

THE IMPACT OF HILL TRAINING ON MIDDLE AND LONG  
DISTANCE ATHLETES: WITH SPECIFIC REFERENCE TO OROMIA  
WATER WORKS ATHLETICS CLUB

ADDIS ABABA UNIVERSITY  
COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCES  
DEPARTMENT OF SPORT SCIENCE

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ADDIS ABABA, ETHIOPIA

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This is to certify that I have examine this copy of master's thesis by Nigatu Worku and I have found that it is complete and satisfactory in all aspects, and that any and all revision required by the final examining jury have been made.

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## **Acronyms and Abbreviations**

- ✓ VO<sub>2</sub> max = maximum oxygen up take
- ✓ IAAF = international association of athletics federation
- ✓ ICECP = international coaching enrichment certification program
- ✓ LSD = Long slow distance run
- ✓ vVO<sub>2</sub> max = velocity of maximum oxygen consumption
- ✓ % = Intensity level.( percent of intensity level)
- ✓ ‘ = minute
- ✓ Int.= intensity (speed at which the training was executed)
- ✓ L.run.F.= Long run forest
- ✓ Temp. = tempo run training
- ✓ L.run..R.= Long run forest.
- ✓ SE = Speed Endurance
- ✓ L.hill = long hill training
- ✓ S.hill = short hill training
- ✓ M.hill = Medium hill training
- ✓ T.hill = tempo hill training
- ✓ 10x3m,2 = 10 times 3 min run with 2m in recovery .
- ✓ RHR = resting heart rate
- ✓ HR max = heart rate maximum
- ✓ DOMS = delay onset of muscle soreness

## Abstract

Maximum O<sub>2</sub> uptake (VO<sub>2</sub> max) and resting heart rate (Rhr) are considered to be best physiological performance indicators that can be attained by hill training. In addition to cardiovascular function, speed endurance and strength endurance are partly detected by neuro-muscular factors. One techniques to improve neuro-muscular activity in athletes is through hill training. The aim of this study was to investigate the effect of 12 weeks hill training intervention on the performance of club level middle and long distance athletes. The study used a longitudinal and controlled experimental design. To test the hypotheses of the study and to investigate the effect; direct pre and post field tests were conducted on VO<sub>2</sub> max, Rhr, SE, race performance improvement, consistency of the improved performance and status of injury. Thirty two athletes divided randomly in to control and experimental group (n=32; 18.8 ± 3 years, 51.3 ± 5.2 kg, 1.68 ± 0.05 m) and passed through 12 week of intervention with two session of 40' - 60' hill workout a week to the commutative of 16 - 24 hours. During week 0, 6, 12 each subject complete three assessment testes, two records and additional three tests for experimental group at week 16, to assess the consistency of performance. Although the subjects were similar in all aspects prior to the pre-test was performed; 12 minute cooper test (VO<sub>2</sub> max), resting heart rate (mean of three 15 sec. Rhr. count x 4), speed endurance (300 m anaerobic threshold test), race time records (from 4<sup>th</sup> to 16<sup>th</sup> weeks) and injury report records (from 2<sup>nd</sup> to 12<sup>th</sup> week) were administrated. The intervention group show significant improvement in VO<sub>2</sub> max, resting heart rate, speed endurance at week 6 (p=0.00, α=0.05) and 12 (p=0.00, α=0.05) and race time but the developed performance at week 16 have showed insignificant change. The control group showed insignificant change at either time points. There were no significant change in injury records between and within groups (p=0.381, α=0.05). The study demonstrate that 12 week of hill training can significantly improve VO<sub>2</sub> max, Rhr., speed endurance and race performance in club level middle and long distance athletes and the developed performance is consistent over four week period and hill training by itself was not cause of athletic injury.

**Key words:** Distance athletes, hill training, Vo<sub>2</sub> max, Rhr., speed endurance, coaching method.

# CHAPTER ONE

## INTRODUCTION

### 1.1. Background Of The Study

Sport training was a scientific and systematic approach to teach human physiology in order to cope-up with any stress full activities in demand to the sporting events, though running is one of the sportive events that involves a rapid change of muscular contraction and relaxation. A skillful runner can able to avoid unnecessary muscular tension so that one can apply energy more effectively. Schmolinsky (1983) showed that the ability to relax is therefore of vital importance in an economic running movement. Training is a systematic process of preparing athletes for the highest level of performance. As an old Latin proverb says: “Many roads lead to Rome”, which means that many ways can lead to the same goal(Coach/Instructor: Wong TakShing.). The purpose of training is to teach the body how to deal with the physical and mental elements of running for time and distance. Training runs and workouts should balance themselves between comfortable and uncomfortable in order to develop different aspects of mind and body. Running the Marathon distance involves much more emotion and adrenaline and requires the runner to operate close to the edge of exhaustion.

Training methods can be used to improve the general fitness and the ability to train better. To minimize the risk of injury, it is a preliminary requirement to develop a base level of aerobic running for several months before attempting some of the more challenging training methods.

Hill running is one of the training method for middle and long distance athletes that can be done in different systematic ways either by running a series of repetition sprints up a hill with recovery periods between or by selecting a course containing several varying hills and run it on a continuous circuit. By doing the latter type of training, large percentage of VO<sub>2</sub>max can be utilized as that would be more difficult to achieve while running on the flat. Obviously it need fitness and careful introduce of the right amount. This method brings strength to the legs as well as to the heart and lungs.

Hill running (also called “fell running” when it takes around Addis” Intoto” ) is simply mean running over the hills, moors and mountains of “Intoto” and beyond. It often takes

the athletes off the paths and into wild, unspoiled and beautiful terrain; it can be as much about the places it takes them as the physical challenge of doing it.

Hill running has a strengthening effect as well as boosting the athlete's power and it is ideal for those athletes who depend on high running speeds. Tulloh (1992) explained that to reduce the possibility of injury hill training was conducted once the athlete has a good and solid base of strength and endurance.

In fact Sport training is a process of carefully and systematically acquired physical and physiological skill of the body to perform the demand activity of the events which athletes train and compete for. Therefore coaches are expected to have knowledge how the correct method and techniques upgrade their athletes. Such knowledge only is not enough for coaches to improve their athletes, they have to also know basic and detail information about the types of training, the load and long time effects on the physical and physiological process improvements that directly influence the performance of the athletes.

Long distance events require different qualities of physical fitness that could be primary important for the improvement of performance. Of these, aerobic endurance, strength endurance and speed endurance are among the primary demands of performance to be in a good athletic conditions. Therefore athletes and coaches have to know these and should consider while they develop training plan that includes a possible method to advance physical qualities for betterment of performance.

Hill training is one of the well known method of training that can develop all the three physical qualities at the same time. Assumably varying the training method on the hill provides pre dominant physical qualities for long distance events. Incorporating hill training in the coaching system could help coaches to build and improve the athletes' performance, correct their weakness for different competition and also excel the result they score for their clubs and the country in general.

Many international coaches and authors of different books and literature like Arthur Lidyard, Jack Denial, Renato Canova, Hegdon and Abri Deswart which is IAAF higher level coaching course lecturer were using hill training in their coaching system and agreed that it is one of the best training method to improve and sharpen the athletes performance. All of them emphasized that hill training method can develop all rounded physical

performance, specially aerobic and strength endurance, as well as psychological strength for the long distance athletes.

Similarly it works on the physical and physiological aspects of the athletes. When I was an athlete, my coach Tolosa Qotu used to include hill training in his most types of training and number of his athletes from middle distance to marathon was very strong and showed outstanding performance in the national and international competition. Athletes like Tesfaye Jifar , Tesfaye Tola , Gezahgn Abera, Hailu Nigusse , Mamo Qejela, Kenenisa Bekele were all from a Mugger sport club represented Ethiopia in different world championship and Olympic games and brought historical results for themselves and their country. Those coaches of the time and their coaching system was much focused in hill training to build aerobic and anaerobic endurance, strength endurance, speed endurance and the finishing kick technique which was the best reason for our athletes' performance and dramatic final kick which is historical in athletics world. The system used to develop many world star athletes from the time of Mirust Yifter to the time of Kenenisa Bekele and Tirunes Dibaba, which show an excellent performance to the world had including hill training .Let alone international events, the local competitions and championships like Ethiopian track and cross country championship has been very competitive and strong that provides strong and outstanding athletes.

Generally the previous coaching system emphasized on hill training was build strong, consistent performance and made the athletes to perform far in many national and international races. The athletes had been champion for more than two world champion or Olympic games. According to the statistics data of IAAF of the last two decades, many of the world record and best time was achieved by our athletes at that time.

In contrast, recently, the pattern reversed and the coaches in the current coaching system were putting injuries like knee, heel and Achilles tendon resulting negligence of hill training from planning and training system. As the result, they are training their athletes with incomplete performance development. Likewise, the athletes' basic endurance and strength is not built properly that could makes the athletes performance less and inconsistent. Due to the current coaching system the performance of the athletes is becoming very weak which in turn makes the clubs to lose their result and previous record. The weakness the clubs become a major factor on the poor performance of

national team that makes it to lose results on many different big international competition of the world.

This decline in performance of racers should be solved by searching solutions of this problem so that the athletes can to perform better and that bring a lot of change on our long distance performance and result. Systematic study that intends to find out the basic physical and physiological benefit obtained by hill training method and sharing the findings with the national coaches to know and understand about hill training and include it in future training system, moreover, current and future study that correct the problem and bring up advancement on performance of athletes' to regain and maintain national history in long distance events.

## **1.2. Statement Of The Problem**

In fact every citizen of the country had celebrated with one of the Olympic winner of long distance athlete before the last two Olympic, the feeling was different for me since I have been in the athletics profession from more than two decades. Being an Ethiopian former athlete and working in a coaching profession with different clubs and national team provided me the opportunity to have good experience in the field. In my coaching carrier, I have observed that many of long distance event athletes were able to show an outstanding result on one or two of their races. However, most of them were unable to perform and score as good result as expected from them and still unable to keep their showed performance consistent. Now a day, most long distance athletes' performance shows lack of consistency and also a number of athletes get injured due to the lack of the demanding physical qualities for the event, this implies that the athletes' basic strength for performance is not build properly. The main reason for this is coaches were using inappropriate training type and method to develop strength, due to this fact athletes lack the important strength for the event they trained and compete for. It is because, most coaches of different clubs' neglect including hill training method in their training system, since they plan on winning race coaches focus on continuous and interval training method in different variation in their plan. Researcher is hoping that by implementing hill training method, athletes would be able to show progressively improved performance on their training and competitions. This is important in order athletes to be successful for a longer period of time. Finding the importance of hill training methods and showing the benefits for coaches would improve their planning skill and that will equip them to help the

athletes to improve and keep their performance consistent as well as athletes will train and compete with less injury.

Researcher is looking forward to working on this area of concern, and sharing his findings with club level long distance coaches.

### **1.3. Research Hypothesis**

**H<sub>1</sub>:** Hill training enables to brings improvement on Vo2 max level of middle and long distance athletes.

**H<sub>1</sub>:** Applying hill training method helps to reduce the resting heart rate of the athletes.

**H<sub>1</sub>:** Hill training method increases the speed endurance ability of distance athletes.

**H<sub>1</sub>:** Hill training plays important roles in improve racing performance of middle and long distance athletes.

**H<sub>1</sub>:** Hill training serve as a mechanism to maintain the improved performance for longer period.

**H<sub>1</sub>:** Hill training method helps to reduce risks of athletic injuries for distance athletes.

### **1.4. Objectives Of The Study**

#### **1.4.1. General objective**

The objective of this study is to assess the impacts of hill training method on the performance improvement, maintenance and injury status of middle and long distance athletes.

#### **1.4.2. Specific objectives**

- To find out the importance of hill training methods on improvement of athletes VO2 Max level;
- To explore the impact of hill training on the resting heart rate of the athletes ;
- To perceive the significance of hill training on the improvement of speed endurance;
- To ensure the influence of hill training on the race performance of the athletes;
- To identify the value of hill training on the maintenance of performance;
- To assess implication of hill training on the risks of athletic injuries.

## **1.5. Significance Of The Study**

Hill training was more familiarized by coaches of Ethiopia, thereby it was used for performance improvement of long distance athletes and was help them to keep their performance consistency and reduce risks of injury. Likewise, the findings of this research may prove useful to the athletes in having a clearer view and first hand planning experience of the coaches'. This may lead to better enthusiasm and develop good racing experience and their performance could be consistent. Coaches may heighten their awareness on identifying the importance of hill training on the performance improvement and consistency, that enhance their interest to integrate hill training method in their training plan. This may further be a motivating factor to adapt measures and new strategies for the improvement of coaching system.

In addition, it may encourage administrators and managers to review, control and monitor coaches training plan and coaching system by improving their coaching performance through different clinics, refreshment courses and short term training programs. With the use of the results of the study, any athletics club benefit as it may improve the quality of coaching system, the health status of the athletes, the performance and competency of the athletes as well as the total result of the club could be promoted.

The result of this study may benefit the athletics federation by equipping athletics coaches with the planning and implementing hill training, which in turn make them competent. The information and insights that was gained from this study may serve as guide for other researcher in framing their conceptual framework and design and at the same time encourage them to conduct lateral studies within their area of preferences.

## **1.6. Scope Of The Study**

The study focused on athletics club in Sululta areas that possess middle and long distance event athletes. The study was conducted from December to April, 2017 on the improvement of athletes'VO<sub>2</sub>max, resting heart rate, racing performance, performance consistency and risks of injury through the use of hill training method in the club level middle and long distance athletes. The study covered 12 weeks of training intervention, resting heart rate, VO<sub>2</sub> Max copper test, speed endurance test, races time improvement and injury report was considered.

### **1.7. Limitations Of The Study**

- ✓ This study Limited by its solely application only a single club athletes because of lack of interest and unwillingness of other clubs coaches and athletes.
- ✓ It limited by other intrinsic and external factors like sleep pattern, fluid intake and recovery activities were not controlled.

### **1.8. Operational Definition**

- ✓ Threshold = the point exactly before the onset of lactic acid.
- ✓ Middle and long distance events = the running distances category from 800m to 10,000m.
- ✓ Hill training = different form of running training over inclined area with the inclination of 5 degree and above.
- ✓ Running economy =
- ✓ Intensity = the degree at which the given task is accomplished.

