle of training

Coaches and athletes alike, in all over the world, is the general concept that physical performance improves through proper training. Proper training for peak sporting performance contains training for physical development (general and sport-specific factors), and technical and tactical training. Training adaptations can be classified either as those changes that increase performance of muscle power, speed, strength, agility increased ability to resist fatigue, or increased motor coordination or those changes that condense the danger of injury. There is commonly a positive relationship between training load and the physiological adaptations resulting in improvements of athletic performance (Meeusen et al. 2006).

2.9.1 Specificity

Specificity of exercise and training is the most important consideration when selecting suitable equipment for training methods, especially if performance enhancement is a primary goal. Transfer of training effect deals with the degree of performance adaptation which can result from training exercise and is strongly related to specificity. This includes movement patterns, peak force, and rate of force development, acceleration, and velocity parameters. The more similar a training exercise is to the actual physical performance the greater the probabilities of transfer (Siff and Verkoshanski, 1998).

2.9.2 Progression

Progression refers to the choice of exercises, loads, order of exercises, and readiness of the athlete that are just right (not too hard, not too easy) for the status of the athlete and the demands of the activity. To sustain increases in muscle improvement and performance one constantly needs to progress the program by gradually increasing the demands placed on the body. This can be incorporated into a training program by manipulating any of the following training variables appropriately: increasing the frequency of training; increasing the repetitions in each set; increasing the number of exercises; decreasing the rest periods between sets or exercises; increasing the load utilized; or changing the speed of movement (ACSM, 2002).

2.9.3 Variation

Variation is concerned with appropriate manipulation in training volume and intensity, speed of movement and exercise selection. Proper variation is an important consideration for the lengthening of adaptations over uninterrupted training program. Moreover, appropriate sequencing of volume, intensity, and activity selection including speed-strength exercises in a periodical manner can lead to superior improvement of a variety of performance abilities. There is adequate evidence to support the idea that varying the exercises trained on a specific body part is improving strength and power gains (Pearson et al., 2000). Variety is the spice of our training methods because improved motivation and prevent boredom.

2.9.4 Overload

An athlete has to be exposed to an overload stimulus at daily intervals for the induction of training for eliciting a desired physical, physiological or performance adaptations. An overload stimulus can be influenced by changing the mode of exercise, duration, frequency, intensity, and recovery period between training sessions (Bompa, 1999). According to this principle, physical exercise must be done at a higher level than usual to bring about various training adaptations will function more effectively and efficiently. The intensity of training is related with the pace of performing work and the rate at which energy is expended: the volume of training is a measuring or estimate of how much overall work is performed and the total amount of energy expended (number reps, sets, the number and types of exercises, and the number of times per day, week, month).

2.9.5 Reversibility

Principles of reversibility indicate that loss of fitness results after terminating usual training. A common saying "if you don't use it, you lose it". Even if the training load is repeatedly too much or rest periods continuously too short, the athlete will not recover sufficiently to cope with the next training load, and causing over training and a subsequent decrease in performance. During this time, the training intensity must be managed and an active rest phase is suggested.

2.9.6 Recovery

Players must get adequate rest between each workout in order to recover and be well prepared for then exercise bout. The following are factors that need to be considered during the recovery process after a training session: First, An athlete aged older than 40 years needs longer recovery periods than younger. Second, Environmental conditions training and competing in the heat imposes more physiologic stress on the athlete and requires a longer recovery period. Third, the type of training that induces muscle damage requires longer recovery periods than activities that cause fatigue (Bompa, 2009).

2.10 Theoretical framework of Physical fitness

According to Abiyu, 2014, described physical fitness as the ability of the body to perform moderate to vigorous levels of physical activity without being overly fatigued and capability of maintaining such abilities throughout the life. Haskell & Kiernan (2000) physical fitness is defined as —the ability of players.

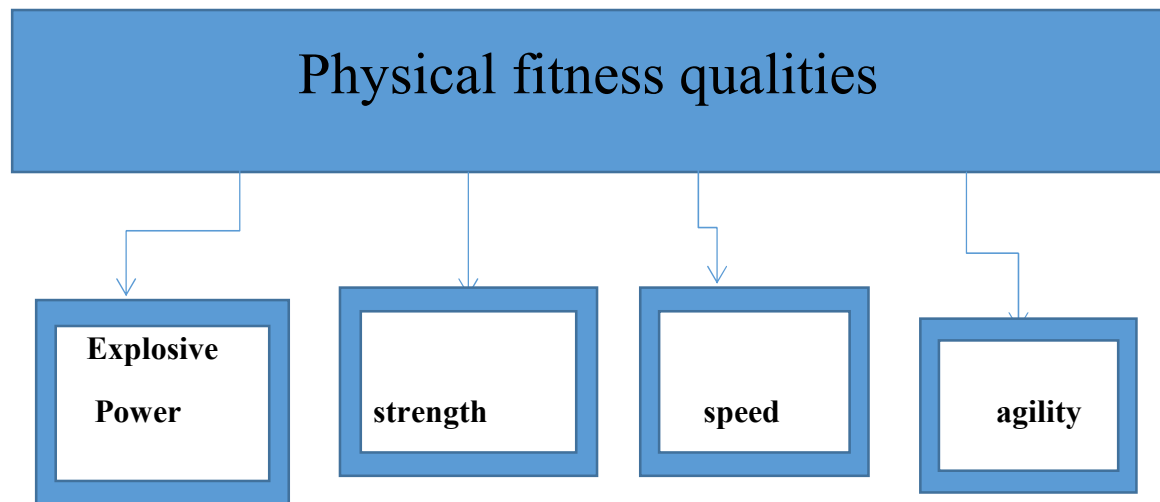


Figure 1: Conceptual framework of physical fitness qualities

2.11 Physical fitness qualities of volleyball players

Physical fitness has two categories that is health related and skill related components of fitness abilities. Health related physical fitness components are components which are related with the health of individuals which include; aerobic fitness, muscular strength, muscular endurance, flexibility and body composition. it's important to increases muscle tone, decreases injuries and illness, improves bone mineral density, reduce risk of osteoporosis, improves posture, increases efficiency of the respiratory and circulatory systems and facilitate metabolism, increase energy level and academic achievement. Skill related components are physical fitness components which are associated with the performance of individuals and includes agility, balance, coordination, speed, power and reaction time (Wilmore and Costill, 2004). Also its types of activities dedicated to improving physical skills category especially preparing the athletes for competition. However, physical attributes such as explosive power, muscular strength, speed and agility are important factors for success in competitive volleyball.

Explosive Power

Muscle power is a function of the interaction between power /force/ of contraction and the speed/velocity/ of contraction is related with the explosiveness of the muscle. Explosive power is the most necessary part of players' skills and enables players' activities during the games to be not only the required height and with the necessary power but also at the right bit. In many sports such as volleyball, handball, football and basketball, power is very important component for players. Power is important in energetic performance because it determines how hard individual can hit, jump, and spike (Gordon, 2009)

Speed

Speed consists of a number of elements, all of which are independent qualities: acceleration speed, maximum/upper limit/ speed, and speed endurance/stamina. Performance in the 10-m sprint is affected by acceleration speed, whereas performance in the 40-m sprint is needy on both acceleration speed and maximum speed. Speed can be developed by increase the power to weigh ratio. Interval related training (i.e., counter-movement jumps or loaded squat jumps) is effective for improving speed (Cronin and Hansen 2005).

Muscular strength

Strength refers to the maximum tension or force muscles develop in a single contraction against a given resistance. It is crucial for optimal performance in volleyball sport activities such as spiking, sitting, digging, floor defending, blocking, running, pushing during block, and other actions. Strength training helps players protect their joints and reduce the risk of injury as they build explosive power, endurance, move more freely, and achieve a greater range of motion (Widmer, 2020). Upper, middle and lower body muscular strength training is required to perform serve, pass and spike and to demonstrate aggressive blocking in volleyball. Strength is the maximum effort that can be issued by a muscle to overcome pressure in playing activity of volleyball sport. Volleyball sports event concerned almost all muscles that play the same significance (Sattler et al., 2015). Strength of arm muscled are very vital in volleyball sports competition. Strength of arm is one issue that used to predict

the quality of volleyball players (Ahmad and Ahmad, 2018). Volleyball is a game it dominated by strength and power consequently; volleyball players need strength in their upper body part during smash, block, and digs and defend the balls from the ground during opponents spike and serve. Strengthening volleyball-specific muscles ensures that athletes are able to attain their highest performance potential. For example, core strength is very vital for a player's stability and allows hitters to transition power more economically from their lower body to their upper body and arm swing in different playing action of volleyball sport (Koley and Kaur, 2011).

Agility

Agility movements can be defined as rapid, whole body movements that require single or multiple changes in velocity (i.e., acceleration or deceleration) or direction (i.e., vertical, lateral, or horizontal) in response to an external stimulus (e.g., opponent movements, location of the ball,) (Gabbett and Benton, 2007). In team volleyball reactive decision-making, tactic, technique, and physical capabilities all contribute to the success of an agility performance. Therefore, agility training programs should include all four of these aspects (Markovic, 2007).

2.12 Factors that affect fitness qualities of volleyball players

There are different factors that affect physical fitness qualities of the players some of them are:

Training: It is perhaps not surprising that high levels of training or practice are required to attain performance of volleyball players. Skill development clearly supports the relationship between training practice and skill acquisition. Vigorous physical fitness training will be conducted 3-5 times per week. For optimal results players must strive to conduct 5 days of physical training per week. Training improves the function and capacity of the body such as respiratory system, cardiovascular system, etc. for instance, HIIT improves muscle's ability to produce energy via facilitating the muscle fiber (Sharkey, 1990).

