Correlation between an Athletes' Consideration of Future Consequences and Their Improvement in Strength, Speed, and Agility with a Six Week Training Program

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A thesis submitted to the faculty of the Department of Health and Human Performance in partial fulfillment of the requirements for the degree of Bachelor of Science in Human Performance

Spring, 2010

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This thesis represents my own work in accordance with all applicable Department of Health and Human Performance and university guidelines and expectations for intellectual work.
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Acknowledgement

I would like to thank the Health and Human Performance Department at Montana State University – Billings for assisting in the production of this project. I would like to thank Adam Sanchez, AMP Program Director, for the use of the AMP facility and equipment, cooperation in gathering participants, and overall contribution to the project. I would also like to thank the athletes who participated in the study, and all others involved in the project.

Abstract

Training programs are used by athletes of all skill levels to improve performance by increasing muscular strength and endurance, agility, flexability, and cardiovascular capabilities. Preventention of future injury is also a primary goal during these programs. These goals can be accomplished through appropriate design, structure, and research into skills and exercises which will allow athletes to make gains and show improvement in these areas. As well as the physical capabilities of the athlete, sport psychology has become more prevelant in the analysis of an athlete's performance, showing how different types of personalities respond and react in various sporting scenarios and with different types of coaches. This study aims to investigate the relationship between a personality construct and the improvement an athlete shows in performing five NATP tests over a six week plyometric training program. The Consideration of Future Consequences scale (CFC) was used to assess the extent to which an athlete thinks about the proximal or distal outcomes of their actions, which was then compared to their level of improvement in each of the five NATP tests. These tests measured speed, agility, upper body power, jump height, and jump distance. Results indicated that there was no significant correlation between an athlete's level of improvement and their consideration of future conseqeunces ($p = 0.7$). As a result, the CFC scale may not be appropriate for exercise –performance based interventions. Adolescents may also be unable to accurately forecast their consideration of future consequences.

Introduction

Research Problem

The goal of all training programs is to improve performance, aid recovery, or prevent future injury of the participants. The structure and design of these programs must be researched and executed in the correct way in order to reach the above goals, and so we must analyze the magnitude of improvement seen in the performance of participants in order to evaluate the success of a training program. It is not only the design and instruction involved with a training program that determines its success, but the characteristics of the athlete are involved in their response to coaching styles, demands of exercises, and physical and mental response to a training setting with their peers. Sport psychology research attempts to explain the ways in which the personality traits influence the performance of an athlete. The personality of the athlete can be said to influence their performance in a training setting, and so research in this area aims to determine how personality factors contribute to improvement using a training program. By establishing factors which influence performance and their magnitude of influence, coaches, teachers, and specialists can attempt to eliminate those limiting factors, and encourage enhancing factors to reach training program goals.

Purpose

The purpose of this study was to determine whether the extent to which an athlete thinks about the future consequences of their actions, is predictive of their improvement in five skills, after completing a six week training program. Looking at this relationship, the aim is to incorporate results into a basis for coaching athletes in a number of ways which are shown to enhance the probability of greater improvement during the training program. Using the Consideration of Future Consequences Scale (CFC) we aim to establish the types of athlete who show most improvement over the course of the six week training program, and identify which types of athlete may show less improvement so that different coaching styles and techniques can be applied to aid development throughout the program.

Hypothesis: Taking the null hypothesis, with regard to determining which level of CFC score, high or low is predictive of most improvement using Improvement Index.

Operational Definitions

The following operational definitions were used to conduct this study:

- Training Program will refer to the strength and agility program developed by AMP Fitness, in Billings Montana. This protocol has been designed and structured by nationally certified Strength and Conditioning Specialists, and Orthopedic Surgeons in Billings Montana, and has been operating for over ten years.
- Improvement in this context will define the change the performance on the four testing skills during the pre-test and post-test procedures. This will be measured using an ‘Improvement Index’, created by summing the numerical differences in pre-test and post-test scores.

- ‘Personal attitudes’ represent an athlete’s consideration of future consequences, and therefore relates to the use of the CFC scale.

- ‘Plyometrics’is a type of training based upon eccentric phases of loading, and involved high intensity, explosive movements in which motor units must be coordinated by neurological pathways efficiently for optimal performance. Rapid deceleration followed by rapid acceleration in different directions is often applied, and can be used for sport specific training. (Reilly et al. 2009)

- Agility will describe the way in which an athlete is able to change the direction of their body while moving at high speeds. Multiple changes of direction within a short period of time are primarily used.