### **1.9. Organization of The Study**

This research is organized in five chapters. The first chapter is the introduction of the study with in which back ground of the study, Statement of the problem, purpose of the study, hypothesis, scope of the study, significance of the study, limitation of the study, and operational definition of terms are discussed. The second chapter provides the review of related literature. The third chapter deals with the research methodology in which Research design, source of data, sample and sampling technique, and data collection method are discussed. Chapter four is about the result of the research and the last chapter, chapter five, provides discussion, conclusion and recommendations of the study.

# CHAPTER TWO

## REVIEW OF RELATED LITERATURE

### 2.1. Training Methods For Long Distance Athletes

Running Events, middle and long distance running training aims at improving both the anaerobic and aerobic capacities of athletes. The longer the running distance, the more important aerobic capacity with related to performance, and vice versa. Although, most long distance running training programs include both anaerobic and aerobic running training, running training that raises the heart rate to about 80% of the athlete's maximal heart rate (HRmax) is mainly for the development of aerobic capacity (Fox *et al.*, 1993). Similarly, running training that raises the athlete's heart rate to 90% of HRmax or higher aims at anaerobic development. In practice, the proportion of anaerobic and aerobic training depends on the athlete's major event. Meaning, the longer the race distance, the more aerobic running training should be emphasized, and vice versa (Fox *et al.*, 1993).

### 2.2. Varieties of running training

Usually long distance runners employ different varieties of running training; continuous, interval,, repetition and fartlek training are commonly utilized by many long distance runners in their training programs. Continuous running training involves continued running for relatively long distances, according to wilt it can be classified into continuous slow-running training and continuous fast-running training (Wilt,1968). Continuous slow-running or LSD (long, slow distance) is running for long distances at a slow pace (Fox *et al.*, 1993). This type of training is mainly used by long distance runners as foundation training before moving up to continuous fast-running training, or as easy running sessions on recovery days. The other variety is when the athletes conduct a faster pace, resulting in an earlier fatigue and covered less distance . This, continuous fast-running training, also simulates the race situation better than continuous slow-running training. As fox said doing so, the intensity of the run should bring the athlete's heart rate to 85 to 95% of the HRmax (Fox *et al.*, 1993).

The athlete can also be trained through interval running training, in which a series of repeated bouts of runs alternated with periods of recovery. The intensity or speed of the runs is usually greater or faster than that can be done continuously for the whole training

session. In this method, the recovery periods are usually occupied by light or mild exercise (e.g., walking or jogging) rather than complete rest.

Similar to interval running training, the length of the runs is usually longer, in repetition running training. Here, the recovery between repetitions is more complete and, therefore, repetition running training is usually employed by the competitive track athletes to simulate the type of stress they normally encounter under race situations. As Daniels said in his book of running formula, it can be split into two forms; running one-half the race distance and running three-quarters of the race distance. The first one is done at race pace or faster than race pace. This is repeated so as to accumulate from 1.5 to 2 times the race distance. (Daniels, 1998). The other form, which is running three-quarters of the race distance should be at slightly slower than race pace. Again, repetitions should accumulate from 1.5 to 2 times the race distance (Daniels, 1998). No matter which form of repetition running training is being used, the recovery between repetitions should be almost complete.

More over, running training like fartlek, which is interval running training without the use of a stopwatch or measured track and that usually involves alternating fast- and slow-running over natural terrain can be used. This can be thought of as an informal interval running training program in that neither the runs nor the recovery periods are precisely timed (Gardner and Purdy, 1970). Considering recovery time may help in interval running training. Accordingly, the longer the race distance, the longer the recovery takes, or the quality of the subsequent runs has to drop. The advantage of interval running training is that quantity of the runs can be increased while quality can be maintained. Literature like in Åstrand et al. (1960) indicated that a workload (350 W) that could originally be tolerated continuously for 9 minutes, if changed to be performed intermittently, could be executed for 30 minutes within an hour. In addition, Christensen et al. (1960) also obtained similar physiological results with their treadmill test. In their experiment, when the treadmill was set at a speed of 20 Km/hr, the subject could only run continuously for 4 minutes (covering a distance of about 1300 m), and the blood lactic acid level at the end of the test was 16.5mM. When the activity was conducted as alternating periods of 10-second run and 5-second rest, the subject completed 20 minutes of running at 20 Km/hr in a 30-minute period (covering a distance of 6670 m) without undue fatigue, and the blood lactic acid level at the end of the test was only 4.8 mM. The low blood lactic acid level at the end of the test indicates that anaerobic glycolysis was not the

predominant source of energy supply. It should also be noted that the oxygen uptake and pulmonary ventilation were also high during the interspersed resting periods (Åstrand and Rodahl, 1986).

In general, from the reviewed literature above, interval running training allows to have better efficiency than attained during continuous exercise alone. By adjusting the speed and length of the runs, number of repetitions, duration and type of recovery, it is possible to stress either the aerobic system without significantly mobilizing the anaerobic systems, or the anaerobic systems without maximally taxing the aerobic system, or else both the aerobic and anaerobic systems at the same time (Åstrand and Rodahl, 1986).

### **2.3. Principles Of Running Training**

Training of planned, purposeful practice and careful preparation makes change (Vernacchia *et al.*, 1992), because training programs must be structured to fit individual athletes, with their events consideration. Thus, how to determine the proper training workout for each athlete is an important step in this matter. Not surprisingly, many guidelines for conducting training programs have been provided by exercise physiologists (Astrand and Rodahl, 1986; Fox *et al.*, 1993) through careful study the over all effects of training.

Actually, the principles of running training are not much different from the more general sport training principles. Among these principles; Specificity and progressive overload are important (Fox *et al.*, 1993). As stated in Hewson and Hopkins (1996), in distance running, training could consist of a variety of workouts that appeared to differ in specificity for events of different duration. For instance, continuous running at moderate intensity would appear to have the most specificity for the aerobic system and the longest running events, whereas strength training would seem to be more appropriate for sprinters than for endurance athletes (Hewson and Hopkins, 1996). Specificity is a maximal training effect that can be achieved only when the mode of exercise is the same as that used during the skill performance (Foster *et al.*, 1995). Similarly, principle of progressive overload states that the intensity of the workload required to produce a training effect which increases as the performance is improved in the course of training (Astrand & Rodahl, 1986). This principle argues that once the athlete has adapted to a workload of the training program, the workload should be increased. Besides, the workload should be

increased throughout the training program whenever the condition of the athlete has been improved so that the workload is always near to the maximal fitness capacity of the athlete (Fox *et al.*, 1993). The effectiveness of the principle has been found encouraging in some literature (Foster *et al.*, 1995). Unfortunately, if the exercise involves a large eccentric component, such as downhill running, damage is generally more severe (Knitter *et al.*, 2000; Gómez *et al.*, 2002). And, even after injury, the repairing process might take weeks to be recovered (Grobler *et al.*, 2004). The defects of the principle can be minimized by side ways principle, considering easy days in between so that recovery is possible. On the easy days, the athlete may take complete rest or do some easy runs. Even if the athlete insists to run every day, the principle of hard and easy days must still be followed.

Although Specificity and progressive overload are important, principle of individual differences and periodization are among the new and systematic principle. In fact, athletes, even of similar performance levels, may respond differently to the same training program. There for, principle of individual differences dictates that athletes or coaches should never blindly copy others' training programs and follow them as blueprints. But, all training programs should aim at improving or "fine-tuning" the technical, physical and mental qualities of individual athletes. The same applies in the principle of periodization, Schmolinsky (1983) emphasized on developing the athlete for top performances . In this principle, training plans for international athletes may extend over years. For most athletes, periodization will divide their yearly plan into three periods (assuming that there is one important competition in a year); Preparatory, Competition and transition Periods.

## **2.4. Hill Running**

Hill running is designed to enhance the ability to maintain an optimal stride length for the duration of a competitive distance. All exercises in this category correspond to the movement pattern involved in the target race, but the runner perform them at a high-intensity level. Although other exercises can promote this objective, hill running doesn't require special apparatus such as a harness, a weighted vest or other gear, or a flotation device for the pool. All that is required is a hill or two. Flat lander can always seek out freeway overpasses, or treadmills with elevation features. Hill running and bounding create strong resistance for the muscle groups carrying most of the load in running the

ankle, hip, and back muscles, particularly the extensors and plantar flexors of the ankle joint and toe flexors. These muscle groups are important in middle-distance running, not only in driving the body forward but also in the muscle recovery phase of the stride. The forward movement of the body is a coordinated function, an example of which is the simultaneous extension and flexion from the hip joint as the swinging motion of one leg helps the driving action of the other. Therefore, high knee lift should be employed to complement the strong driving action from push off as the hill running or bounding is performed. Quality of form, especially arm and leg action is far more important than speed going up the hill. Hill length between 300 and 500 meters is recommended once initial adaptation to the training load has occurred.

## **2.5. Hill Running Training**

Hill training is a highly specific form of strength/resistance training that has many benefits for the endurance runner including improvements in stride frequency and length, muscle strength and power, neuro - muscular co-ordination, running economy, fatigue resistance, muscular endurance, speed, aerobic and anaerobic power and protects leg muscle-fibers against damage and delayed onset muscle soreness (DOMS). Research of Sloniger (1997) shown that high intensity hill running leads to a greater level of muscle fiber activation and recruitment in a number of muscle groups compared with running on a level slope. Swanson and Caldwell(2000); Sloniger (1997) noted that particular uphill running appears to increase a greater activation of the vastus group (quadriceps), gastrocnemius (calf), soleus (lower calf), and gluteus maximums (buttocks) and reduced activation of the hamstring group of muscles. Therefore, the integration of regular hill training is a highly sport specific way to increase muscle activation and hence lead to improvements in muscle strength and neuron-muscular co-ordination. Hill training also increases both aerobic and anaerobic power – hill training places a much greater emphasis on anaerobic energy metabolism than is the case when running across flat terrain.

## **2.6. Hill training methods for distance athletes**

The contribution of hill training during long distance running preparation is important for several reasons. Unfortunately, during a race, runners inevitably encounter hills, It seems adequately preparation definitely needed by athletes with enough time for train on them. As Bompa said, aside to race performance, running hills also improves functional

strength (2003). If performed properly, hill training can also help improve running economy. Any area with moderate sized hills will usually be sufficient for this method of training. However, if the race place contains more significant hills, it is good to implement similar terrain in some of athletes training.

In time of hill training, special care should be provided while athletes sprinting downhill to minimize delayed onset muscle soreness due to the forceful elongation of muscle fibers in the lower extremities.

Conversely, it is also important to avoid “putting on the breaks” when running downhill, as this will cause a significant “jarring” effect on foot strike, also accentuating the amount of stress the body must endure. (Ref: Endurance Features Power Training For Endurance Athletes David Sandler, MS, CSCS,\*D Training For the Half Marathon Chris Crawford, MS, NSCA-CPT).

## **2.7. Hill training method**

Like continuous training method hill training can be performed in different ways to collect the benefits of the hill as demanded by events. As the name indicates, one has to find a hill with a long gradual slope that rises at 7-10% over a prolonged distance is preferable. Different studies showed that running up a hill require additional energy system. It means engaging a different energy system and muscle group than needed on the flats (Midgley *et al.*, 2007). As long as a reasonable pace maintained, hill climbing will require the kind of force that is generated by Type II muscle fibers and anaerobic energy system (Davis, 2012). These were the twin engines that get involved when an athlete sprinted, jump or do heavy lifting.

## **2.8. Impact of hill training on physical fitness**

The benefits of training on an hill come from pushing the body to exert more mechanical energy. The need to run up the hills at a speed that is in the same range as the comfortable running speed on flat ground (Lanao *et al.*, 2007). Hill training is important to maintain proper form. This can be done by shortening the strides slightly while increasing cadence. Athletes should concentrate on driving knees upward and extending fully through the drive/support leg while maintain momentum (Lanao *et al.*, 2007). An evaluation of kinetics during uphill running demonstrated that the hip extensor muscles, which were not as active during level running, were extensively used during incline running one so it is

critical to lift the knees to generate sufficient force. Those who run on hills have also been shown to be less likely to lose fitness when they take time off from training. And many scientists believe that hill training can improve the elasticity of muscles, tendons and ligaments, allowing these tissues to carry out more work with less effort and fatigue.

## **2.9. Physiological benefits of hill training**

Runners who trained on hills have much higher concentrations of aerobic enzymes, the chemicals which allow the muscles to function at high intensity for long periods without fatigue, in their quadriceps muscles than those who did all their running on flat terrain (Bangsbo, 2010). Type II muscles exert more power but they also burn glucose faster and produce lactic acid – the waste product that makes muscles burn during intense workouts. Engaging type II muscles enables working the full spectrum of muscle fibers. This develops total muscle strength and prepares body for situations when one have to pick up the pace – like the final kick when the finish line comes into sight (Davis, 2012).

## **2.10. Types Of Hill Workout**

**Long hill intervals** – this typically involves running 4-8 intervals of 400 – 1600m duration up a moderate slope

**Running across hilly terrain** – as the name suggests this simply involves continuous running across hilly terrain.

**Short hill intervals** – this is the most popular type of hill interval and normally involves 10-16 intervals of 150-300m intervals run up a moderate slope

**Tempo hill training** – this variation involves running 20-30minutes of continuous hill reps, up a moderate slope. Uphill efforts are run above lactate threshold intensity, whilst downhill recoveries are run at a steady pace that is only slightly slower than the uphill.

**Treadmill Hill Running** – involves running hill intervals on a treadmill.

## **2.11. Long Hill Running Intervals**

Long hill interval training involves the use of 4-8 repetitions of around 400-1600m (sometimes longer), up a moderate slope, with a jog down recovery. The length of the uphill intervals were considerably longer than short hill intervals and as such the pace is reduced to between 10k and half marathon pace (Jung, 2003). The down hill section was run at moderate/steady pace that takes approximately 25-50% longer to run than the uphill section.