Heredity is other types of physical fitness factors that genetically we inherit have factors that contribute to our fitness and skills. For instance, in aerobic fitness,

including the maximal capacity of the respiratory and cardiovascular systems, a large heart, more red blood cells and hemoglobin mitochondria, the energy producing units of muscle and other cells, are inherited from the maternal side (Sharkey, 1990).

Players' diet: The importance of players' diet cannot be underestimated when planning the path to increase performance. If a player does not have a healthy diet, they will not be able to train as hard, will struggle to improve their competition and be more susceptible to tiredness (Stewart, 2001).

Way of coaching and instruction: A coach normally constructs a high percentage-in some cases 100% of players practice time. The ability of the coach fosters optimal learning thus becomes one of the most significant keys to players performance development. Planning of practice is one hallmark of coaching expertise. Coaches spent more precise in their goals and objectives for the practice session than their non-expert counterparts (Stricker, 2010).

Cultural factor: are a significant and often overlooked component of the environmental equation and development of players' performance. The importance the society places on a particular sport can have a dramatic influence on performance achieved (Davenne, 2009).

Anger is usually thought of as post performance emotion for circumstances such as performing poorly and /or losing a game. However, anger may also influence on players performance and carry over in to competition. The lower an athlete's level of anger, the better they tend to perform.

Rest: It is not secret the body needs rest in order to function at its highest level. During the period of rest that the body discards unnecessary information from the brain, heals and gains energy for the next day's activities (Lane, et al., 2010).

2.13 Technical skill of volleyball

Technical skills are different from one ball game to another in specialization of the sport type. The basic technical skills in volleyball are: service, dig pass, fore arm pass, set, spike, block and floor defense. Focusing in the fundamental is crucial in volleyball that sounding teams have best skill in order to focus and to be confident; as

a result it leads to success. The game always starts by a serve and it is the first chance of gaining point. The second action will be service reception and pass to the third executer setter and the last but not the least attack will be spike. The fifth and sixth action are block and back court defense. Dig is one of the back court defense skill which needs agility, flexibility and fast reaction. Service, reception errors and attack blocked are major to losing and winning a match in volleyball (Patsiaouras et al., 2011). Team success depends on the individual mastery of these fundamentals. From the basic six skills of volleyball this study focus on the more fundamental skills which leads to success and critically related to jumping activities.

2.14 Spiking technique of volleyball

Spiking is highly related to the explosive jumping activity and had a great influence in the winning and losing of the game (Cieminski, 2017). In volleyball, the spike technique is the game action that attains the most points and that has the highest correlation to the team's performance during competition (Marcelino and Mesquita, 2008). The performance of the spike technique, from a mechanical viewpoint, depends on the height of contact, the direction the ball is sent, and the release speed of the ball. The volleyball spike is vital skill which an average top level volleyball player performs about 40,000 times per year (Trouillier and Rosemeyer, 1996) accordingly; insight in the mechanics of the spike motion is an important issue in developing training programs. The volleyball spike is a difficult motion that can be characterized in four phases those are approach stage, arm cocking phase, acceleration phase and follow through phase. From the moment of take-off until striking the ball, energy and (angular) momentum of the total body are preserved physical fitness quantities (Bolt, Ruan, et al., 2010).

2.14.1 Spiking speed of volleyball

Spiking is one of the most important components of volleyball technique. In volleyball, spiking technique is the offensive play where a player hit /slams/ the ball sharply downwards over the net and into the opponents' court, making it hard for the opposing team to recover the ball. From mechanical point view, there are three aspects that describe spike success during volleyball game: a) hit height, b) ball speed, and c) ball direction. Hitting height highly depends on the players' technical

execution of the spike and lower body strength. Ball from the mechanical speed depends on the technical execution of the spike and upper body strength (Coleman, Benham, and Northcott, 1993).

Ball speed is one of the primary factors that contribute to successful offensive. The harder the ball is attack, the faster the ball will travel and the shorter the time opposing defender will have to successfully keep the ball in play. The speed of ball and hitting direction (position between the hitting arm and the trunk) were measured for the standing and jump spikes. During each spike, the spiker generates the momentum imparted to the ball. Many factors may possibly influence the spike performance: such as, the linear speed of the spiker in the direction of the spike, The smashers torso rotation, arm swing and wrist snap, The downward speed/velocity/ of the spiker, that is, the drop speed of the spiker before contacting the ball; and the mass and inflexibility of the spiker's hand (K. Bonnie, 2006).

Another significant factor is the choice of the appropriate direction of the attack area. The biomechanical principle of effectiveness (accuracy of the attacking area) is met when the ball is directed into the opponent's weak area. The ability of the leg muscles to produce explosive type of power and strength is in volleyball terminology referred to as the vertical jump. The spike's success depends on numerous factors, such as the pathway of the set, opponent positioning, the physical and technical skills of the attacker, speed of ball, etc. Commonly in volleyball sport, the uses of radar testing machines are commonly used and in fact, radar is used to monitor spike speed in competition and training.

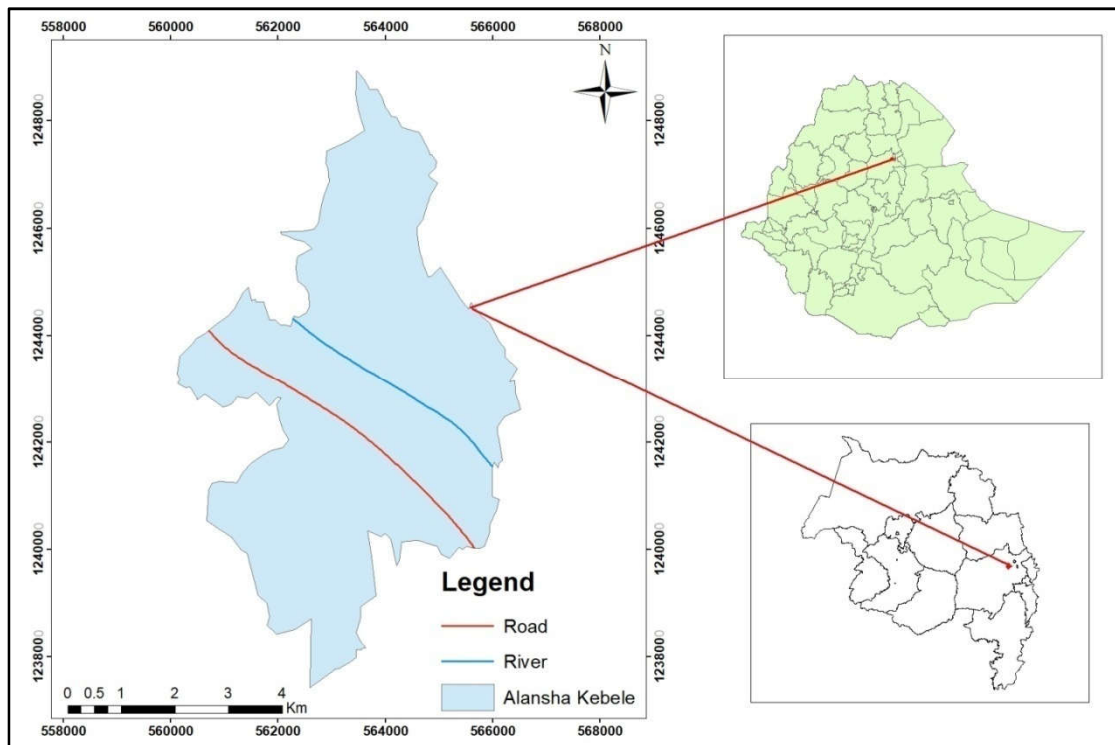
In modern volleyball game, every winning point is based on performing key skills better than the opponent. A point is scored if one team causes the ball to land inbounds on the opponent's side or forces /speed of attack/the opponent to make an error and the speed of the spiking ball is very difficult either to organized the ball for attack and to receive or making it difficult for decision making so, opposing team have limited time to respond. A successful attack in volleyball is generally referred to as speedy kill (Gilbert, Lee J and Hunter, 2013).

CHAPTER THREE

RESEARCH METHODS

3.1 Description of the Study Area

This study was conducted on Kutaber Woreda and Kutaber is one of the parts of the S/Wollo zone Woredas in Amhara Regional state of Ethiopia. Kutaber is also bordered on the South by Dessie zuriya, on the West by the Adila River which separates it from Tenta, on the North by the Wolano which separates it from Ambasel and on the East by Tehuledre. Elevations of this Woreda range from 800m at the northernmost point. It is located at 11012'36" -11018'36" N latitude and 39031'12"-39034'12" E longitude also the average annual temperature is 22°C (Kado, 2018). Alanesha kebele is also the administrative center of Kutaber district, that found between Dessie and Kutaber town that distant 15 km from Dessie and located at around 497Km Eastern of Amhara Region. Kutaber is located 422km far away from north of Addis Ababa and this district is located in north central Ethiopia (Svein Ege, 2011).



Source: Andualem Kassegn Amede (2020)

Figure 2: Map of the study area

3.2. Research Approach

This research was followed quantitative approach because, quantitative research relies on the collection and analysis of mathematical data to describe, explain, predict or control variables and phenomena of interest (Gay and Airasian, 2009).

3.3. Research Design

This research approach follows experimental design because, participants are randomly assigned to either the experimental or control group (Creswell, 2012).

3.4. Population, Sample and Sampling technique

There are 24 male project volleyball players found in Kutaber woreda at Alansha kebele. In order to select the samples for this experimental study, comprehensive sampling techniques was used, because populations are small in number. Therefore, the sample population of this study incorporates every one of the volleyball players at Alansha project volleyball players. These research participants were randomly assigned to the control (n=12) and EG (n=12). For both groups, before applying the intervention a pretest was administered and a posttest was also conducted at the end of the intervention. Finally, the EG (n=12) underwent an additional 8 weeks HIIT with 3 sessions per week, each lasting 45-50 minutes, and the CG performed only regular volleyball training sessions given by the coach. Both the EG and the CG was participated in the typical volleyball technical training sessions of three days per week.