- ‘Foot Touches’ is a system used to measure the content of a plyometric program, based on the intensity, frequency, and duration of exercises. Used as an alternative to counting sets and repetitions of an exercise, and is literally quantified by the number of times a participants foot touches the ground.

Assumptions

The following assumptions were made to conduct this study:

- The CFC scale used is reliable and valid, in that it measures the extent to which someone is influenced by the proximal and distal consequences of their behavior.

- It is assumed that athletes are injury free during both testing periods, and attended at least 75% of the scheduled training sessions over the six week period. This incorporates injuries which have prevented them from safely completing a previous training session, and does not include effects of fatigue. Athletes who missed five sessions, or were not present for testing days were not included in the study.

- Athletes will perform at maximal effort during both pre-test and post-test, and demonstrate their abilities to perform each skill at maximum capability. This will be monitored and assessed by the coaching staff, who prioritize encouragement of maximal effort.

- The CFC scale will be completed by athletes as an honest reflection of whether each statement is characteristic of them. This ensures that the athlete’s score on the CFC scale validly indicates the extent to which they consider future consequences.

- Athletes are familiar with testing procedure and have previously performed the skills which they will be tested on. Any unfamiliarity in this area will decreases

the reliability of the testing procedure, and results will not be reflective of that athlete's capabilities of performing that skill.

Limitations and Delimitations

The primary limitation of this study was the physical condition of the athletes on the days of testing. Due to their daily activities and possibly other sporting activities, each athlete had a varying level of condition on the days of testing. As this could not be controlled, testing was conducted assuming that all athletes were in sufficient physical condition to safely carry out testing procedure. Athletes with injuries prior to testing were instructed to rest a sufficient amount of time before testing, so that testing could be completed. Another limitation of this study was that not all athletes attended all 18 training sessions of the program. A number of athletes missed training sessions for a variety of reasons, and so this was incorporated into individual results when conducting analysis, as this may account for decreases in performance between pre-test and post-test results. A final limitation of this study was that some athletes may have been exposed to some form of consideration of their future consequences, either in a school or home setting, and so this may have influence how much they were thinking about this construct at the time.

The delimitations of this study were the specific testing procedure chosen to most effectively evaluate changes in performance, the exercises selected for each training session in order to train the athletes in a number of areas, the use of the CFC scale to measure the consideration of future consequences of the athlete, and the use of an 'improvement index' created to quantify the magnitude of improvement of each athlete as a result of the training program. The testing procedure, and the exercises uses during each training session, were selected and justified by nationally certified strength and conditioning specialists, as well as orthopedic surgeons and athletic trainers in the Billings area. It is on this basis that selected exercises and testing procedures are justified, and determined valid in this context. The CFC scale (Strathman, 1994) was used as it is currently one of the most reliable and valid instruments for measuring individual differences in people and their personalities. The improvement index was used to quantify the improvement made by each athlete, which can then be used statistically to determine the influence of a CFC score on and athlete's difference in pre-test and post-test performance.

Literature Review

Consideration of Future Consequences:

Measurement of personality traits has been an important aspect of social psychology for some time. In relation to the goal of individual athletes when participating in a training program, which is primarily to have improved performance in the future, the future time perspective (FTP) has been widely studied (Strathman, Gleicher & Boninger, 1994). The consideration of future consequences (CFC) is a construct of FTP developed by Strathman , which measures "the extent to which people prefer to construct the future by considering distant versus immediate consequences of potential behaviors and the extent to which behavior is influenced by such perceived outcomes"(Pertrocelli, 2003) on a

scale from 12 to 60. Petrocelli conducted an analysis of the CFC scale in which validity, and gender differences were discussed. This study provided further evidence for validity in health related environments, while suggesting the possibility of reducing the scale from 12 items to 8 items to increase reliability. This has also been proposed after a previous study (Rappange, Brouwer, van Exel, 2009), in which factor analysis of the CFC scale was conducted showing support for validation, using Cronbach's alpha, and feasibility for use with adolescents, with successful results. In a study of awareness of hypertension using the CFC scale (O'Conner el al. 2009), theory developed by Rothman and Salovey suggesting that preventative behaviors will be encouraged if information is presented in terms of gains, "eg. If you do 'X' you will achieve 'Y'". While this study investigated consideration of future consequences in relation to a disease, the health principle could be applied to different future consequences, such as athletic performance.