### **2.11.1. The benefits of long hill intervals**

As with other types of hill training, long hill intervals improve muscular strength, running economy, muscular endurance, fatigue resistance, and aerobic metabolism with a much reduced emphasis on anaerobic metabolism, due to the slightly slower pace of repetitions, compared with short hill intervals (Williams and Wikins, 2011). Therefore, this type of hill training is more suited to distance runners than the short hill repetitions.

## **2.12. Running across hilly terrain**

Including hilly/undulating routes as part of the weekly steady state running can be a good way to improve muscular strength, running economy, and aerobic and anaerobic power and can be a good preparation for running hill intervals (Lydiard, 1999). Another benefit is that during the downhill phases the will increase the proportion of work done through eccentric muscle contractions which will help to strengthen muscle fibers and provide some protection against delayed onset muscle soreness. A further benefit of running across undulating terrain is that the level of activation of individual muscles changes throughout the run, dependent on the slope (uphill, downhill, or flat) and helps to ensure that there is a more equal activation of different leg muscles during the run (Davis, 2012). Unless for fell runner, or targeting the cross country races, only include one continuous run, across hilly terrain, per week. It appears to be particularly beneficial to incorporate a hilly route as part of the weekly long run, particularly if the include several long hills in the first 20mins of the run. This improves muscle fatigue resistance, and helps to speed the depletion of muscle glycogen during the long run, as muscle glycogen levels drop there is an increased emphasis on fat metabolism and this will help to train the muscles to be more efficient at utilizing fat as an energy source.

## **2.13. Short Hill Intervals**

A typical short hill interval training session would involve running approximately 10-16 repetitions of about 150-300m, up a moderate gradient, with a slow jog down recovery. Typically, the uphill, or effort section, would be run at around 3 - 5k race pace, and the downhill, or recovery section, would be run at an easy jog pace that takes approximately twice the time to run down as to run up the hill (William and Wikins, 2003).

This type of hill training will improve muscular strength, running economy/exercise economy, muscular endurance, aerobic and anaerobic metabolism. But, because of the speed of these intervals the place a much greater emphasis on anaerobic energy sources. These sessions were more beneficial to 1500m – 5k runners, who use a greater proportion of anaerobic energy, compared with distances of 10k or greater (William and Wikins, 2003).

## **2.14. Tempo Hill Intervals**

### **2.14.1. Long hill repeats**

These were analogous to running long intervals on the track. Find a moderate-grade (5% to 8% or three to four degrees) hill just steep enough to try the legs and just long enough to try the mind. Long hills were particularly good for building strength and endurance for races of half-marathon to the marathon (Chen, 2007). Find a hill that is about one-quarter to one half-mile in length. It should take about two to five minutes to run up at the 5K to 10K race pace effort or slightly faster. If the hill is too long, the recovery coming back down was too long. If they can't find a long-enough hill, run hard on the flats going into the hill so the total hard effort is at least three minutes. Do about three to five repeats, five to 10 for more experienced competitors (Braun, 2003).

### **2.14.2. Short hill repeats**

These were particularly good for sharpening speed for races of 5K to 10K since they were run at faster than race-pace effort. They were of similar benefit as short, hard- and fast-paced intervals on the track. Pick a hill that's 50 to 200 yards in length and steep enough (10% to 15% or seven to nine degree grade) to really challenge you, but not so

steep that it makes good form impossible. It should take about 30 to 90 seconds to get to the top (Magill, 2011) .

If the hill is too steep or too long, they won't be able to maintain a strong effort to the top. They don't have to run these too hard since gravity will take were of the intensity. Do not sprint all-out. Envision you're running to a 5K-race finish line at the crest of the hill. Do about four to six repeats, six to 12 for more experienced competitors (Davis, 2009).(The Competitive Runner's Handbook ,5<sup>th</sup> edition ,April 1999).

## **2.15.Common Mistakes In Hill Training**

**Attacking the uphill:** A quick ticket to oxygen debt. Hill races were rarely won by the person who is the fastest at the bottom. They must concentrate on relaxing and metering out the energy over the hill. Many hills were steepest at the bottom and flatten out near the top. A well run hill has the picking it up at the top and into the downhill transition.

**Over striding uphill:** Remember that the muscles of the legs were major pumps for the blood supply of oxygen and fuel while running. A short quick stride helps supply more fuel and oxygen than a long slow & one uphill. This is the same reason that it is more efficient to use low gears and a fast cadence when riding a bicycle uphill rather than high gears and a slow cadence.

**Looking at the feet:** Maintain the posture uphill and downhill by looking into the distance. Hunching over or looking at the feet will tense up the muscles and hinder the breathing and balance, (not to mention exposing yourself to collisions with solid objects).

**Resting or holding back on the downhill:** If they do not accelerate on the downhill, they will lose the opportunity to get something for nothing. If they don't believe this, try running downhill with a pulse rate monitor and notice how much faster they can run at the same pulse rate than on the flat. A sure sign that they were holding back is the sound of "popping" from the feet as the run downhill. Work on increasing stride length and using the arm swing for balance.

**Not thinking ahead:** Look ahead for variations in the slope up or down and adapt to them immediately. If they have to wait until they were tying up from lactic acid uphill or hearing the "popping feet" downhill to change the form, it's too late and they have already wasted energy.

Repeat the drill concentrating on the images and performing the running circuits until they can bring up the images as the run (i.e. picture yourself running easily and relaxed uphill while they were actually doing it).

## **2.16. Importance Of Hill Training**

### **2.16.1.Risks of hills and injury prevention**

Up hill running can cause lower leg maladies, and that downhill running can cause knee and impact injuries, I will respectfully disagree that the hills were the actual source of the problem. The majority of these types of injuries likely come as a result of the runner undertaking their training program with too much zeal or not knowing how to properly train (Pfitzinger, 1999). Hill training would be an adjustment to terrain and running surface, making hills a likely benefit. It seems that injuries “from” hill training were likely no different than other overuse running injuries, in that they come as a result of the athlete jumping into the activity too hard and too quick without giving the body time to build up and adjust (Pfitzinger, 1999). Any runner who regularly does uphill training could suddenly contract an injury such as Achilles tendinitis without any major changes to their regular regimen. Most likely this type of injury would occur with a sudden increase in either the volume or intensity of training, or with an unnatural increase in the amount of uphill training they were doing. Perhaps, developing a variety of training alternatives is important to prevent overuse injuries and maintain motivation (Miller, 2002).

According to British distance coach, Brian Mackenzie (2007), the amount of distance run can be reduced due to the hard going of the terrain. Obviously, stronger muscles provide more power for running up inclines. Just as important, they also offer better shock absorption, and therefore more injury protection, when running down declines (Westcott, 1998). The nature of downhill running can provide what some call soreness protection. By doing downhill running, the body is protected against muscle soreness in the future, and therefore protected from injuries that might usually occur while trying to train hard on muscles that were already sore (Higdon, 1999). “Many runners develop muscle soreness after strenuous workouts or races. Research (Muscle function after exercise induced muscle damage and rapid adaptation, *Medicine and Science in Sports and Exercise*, vol. 24, pp. 512-520 1992) has shown that the muscle pain and loss of strength can be minimized if runners undertake regular sessions of eccentric training. For

runners this would involve downhill running, since downhill put the muscles in the front of the leg under intense eccentric duress. A single downhill session (6 to 10 downhill runs over 300 meters) on a 300 to 400 meter hill with an inclination of 10 to 15 degrees should provide protection against muscle pain and loss of strength for at least six weeks.”

### **2.16.2.Improvement of anaerobic threshold**

Anaerobic threshold best improved by doing high intensity training and fast strength workouts as European Journal of Applied Physiology (1977) concluded that runners who followed an intense six-week program of hard uphill running enjoyed "significant improvements in training distances, anaerobic capacity, and strength." (Burfoot, 2005). Hill running is 'speed work in disguise. Daniels (1998) highlighted that It can be used in place of grueling track workouts to improve the anaerobic efficiency.

A great way to increase the Lactate Threshold is by running long hills. This increases number and size of mitochondria (increase  $O_2$  consumption); increase aerobic enzyme activity (speed energy production); increase capillarization (improve efficiency of delivery and removal which allows aerobic energy production to be maintained at a higher rate); increased myoglobin (more  $O_2$  can get to the mitochondria) (Pfitzinger and Douglas, 1999).

### **2.16.3.Improvement on $VO_2$ Max**

It's difficult to talk about endurance performance and endurance training without mentioning  $VO_2$  max or maximal oxygen uptake. Elite endurance athletes typically have a high  $VO_2$  max and for the most part it seems to be genetically determined ( Bouchard,1992 ). However, in untrained individuals  $VO_2$  max can be improved by as much as 20% ( Wilmore, 2005 ). A goal of any endurance training program is to help the athlete reach their genetic upper limit for aerobic power.

Mixed hill running can also be used to improve running economy and boost an athlete's  $VO_2$  max.(Mackenzie, 2007). Hill training increases  $VO_2$  max as more total work can be performed at a higher intensity due to the recovery period between sets. The combination of high intensity and a high amount of total work then stimulates the cardio respiratory and muscle systems to adapt which increases  $VO_2$  max.

#### **2.16.4.Improvement in race performance**

Hill sessions, force the muscles in your hips, legs, ankles and feet to contract in a coordinated fashion while supporting your full body weight, just as they have to during normal running. In addition, on uphill sections your muscles contract more powerfully than usual because they are forced to overcome gravity to move you up the hill. The result is more power, increase running economy which in turn leads to longer, faster running strides and improves running speed .The repetitive nature of hill workouts forces the muscular system to develop in response to the stress placed on it, while the nervous system increases firing patterns to fast-twitch muscle fibers. Completing hill workouts also increases speed and endurance because of the resistance inherent to running up hill and the associated increase in heart rate and competitive ability that leads to the racing performance improvement of the athletes. Short and fast training lets the athlete get very comfortable with the type of racing that he or she will be doing (Daniels, 1998).

# **CHAPTER THREE**

## **RESEARCH METHOD**

### **3. Research design**

To test the hypothesis of this study, quasi experimental design was used to investigate the effects of 12 week hill training intervention on endurance quality speed endurance, key physiological performance indicator ( $VO_2$  max and resting heart rate) was applied in club level middle and distance runner (800m - 10000m). A two group repeated measures (pre - mid - and post-test) design was used. After eight weeks of off-season, subjects were randomly divided in to two groups. The two group consists of intervention group (endurance and hill training group  $n= 16$ ;  $18.8 \pm 3$  years,  $51.3 \pm 5.2$ kg,  $1.68 \pm 0.05$ m) and control group (only endurance training  $n = 16$ ; 19 years,  $52 \pm 1.3$ kg,  $1.69.0.03$ m). during preliminary assessment between groups there was no significant difference between baselines of all measures. Prior to the start of the research all athletes and coaches were instructed not to deviate from their normal (800m - 10000m) endurance training. It is known that the control group did not employ any strength training as a part of their normal training program. The endurance training volume and intensity was controlled.

In addition to the endurance training, hill training was given twice per week thought out the study period (week 1 - 12). All the hill training sessions were provided by experienced coaches of the club.

#### **3.1. Sample and Sampling Technique**

Thirty six competitive club level distance athletes (800m - 10,000m) participated in this study. However, due to the selection for national and international cross country competition, thirty two subjects ( $n = 16$ ;  $16$ ;  $18.8 \pm 3$  years,  $51.3 \pm 5.2$  kg,  $1.68 \pm 0.05$ m as experimental) and ( $n = 16$ ; 19 years,  $52 \pm 1.3$ kg,  $1.69 \pm 0.03$ m as a control group) completed the study. The preliminary information assure that the subject didn't have any strength training with in the past five month (July – November 2016). All subject were taken from Oromia water works sport club. After being informed of the benefit and potential risks of investigation, each subject complete the basic health screening check-up and provided detailed information prior to participation in the study.

### 3.2. Data Collection Instruments

During week (0, 6, 12) each subject completed two assessment days. VO<sub>2</sub> max and speed endurance. Resting heart rate taken at one of the days early in the morning while all subjects were on their bed. All VO<sub>2</sub> max, speed endurance and resting heart rate were under taken at the same time and date to avoid diurnal variation on the performance. There were 48 hours between each testing days. To control the effects of diet and physical readiness, each subject was asked to consume habitual diets and avoid vigorous exercise 24 hours prior to assessments. For resting heart rate assessment subjects were oriented to stay on their bed until their heart rate count was conducted.

**Table 1. Dependent Variables and their Respective Tests**

No	Criterion Variables	Test Item	Unit of Measurement
1.	Cardio-respiratory Endurance (VO <sub>2</sub> max)	Cooper's 12 minutes Run	Meters /12min
2.	Resting Heart rate	Heart beat per minute	Beat/minute
3.	Speed endurance	300m anaerobic threshold	Second
4.	Race performance	Race performance records	Meter/second
5.	Acquired performance consistency	Tests comparison	-
6.	Status of athletic injury	Injury report records	Numbers

#### 3.2.1. VO<sub>2</sub> max test

The VO<sub>2</sub> max (physiological variable) was determined during three phases testing procedure of the study. Oxygen consumption was determined accordingly for each subject. All tests were conducted on standardized track and the subjects were ordered to do 15' warming up and 10' mobilization exercises prior to the tests. The 12' cooper test was conducted by dividing each group in to two equal numbers. The test start and end with whistle and subjects were strictly oriented to stop at the blown whistle. The distance covered by each subjects was recorded as the rules of the test and it was converted to the VO<sub>2</sub> max level using online software application.

### Cooper test procedure, validity and reliability

The Objective of Cooper Test (Cooper 1968) is used to monitor the development of the athlete's aerobic endurance and to obtain an estimate of their VO<sub>2</sub> max. To conduct the test there must be stopwatch, 400m track, whistle and assistant. The test require the athletes to run as far as possible within 12 minutes. There are four basic procedures in conducting the test (1) proper warming up (2) the go command and starting stopwatch, (3) keeping the athletes informed of the remaining time at the end of each lap (400m), (4) whistle at the end of 12 minutes and record the distance covered to the nearest 10m. to find the VO<sub>2</sub> max value ( distance covered in meter - 504.9)/44.73 formula was used. Since the test is highly consistent, strictly conducted and high individual motivation to perform the test ,the test is reliable and the test measure what it intend to measure and appropriate and meaningfulness decision could be made on the base of scores so the test is said to be valid.