3.5 Sources of Data

This research was used primary source of pre and post field test data quantitative data were gathered through the appropriate physical fitness test measures and volleyball spiking technical skills tests of (vertical jump for explosive power, 30m sprint for speed, push up test for strength, SEMO test for agility).

3.6 Variables of the study

3.6.1 Independent variable

The independent variable is a characteristic that the researcher manipulates in order to identify a specific factor and used to measure the effect in the dependent variable. Therefore, the independent variable of this study was HIIT.

3.6.2 Dependent Variables

It is defined as the variable that is measured using independent variables. In this research, the dependent variables were physical fitness components such as explosive power, speed, strength, and agility and spiking speed.

3.7 Data Collection Instruments

In order to get better result quantitative data was collected before and after the intervention through the appropriate selected physical fitness quality tests concerning to the effects of HIIT and thus, all data were administered as per the following criteria measures.

Table 2: criterion measures of the study

No	Criterion Variables	Test items	Unit of Measurement
1	Explosive power	Vertical jump test	Centimetre
2	Speed	30-meter sprint test	Second
3	Strength	Push up	Score
4	Agility	SEMO test	Second
5	Spiking technique	Radar test for spike's speed	Km/h

3.8 Training protocol

Experimental group was completed HIIT training in their assigned training program three days a week during eight week HIIT period in addition to their usual training. The control group participate only the usual volleyball training without additional HIIT. Then, athletes complete a 10-min standardize warm-up consisting of walking, jogging, dynamics stretching, and specific skills related to their sport. Following the

warm-up, athletes carry out their assigned training for that day. Each exercise was performed to the participants' best effort and was done for 60 seconds per a set and followed 10 seconds active rest period. This repetition continues until the completion of one minute. The intensity of the intervention was fixed by calculated training heart rate. 80 and 85 % intensity of players was calculated, by using Karvonen formula.

Target Heart Rate= (maximum heart rate – resting heart rate) x % intensity) + resting heart rate, maximum heart rate can be taken as 220.

Adopted from (Dalwinder and Satish, 2015)

Table 3: training protocol

Treatment	HIIT
Frequency	3 days a week
Total duration	8 weeks
Duration of training per session	45-50 minutes
Intensity	HI with active or total rest
Exercise day	Monday, Wednesday, and Friday
Timing of training	Afternoon (10:00-10:50)

(See appendix B page 80)

3.9 Procedures for administration of tests

3.9.1 Physical fitness qualities and spiking speed tests

During this research test procedures the pre test was conducted from March 15-16/07/2014 E.C at the morning after two days the intervention was started and post tests was also conducted after the completion of eight weeks HIIT program after one days rest from May 14-15/09/2014 E.C similar to the pre tests at the morning and the data was collected in Wollo university inside the gymnasium center, three on one court and outdoor volleyball court (see appendix G), and during data collection researcher used four data collector (that have Bachelor of science degree and Master of science in sport science).

All pre test measurements were applied within the first week prior to the intervention, while post testing was performed within first week following the completion of the program. Every assessment session take place under similar environmental conditions and at the same time of the day and the participants were perform enough warming up and stretching exercise to all tests at the beginning. All tests was explain and demonstrate before testing, subjects given practice trials to become familiar with the testing procedures in a single session conducted at one week prior to actual testing. Subjects were performed each test as per test procedure and the scores of best trials were taken for this study. The testing had schedule on a day that allowed for hours rest from vigorous training and the participants were instructed to maintain normal sleep and nutritional intake prior to attend the testing session.

3.9.2 Explosive power Test procedures

Power was measure using vertical jump test

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

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

Procedure: The player warms up for 10 minutes. The player chawks the end of her or his fingertips .The player stands side onto the wall, keeping both feet remaining on the ground, reaches up as high as possible with one hand and marks the wall with the tips of the fingers (M one). The player from a static position jumps as high as possible and marks the wall with the chalk on his fingers (M two). The assistant measures and records the distance between M one and M two. The player performed three trials. The assistant calculated and recorded the highest jump from the three trials.

Scoring: The jump height is usually record distance score in centimetre.



Adopted from Sergeant Jump Test, 1921

Figure 3: vertical jump tests

3.9.3 Tests for Muscular Strength

Push-up test

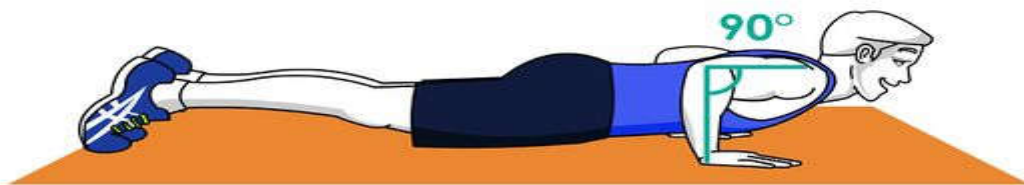
Objective: to measure upper body strength and it's the basic fitness test used by coaches, trainers and players to assess upper body strength and to monitor progress of fitness training.

Equipment required: floor mat, stopwatch, wall, and chair and flat surface.

Procedure: The push-ups test is conducted as follows:

- Be positioned/lie on/ on the mat, hands shoulder width apart & completely extend the arms.
- Keeping the back and knees straight, the participant lowers the body to a predetermined point, to touch the floor.
- Lower the whole body until the elbows reach ninety degree (90°).
- Return to the initial position with the arms completely extended.
- The push up action is to be uninterrupted up to fatigue of the participants muscle.
- Complete as many press-ups as possible.

Scoring: Record the total number of full body push-ups on the evaluation form.



Adopted from, Mackenzie B, 2005

Figure 4: push up strength test

3.9.4 Speed test procedures

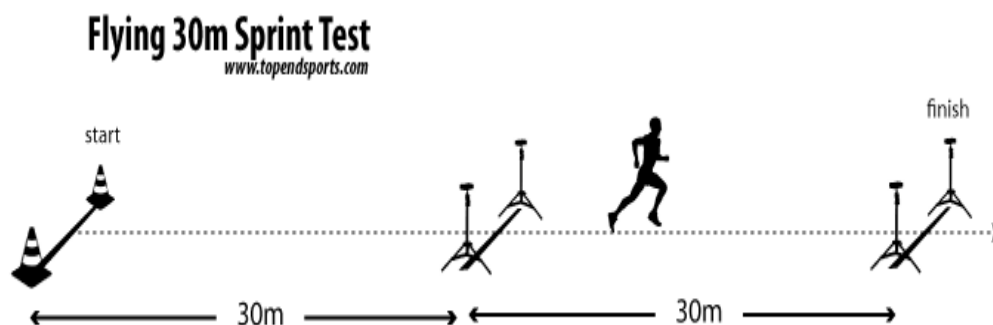
Flying 30 Meter Sprint test

Purpose: The aim of this test is to decide maximum running speed. This test can also perform as part of a 60m sprint test, using split times to measure the flying 30m time

Equipment required: marked track, stopwatch, cone markers, flat and clear surface of at least 80 meters.

Procedure: Set up cones at 0, 30m and 60m beside a straight line, and timing gates if available at 30m and 60m. The experiment involves a 30m acceleration area to enable the sprinter to get up to their maximum speed, then maximal sprinting over 30 meters. The tester should offer hints for maximizing speed (such as keeping low, driving hard with the arms and legs) and support them to keep on running with maximum effort until pass the end line.

Scoring: Two trials are allowed, and the best time is recorded to the nearest two decimal places. The timing starts from when the participant's torso passes through the first timing gate, or by stopwatch when they pass the 30m cone, and finishes at the 60m cone indicator.



Adopted from (Robert, 2019)

Figure 5: flaying 30m sprint test

3.9.5 Agility test procedures

Southeast Missouri (SEMO) Agility Test

The SEMO Agility Test is a measure of running agility appropriate for testing field sport athletes (Kirby, 1971). This test is different from many other agility tests in that it integrates backwards and sideways movements too.

Objective: to test the ability to maneuver the body in a forward, backward and side wards direction.

Materials required: marker cones, measuring tape, non-slip surface, and stop watch.

Pre-test: clarify the test procedures for the participant and mark out the cone. Ensure that the participants are adequately warmed-up.

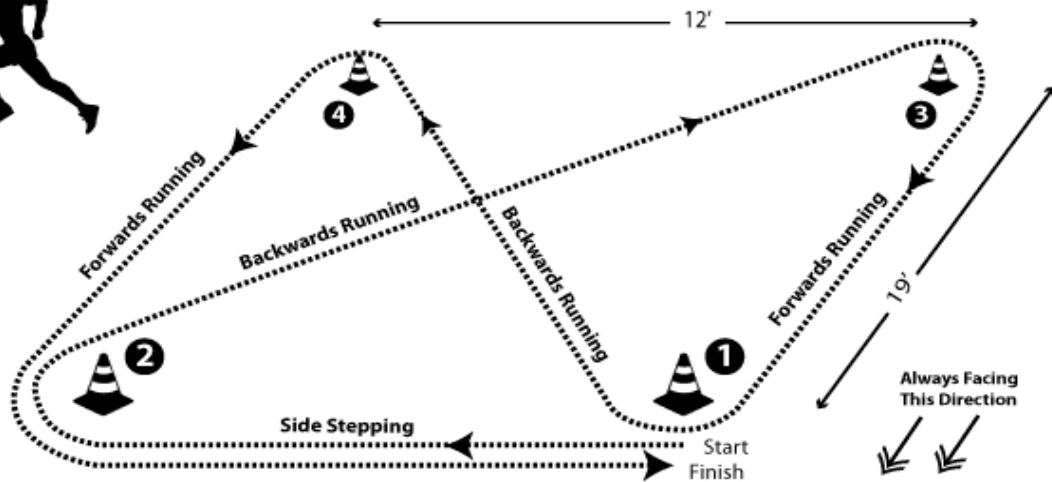
Test layout: Set up the cones as illustrated in the diagram. Four cones are mandatory, making a rectangle 12 x 19 feet, for the unique test explanation the measurement was in feet, which converts to 3.7 x 5.8 meters.