Plyometric Programs:

The use of plyometric exercises have become a widely used form of training in recent years, and extensive research has been conducted into their effects on neuromuscular adaptations and benefits during musculoskeletal rehabilitation and injury-prevention performance training. Studies by Chimera et al. (2004) and Wilkerson et al. (2004) have investigated the use of plyometric jump training on female collegiate athletes, finding significant improvement in neuromuscular function, joint stability particularly at the knee, and decreased risk of anterior cruciate ligament injury. These results were established using EMG at the "vastus medialis, vastus lateralis, medial and lateral hamstrings, and hip adductors and abductors" (Chimera, 2004), as well as isokinetic peak torque and force plate measurements (Wilkerson, 2004). In studies of a younger population, plyometric programs have been compared against resistance training programs for both strength and power variables. Lephart et al. (2005) found that a plyometric program improved peak quadriceps strength in female high school athletes, and noted an importance in vertical ground reaction force in landing efficiency. Ingle et al. (2006) studied the effect of training and detraining programs on young male athletes, concluding that a combination of resistance and plyometric training was most effective in improve athletic performance of standardized tests such as standing long jump and vertical jump.

The effect of plyometric training has been researched not only in interval-type sports such as basketball, but continuous sports such as running and cycling. A review study (Bonacci et al. 2009) considers the effect of plyometric training on running economy, finding that increased capabilities to store and utilize elastic energy which comes from plyometric training can increase muscular power in the lower limbs and therefore improve running economy. Plyometric training aims to enhance components of performance such as strength, power, speed, agility, and balance. Andrew, Kovaleski, and Robert (2010) analyzed the differences in lower extremity power after plyometric training using three types of depth jumps, and lower extremity weight training. Results indicated that test procedures which required power in the lower extremities were performed more successfully by the plyometric groups. In review of resistance training studies by Brughelli et al. (2008), agility testing protocols were analyzed for reliability, correlation to 20 meter sprint speed, and vertical and horizontal jump performance. From

this review, it was concluded that eccentric strength gains from performing exercises such as vertical jumps will enhance and athlete's ability to change direction.

Methods

Research Design

Pre-testing was completed on week one (January 11th 2010) of the six week training program, at the AMP facility. This testing procedure included five skills: 10 yard sprint, Agility Shuttle, Vertical Jump Test, Broad Jump and Shot Putt Chest Throw. The training program was then conducted for the following six weeks, on three days of the week (Monday, Wednesday, and Friday), for a duration for 90 minutes. The structure and focus of each training session varied each week, however most weeks used the following structure: Monday – Upper body agility and core strength, Wednesday – Lower body agility and core strength, Friday – Speed and lower body agility. Each training session used a number of exercises and sport-related movements tailored to the focus of that training session.

After six weeks of this protocol, post-testing was conducted during week six of the program (February 22nd 2010), at the AMP facility. The testing procedure was the same as the post-test procedure, measuring performance of five skills, and data was recorded and analyzed.

Population

The population for this study was young athletes whom participate in a regularly scheduled strength and agility training program. From this population, a sample of 18 (10 female, 8 male) people were selected as members of a group. These athletes ranged in ages from 15 to 18 years old, and are currently enrolled in a high school in Billings Montana.

Sampling Method

Participants were selected using purposive sampling, as they are all members of a group which regularly attends a strength and agility training program at the AMP Fitness facility. They were selected on the basis of their membership of this group, in which they have paid to attend the scheduled program hosted at the AMP Fitness facility.

Research Instruments

A number of instruments were required for testing. A dynamic warm-up was performed prior to testing (20 minutes).

10 Yard Sprint

Sprint speed was measured using an infra-red based light gate system (Athletics Inc). From a block-start position, participants placed their leading hand on a sensor to engage timing device and set clock to zero. As the hand was removed from the sensor timing was initiated, and stopped as the participant broke the 'beam' and the end line. Fastest time of three trials was recorded.

Agility Test

Infra-red timing device was used to measure agility run time (Athletics Inc.) Participants placed foot on floor sensor to engage timing device and set clock to zero. Agility run started at discretion of participant and they were instructed to touch the end lines five yards to the left and to the right of the start position. Timing began when foot moved off floor sensors, and stopped when participant broke 'beam' for second time. Fastest time of three trials was recorded.

Broad Jump

Broad jump distance was measured using ruler pre-marked on floor of facility. Participants jumped from two feet to land on two feet, and distance from toe to heel of furthest foot was recorded. Longest distance of three trials was recorded.

Medicine Ball Chest Throw

Distance was recorded using ruler pre-marked on floor of facility. Participants sat with both legs extended, back, shoulders, and buttocks touching a wall, and projected an 8 pound medicine ball with two arms in a forward direction. Point at which ball landed was recorded, and longest distance of three trials was recorded.