**Table 2. Normative data, cooper (1968) test**

Sex	Cooper test					
	Age	Excellent	Above Average	Average	Below Average	Poor
Men	13-14	>2700m	2400-2700m	2200-2399m	2100-2199m	<2100m
	15-16	>2800m	2500-2800m	2300-2499m	2200-2299m	<2200m
	17-19	>3000m	2700-3000m	2500-2699m	2300-2499m	<2300m
	20-29	>2800m	2400-2800m	2200-2399m	1600-2199m	<1600m
	30-39	>2700m	2300-2700m	1900-2299m	1500-1999m	<1500m
	40-49	>2500m	2100-2500m	1700-2099m	1400-1699m	<1400m
	>50	>2400m	2000-2400m	1600-1999m	1300-1599m	<1300m
Women	13-14	>2000m	1900-2000m	1600-1899m	1500-1599m	<1500m
	15-16	>2100m	2000-2100m	1700-1999m	1600-1699m	<1600m
	17-20	>2300m	2100-2300m	1800-2099m	1700-1799m	<1700m
	20-29	>2700m	2200-2700m	1800-2199m	1500-1799m	<1500m
	30-39	>2500m	2000-2500m	1700-1999m	1400-1699m	<1400m
	40-49	>2300m	1900-2300m	1500-1899m	1200-1499m	<1200m
	>50	>2200m	1700-2200m	1400-1699m	1100-1399m	<1100m

Source: [www.brianmac.co.uk/gentest.htm](http://www.brianmac.co.uk/gentest.htm)

### 3.2.2. Resting heart rate test

Prior to the vo<sub>2</sub> max and speed endurance assessment days, resting heart rate count was conducted on both group subjects and each subject instructed to stay on their bed until the resting heart rate count was carried out. To insure the accuracy of the count, three times 15 second count multiplied by 4 and divided by 3 to get the average of beat per minute value.

The same procedure were used to measure during and after experimentation using hill training method.

**Table 3. Normative data of resting heart rate for man and women based on age category (topendsport)**

HR	Men					
	18-25	26-35	36-45	46-55	56-65	65+
Athlete	49-55	49-54	50-56	50-57	51-56	50-55
Excellent	56-61	55-61	57-62	58-63	57-61	56-61
Good	62-65	62-65	63-66	64-67	62-67	62-65
Above	66-69	66-70	67-70	68-71	68-71	66-69
Average						
Average	70-73	71-74	71-75	72-76	72-75	70-73
Below	74-81	75-81	76-82	77-83	76-81	74-79
Average						
Poor	82+	82+	83+	84+	82+	80+
	Women					
	18-25	26-35	36-45	46-55	56-65	65+
Athlete	54-60	54-59	54-59	54-60	54-59	54-59
Excellent	61-65	60-64	60-64	61-65	60-64	60-64
Good	66-69	65-68	65-69	66-69	65-68	65-68
Above	70-73	69-72	70-73	70-73	69-73	69-72
average						
Average	74-78	73-76	74-78	74-77	74-77	73-76
Below	79-84	77-82	79-84	78-83	78-83	77-84
average						
Poor	85+	83+	85+	84+	84+	84+

### 3.2.3. Speed endurance tests

The physical fitness quality; speed endurance test was conducted on both groups. Four testes for the experimental group and two tests for control group were conducted and measured using the 300m anaerobic threshold test. The test was conducted on standard track; the subjects were oriented to run as fast as they could to score their best and the time scored by each subjects were recorded.

### **300 meter Run Test**

The purpose is to measure anaerobic capacity. The test required equipment like running track, stopwatch, and marker cones placed around the course. It can be applied with specific procedure that aimed to complete 300 meters in the quickest possible time. The procedure starts with a good warm up including a jog, stretches and some short sprints. To start, all participants line up behind the starting line. On the command 'go,' the clock will start, and they will begin running. Scoring is the total time taken to run 300m is recorded, to the nearest tenth of a second.

**Table 4. Ratings table for the test of adult males. (Topendsport)**

<b>Rating</b>	<b>Time (seconds)</b>
Poor	> 77
below average	71.1 – 77
average	65.1 – 71
above average	59.1 – 65
Good	54.1 – 59
very good	48 – 54
excellent	< 48

#### **3.2.4. Improved Racing Performance Measure**

The race time record was conducted from the 4<sup>th</sup> weeks of intervention to the last test and any race time scored by subjects' during the local competition was recorded. This is used to correlate improved race performance with the method of training strategy. After an increment race performance had been analyzed, maintenance of VO<sub>2</sub> max level and endurance adaptations was observed.

#### **3.2.5. Consistency of Improved Performance**

Additional test was conducted on the experimental group at fourth week after the end of the intervention and all test results were used to compute with the post test result values to determine whether improved physical and physiological variables were consistent or not.

### 3.2.6. Risks of injury count

Any injury reports from either of the groups was recorded from the 2<sup>nd</sup> week of the intervention to the end (12<sup>th</sup> week of the study), the recorded data used to compare the injury situation b/n experimental and control groups

### 3.3. Hill training program

The researcher, an experienced IAAF and ICECP accredited long distance national team coach, designed and coached the hill program over the 12 weeks. The subcategories for hill training in this program included (1) long hill repetition that targets speed endurance development through low-load, high intensity running (8 - 10 x 500m hill with 7-12 degree inclination using 90-100% intensity run); (2) short to medium hill repetition (strength-speed and speed-strength) that improves strength and maximal power output through high load and high intensity running(12-16 x 200m and 10 - 12 x 300m hill with 15 - 20 degree inclination using 90 - 100% intensity running); and (3) tempo hill repetition that targets VO<sub>2</sub> max development and resting heart rate improvement through low-load, high-intensity running(5x 3 - 5' tempo run on undulating hill with 10 - 20 degree inclination using 90 - 100% intensity run)

There were two hill sessions per week with 72 hours of recovery between sessions, 24 hill training sessions and from 16 - 24 hours covered during all the 12 week intervention period. The volume and the intensity of the session was increased progressively from the minimum to the maximum repetition and intensity within the first six weeks

**Table 5. Sample training plan which was implemented during the intervention of the study**

Week&day	M	Tu			W	Tr			Fri		Su		Total
	easy	Workout		%	easy	Workout	Time	%	Easy	%	Workout//time		km
1 <sup>st</sup> week	60m	S.Hill	12x 300m	95%	65m	M. Temp	35m	90%	65m	75%	L .hill	8x500m	60k
Distance	15k		2.4km	3.09	16k		10.8km	3.25	16k	4.00	90%	4km	
2 <sup>nd</sup> week	65m	M.Hill	10X 300	95%	60m	Crucial.T	3x10m,3	90%	60m	75%	T. Hill	5x3'	63k
Distance	16k		3km	3.09	15k		9km	3.25	15k	4.00	90%	15' /5km	
3 <sup>rd</sup> week	70m	L.Hill	8x500m	95%	65m	L .run F	80m	80%	65m	75%	M.Hill	10x300m	79k
Distance	17k		4km	3.09	16k		23km	3.45	16k	4.00	100%	3km	
4 <sup>th</sup> week	70m	T.Hill	5x4'	90%	60m	S.Temp	2x20m	90%	60m	75%	S. Hill	14x200m	68.6k
Distance	17k		20'	3.25	15k		12km	3.25	15k	4.00	100%	2.8km	

### **3.4. Data Analysis**

The collected data in this study was analyzed depending on the type of data collected. First, data from pre, during and post- test results of the experimental group was analyzed to see whether the athletes attended in planned and implemented hill training program improved their performance or not. Second, data from the Control group test was analyzed to compare and verify the validity of hill training method, if it brought significant impact on the improvement and consistency of the long distance athletes' performance. The study was also measure whether hill training helped athletes to maintain their performance for longer duration or not. Finally, data recorded for injury report was analyzed to check if hill training minimized the risks of athletics injuries. Independent variables were defined in terms of the different interventions (experimental vs. control) and the three measurement points (pre - test vs. mid-test vs. post-test). The dependent variables were Resting heart rate, VO<sub>2</sub>max, race performance, speed endurance, occurrence of injury and performance consistency . All data set were presented as mean  $\pm$  standard deviation or percentage change. Descriptive (percentage, average, mean and median) and inferential statistics (graph, histogram and bar charts) was used to analyze the club's variation and performance change within and between athletes. To test for differences between groups at week zero, an independent t-test was used. For each group, measurement values are recorded at before, during and after. Experimental training method and difference between groups compared using a one-way repeated measure ANOVA was used. The level of significance was set at  $P \leq 0.05$ . IBM SPSS Statistics version 20 software was used for all statistical analysis.

## CHAPTER FOUR

### RESULT AND DISCUSSION

#### 4.1. Result

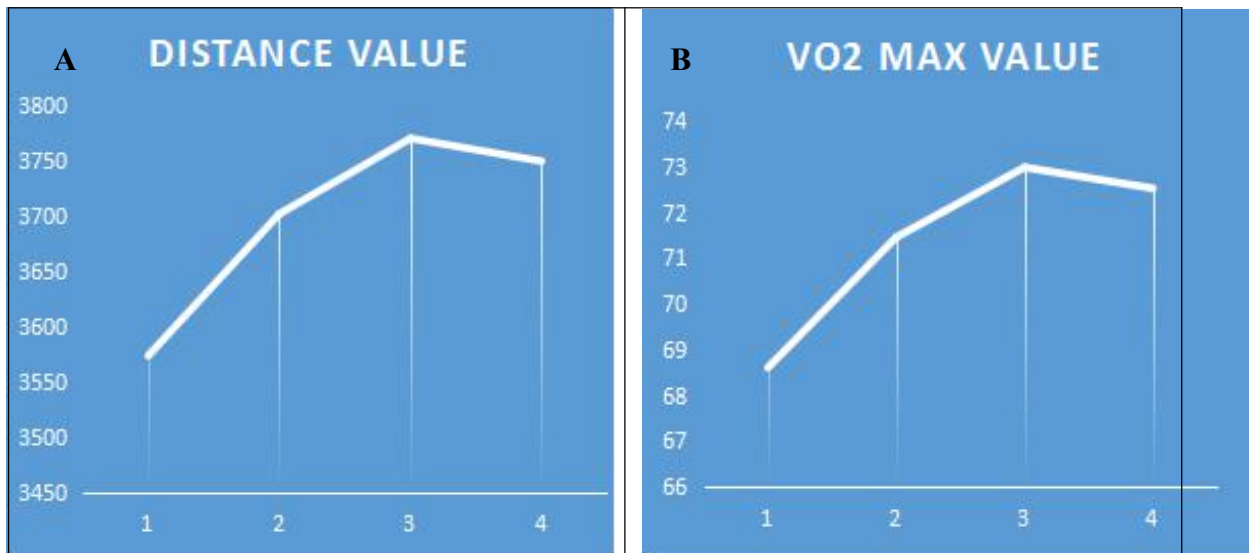
##### 4.1.1. The importance of hill training methods on improvement of athletes VO<sub>2</sub> Max level.

The mean weight value of subjects of normal training method (control) of this study was 51ml/kg/m and the mean distance was 3573m before test was conducted (Table 6). Similar pre measurement was found for treatment group with hill training, which was almost equivalent figure, was recorded.

**Table 6. Summary table for all general information of subjects and parameters tests**

Variables	Experimental / control					
	Experimental			Control		
	Mea	Maximum	minimum	Mean	maximum	minimum
Weight	51	58	46	52	58	46
Age	18	21	17	19	21	17
Athletes event	3325	10000	800	3325	10000	800
P.dis.VO <sub>2</sub> max	3573	3750	3420	3549	3730	3380
VO <sub>2</sub> max pre-test	69	73	65	68	72	64
Pre Rhr.	68	73	64	66	72	62
Pre - speed Endu.	53	59	47	52	57	48

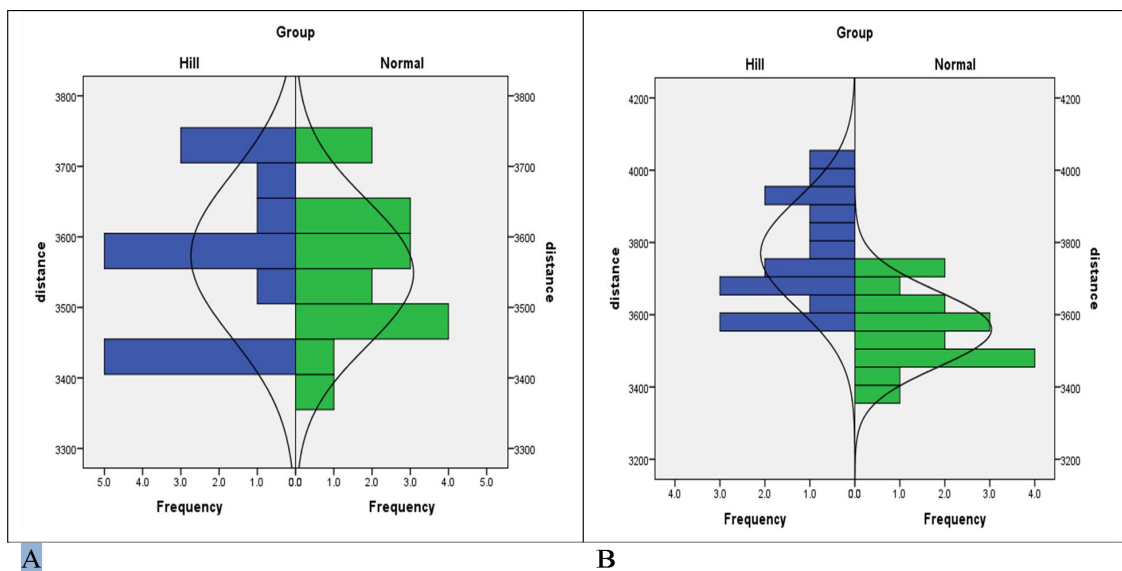
Although the subjects were similar in all aspects prior to the test was performed, significant difference in VO<sub>2</sub> max was resulted after hill training was systematically applied. Hill training was measured after it was implemented in three methodological periods and the initial value of athletes were different ( $p=0.00$ ,  $\alpha=0.05$ ; Table 8).