Procedure: begin with one foot at the back of the start line, no rocking movement is tolerable. Hand timing starts from the first movement from the set situation. Beginning at cone 1, move to cone 2 using a side-stepping movement, then turn around the cone and run backpedals to cone 3. One time player are turn on cone 3, sprint forwards to cone one, go around the cone and backwards running again to cone 4. Just the once around cone four, sprint forwards to cone two, then side step back to the initial cone 1. Stay on facing forwards towards the baseline throughout the test. Two trials were tolerable.

Scoring: The stopwatch is started in the starting command "go" and stopped after the players' returns to the start/finish line. The best time of two trials to the closest one decimal place is recorded. A good score for males would be greater than 10.5 seconds, for females greater than 12.2 seconds.

SEMO Agility Test

www.topendsports.com



Adopted from (Kirby, 1971)

Figure 6: Southeast Missouri (SEMO) Agility Test

Target population: this test is appropriate for team sport athletes that involve movements in multiple directions, such as volleyball, tennis, badminton.

3.10 Volleyball spiking technical skills test

3.10.1 Radar test for spike's speed

Spike speed in volleyball is directly measured through the radar test. The radar test is measure of spike speed which uses the radar device to measure spike speed performance of volleyball players. Monitoring the spike speed is less frequently done in training. This is likely due to the fact that the necessary instrument (i.e. radar) is not very common in the sport environment (Valadés & Palao, 2012).

Materials: radar/TRUCAM speed test 2020 new model/, meter, net, volleyball court,

Testing setup

For the radar tests, the net height was 2.24m and the target zone should be placed 5m from the players/ from the net. This distance is important for players to spike the ball by using his/ her maximal power toward the target zone. If the players were

positioned nearer, the spike speed would not be realistic. It would be too vertical and would change the kinetic chain of the spike. If the players were positioned farther, the precision would not allow players to apply all their strength.

Testing protocol

The spike speed protocol is composed of different steps:

- Write code number on the participants dressing shirt either on the back or the front the code should be more than two digits.
- The coach (assistant) tosses the ball between the antennas, 1m to 3m from the net high.
- Check the display makes sure the speed reading should be zero km/h.
- Target area (1mx1.5m)
- Should have 3 second time limit between measurements and there are three attempts with 30s recovery between them.
- The minimum distance of the subject and expert should at least 15m (50 feet).
- Make sure that the radar/TruCAM machine/ is powered on & the speed mode is active.
- The ball has to go directly toward the target zone to ensure proper measurement. The score will not be legal if players cannot control their spikes and do not send the ball into the target zone and it shall orientated toward the zone where the ball is contacted.

Incomplete test: The radar was not registering the speed.

✓The ball does not pass between the antennas.

✓The player touches the net.

✓The ball setting is wrong (the ball set affect the approach, steps, jump or spiking).

Score: The result was measured in km/h.



Image from American company Laser Technology, Inc

Adopted from, (Palao & Valades, 2012)

Figure 7: TRUCAM radar test

3.10.2 Validity and reliability of radar test

Radar testing has been shown to be a valid and reliable measure of upper-body explosive power (Palao & Valades, 2012). Compared to the Video analysis (indirect measure) and another test measures, the Radar (direct measure) is a valid and accurate type of spike speed test. Technological development has acceptable the radar to be used in sport research and training to monitor spike speed.

3.11 Tester Competency

The researcher takes all the measurements in this study with the assistance of his colleagues and experts working with the scholar. To ensure that the researcher was well knowledgeable and well informed with the technique of conducting tests and researcher would have a number of practice sessions by using the correct testing procedure. The tester's reliability was established by test and retest method.

3.11.1 Reliability of a test

The reliability of a test was assured by establishing efficient and necessary equipments, and to ensure the uniformity and reliability of the testing technique the researcher had a number of practice sessions in the testing procedures with the

guidance of the respective experts. The researcher was taken all the measurement for the study with the assistance of professional experts.

3.12 Methods of Data Analysis

A quantitative method of data analysis would be used for the collected data from physical fitness and technical performance tests. After administering a field test on selected variables before and immediately after intervention of HIIT, the researcher recorded these quantitative data in the form of pre test and post test results. The collected data were analyzed and interpreted in to a meaningful idea by using computer in order to compare the selected physical fitness and technical skill variable changes observed among groups. Descriptive statistics (mean \pm SD) were presented and the collected data were statistically analyzed by ANCOVA to compare post tests between groups with effect sizes of independent variables on dependent variables after intervention. All data analyses were performed with in computer system using statistical package for social science (SPSS), version 23. The significance level for all of the hypotheses was set at 0.05. In addition based on the data results and discussion, brief conclusions and recommendation were wrote.

3.12 Ethical considerations

Before the beginning of this study, researcher obtained paper from Bahir Dar University Sport Academy post graduate studies to make sure it is not resulting to any risk or harm to the participants of this study. Additionally, the researcher obtained permission from the subjects' to participate, whether they were volunteers or not and the researcher obtain permission from the coach, district sport office and all the players had clear information about the purpose of the study, the procedures to be use, the potential benefits and the possible risks of participation in this study was explained and researcher got some information about their physical status by using PAQ-R before starting the intervention. Participants were fully aware of all data gathering techniques and research data was confidential (**See appendix A, page 79**).

CHAPTER FOUR

RESULTS/FINDINGS

4.1. Introduction

This chapter presented the description of the data and analysis of pre and post test data collected from randomly selected experimental (N=12) and control (N=12) groups.

4.2. Results of the study

Table 4: Demographic characteristics of participants

Group	N	Sex	Age	Height(m)	Weight (kg)	Age of training
			Mean ± S.D	Mean ± S.D	Mean ± S.D	Mean ± S.D
Experimental group	12	M	17.83±0.84	1.72±0.54	51.83±5.75	1.7±0.49
Control group	12	M	18.08±0.79	1.71±0.48	52.08±4.91	1.58±0.51

Key: N= number of participant or players, SD= standard deviation

The above table 4 indicates the general characteristics of the study participants regarding to their age, height, weight and age of training. The mean of the experimental group's age, height, weight and age of training were 17.83±0.84 year, 1.72 ±0.54 m, 51.83±5.75 kg, and 1.7±0.49 years respectively, whereas, that the mean of the control group's age, height, weight, and age of training were 18.08±0.79 years, 1.71±0.48, 52.08±4.91, and 1.58±0.51 year correspondingly. Here result indicated that the participants were nearly similar in their demographic characteristics.

4.3 Results of physical fitness tests

Table 5: Descriptive statistics of physical fitness tests

Test of physical fitness variables	Group	N	Pretest (baseline)		Posttest (post intervention)		
			M	SD	N	M	SD
Explosive power	EG	12	39.58	4.66	12	47.81	8.53
	CG	12	40.33	7.8	12	40.41	7.66
Speed	EG	12	5.05	0.27	12	4.35	0.30
	CG	12	5.03	0.27	12	5.01	0.33
Strength	EG	12	20.17	1.6	12	29.67	2.1
	CG	12	20.17	6.31	12	19.0	5.56
Agility	EG	12	13.33	0.64	12	11.86	0.45
	CG	12	13.06	0.41	12	13.13	0.63

* The mean difference is significant at the 0.05 level.

Key: EG=experimental group, CG=control group, N=number of players, M=mean, SD=standard deviation

Having established on the above table physical fitness test of explosive power during vertical jump pre test (prior to the intervention) of experimental group (N=12) results was (M=39.58, SD=4.66) and post test (after the eight week HIIT intervention) M=47.81, SD=8.53. However, after eight weeks HIIT, the mean score of explosive power of EG has a change from pre to post test, whereas, the control group (N=12) of explosive power during vertical jump pre test was M=40.33, SD=7.8 and post test also M=40=40.41, SD=7.66. Finally, the control group shows similar results in the pre and post tests. In similar way, fitness test of speed (flying 30m sprint test) EG pre test result was M=5.056, SD=0.27 and post test as well M=4.35, SD=0.30, while, the pre test result of CG was M=5.03, SD=0.27 and post test M=5.01, SD= 0.33 respectively.

Similarly, strength during push up test of EG pre test (prior to the intervention) (M=20.17, SD=1.6) to post test (after the eight week HIIT intervention) M =29.67, SD=2.1 the mean of pre to post result of EG indicated that change on strength whereas, the CG pre test M=20.17, SD= 6.31 and post test M=19.0, SD=5.56 respectively this indicated CG showed no improvement in the pre post results. Besides, the participants result of EG on agility pre test was found in M=13.33, SD=0.64 and post test also M= 11.86, SD=0.45. Based on this data indicated EG had change after the eight weeks HIIT programs still, the mean value of CG stays very close from pre to post test result.

ANCOVA has the same assumptions as any linear model except that there are two important additional considerations in this study that is independence of the covariate and treatment effect of HIIT on the experimental group. Moreover, from the above table we can see that there were mean differences between the pre and post tests; however it is not possible to decide at this point if those differences were statistically significant. For this reason ANCOVA was given advantages to compute and examine whether the post and pre test scores had a statistically significant difference or not. The following table shows this test of significance.