**Figure 1. VO2 max value with respective distance covered during four tests**

Vo2 max show progressive increment during the intervention and slight decrease four week after intervention.

A. Distance value for all tests; B. VO<sub>2</sub> max value of all tests of the hill training groups.



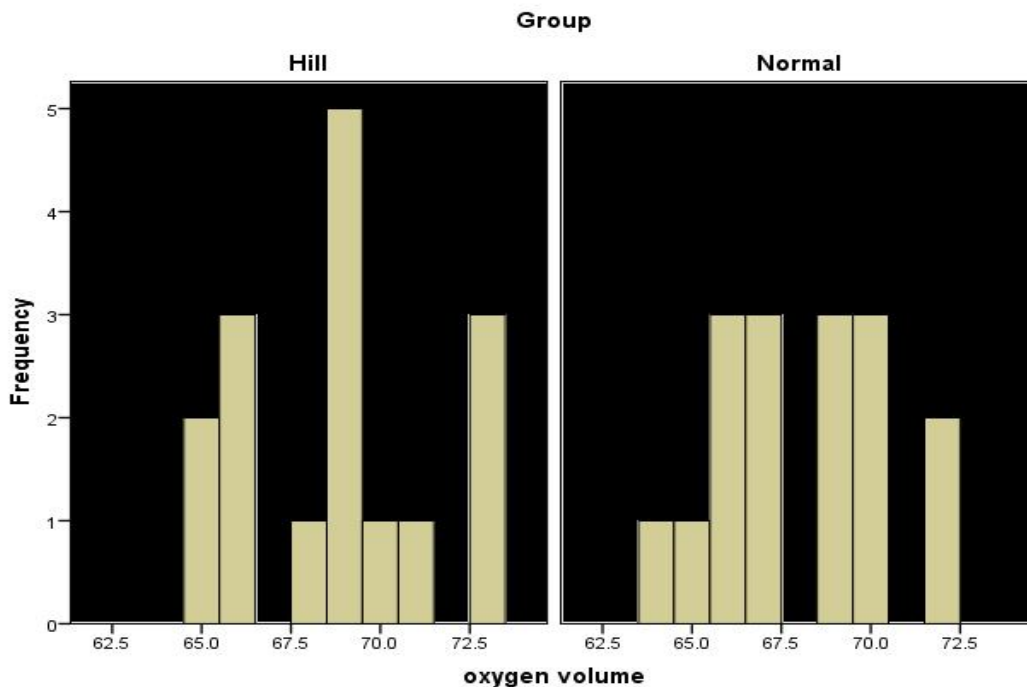
**Figure 2. the pre-test value of distance covered for vo2 max test and vo2 max value**

The hill training group showed significant improvement and the control group has showed insignificant change which indicates that hill training has positive effect on the improvement of vo2 max value

**Table 7. T - test for testing the difference in VO<sub>2</sub> max among groups**

		Sum of Squares	df	Mean Square	F	Sig.
VO <sub>2</sub> pre test	Between Groups	4.500	1	4.50	.67	.41
	Within Groups	199.37	30	6.64		
	Total	203.87	31			
VO <sub>2</sub> test 2	Between Groups	180.50	1	180.50	20.48	.00
	Within Groups	264.37	30	8.813		
	Total	444.87	31			

Analysis of paired t test shows that there was significant progress ( $p=0.00$ ,  $\alpha=0.05$ ) in the attainment of VO<sub>2</sub> max in hill training from than normal method.



**Figure 3. post vo<sub>2</sub> max value of experimental and control group**

All of the subjects in treatment group were seen showing change in first post test and middle stage test (Table 7). The test for attainment of the improved VO<sub>2</sub> max shows there

is consistency of VO<sub>2</sub> max value. The vo<sub>2</sub> max value of the control group show similar result .

**Table 8. Paired Samples Test to analysis the progressive improvement of VO<sub>2</sub> max in the treatment group**

Paired Differences									
Pared testes		Mean	Std.	Std.	95% Confidence		t	df	Sig.
Pair 1	vo <sub>2</sub> pre test - vo <sub>2</sub> test1	2.750	1.342	.335	-3.465	-2.035	8.199	15	.000
Pair 2	vo <sub>2</sub> test2 - vo <sub>2</sub> test3	.625	.500	.125	.359	.891	5.000	15	.000
Pair 3	vo <sub>2</sub> test1 - vo <sub>2</sub> test2	1.500	1.211	.303	-2.145	-.855	4.954	15	.000

#### 4.1.2. The impact of hill training on the resting heart rate of the athletes

Similar to VO<sub>2</sub> max The magnitude of resting heart rate was similar in all athletes of the study. Although after hill training was implemented and tested there was a significant change for experimental subjects ( $p=0.00$ ,  $\alpha=0.05$ ) while no change was recorded when measurement of the heart rate checked for normal groups without the hill training implemented ( $p=0.141$ ,  $\alpha=0.05$ ).

**Table 9. Independent Samples Test to analysis the change in Resting heart rate**

T - test for equality of mean								
		t	D	Sig.	Mean	Std.error	95% confidence	
							Lower	Upper
Pre Rhr.	Equal	1.510	30	.141	1.381	.952	-506	3.381
Post 2 Rhr.	Equal variance assumed	9.222	30	0.00	-9.938	.969	-10.917	-6.958

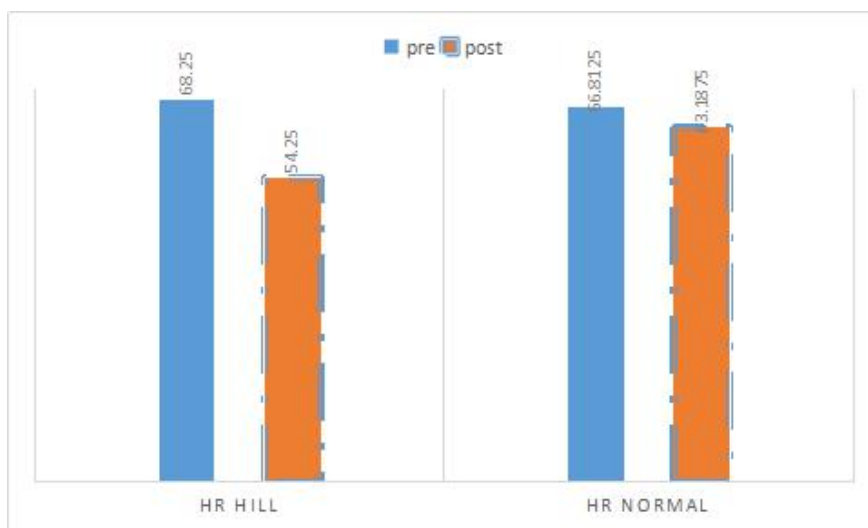
The hill training method improves the resting heart rate even after a few training sessions and the progress is evident from the table below, which depicts complete transformation of the athletes physiological stability and better condition through every stage of the test conducted (table 10)

**Table 10. Paired Samples Test of step wise tests for checking impact of hill training method on resting heart rate of athletes of different event**

		Paired Differences					t	df	Sig. (2tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence				
					Lower	Upper			
Pair 1	pre RHR - Post 2 RHR	8.813	5.767	1.019	6.733	10.892	8.64	31	.000
Pair 2	Post 1 RHR - Post 3 RHR	8.688	3.459	.865	6.844	10.531	10.04	15	.000

**Resting heart rate**

Resting heart rate value have no difference before the intervention, but the hill training group result show 21% decreases in count values while the control group change only 6% which was very little. This result indicates that resting heart rate improved with hill training method



**Figure 4. Resting heart rate across groups for pre and post tests**

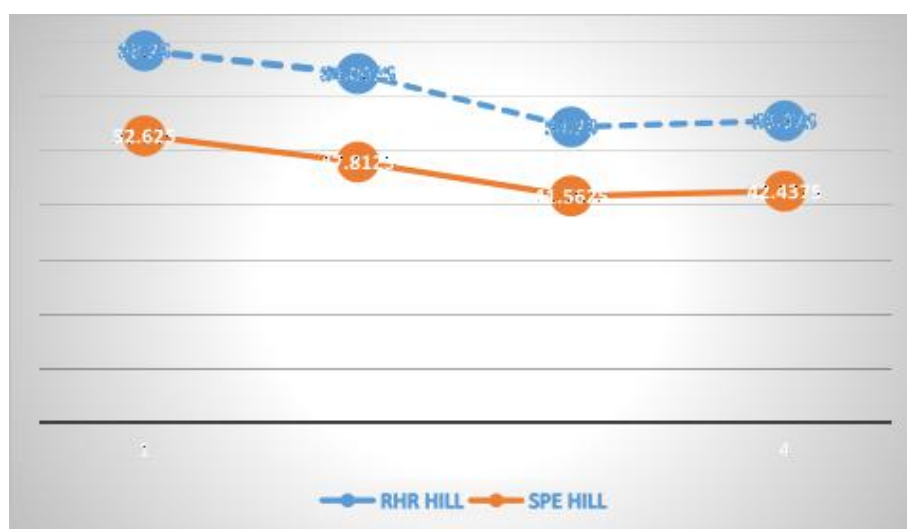
### 4.1.3. Significance of hill training on the improvement of speed endurance.

The data from pre test shows that athletes were not different in their speed endurance. This pattern was completely inverted when the groups were treated in different training technique, the group with hill training workout showed significant upgrade in the speed endurance they scored before. But for the athletes in normal training techniques were show no difference, that means they only attain their pre tested speed. (Table 11 and 12)

**Table 11. Pre hill workout test showing the level of variation among groups of training experiment**

		t-test for Equality of Means				
		t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Pre. Speed End.	Equal variances assumed	.65	30	.52	.75	1.16

The value of speed endurance test show progressive decrease, in the same manner resting heart rate improved significantly during and after intervention. The resting heart rate and speed endurance show direct relation in this study.



**Figure 5. The relationship between resting heart rate and speed endurance for hill training method using group**

**Table 12. Independent Samples Test to check the difference among groups of training methods**

		t-test for Equality of Means						
		t	df	Sig. (2-tailed)	Mean Differenc	Std. Error	95% Confidence	
							Lower	Upper
Post 2 Speed End.	Equal variances assumed	-10.15	30	0.00	-7.500	.738	-9.008	-5.992

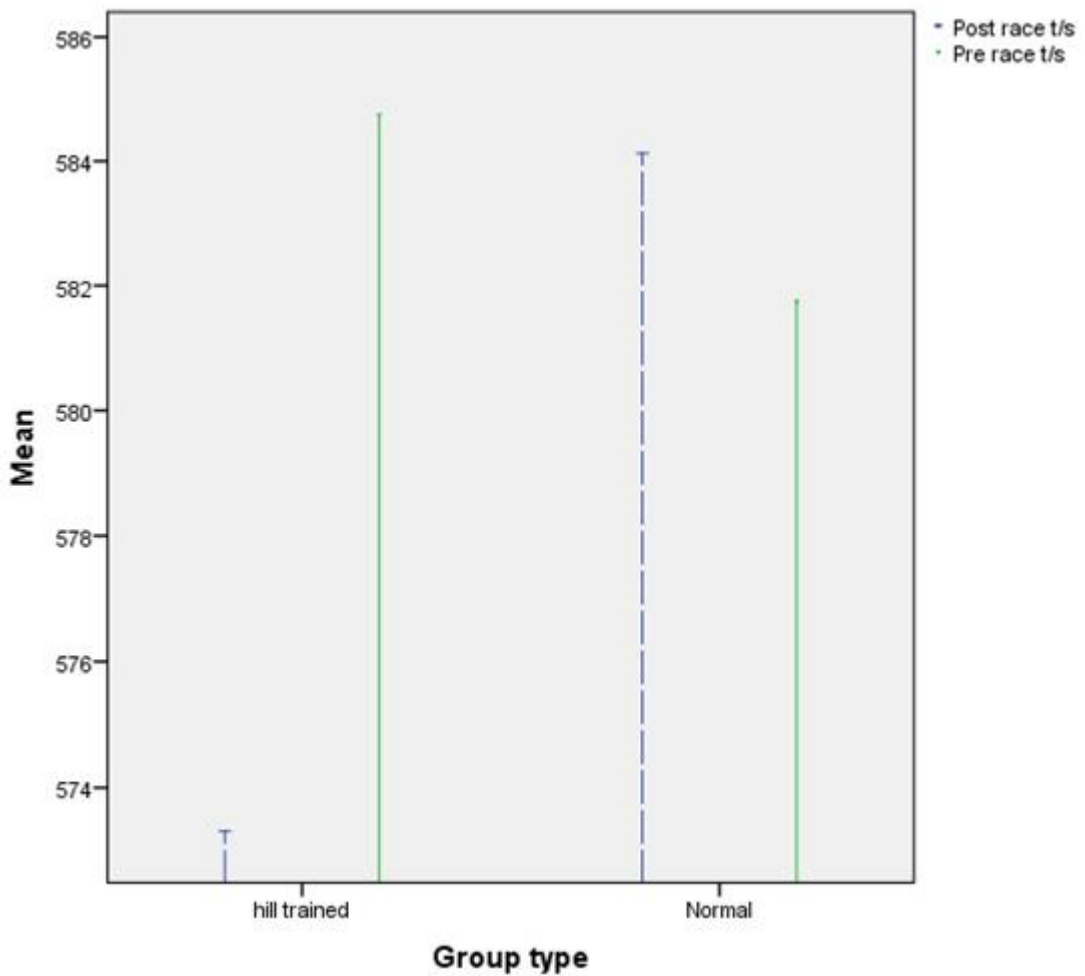
The tests among the experimental group to check if there is progressive improvement showed significant change in all test stages (table 12).

**Table 13. Athletes test result and test difference for speed endurance by Paired Samples Test**

Paired difference									
		Mean	Std. deviation	Std. error mean	95% confidence		t	d	Sig. (2tailed)
					Lower	Upper			
Paire1	Post 1 speed end Post 3 speed end	5.37	2.60	.65	3.98	6.76	8.25	15	0.00

#### **4.1.4. The influence of hill training on the race performance of the athletes**

Data was used to predict the persistence of the performance attainment after hill training was used as a new improved system of coaching. Performance prediction showed that the effectiveness of hill training in boosting physiology and race performance of an athlete. Although it is true for any method of training, hill training should be used systematically to keep up with the rate of change (fig 1).



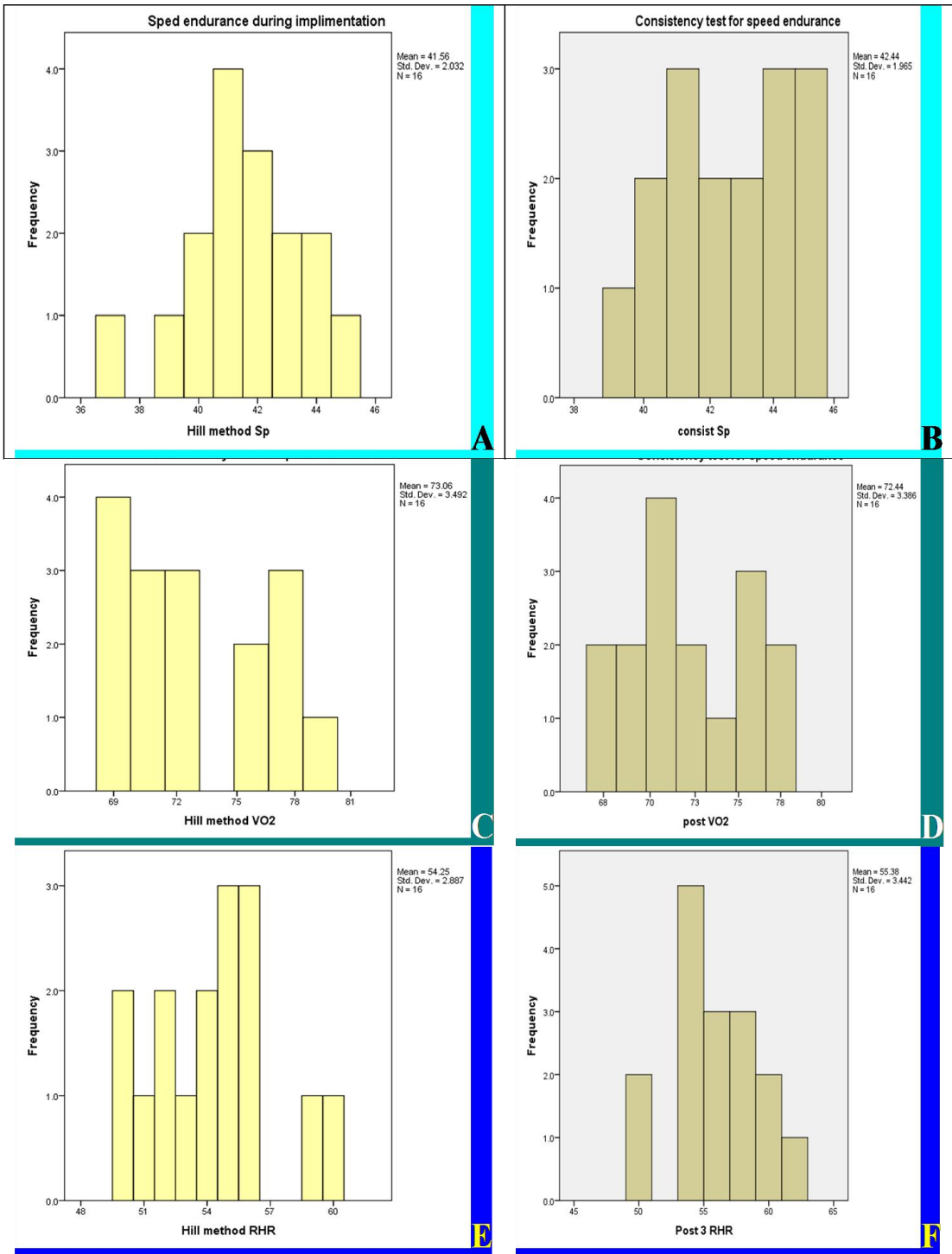
**Figure 6. Race time comparison of experimental and control group**

The hill training (experimental groups) have shown a significant decrease in their race time. The result indicate that all athletes improve their race time significantly after the intervention. As seen on (figure 6) the post result of experimental group indicate dramatic change in race performance while the control group show little change in race performance.

#### **4.1.5. Consistency of acquired performance**

The result indicates that physiological and physical quality of the athletes have improved by hill training program given in 12 weeks of intervention and additional test was conducted to see the consistency of the developed performance. This was evident from the result in increased mean frequency value, where the distribution of test measurements for different parameters are indicated high for all subjects and test conducted (Figure 7 A, B. speed endurance value during intervention show  $41.5 \pm 2$  and after four week  $42.4 \pm 1.9$  which show the values were found similar four week after hill method. This change in performance were found consistent . In the same manner the vo2 max level of the testes

during the intervention and four week after the intervention have been compared and show insignificant change (figure 7 C, D the  $\text{VO}_2$  max value during intervention shows the mean value  $73 \pm 3.4$  and the test result after four week also show similar mean value  $72.4 \pm 3.3$ ). this result show the consistency in vo2 max level. In addition the heart rate value was computed by its during and after four week test value which similarly show insignificant difference (Figure 7, E,F). General the result of all the three performance indicative variables have shown similarly insignificant change value which lead us to conclude that the performance of the athletes showed consistency.



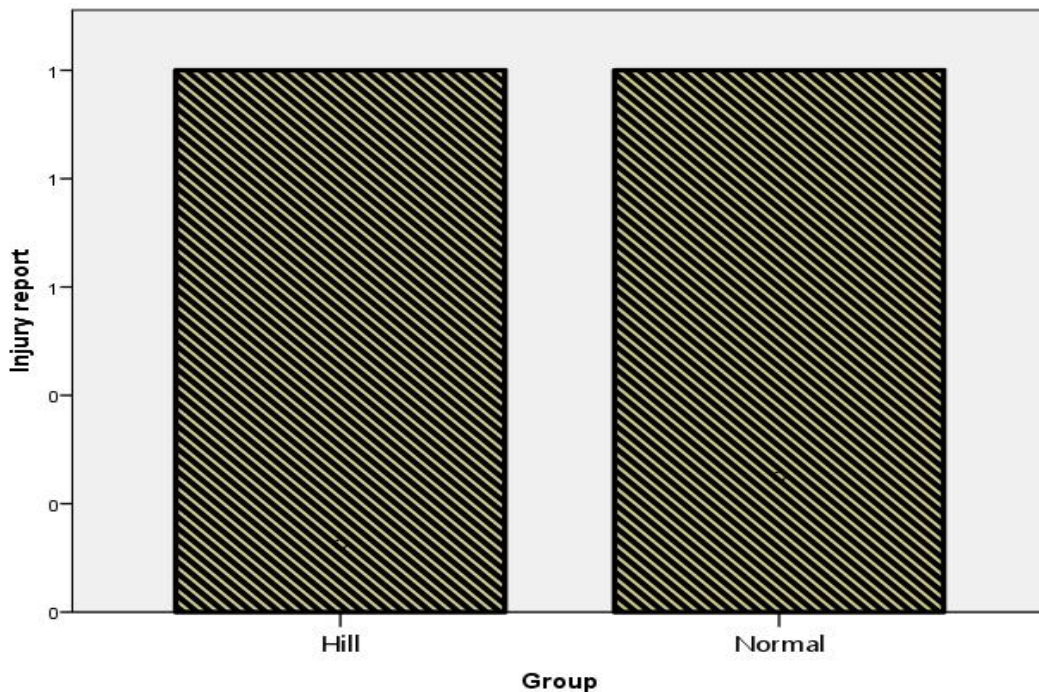
**Figure 7. The impact of hill training on performance consistency**

#### 4.1.6. Implication of hill training on the risks of athletic injuries.

**Table 14. Athletes injury report result**

		No of athletes	Injury re	difference	%
INJURY REPORT	Experimental	16	2	14	12.5%
	Control	16	4	12	25%
	Total	32	6	26	37%

This research found that the presence of hill training is not a cause of athlete injury, Analysis of variance for injury resulted insignificant deference (12.5% and 25%) among treatment and control subjects respectively.(table 14)



**Figure 8. Comparison of injury report of the groups**

The study shows that hill training has no significant effect on the athletic risks of injury. As it is seen on (figure 8 and table 14) there is no change is observed on experimental group that indicate carefully planed and implemented hill training could not be the cause of athletic injury.

## 4.2. Discussion

The aim of this study was to investigate the effect of a twelve week hill training intervention on key physiological and physical performance indicators, vo2 max, resting heart rate, speed endurance, race performance, the consistency of the developed performance and status of athletic injury in competitive club level middle and long distance runners. The main finding of this study was that hill training can significantly improve vo2 max, Rhr, speed endurance, race performance and the finding also show that the is the consistency of developed performance over 4 week period in competitive distance runners. Interestingly, the improvements in VO<sub>2</sub> max, speed endurance and race performance were attained without significant changes in risks of athletic injury status. These results strongly support the application of hill training on the distance running athletes; demonstrating that to optimize endurance performance, strength training should be a vital component in the physical preparation of distance runners.

### 4.2.1. Vo<sub>2</sub> max

The maximal oxygen uptake (VO<sub>2</sub>max) has been suggested to be the single most important physiological capacity in determining endurance running performance. Radovanovic (2009) define Vo<sub>2</sub> max as one of the most objective measures that can be used to assess aerobic or cardio-respiratory endurance is maximum oxygen consumption. The VO<sub>2</sub>max value is a direct indicator of the ability to supply the energy for muscle contractions during the process of anaerobic exercise.

Athletes can generally improve their absolute VO<sub>2</sub>max values by 15 to 20% and their relative values by 20 to 40% (Maglischo, 2003). A high VO<sub>2</sub> max is indicative of an enhanced ability of the aerobic systems to provide energy to the working muscle.

As explained by Beattie (2014), VO<sub>2</sub>max and resting heart rate are accepted as the two most important performance indicators for distance running. The enhancement in VO<sub>2</sub>max may therefore have been related to an increased training intensity rather than an increase in training volume (Midgley et al., 2007) and Shaw (2014) showed that VO<sub>2</sub> max represents the ability of a runner to translate energy production at a cellular level into running locomotion. An economical runner will use less energy for a given workload and spare vital reserves for maximal and supra-maximal stages of competition (i.e. a sprint

finish). In this study, the hill training group displayed a significant ( $p=0.000$ ,  $\alpha=0.05$ ) improvement in  $VO_2$  max from week 0 to week 12. These improvements in  $VO_2$  max occurred with additional significant improvements on resting heart rate. The control group showed no significant ( $p=0.41$ ,  $\alpha=0.05$ ) change in  $VO_2$  max throughout the 12 weeks (see table 9).

#### **4.2.2. Resting heart rate**

RHR is dictated by a complexity of factors such as volume and intensity of endurance training, nutrition and environment (Barnes, 2015). These results are evidence for effect of the application of hill training on the distance running athlete of various events; explains that to optimise race performance, hill training could be an optional method in the physical preparation of athletes for competition.

RHR represents the ability of a runner to translate energy production at a cellular level into running locomotion. It is better achieved by a systematic use of training methods such as hill workouts. This effect of hill training method can be maximized through management of intensity of endurance training. In this study, the effect of hill training in all event and in all test scenario of test group displayed a significant change for experimental subjects ( $p=0.00$ ,  $\alpha=0.05$ ) improvement and showed considerable consistency while insignificant change ( $p=0.141$ ,  $\alpha=0.05$ ) was recorded when measurement of the heart rate checked for normal groups without the hill training.

#### **4.2.3. Speed endurance**

Hill running is 'speed work in disguise'. It can be used in place of grueling track workouts to improve your anaerobic efficiency (Jack Daniels, 1998, pg. 179), it is almost as effective in building aerobic power as track interval training and by improving  $VO_2$  max, boost running economy and buffer anaerobic (Lactate) threshold significantly improve speed endurance. Many scientific studies indicate that the lactate threshold (anaerobic threshold) is one of the best predictors of distance running performance. A faster threshold speed indicates that the athlete may perform at this speed for a fairly long period of time (possibly up to a marathon) without experiencing undue fatigue. It was found that when highly-trained distance runners added a weekly 20 min run at the lactate threshold the

speed at which the threshold was reached increased after 14 weeks of such training (Sjodin et al.,1982).

Speed endurance and VO<sub>2</sub>max have strong associations with both middle- ( $r = 0.71$ ) (Ingham, 2008) and long-distance ( $r = 0.89 - 0.94$ ) (Noakes,1990) performance in elite running populations. These relationships are most likely due to vVO<sub>2</sub> max & speed endurance being a composite variable of both speed endurance and maximal oxygen consumption. Interestingly, the anaerobic threshold test (300m anaerobic endurance test) was found to be strongly associated with VO<sub>2</sub>max and resting heart rate( $r = 0.85$ ) and maximal-velocity sprinting ( $r = 0.96$ ) (Paavolainen, 2000); emphasizing the anaerobic system's contribution in providing energy production for race velocities at and above VO<sub>2</sub>max (Nummela, 2006). In this study, the hill training group showed a significant improvement in speed endurance ( $p=0.00$ ,  $\alpha=0.05$ ) during the first six weeks of hill training (week 0→6), and a significant ( $p=0.00$ ,  $\alpha=0.05$ ) improvement throughout the 12 weeks (table 12 and 13). The control group however showed no significant changes in speed endurance throughout the 12 weeks.