Table 6: Analysis of variance for explosive power

Tests of Between-Subjects Effects of explosive power						
Dependent Variable: post test explosive power						
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected M	1709.441 ^a	2	854.72	192.620	.000	.948
Intercept	9.104	1	9.104	2.052	.167	.089
Explosive power pre test	994.399	1	994.399	224.098	.000	.914
Groups	818.537	1	818.537	184.465	.000	.898
Error	93.184	21	4.437			
Total	52311.0	24				
Corrected Total	1802.65	23				

* The mean difference is significant at the 0.05 level.

Key: *Df* = degree of freedom, *F*=*F* ratio calculate

Having on above table points that ANCOVA result in case of explosive power presented that there was a significance difference between the experimental and control group with $F (1, 21)=184.465$; $P=.000$) on explosive power during vertical jump test of volleyball players after eight weeks HIIT program. Additionally there was significant difference between the covariate (pretest result of explosive power) and dependent variable (posttests of explosive power) with $F (1, 21) =224.098$; $p=.000$) in the experimental group. Additionally, ANCOVA also give a chance to communicate the practical significance of this result, instead of only reporting the statistical significance. So, the effect size (partial eta squared) of on explosive power of volleyball players according to Cohen's (1988), reported partial Eta Squared value indicates (if the effect size 0.2 – the result indicates small effect, 0.5 – medium effect and if the effect size gives 0.8 – that has large effect size); therefore, the effect size of HIIT on explosive power was =0.898 (89.8%), hence this result was greater than 0.8 (80%) and HIIT program has large effect on the improvement of explosive power of volleyball players.

Table 7: Analysis of variance for speed

Tests of Between-Subjects Effects of speed						
Dependent Variable: post test of speed						
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected M	2.628 ^a	2	1.314	23.536	.000	.695
Intercept	1.059	1	1.059	10.02	.005	.323
speed pre test	.027	1	.027	56.258	.000	.012
Groups	2.62	1	2.62	47.434	.000	.693
Error	2.22	21	.106			
Total	532.190	24				

Corrected Total	4.846	23
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* The mean difference is significant at the 0.05 level.

Key: *Df* = degree of freedom, *F*=*F* ratio calculate

Based on the data presented on the above table 7, ANCOVA result on speed (flying 30m sprint test) indicated that there was a significance difference between the EG and CG with $F(1, 21) = 47.434; P = .000$ on speed of volleyball players after eight weeks HIIT intervention. Additionally there was significant difference between the covariate (pretest result of speed) and dependent variable (posttests of speed) with $F(1, 21) = 56.258; p = .000$ in the EG. So, the effect size (partial eta squared) of on speed of volleyball players was $=.693$ (69.3%), hence this result was greater than 0.5 (50%) and HIIT program has moderate effect on the improvement of speed of volleyball players. Look at first at the significant value it is clear that the covariant (pre test result of speed) has significant effect on the dependent variable (posttests of speed), because the significance value is less than 0.05. Therefore, the EG was influenced by HIIT program. Model without the covariant shows an insignificant effect of HIIT on control group.

Table 8: Analysis of variance for strength

Tests of Between-Subjects Effects of speed						
Dependent Variable: post test of strength						
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	996.732 ^a	2	98.366	140.289	.000	.930
Intercept	64.622	1	64.622	18.191	.000	.464
Strength pre test	316.066	1	314.066	88.409	.000	.808
Groups	691.639	1	691.639	194.639	.000	.903
Error	74.601	21	3.552			
Total	15282.0	24				

Corrected Total	1071.33	23
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* The mean difference is significant at the 0.05 level.

Key: Df = degree of freedom, F=F ratio calculate

The above table displays ANCOVA result of strength that there was a significance difference between the EG and CG with $(F, 1, 21) = 194.639; P=.000$) on strength during push up test of volleyball players after eight weeks HIIT program. Additionally there was significant difference between the covariate (pretest result of strength) and dependent variable (posttests of strength) with $F (1, 21) = 88.409; P=.000$) in the experimental group. Furthermore, the practical significance of this result, effect size (partial eta squared) of strength on volleyball players was=.903 (90.3%), thus this result was greater than 0.8 (80%) and HIIT program has large effect on the improvement of strength of volleyball players. The significant value is clearly that covariant (pre test result of strength) has significant effect on the dependent variable (posttests of strength), because the significance value is less than 0.05. Therefore, the EG was influenced by HIIT program. Model without the covariant shows an insignificant effect of HIIT on control group.

Table 9: Analysis of variance for agility

Tests of Between-Subjects Effects of agility						
Dependent Variable: post test of agility						
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	14.893 ^a	2	7.447	26.785	.000	.718
Intercept	2.086	1	2.086	7.503	.012	.263
Agility pre test	.878	1	.878	3.160	.000	.131
Groups	14.892	1	14.892	53.565	.000	.718
Error	5.838	21	.278			
Total	3693.137	24				

Corrected Total	20.732	23
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* The mean difference is significant at the 0.05 level.

Key: Df = degree of freedom, F=F ratio calculate

Similarly, the data as showed in the above table, ANCOVA result agility (SEMO test) presented that there was a significance difference between the EG and CG with (F, 1, 21) =53.565; P=.000) on agility of volleyball players after eight weeks HIIT program. Additionally there was significant difference between the covariate (pretest result of agility) and dependent variable (posttests of agility) with F (1, 21) =3.160; p=.000) in the EG. Additionally, the practical significance of this result effect size (partial eta squared) of on agility of volleyball players was 0.8 – that has large effect size); therefore, the effect size of HIIT on agility was =.718 (71.8%), for this reason this result was greater than 0.5 (50%) and HIIT program has moderate effect on the improvement of agility of volleyball players and the significant value is obviously showed that the covariant (pre test result of agility) has significant effect on the dependent variable (posttests of agility), because the significance value is less than 0.05. Therefore, the EG was influenced by HIIT program. Model without the covariant shows an insignificant effect of HIIT on control group.

4.4 Results of spiking technique

Table 10: Descriptive statistics of spiking techniques tests

Test of spiking technique	Group	Pretest (baseline)			Posttest (post intervention)		
		N	M	SD	N	M	SD
Spiking speed	EG	12	61.17	5.99	12	71.58	5.58
	CG	12	61.57	5.47	12	61.83	4.2

* The mean difference is significant at the 0.05 level.

Key: EG=experimental group, CG=control group, N=number of players, M=mean, SD=standard deviation

The above table result indicated the pre test result (prior to the intervention) of EG was M= 61.17, SD=5.99 and post test (after the eight week HIIT intervention)

M=71.58, SD=5.58 whereas, the pre test result of the CG was M=61.57, SD=5.47) to post test M=61.83, SD=4.2 respectively.

Table 11 : Analysis of variance for spiking speed

Tests of Between-Subjects Effects of spiking speed						
Dependent Variable: post test of spiking speed						
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	907.170	2	453.585	51.827	.000	.832
Intercept	117.978	1	117.978	13.480	.001	.391
Spiking speed PT	336.795	1	336.795	38.483	.000	.647
Groups	603.228	1	603.228	68.926	.000	.766
Error	183.788	21	8.752			
Total	107891.000	24				
Corrected Total	1090.958	23				

Here indicates in the above table that ANCOVA result in case of spiking speed presented that there was a significance difference between the experimental and control group with $(F, 1, 21) = 68.926; P=.000$) on spiking speed during radar test of volleyball players after eight weeks intervention. As well there was significant difference between the covariate (pretest result of spiking speed) and dependent variable (posttests of spiking speed) with $F (1, 21) = 38.483; p=.000$) in the experimental group. Moreover, the practical significance of this result effect size (partial eta squared) of on spiking speed of volleyball players was $=.766$ (76.6%), hence this result was greater than 0.5 (50%) and HIIT program has moderate effect on the improvement of spiking speed of volleyball players and this assumption of the significant value is evidently showed that the covariant (pre test result of spiking speed) has significant effect on the dependent variable (posttests of spiking speed), because the significance value is less than 0.05. Therefore, the EG was influenced by

HIIT program. Model without the covariant shows an insignificant effect of HIIT on control group.

4.5 Discussions and Implication

The purpose of this study was to investigate the effect of eight week HIIT on some selected physical fitness qualities and spiking technique of volleyball team players in Kutaber Woreda. Both groups were performing their usual volleyball training but, the experimental group was participate in eight week HIIT exercises program, while the control group did not participate in the eight week HIIT program. Based on the above analysis data indicated that participating in HIIT exercise program regularly had significant effects on selected physical fitness and spiking technique variables. In this research, the EG had significantly greater improvements than the CG on explosive power, speed, strength, agility and spiking speed performances after the eight week HIIT program in male volleyball players ($p < 0.05$). In this part, the researcher discussed findings and results that were indicated in the above interpretation in line with the pre described research hypotheses. Therefore, the finding of this study in each variable was discussed as follows.

4.5.1 Effect of HIIT on explosive power of volleyball project players

The first objective of this study was to analyze the effect of HIIT on explosive power of volleyball project players in Kutaber Woreda. Concerning to the effect of HIIT on explosive power during vertical jump test, there was significant difference test score on EG and CG due this intervention with $F(1, 21) = 184.465; P = .000$ which means $P < 0.05$ and this indicated that significant improvement was observed on explosive power during vertical jump test of EG than CG of volleyball players after eight weeks HIIT program. Additionally there was significant difference between the covariate (pretest result of explosive power) and dependent variable (posttests of explosive power) with $F(1, 21) = 224.098; p = .000$ in the experimental group. Thus, the effect size (partial eta squared) of on explosive power of volleyball players according to Cohen's (1988), reported partial Eta Squared value indicates (if the effect size 0.2 – the result indicates small effect, 0.5 – medium effect and if the effect size gives 0.8 – that has large effect size); therefore, the effect size of HIIT on explosive power was

=0.898 (89.8%), hence this result was greater than 0.8 (80%) and HIIT program has large effect on the improvement of explosive power of volleyball players.