#### **4.2.4. Reduction of risk of injury**

The improvement of VO<sub>2</sub> max, strength, speed endurance, vVO<sub>2</sub> max and running economy results on significant improvement on race performance and it was consistent with proper training and follow up method. This study showed that hill training have insignificant effects on the risks of athletics injury which is 12.5% or 2 athletes out of 16 for the experimental group while 25% or 4 athletes out of 16 report injury. From this result it is possible to conclude that hill training was not the cause for athletic injury specially achilis tendon , heel knee and hamstring so it could not be the fear for coaches to include hill training in their training plan and provide for their athletes. (see Table 14)

## **CHAPTER FIVE**

### **SUMMERY, CONCLUSSION AND RECOMMENDATION**

#### **5.1. Summery**

The main finding of this study demonstrated that 12 weeks of hill training can significantly improve speed endurance qualities, as well as physiological markers of resting heart rate and VO<sub>2</sub>max ability of club level distance runners. Therefore, the research hypothesis of significant changes in VO<sub>2</sub> max, resting heart rate, speed endurance, race performance and consistency of performance is accepted; the research hypothesis for a reduction of athletic injury status is rejected. Interestingly, the improvements in speed endurance were attained without significant changes in risks of injury. A significant improvement were gained through the 12 week period, and it maintained over four week period as programming shifted towards hill free training. However, within the control group, physiological, physical and important strength quality of running remain unchanged throughout the study period. Upon consideration of the limitations of current research, I believe that if more quantitative scientific research proved the effectiveness of the current training methods, it could be used for the country level. This study showed that in distance runners those who do not perform strength training, hill training can be considered as solution, specially club level coaches should consider including hill workouts in their training method. More over for distance runners who are already on pick may need to place a greater emphasis on keeping the performance consistence.

## 5.2. Conclusion

- A general strength orientated hill training program is an appropriate and efficient method for improving both strength and speed endurance ability in distance runners.
- Well planed hill training program can significantly improve VO<sub>2</sub> max, resting heart rate, speed endurance and race performance of middle and long distance athletes.
- The present study suggests that hill training method can be used for further consideration in contribution of the scientific knowledge.
- Carefully programmed hill training is important to keep the developed performance consistent.
- Hill training have no negative effect on the risks of athletic injury.

### **5.3. Recommendation**

- To enhance the performance of middle and long distance events athletes, the coaches have to include hill training workouts in their training plan.
- The physiological and physical variables have to develop by hill training to improve race performance of the athletes.
- Hill training should be carefully planned and provided to develop the demanded physical quality and keep the improved performance consistency of distance athletes.
- Hill is not the cause of athletic injury, so coaches have to change their attitude towards it and try to get benefited.
- Further standardized scientific researches have to be conducted on the field to support the coaching system of the country.

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## Appendix 1: Summary of measurement parameters result for test and control units

Athlets information				VO <sub>2</sub> max								RHR				Speed endurance				Injury			
Group	running events	Age	Hight	Weight	pre test vo2 max	Dist. covered	post 1 vo2 max	Dist. Covered	post 2 vo2 max	Dist. covered	post 3 vo2 max	Dist. covered	pre RHR	Post 1 RHR	Post 2 RHR	Post 3 RHR	Pre. SE.	Post 1 SE.	Post 2 SE.	Post 3 SE.			
Experimental	800	N	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	
		Mean	18.50	1.61	49.75	3590.00	69.25	3752.50	72.75	3785.00	73.25	3770.00	73.00	66.50	63.00	53.00	53.50	55.00	49.25	42.25	42.50		
		Std. Dev.	0.58	0.06	3.86	184.93	4.35	214.07	4.99	209.84	4.92	215.56	4.69	2.65	3.56	2.58	2.89	2.94	1.71	2.75	2.38		
	1500	N	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
		Mean	18.50	1.65	49.00	3620.00	70.00	3810.00	74.00	3897.50	76.00	3865.00	75.00	69.50	65.50	55.00	55.50	54.25	48.75	40.75	42.00		
		Std. Dev.	1.29	0.09	2.58	92.74	2.16	124.10	2.58	122.30	2.94	130.26	2.94	3.11	3.00	2.94	3.11	4.92	2.50	2.63	2.94		
	3000	N	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
		Mean	18.00	1.74	53.33	3540.00	68.00	3626.67	70.00	3703.33	71.67	3686.67	71.00	68.00	65.67	56.00	57.33	51.67	48.67	41.67	42.33		
		Std. Dev.	1.00	0.01	4.16	78.10	1.73	111.50	2.65	45.09	1.15	35.12	1.00	2.65	4.04	3.61	4.04	3.79	2.31	2.08	1.53		
	5000	N	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
		Mean	19.33	1.75	54.33	3570.00	68.67	3653.33	70.33	3736.67	72.33	3716.67	71.67	67.00	61.33	52.33	53.67	50.33	45.33	41.33	43.00		
		Std. Dev.	0.58	0.03	1.53	115.33	2.52	125.83	3.06	137.96	3.06	145.72	3.21	1.00	1.15	3.21	4.04	3.06	2.52	1.53	2.00		
	10000	N	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
		Mean	20.50	1.75	51.50	3500.00	67.00	3565.00	68.50	3630.00	70.00	3615.00	69.50	71.50	65.00	55.50	58.50	49.50	45.50	42.00	42.50		
		Std. Dev.	0.71	0.04	0.71	113.14	2.83	91.92	2.12	84.85	1.41	91.92	2.12	2.12	2.83	0.71	2.12	0.71	2.12	0.00	0.71		
	Total	N	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
		Mean	18.81	1.69	51.31	3573.13	68.81	3701.25	71.56	3769.38	73.06	3748.75	72.44	68.25	64.06	54.25	55.38	52.63	47.81	41.56	42.44		
		Std. Dev.	1.11	0.08	3.42	116.60	2.74	156.46	3.58	152.34	3.49	152.75	3.39	2.77	3.19	2.89	3.44	3.81	2.56	2.03	1.97		

<b>Normal</b>	800	N	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00			4.00		4.00		4.00		4.00	
		Mean	18.25	1.70	50.75	3540.00	67.75	0.00	0.00	3560.00	68.25			66.00		63.75		52.75		50.00	
		Std. Dev.	0.96	0.12	4.03	165.73	3.86	0.00	0.00	175.69	3.86			1.41		1.50		2.22		0.82	
	1500	N	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00			4.00		4.00		4.00		4.00	
		Mean	18.75	1.66	52.25	3632.50	70.00	0.00	0.00	3637.50	70.00			67.75		63.00		53.00		50.50	
		Std. Dev.	0.96	0.06	5.56	71.36	1.41	0.00	0.00	68.98	1.41			2.63		2.16		3.16		2.38	
	3000	N	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00			3.00		3.00		3.00		3.00	
		Mean	19.00	1.66	52.33	3483.33	66.33	0.00	0.00	3496.67	67.00			67.00		61.67		51.33		48.67	
		Std. Dev.	1.00	0.04	2.08	32.15	0.58	0.00	0.00	37.86	1.00			2.00		3.51		4.16		2.31	
	5000	N	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00			3.00		3.00		3.00		3.00	
		Mean	19.67	1.75	52.67	3536.67	68.00	0.00	0.00	3546.67	68.00			64.00		61.67		50.00		46.67	
		Std. Dev.	1.16	0.02	2.08	73.71	1.73	0.00	0.00	73.71	1.73			1.73		2.08		1.00		1.53	
	10000	N	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00			2.00		2.00		2.00		2.00	
		Mean	20.00	1.69	55.00	3515.00	67.50	0.00	0.00	3520.00	67.50			70.50		67.00		51.50		48.50	
		Std. Dev.	0.00	0.01	1.41	77.78	2.12	0.00	0.00	70.71	2.12			2.12		1.41		2.12		2.12	
	Total	N	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00			16.00		16.00		16.00		16.00	
		Mean	19.00	1.69	52.31	3548.75	68.06	0.00	0.00	3560.00	68.31			66.81		63.19		51.88		49.06	
		Std. Dev.	1.03	0.07	3.52	103.46	2.41	0.00	0.00	105.01	2.33			2.61		2.59		2.66		2.14	

<b>Total</b>	8000.0	N	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	4.0	4.0	8.0	4.0	8.0	4.0	8.0	4.0	8.0	4.0
		Mean	18.4	1.7	50.3	3565.0	68.5	1876.3	36.4	3672.5	70.8	3770.0	73.0	66.3	63.0	58.4	53.5	53.9	49.3	46.1	42.5
		Std. Dev.	0.7	0.1	3.7	164.8	3.9	2010.7	39.0	215.8	4.9	215.6	4.7	2.0	3.6	6.1	2.9	2.7	1.7	4.5	2.4
	15000.0	N	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	4.0	4.0	8.0	4.0	8.0	4.0	8.0	4.0	8.0	4.0
		Mean	18.6	1.7	50.6	3626.3	70.0	1905.0	37.0	3767.5	73.0	3865.0	75.0	68.6	65.5	59.0	55.5	53.6	48.8	45.6	42.0
		Std. Dev.	1.1	0.1	4.4	76.9	1.7	2038.2	39.6	166.6	3.9	130.3	2.9	2.8	3.0	4.9	3.1	3.9	2.5	5.7	2.9
	30000.0	N	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	3.0	3.0	6.0	3.0	6.0	3.0	6.0	3.0	6.0	3.0
		Mean	18.5	1.7	52.8	3511.7	67.2	1813.3	35.0	3600.0	69.3	3686.7	71.0	67.5	65.7	58.8	57.3	51.5	48.7	45.2	42.3
		Std. Dev.	1.0	0.1	3.0	61.8	1.5	1987.7	38.4	119.2	2.7	35.1	1.0	2.2	4.0	4.4	4.0	3.6	2.3	4.3	1.5
	50000.0	N	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	3.0	3.0	6.0	3.0	6.0	3.0	6.0	3.0	6.0	3.0
		Mean	19.5	1.8	53.5	3553.3	68.3	1826.7	35.2	3641.7	70.2	3716.7	71.7	65.5	61.3	57.0	53.7	50.2	45.3	44.0	43.0
		Std. Dev.	0.8	0.0	1.9	88.5	2.0	2002.6	38.6	143.6	3.3	145.7	3.2	2.1	1.2	5.7	4.0	2.0	2.5	3.2	2.0
	100000.0	N	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	2.0	2.0	4.0	2.0	4.0	2.0	4.0	2.0	4.0	2.0
		Mean	20.3	1.7	53.3	3507.5	67.3	1782.5	34.3	3575.0	68.8	3615.0	69.5	71.0	65.0	61.3	58.5	50.5	45.5	45.3	42.5
		Std. Dev.	0.5	0.0	2.2	79.7	2.1	2058.9	39.6	90.0	2.1	91.9	2.1	1.8	2.8	6.7	2.1	1.7	2.1	3.9	0.7
	Total	N	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	16.0	16.0	32.0	16.0	32.0	16.0	32.0	16.0	32.0	16.0
		Mean	18.9	1.7	51.8	3560.9	68.4	1850.6	35.8	3664.7	70.7	3748.8	72.4	67.5	64.1	58.7	55.4	52.3	47.8	45.3	42.4
		Std. Dev.	1.1	0.1	3.4	109.1	2.6	1883.4	36.4	167.0	3.8	152.7	3.4	2.7	3.2	5.3	3.4	3.3	2.6	4.3	2.0

## **Appendix 2: Training program for experimental group**

Age :- 18.8 +3 years.

Weight :- 51.3 + 5.2 kg

Height :- 1.68 + 0.05 m

Training experience :- 3-5 years

Personal best -----

Focused training method :- Hill training( Twice in a week)

Recommended training areas :- Forest, Grass land , Road , Track

Recommended training time :- Morning.

**Aim** :- To see the effects of hill training on the performance of the athletes.

### **1<sup>th</sup> month**

<b>Week&amp;day</b>	<b>M</b>	<b>Tu</b>			<b>W</b>	<b>Tr</b>			<b>Fri</b>		<b>Su</b>		<b>Total</b>
	<b>easy</b>	<b>Workout//time</b>		<b>%</b>	<b>easy</b>	<b>Workout</b>	<b>Time</b>	<b>%</b>	<b>Easy</b>	<b>%</b>	<b>Workout//time</b>		<b>km</b>
<b>1<sup>st</sup> week</b>	60m	S.Hill	<b>12x 200M</b>	<b>95%</b>	65m	M. Temp	<b>35m</b>	<b>90%</b>	65m	75%	L .hill	<b>8x500m</b>	<b>60k</b>
<b>Distance</b>	15k		<b>2.4km</b>	<b>3.09</b>	16k		<b>10.8km</b>	<b>3.25</b>	16k	4.00	90%	<b>4km</b>	
<b>2<sup>nd</sup> week</b>	65m	M.Hill	<b>10X 300m</b>	<b>95%</b>	60m	Crucial.T	<b>3x10m,3</b>	<b>90%</b>	60m	75%	T. Hill	<b>5x3'</b>	<b>63k</b>
<b>Distance</b>	16k		<b>3km</b>	<b>3.09</b>	15k		<b>9km</b>	<b>3.25</b>	15k	4.00	90%	<b>15' /5km</b>	
<b>3<sup>rd</sup> week</b>	70m	L.Hill	<b>8x500m</b>	<b>95%</b>	65m	L .run F	<b>80m</b>	<b>80%</b>	65m	75%	M.	<b>10x300m</b>	<b>79k</b>
<b>Distance</b>	17k		<b>4km</b>	<b>3.09</b>	16k		<b>23km</b>	<b>3.45</b>	16k	4.00	100%	<b>3km</b>	
<b>4<sup>th</sup> week</b>	70m	T.Hill	<b>5x4'</b>	<b>90%</b>	60m	S.Temp	<b>2x20m</b>	<b>90%</b>	60m	75%	S.	<b>14x200m</b>	<b>68.6k</b>
<b>Distance</b>	17k		<b>20' /6km</b>	<b>3.25</b>	15k		<b>12km</b>	<b>3.25</b>	15k	4.00	100%	<b>2.8km</b>	
<b>Total km of the month 271k</b>													

**2<sup>th</sup> month**

Week&	M	Tu			W	Tr			Fri	Sa			Total
		Workout//time		%		Workou	Time	%	Easy	%	Workout//time		km
5 <sup>th</sup> week	70'	S.Hill	16x200m	100%	65'	Temp	40'	95%	65'	75%	L .hill	10x500m	71km
6 <sup>th</sup> week	SE.Test	60'	Easy run	75%	60'	VO <sub>2</sub> max test			60'	75%	T. Hill	5x5'	72km
			15km	4.00	15k				15k	4.00	90%	25' /7km	
7 <sup>th</sup> week	70'	L.Hill	10x500m	95%	65'	L .run F	80'	80%	65'	75%	M. Hill	12x300m	80.6k
	17km		5km	3.09	16k		23km	3.45	16k	4.00	100%	3.6km	
8 <sup>th</sup> week	70'	T.Hill	5x5'	90%	60'	Cr.Temp	4x10'	95%	60'	75%	S. Hill .	16x200m	69.2km
	17km		25' /7km	3.23	15k		12km	3.09	15k	4.00	100%	3.2km	
												Total km of the month 292.8k	

**3<sup>rd</sup> Month**

Week&	Ma	Tu			We	Tr			Fri		Sa		Total
	Easy	Workout//time		%		Worko	Time	%	Easy	%	Workout//time		km
9 <sup>th</sup> week	70'	S.Hill	16x200m	100%	65'	Temp	4x10'	95%	65'	75%	L .hill	10x500m	71km
	17km		3.2km	3.00	16k		12km	3.09	16k	4.00	90%	5km	
10 <sup>th</sup> week	70'	M.Hil	15X300	95%	60'	Cr.	2x20'	95%	60'	75%	T. Hill	5x5'	73.5k
	17km		4.5km	3.09	15k		12km	3.09	15k	4.00	90%	25' /7km	
11 <sup>th</sup> week	70'	L.Hill	10x500m	95%	65'	L .run F	80'	80%	65'	75%	M. Hill	15x300m	80.6k
	17km		5km	3.09	16k		23km	3.45	16k	4.00	100%	4.5km	
12 <sup>th</sup> week	SE.Test	T.Hill	5x5'	90%	60'	VO <sub>2</sub> max test			60'	75%	S.	16x200m	69.2k
			25' /7km	3.23	15k				15k	4.00	100%	3.2km	
												Total km of the month 294.3k	

### Appendix 3: Training program for control group

Age :- 18.8 +3 years.

Weight :- 51.3 + 5.2 kg

Height :- 1.68 + 0.05 m

Training experience :- 3-5 years

Personal best -----

Focused training method :- No focused training.

Recommended training areas :- Forest, Grass land , Road , Track

Recommended training time :- Morning.

**Aim** :- To see the effects of hill training on the performance of the athletes.

#### 1<sup>st</sup> month

Week&day	M	Tu			W	Tr			Fri		Sa		Total km
	easy	Workout//time		%	easy	Workout	Time	%	Easy	%	Workout//time		
1 <sup>st</sup> week	60m	Track	15 laps	95%	65m	M. Temp	35m	90%	65m	75%	Track	4x1200m	69k
Distance	15k		6km	3.09	16k		10.8km	3.25	16k	4.00	90%	4.8km	
2 <sup>nd</sup> week	65m	Track	20 laps	95%	60m	Crucial.T	3x10m,3	90%	60m	75%	Track	3x1600m	68k
Distance	16k		8km	3.09	15k		9km	3.25	15k	4.00	90%	4.8km	
3 <sup>rd</sup> week	70m	Track	10laps	95%	65m	L .run F	80m	80%	65m	75%	Track	5x1000m	81k
Distance	17k		4km	3.09	16k		23km	3.45	16k	4.00	100%	5km	
4 <sup>th</sup> week	70m	Track	12laps	90%	60m	S.Temp	2x20m	90%	60m	75%	Track	2x2000m	68k
Distance	17k		5km	3.25	15k		12km	3.25	15k	4.00	100%	4km	
												Total km of the month 286k	

**2<sup>nd</sup> month**

Week&da	M	Tu			W	Tr			Fri		Sa		Total
	easy	Workout//time		%	easy	Workout	Time	%	Easy	%	Workout//time	km	
5 <sup>th</sup> week	60m	Track	20 laps	95%	65'	M. Temp	35'	90%	65'	75%	Track	2x2000m	69k
Distance	15k		8km	3.09	16k		10.8km	3.25	16k	4.00	90%	4km	
6 <sup>th</sup> week	<b>SE.Test</b>	Easy	60'	75%	60'	<b>Vo<sub>2</sub> max TEST</b>			60'	75%	Track	3x1600m	56k
Distance			4.8km	4.00	15k				15k	4.00	90%	4.8km	
7 <sup>th</sup> week	70m	Track	10 laps	95%	65'	L .run F	80'	80%	65'	75%	Track	4x1200m	81k
Distance	17k		4km	3.09	16k		23km	3.45	16k	4.00	100%	4.8km	
8 <sup>th</sup> week	70m	Track	15 laps	90%	60'	S.Temp	2x20'	90%	60'	75%	Track	5x1000m	68k
Distance	17k		6km	3.25	15k		12km	3.25	15k	4.00	100%	5km	
												Total km of the month 274k	

**3<sup>rd</sup> month**

Week&day	M	Tu			W	Tr			Fri		Sa		Total
	easy	Workout//time		%	easy	Workout	Time	%	Easy	%	Workout//time	km	
9 <sup>th</sup> week	60m	Track	<b>10 laps</b>	<b>95%</b>	65m	M. Temp	<b>35m</b>	<b>90%</b>	65m	75%	Track	<b>5x1000m</b>	<b>66k</b>
Distance	15k		<b>6km</b>	<b>3.09</b>	16k		<b>10.8km</b>	<b>3.25</b>	16k	4.00	90%	<b>5km</b>	
10 <sup>th</sup> week	65m	Track	<b>22 laps</b>	<b>95%</b>	60m	Crucial.T	<b>3x10m,3</b>	<b>90%</b>	60m	75%	Track	<b>4x1200m</b>	<b>68k</b>
Distance	16k		<b>8km</b>	<b>3.09</b>	15k		<b>9km</b>	<b>3.25</b>	15k	4.00	90%	<b>4.8km</b>	
11 <sup>th</sup> week	70m	Track	<b>15 laps</b>	<b>95%</b>	65m	L .run F	<b>80m</b>	<b>80%</b>	65m	75%	Track	<b>3x1600m</b>	<b>81k</b>
Distance	17k		<b>4km</b>	<b>3.09</b>	16k		<b>23km</b>	<b>3.45</b>	16k	4.00	100%	<b>4.8km</b>	
12 <sup>th</sup> week	<b>SE.Test</b>	60' Easy run		<b>75%</b>	60m	<b>Vo<sub>2</sub> max TEST</b>			60m	75%	Track	<b>2x2000m</b>	<b>68k</b>
Distance				<b>4:00</b>	60'				60'	4.00	100%	<b>4km</b>	
												Total km of the month 283k	

### Appendix 4: Experimental group collected data

	Group	Age	Hight	Weight	Event	pre race time	post race time	pre test vo2 max	post 1 vo2 max	post 2 vo2 max	post 3 vo2 max	pre RHR	Post 1 RHR	Post 2 RHR	Post 3 RHR	Pre. Speed END.	Post 1 Speed End.	Post 2 Speed End.	Post 3 Speed End.	INJURY REPORT				
1	A.	18	1.55	47	800	1.51	1.48	3750	72.55	3980	77.69	4000	78.14	3990	77.91	64	61	52	53	52	47	41	41	0
2	B.	19	1.58	46	800	1.54	1.5	3750	72.55	3890	75.6	3930	76.57	3920	76.38	67	63	50	50	53	49	39	40	0
3	C.	19	1.64	54	800	2:10	2.06	3420	65.17	3580	68.75	3600	69.2	3580	68.75	65	60	54	54	58	50	45	45	0
4	D.	18	1.68	52	800	2:06	2.01	3440	65.62	3560	68.3	3610	69.42	3590	68.97	70	68	56	57	57	51	44	44	0
5	E.	19	1.71	50	1500	3.56	3.5	3620	69.64	3860	75.01	3900	75.9	3860	75.01	71	67	59	60	50	48	42	45	1
6	F.	20	1.74	52	1500	3.54	3.49	3750	72.55	3950	77.02	4020	78.59	4000	78.14	73	69	54	54	50	46	37	39	0
7	G.	17	1.58	48	1500	4:10	4.04	3540	67.87	3660	70.54	3730	72.1	3690	71.21	68	63	55	55	59	52	43	44	0
8	H.	18	1.56	46	1500	4:16	4.06	3570	68.52	3770	73	3940	76.8	3910	76.13	66	63	52	53	58	49	41	40	0
9	I.	19	1.73	52	3000	8:25	8.11	3590	68.97	3710	71.65	3750	72.55	3720	71.88	65	61	53	55	56	50	44	44	0
10	J.	17	1.75	58	3000	8:20	8.12	3580	68.95	3670	70.76	3700	71.43	3690	71.21	70	68	60	62	50	50	41	41	0
11	K.	18	1.74	50	3000	10:05	9.53	3450	65.84	3500	66.96	3660	70.54	3650	70.31	69	68	55	55	49	46	40	42	0
12	L.	19	1.75	56	5000	14:30	14:08	3680	70.98	3770	73	3840	74.56	3820	74.11	67	60	51	53	47	43	40	41	0
13	M.	19	1.77	54	5000	14:18	14.03	3580	68.75	3670	70.76	3790	73.44	3780	73.22	66	62	56	58	51	45	41	43	1
14	N.	20	1.72	53	5000	17:23	16:54	3450	65.84	3520	67.41	3580	68.75	3550	68.08	68	62	50	50	53	48	43	45	0
15	O.	21	1.78	51	10000	29:20:0	28:56:0	3580	68.75	3630	69.87	3690	71.21	3680	70.98	70	63	56	60	50	44	42	42	0
16	P.	20	1.72	52	10000	29:18:0	29:02:0	3420	65.17	3500	66.96	3570	68.52	3550	68.08	73	67	55	57	49	47	42	43	0

### Appendix 4: Control group collected data

	Group	Age	Hight	Weight	Event in	pre race time	post race time	pre test vo2 max		post 2 vo2 max		pre RHR	Post 2RHR	Pre. Speed END.	Post 2 Speed End.	INJURY REPORT
1.	I.	19	1.61	46	800	1:49	1.52	3640	70.09	3690	71.21			50	49	0
2.	II.	19	1.59	49	800	1:51	1.5	3720	71.88	3730	72.1	66	65	54	50	1
3.	III.	18	1.82	55	800	2:09	2.11	3380	64.28	3380	64.28	65	63	52	50	0
4.	IV.	17	1.79	53	800	2:12	2.08	3420	65.17	3440	65.62	68	65	55	51	0
5.	V.	19	1.64	47	1500	3:58	3.57	3570	68.52	3580	68.75	70	65	50	48	0
6.	VI.	18	1.59	48	1500	3:50	3.48	3730	72.1	3730	72.1	69	64	51	49	0
7.	VII.	18	1.73	56	1500	3:58	3.55	3640	70.09	3650	70.31	68	63	57	53	0
8.	VIII.	20	1.66	58	1500	4:08	4.11	3590	68.97	3590	68.97	64	60	54	52	1
9.	IX.	20	1.69	54	3000	8:35	8.32	3460	66.07	3480	66.51	65	58	56	50	0
10.	X.	19	1.61	50	3000	8:15	8.18	3520	67.41	3540	67.85	69	65	50	50	0
11.	XI.	18	1.68	53	3000	10:02	10.01	3470	66.29	3470	66.28	67	62	48	46	0
12.	XII.	19	1.74	51	5000	14:15	14.12	3620	69.64	3630	69.87	65	60	50	45	1
13.	XIII.	19	1.77	52	5000	14:18	14.23	3480	66.51	3490	66.74	62	61	51	47	0
14.	XIV.	21	1.75	55	5000	16:48	17	3510	67.18	3520	67.4	65	64	49	48	1
15.	XV.	20	1.68	54	10000	30:06:0	29.56	3570	68.52	3570	68.52	72	68	53	50	0
16.	XVI.	20	1.7	56	10000	29:10:0	29.32	3460	66.07	3470	66.28	69	66	50	47	0

### Appendix 5: Athletes attendance during the intervention

Subjects	Pre performance	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15	Day 16	Day 17	Day 18	Day 19	Day 20	Day 21	Day 22	Day 23	Day 24	Post performance
A	1.51	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	1.48
B	1.54	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	1.50
C	2:10	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	<b>S</b>	√	√	2.06
D	2:06	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	2.01
E	3.56	√	√	√	<b>A</b>	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	3.50
F	3.54	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	3.49
G	4:10	√	√	√	√	√	√	√	√	√	√	√	√	√	<b>P</b>	<b>P</b>	√	√	√	√	√	√	√	√	√	4.04
H	4:16	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	4.06
I	8:25	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	<b>S</b>	√	√	8.11
J	8:20	√	√	√	√	√	√	√	√	√	√	<b>S</b>	<b>S</b>	√	<b>S</b>	√	√	√	√	√	√	√	√	√	√	8.12
K	10:05	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	9.53
L	14:30	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	14:08
M	14:18	√	√	√	√	√	<b>P</b>	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	14.03
N	17:23	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	16:54
O	29:20:0	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	28:56:0
P	29:18:03	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	29:02:0
A1	1:49	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	<b>A</b>	√	√	√	√	√	√	√	√	1.52
B2	1:51	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	1.50
C3	2:09	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	2.11
D4	2:12	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	2.08
E5	3:58	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	<b>A</b>	3.57
F6	3:50	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	3.48
G7	3:58	√	√	√	√	<b>S</b>	<b>S</b>	<b>S</b>	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	3.55
H8	4:08	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	4.11
I9	8:35	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	8.32
J10	8:15	√	√	√	√	√	√	√	√	√	√	√	√	√	√	<b>S</b>	<b>S</b>	<b>S</b>	<b>S</b>	√	√	√	√	√	√	8.18
K11	10:02	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	10.01
L12	14:15	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	14.12
M13	14:18	√	<b>A</b>	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	14.23
N14	16:48	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	<b>P</b>	<b>P</b>	√	17
O15	30:06:00	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	29.56
P16	29:10:00	√	√	√	√	√	√	√	√	√	√	<b>P</b>	√	√	√	√	√	√	√	√	√	√	√	√	√	29.32

## **Declaration**

I the undersigned , declare that this thesis is my original work and has not be presented for a degree in any other university and that all sources of materials used for the thesis have been duly acknowledged.

Name : Nigatu Worku

Signature \_\_\_\_\_

Date \_\_\_\_\_

This thesis has been submitted for examination with my approval as a university adviser

Name : Aschenaki Tadesse(Ph.D)

Signature \_\_\_\_\_

Date \_\_\_\_\_