Additionally the data presented in above (table 6) the mean values of explosive power was $M=39.58$ before HIIT, which was improved to $M=47.81$ after eight weeks intervention this means the explosive power of EG has significant improvement at the $p=0.05$. Whereas, the control group ($N=12$) of explosive power during vertical jump pre test was $M=40.33$ and post test also $M=40.41$ and control group shows similar results in the pre and post tests. The end result declares that due to the effect of eight week HIIT, on explosive power of volleyball players in which they were engaged in the exercise EG had significantly changed. Therefore, the formulated hypothesis was rejected at 0.05 level of confidence.

The findings of the above study were also agreed and supported by the findings of, Nelson, Jim and Arumugam (2020) conducted a study on effect of HIIT on explosive power college volleyball players. The researchers concluded that HIIT has significant effect on explosive power of volleyball players. Similarly, Fajrin *et al* (2018) conducted on the effect of HIIT on increasing explosive power. After being given the treatment for 6 weeks training, the results showed there is significant change in the selected variables. On the other hand, the finding of this research result that was conducted by Rômulo Vasconcelos, et al., 2020 had reverse conclusion because, the final conclusion suggests that six weeks of high-intensity training was no significant effect to increase in performance of vertical jump height (explosive power) which is $p = 0.050$). This controversial idea may be different from this study result because of the finding of Rômulo Vasconcelos, the study design is characterized as observational and the training programs were mostly resistance machine strength exercises.

4.5.2 Effect of HIIT on speed of volleyball project players

The second objective of this study was to examine the effect of HIIT on speed of volleyball project players in Kutaber Woreda. Regarding to the effect of HIIT on speed during flying 30 Meter Sprint test, there was significant difference in statistics of EG and CG as a result of HIIT program with $F = F(1, 21) = 47.434; P = .000$ on speed of volleyball players after eight weeks HIIT intervention. Additionally there was significant difference between the covariate (pretest result of speed) and

dependent variable (posttests of speed) with $F(1, 21) = 56.258; p = .000$ which means $P < 0.05$ and this indicated that significant improvement was observed on speed during flying 30 Meter Sprint test of EG than CG of volleyball players after eight weeks HIIT program. So, the effect size (partial eta squared) of on speed of volleyball players was $= .693$ (69.3%), hence this result was greater than 0.5 (50%) and HIIT program has moderate effect on the improvement of speed of volleyball players and the significant value is clearly that the covariant (pre test result of speed) has significant effect on the dependent variable (posttests of speed), because the significance value is less than 0.05. Therefore, the EG was improved by HIIT program. Model without the covariant shows an insignificant effect of HIIT on control group.

In similar way, the above table 7 physical fitness test mean value of speed (flying 30m sprint test) of EG pre test result was $M = 5.056$ and post test was $M = 4.35$ as well there is significant at $p = 0.05$. Whereas, pre test result of CG was $M = 5.03$ and post test $M = 5.01$ respectively and control group shows similar results in the pre and post tests. The outcome stated that that due to the effect of eight week HIIT, on speed of volleyball players in which they were engaged in the exercise EG had significantly changed. Therefore, the formulated hypothesis was rejected at 0.05 level of confidence. The findings of the study were also agreed with the findings of, Kadir and Ali (2021), study the effect of eight-week HIIT on speed of U19 soccer players. The subjects randomly assigned into two as the EG and CG. In the study, the EG attended a HIIT program three days a week for eight weeks, in addition to their regular training. The players of the CG continued their usual training schedule. It has been observed that 8-week HIIT is statistically significant in the speed of soccer players. In addition, researchers of Fajrin, Kusnanik and Wijono (2018), this study focused on the effect of HIIT on increasing speed. After being given the intervention for 6 weeks training, the results showed there is significant change in this particular variable.

Findings of Jim and Arumugam (2020), those researchers were focused on the effect of HIIT on speed of volleyball Players. The selected subjects divided into two groups. The EG was subjected to the HIIT program for alternative three days for up to 6 weeks period. The experimental design selected for this study was pre and post test randomized design. The collected data were HIIT group statistically showed

significant improvement in speed when compared to the control group. Similarly, Elumalai, *et al.*, (2019) conclude that there was a significant effect of the HIIT method on improving speed performance of U 16 Hockey Players. The training program was conducted for 8 weeks. The paired sample t-test analysis between pre and post tests showed significant differences after performing HIIT in speed.

4.5.3 Effect of HIIT on strength of volleyball project players

The third objective of this research was to identify the effect of HIIT on strength of volleyball project players in Kutaber Woreda. Relating to the effect of HIIT on strength through push up test, there was significant difference between EG and CG with $(F, 1, 21) = 194.639; P=.000$ on strength of players after eight weeks HIIT. Also there was significant difference between the covariate (pretest result of strength) and dependent variable (posttests of strength) with $F (1, 21) = 88.409; P=.000$ in the experimental group. Furthermore, the practical significance of this result, effect size (partial eta squared) of strength on volleyball players was=.903 (90.3%), thus this result was greater than 0.8 (80%) and HIIT program has large effect on the improvement of strength of volleyball players. The significant value is clearly that covariant (pre test result of strength) has significant effect on the dependent variable (posttests of strength), because the significance value is less than 0.05. Therefore, the EG was influenced by HIIT program. Model without the covariant shows an insignificant effect of HIIT on control group.

Similarly, the mean value of strength during push up test of EG pre test (prior to the intervention) (M=20.17) to post test (after the eight week HIIT intervention) (M =29.67) the mean of pre to post result of EG indicated that change on strength whereas, the CG pre test M=20.17 and post test M=19.0, respectively this indicated CG showed no improvement in the pre post results. The final result stated that the EG significantly changed on strength fitness performance of volleyball players ($p= 0.000, P<0.05$). On the contrary, the CG showed that there was no change on strength observed in between pre and post testing. Finally due to the effect of eight week HIIT, on strength of volleyball players in which they were engaged in the intervention EG had significantly changed. Therefore, the formulated hypothesis was rejected at 0.05 level of confidence.

The finding of the study was supported by the findings of, Saravanan and Manju, (2021) this study was focused on the impact of drill based HIIT on strength of volleyball players. The study clearly indicated that the muscular strength of experimental group improved due to the effect of drill based HIIT program. Muscular strength was assessed by modified sit-ups and the unit of measurement in counts. The result muscular strength of drill based HIIT group was showed 3.8 significant improvements compared to the pre test results. Similarly, Sigit Nugroho, *et al*, (2021) this research was determined to examine the influence of intensity and comparison of trapping circuit training intervals on the physical fitness of badminton players. Founded on the results of the analysis, it is recognized that the group which participate in the EG obtained best results of strength parameter by increasing 1.75%.

But, on contrary, Jaime Della Corte, et al (2019) Conducted study on the effect of HIIT on strength performance but, the muscle strength dropped significantly. On the basis of the data obtained in this study has no significant effect on strength performance so, the researcher's finding was not supported by this result. This study result difference may happen researcher's used when HIIT was performed before strength training.

4.5.4 Effect of HIIT on agility of volleyball project players

The forth objective of this research was to find out the effect of HIIT on agility of volleyball project players in Kutaber Woreda. As regards to the effect of HIIT on agility during SEMO agility test based on table 10, there was significant difference between the EG and CG with $F (1, 21) = 53.565; P = .000$ on agility of volleyball players after eight weeks HIIT program. Additionally there was significant difference between the covariate (pretest result of agility) and dependent variable (posttests of agility) with $F (1, 21) = 3.160; p = .000$ in the EG. Additionally, the practical significance of this result effect size (partial eta squared) of on agility of volleyball players was 0.718 therefore, the effect size of HIIT on agility was =.718 (71.8%), for this reason this result was greater than 0.5 (50%) and HIIT program has moderate effect on the improvement of agility of volleyball players and the significant value is obviously showed that the covariant (pre test result of agility) has significant effect on the dependent variable (posttests of agility), because the significance value is less than

0.05. Therefore, the EG was influenced by HIIT program. Model without the covariant shows an insignificant effect of HIIT on control group.

The conclusion declared that the EG significantly changed on agility performance EG which is through pre and post test $M=13.33$ and $M=11.86$ ($p= 0.000$, $P<0.05$). In contrast, the CG was not shown change on agility variable in between pre and post testing $M=13.06$ and $M=13.13$. Lastly due to the effect of eight week HIIT, on agility of volleyball players in which they were engaged in the exercise EG had significantly changed. Therefore, the formulated hypothesis was rejected at 0.05 level of confidence.

The findings of the study were also agreed with the findings of Purkhu, Krustup, and Mohr, (2016) HIIT improves exercise performance in elite women volleyball players during a competitive season. Agility performance improved on post test compared with pre intervention period. Similarly, Chandu and Johnson (2021) the effects of HIIT on agility among inter collegiate badminton players. The EG was administered for 8 weeks training. The result of the study was HIIT group was significant improvement in compared to the control group. Additionally, previous studies have shown different results on the effect of HIIT on agility. For instance, (Fajrin *et al.*, 2018) conducted a research on the effect of HIIT on agility from the data analysis; researchers concluded that HIIT have significant effect on agility.

On the other hand, researcher's result was not agreed with (Sadi, 2022) because of this researcher investigated that effect of HIIT on agility performance of male volleyball players in university teams and concluded that HIIT have no significant effect on agility. This difference may happen the researcher's training protocol was HIIT in addition to their routine training and the intervention period was 4-week HIIT program.

4.5.5 Effects of HIIT on spiking speed of volleyball project players

The fifth objective of this study was to determine effects of HIIT on spiking speed of volleyball project players in Kutaber Woreda. The finding of this study on results presented in case of spiking speed. As regards to the effect of HIIT there was significant difference between EG and CG with $(F, 1, 21) = 68.926$; $P=.000$ on

spiking speed during radar test of volleyball players after eight weeks intervention. As well there was significant difference between the covariate (pretest result of spiking speed) and dependent variable (posttests of spiking speed) with $F(1, 21) = 38.483$; $p = .000$ in the experimental group. Moreover, the practical significance of this result effect size (partial eta squared) of on spiking speed of volleyball players was $.766$ (76.6%), hence this result was greater than 0.5 (50%) and HIIT program has moderate effect on the improvement of spiking speed of volleyball players and this assumption of the significant value is evidently showed that the covariant (pre test result of spiking speed) has significant effect on the dependent variable (posttests of spiking speed), because the significance value is less than 0.05. Therefore, the EG was influenced by HIIT program. Model without the covariant shows an insignificant effect of HIIT on control group.

The conclusion confirmed that the mean value results of EG pre test was 61.17 and post test $M = 71.58$, $SD = 5.58$ on spiking speed performance ($p = 0.000$, $P < 0.05$). In contrast, the CG was not shown change on spiking speed technique in between pre and post testing $M = 61.57$ and $M = 61.83$. Finally due to the effect of eight week HIIT, on spiking speed of volleyball players in which they were engaged in the exercise EG had significantly changed. Therefore, the formulated hypothesis was rejected at 0.05 level of confidence because the posttest mean was statistically higher than the pretest mean.

The rationale behind the increment of spiking speed in EG was due to the participation of the eight weeks HIIT program. This implication indicates that HIIT is an effective, potent, practical and time efficient method of improving spiking speed. Therefore, the present study results show that spike speed, which is a sport-specific performance, was increased and transferability of strength gains and vertical jump were achieved by HIIT methods. Because of, the spike is a complex and the most explosive movement of volleyball technique (Celik, 2017). In other expression this study, shows significantly greater performance improvement on EG in the spiking speed of 13.97% at the end of 8-week HIIT program (61.17 km/h in pre-training and 71.58 km/h in post training. on the contrary, the controls group have no change in spiking speed ability (0%).

The above findings was supported by in previous studies, it was found that spiking speed correlates with vertical jumping performance of volleyball players (Sattler, Hadžic, Dervišević and Markovic, 2015; Ziv and Lidor, 2010). Those findings had effort to investigate the relationship of vertical jump and spiking speed during spiking technique of volleyball to enhance the potential for various different types of actions and to take full advantage of the effective court size, allowing for a vertical ball trajectory at great ball speed. So, vertical jump (explosive power) has its own effects on spiking speed of volleyball. Subsequently, a dynamic arm swing, elevation of upper body, and extension in the hips, knees, and ankles are depends on vertical jump (explosive push-off) and it gives great advantage during spiking speed. During the end of push off, pelvis rotation generates momentum that is transferred during the flight phase via trunk rotation and flexion into fast shoulder and elbow movements to spike the ball at maximal speed. In the spike, the goal of an offensive player is to achieve great jumping height to be unpredictable and ensure diverse actions. The higher the player's jumping height during the spike, the larger the effective field size and the steeper the ball trajectory at high ball velocity. The higher a player is able to vertically jump, the greater his/her potential for successful spiking speed to hit unpredictable ball or speedy hitting action during volleyball game.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

The general objective of this study was to investigate the effect of high intensity interval training selected physical fitness qualities and spiking technique of volleyball project players in Kutaber Woreda. For this purpose, the researcher tried to review relevant and related literatures on the area in order to decide the focus of the study and methodologies. In order to accomplish the general objective of the study, the following specific objectives were formulated.

1. To identify the effect of HIIT on explosive power of volleyball project players in Kutaber Woreda.
2. To examine the effect of HIIT on speed of volleyball project players in Kutaber Woreda.
3. To identify the effect of HIIT on agility of volleyball project players in Kutaber Woreda.
4. To find out the effect of HIIT on strength of volleyball project players in Kutaber Woreda.
5. Determine effects of HIIT on spiking speed of volleyball project players in Kutaber Woreda.

To attain the purpose of this study, all 24 volleyball project players at Kutaber Woreda were taken as a sample by using a comprehensive sampling technique and their age of 17-19 years participated in the research. Participants were randomly assigned to either the EC (n=12) or CG (n=12). The EG (n=12) was performed additional eight-week HIIT program. But, the CG was participating only their usual training. The research design was true experimental. For both groups, before applying the intervention a pre test was administered and a post test also conducted at the end of the intervention. HIIT program had eight week duration with 3 sessions per week for 45-50 minutes duration a day. The selected dependent variables were explosive

power (vertical jump), speed (30 Meter Sprint test), strength (pushup test), agility (SEMO test) and spiking speed (radar test) was taken from the subjects. The data was gathered from the EG and CG results in the form of pre test and post test method. Raw data was statically analyzed by using SPSS version 23. ANCOVA used to compare post tests between groups with effect sizes of independent variables on dependent variables after intervention. Finally, the significance level for all of the hypotheses was set at 0.05. Therefore, the following major findings were investigated.

1. The findings of this study indicated that explosive power (vertical jump test) of EG was significantly changed after 8 weeks of HIIT. There was no significant difference that found between the pre to post test result in CG
2. The pinpoint of this study indicated that speed of the EG had shown improvement from pre test to post test due to the effect of eight weeks HIIT. In CG, there was no significant change was found in pre to post tests.
3. The finding of this study showed strength was significantly improved in EG after exposed to HIIT. In CG no significant change between pre to post test was observed.
4. The obtained result of this study signify that agility was significantly changed in EG as a result of eight weeks of HIIT. In CG had no significant change observed.
5. The finding of this study showed that spiking speed was significantly changed in EG after due to the effect of eight week HIIT program. Conversely, no significant change was found between pre to post test results of CG.

5.2 Conclusion

Based on the major finding of this study, the following point was stated by the researcher as a conclusion.

- ✚ There was significant change when comparing pre and post test on explosive power due to the effect of eight week HIIT at volleyball project players.
- ✚ Eight week HIIT had a positive effect on the improvement of speed performance of volleyball project players.
- ✚ There was significance difference exists between EG and CG on strength of volleyball project players.
- ✚ Based on the findings of this study, it was concluded that HIIT has a significant effect on the change of agility performance of volleyball players.
- ✚ Finally, eight week of HIIT program was found significant change on spiking speed performance of volleyball team players. On the other hand, the control group had not shown any improvement on the selected variables.

5.3 Limitation of the study

Uncontrollable factors associated with the study were accepted as limitations. Thus, the subject's body type and socio economic status of the participant were not taken into consideration, The heterogeneous characters of the subjects which are hereditary and environmental factors were recognized as a limitation, this research was conducted in the open field and not under laboratory settings and participants were only attended supervised exercise three days a week for 8 weeks.

5.4 Recommendations

Based on the above results, discussions and findings of this study, the researcher wants to forward the following recommendation issues:

- ✚ Volleyball coaches should emphasize on HIIT programs for better improvement and highly recommended as a best mode of training rather than devoting most of their time only on games.
- ✚ Engaging in HIIT was highly recommended at least 3 days per week 45-50m.
- ✚ Coaches & players should endeavour to equip players with HIIT program that would build their leg explosiveness, speed, upper body strength and agility of the players.
- ✚ Further study of this concern is still required to assess and incorporate the players' vertical jump, speed, and strength and agility performance.
- ✚ Spiking direction and hit height should be accounted for in future studies

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APPENDICES

APPENDIX A: Health history and PARQ

Dear participants,

Physical activity readiness questionnaire (PAR-Q) is the primary step to take in to consideration if one planned to participate in to regular exercise. Many health benefits are related with participating in regular exercise. PAR-Q is planned to identify the small number of participants for whom strength training might be inappropriate or those who should seek medical advice concerning the type of activity most suitable for them. The following questions are prepared and distributed to participants regarding to their health status for the participation of the designed strength training.

Direction: Please read the following questions carefully and specify your correct responses to each question by writing on blank space or by putting a tick (x) mark under one of the two boxes(“Yes” or “No” options) given below that represents your thought correctly. Participant’s full Name: _____

Participant’s Signature: _____ Date: _____

No	Questionnaires	Yes	No
1	Do you currently participate in regular exercise at least 3* per week?		
2	Do you have upper and lower extremities pain which has been aggravated by physical exercise?		
3	Do you have chest pain when you were not doing physical activity before this time?		
4	Have you currently take medications?		
5	Do you have high blood pressure?		
6	Do you have diabetes mellitus or any other metabolic disorder?		
7	Do you ever lose consciousness /your balance because of dizziness/?		
8	Do you have a joint or bone problem that may be made worse by a change in your physical exercise?		
9	Do you have coronary heart disease?		
10	Have you ever suffered from shortness of breath at rest or when you perform physical exercise?		

Adapted from Jamink et al, (2011).

APPENDIX B: Eight Week HIIT Program for Experimental Group

The training time is always at the afternoon starting from 10:00- 11:50 am.

Activity	Exercises during 8 week intervention	Exercise per a day	set	Rep	Intensity	Rest b/n rep	Mode of rest	Total time
Warming up exercise					Moderate			10minute
	<ul style="list-style-type: none"> ▪ Dip ▪ Spike jump at the net ▪ Push up ▪ Burpees ▪ Tuck jumping ▪ Mountain climber ▪ Jumping jacks ▪ Zigzag double leg jump over the line ▪ High knee ▪ Squat jump ▪ air squat ▪ skipping rope ▪ 30m run 	6	3-5	7-10	80-85% of participants HR	6 *3=24* 10seconds =4 minutes	Active rest 1minute for each = 6 minute	30-35 Minute
Cooling down					Low			5minute

Adopted from Sudhir Kumar, Jogiswar Goswami, and Ajit Kumar. (2016) Michal Lehnert, Ivona Lamrová, Milan Elfmark. (2009) and Tara B. Blackshear. 2020).

Key: - Rest between rep = six exercise per a day (6) * three set (3/4/or 5 and 6) =24*10seconds =4 minutes (6*7=42*10seconds =4 minutes) there is 660 seconds rest between repetition. Active rest between set: - 1minute for each exercise = 6 minute.

Notice: **Week 1** march 19-23 set of the exercise was 3, rep also 7 & intensity was 80%. **Week 2** March 26-30: set=4 rep=8, intensity= 80%. **Week 3** from April 3-7: set=4, rep=8 and intensity= 80%. **Week 4** from April: 10 -14 day set=4, rep= 8 and intensity=85% **Week 5** April 17-21: set=5, rep= 8 and intensity=85% **Week 6** from April: 24 -28: set=5, rep= 9 and intensity=85% **Week 7** from may 1-5: set=5, rep= 10 and intensity=85%. **Week 8** from may 8-12: set=4, rep= 10 and intensity=85%

APPENDIX C: Profile of study participants

A. Experimental group

No	Name	Age in year	Weight (kg)	Height (m)	Training years of the subject
1	JEA	19	54	1.68	2
2	YAB	18	44	1.60	2
3	YMC	18	54	1.76	1
4	MMD	17	50	1.73	2
5	TSE	17	49	1.71	1
6	EAF	17	42	1.67	2
7	FAG	18	52	1.72	2
8	AGH	17	53	1.80	1
9	HAI	19	56	1.70	2
10	MMJ	18	55	1.77	1
11	MEK	17	49	1.76	2
12	MAL	19	64	1.75	2

B. Control group

No	Name	Age in year	Weight (kg)	Height (m)	Training years of the subject
1	SAM	19	53	1.72	2
2	AYN	18	45	1.63	1
3	MAO	18	52	1.70	1
4	MYP	17	52	1.69	2
5	MNQ	19	48	1.73	1
6	SER	19	45	1.70	2
7	YGS	17	52	1.65	2
8	EMT	18	52	1.68	2
9	GMU	19	59	1.75	2
10	EMV	18	56	1.79	1
11	AAW	17	50	1.74	1
12	AEX	18	61	1.78	2

APPENDIX D: Pre and Post test result of physical fitness variables for EG.

No	Name	Physical fitness variables							
		Explosive power/meter/ /VJ/		Speed (sec)		Strength (score)		Agility (sec) SEMO test	
		Pre test	Post test	Pre test	Post test	Pre test	Post test	Pretest	Post test
1	JEA	45.00	58.00	5.1	4.7	23	34	13.58	11.5
2	YAB	37.00	49.00	4.7	4.4	21	30	13.49	12.11
3	YMC	36.00	46.00	5.3	4.4	19	27	13.50	12.00
4	MMD	37.00	50.00	4.9	5.1	19	27	13.48	12.15
5	TSE	34.00	42	4.7	4.1	20	31	13.50	11.07
6	EAF	34.00	44.00	5.5	4.1	18	27	13.40	12.00
7	FAG	40.00	53.00	4.8	4.2	19	29	14.50	12.15
8	AGH	46.00	58.00	5.2	4.0	21	30	12.46	11.05
9	HAI	40.00	54.00	4.8	4.3	19	30	13.53	11.50
10	MMJ	36.00	48.00	5.2	4.2	20	30	12.60	11.25
11	MEK	47.00	59.00	5.1	4.5	20	29	12.11	11.00
12	MAL	43.00	48.00	5.4	4.3	22	34	13.82	11.49

APPENDIX E: Pre and Post test result of physical fitness variables for CG.

No	Name	Explosive power/m/		Speed (sec)		Strength (score)		Agility (sec)	
		Pre test	Post test	PRT	POT	PRT	POT	Pre test	Post test
1	SAM	33.00	37.00	4.80	4.70	21	24	12.58	13.13
2	AYN	39.00	41.00	5.20	5.30	16	18	13.39	13.49
3	MAO	36.00	34.00	4.60	4.60	14	15	13.40	12.15
4	MYP	30.00	31.00	5.30	5.50	16	13	13.38	12.45
5	MNQ	30.00	28.00	4.70	5.10	27	26	13.00	12.55
6	SER	36.00	35.00	4.80	5.30	28	24	12.48	13.00
7	YGS	40.00	41.00	5.20	4.60	13	11	13.00	13.65
8	EMT	43.00	44.00	5.10	5.30	25	20	12.57	12.55
9	GMU	45.00	44.00	5.20	4.90	12	14	13.56	13.00
10	EMV	53.00	53.00	4.80	4.80	17	14	12.59	13.45
11	AAW	51.00	50.00	5.30	4.70	23	22	13.25	13.05
12	AEX	48.00	47.00	5.40	5.40	30	27	13.52	14.59

APPENDIX F: Pre and Post test result of technical skill variables for EG and CG.

No	Name	Technical skill variables of volleyball					
		Experimental group		Control group			
		Spiking speed(Km/h)		Spiking speed(km/h)			
		Pre	Post	No	Name	Pre	Post
1	JEA	60.4	66.6	1	SAM	59	60
2	YAB	67.7	75.7	2	AYN	67	67
3	YMC	64.8	69.3	3	MAO	67	68
4	MMD	60	74.7	4	MYP	62	65
5	TSE	59	65.8	5	MNQ	59	63
6	EAF	52	59	6	SER	56	58
7	FAG	50	67	7	YGS	51	54
8	AGH	70	77	8	EMT	71	65
9	HAI	61	73	9	GMU	61	62
10	MMJ	59	74	10	EMV	58	59
11	MEK	64	74	11	AAW	64	60
12	MAL	68	79	12	AEX	64	61

APPENDIX G: players' pictures during test



Figure 1: vertical jump test for explosive power

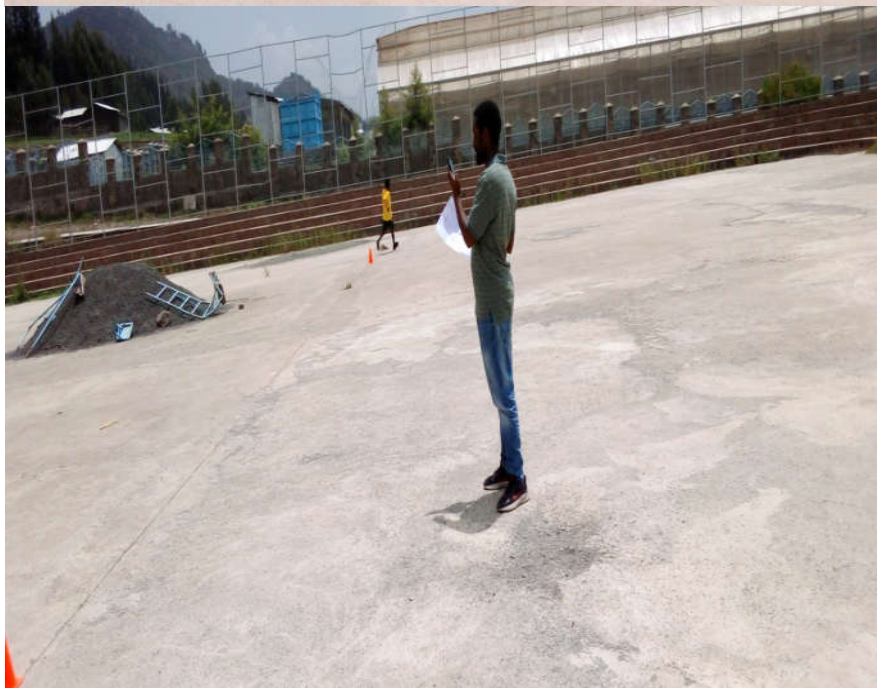
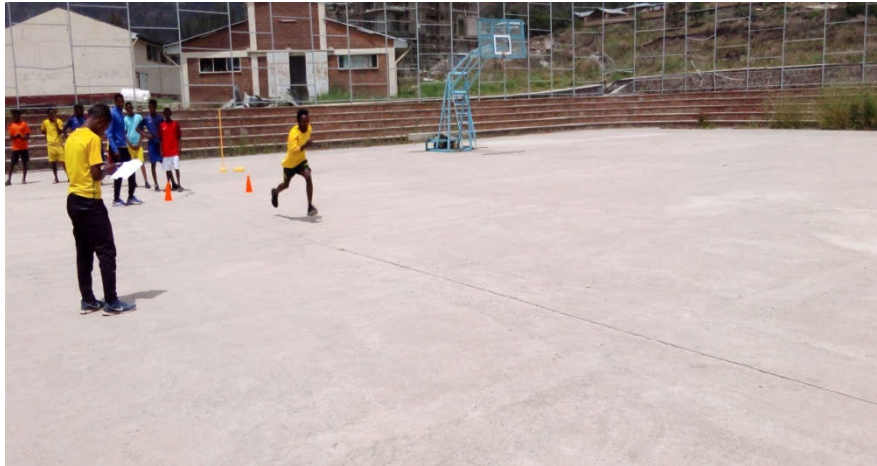


Figure 2: flying 30m sprint test of players speed



Figure 4: SEMO test during agility test picture



Figure 3: push up test for strength picture



Figure 5: Radar test during spiking speed test picture