Vertical Jump

Vertical Jump height will be measured using the VERTEC® (Sports Imports, Columbus OH). This device has colored plastic vanes extended from a long poll to allow for measurement of height in 0.5 inch intervals. Participants were instructed to jump as high as they could from a) a two feet start position and b) a two –step starting position. In both jumps the maximum height recorded was the highest plastic vane which was touched by the participant during the five jumps. Reliability of VERTEC® is noted as "correlation coefficient of 0.92" for a two step jump, and 0.94 for a two feet standing jump (Chimera et al. 2004).

The CFC scale and the 'Improvement Index' were used to quantify results of both the personality aspect and the physical improvement shown by each athlete. The 'Improvement Index' was created using a percentage change in each of the five skills performed during testing. This change in performance was then totaled across the all skills to create an 'Improvement Index' for the athlete, which was then used in statistical analysis with their CFC score.

Procedure

Intervention

After completing pre-testing, the training program was completed over a six week period, at which point post-testing was conducted. The focus of the program was to improve the participant's strength, agility, and speed by using a variety of exercises, different equipment, and different exercise techniques in combination with instruction by qualified strength and conditioning specialists. Variation in the exercises prescribed and the intensity at which they were performed were at the discretion of the coaches who followed protocol developed by Ortho Montana, and based these decisions on the skill level of individual athletes, ability to perform with correct biomechanics, and the challenge each athlete needed in order to be pushed towards their goals.

Each training session followed a routine structure including a dynamic warm-up, exercise drills related to focus for that day, core strengthening exercises, and a cool-down. The coaches of the program used specific verbal cues, visual demonstrations, and one-on-one feedback to the athlete in relation to their performance on a daily basis, and will use these techniques to enhance the confidence of athletes, correct their biomechanics to make them perform more safely and more efficiently, and to show each athlete how they are performing certain skills.

This routine was followed for the course of the six week program, until post-testing begins on the final week of the program. Consent forms were administered to the group of athletes on week four, to ask permission of the athlete and their parents, that their performance data may be used anonymously in this study. Upon receiving this permission, CFC scale surveys were given to the athletes on week five of the program, one week before post-testing. Completion and analysis of consent forms and CFC scale surveys was completed one week prior to final testing procedure.

Data Collection

Pre-test data was collected on week one of the training program, and recorded on site at the AMP Fitness facility. This included age and gender of each athlete, as well as test score for each of the five skills performed. Post-test data was collected on week six of the program, and recorded and analyzed with pre-test data in the computer database at the AMP facility. Of the 18 athletes that were selected, only eleven responded with consent form information. Therefore only these eleven athletes could be used in the study.

Budget

There was minimal cost for the completion of this study, all of which will be incurred by the researcher. This came from producing and coping CFC and consent forms. The use of all equipment came at no cost to the participants as all equipment is property of the AMP Fitness facility. The cost involved with receiving the service of the strength and agility program had already been voluntarily incurred by the athlete as they have chosen to attend regular training sessions at a cost previously specified by AMP Fitness.

Data Analysis

Analysis of collected data was conducted using SPSS statistical software (SPSS Inc, Chicago, IL). Correlation between CFC score and Improvement Index will be assessed using Pearson's r correlation coefficient. Differences in data according to gender and age with reference to Improvement Index and CFC score will also be analyzed, using t-tests, with significance level of 0.05 chosen when applicable.

Results

Post-program test results were compared against pre-program testing scores to calculate differences in performance, and percentage increases or decreases. Percentages were then accumulated to comprise the Improvement Index for each athlete. Table 1 (Appendix B) shows the data for CFC score ($\bar{x}$ = 43.1, SD = 5.2) and Improvement Index ($\bar{x}$ = 26.1, SD = 16.7). Correlation shown between CFC Score and Improvement Index (r = -0.12, p =

0.724) in Table 2 (Appendix B) is not significant ($p > 0.05$). Relationship between Age and CFC Score ($r = 0.169$, $p = 0.619$), and Gender and Improvement Index ($r = 0.275$, $p = 0.413$) are also not significant. Analysis comparing Gender and CFC score, as well as Age and Improvement Index showed significant correlation ($p < 0.05$) in Table 3 (Appendix B). Age and Improvement Index showed negative correlation ($r = -0.672$). Figure 1 shows CFC scores by Age, indicating that 17 year old athletes scored highest on the CFC scale, with all other ages scoring similarly. Figure 2 displays Improvement Index by CFC score for each athlete, indicating outliers for both variables, and clusters areas for further analysis. Figure 3 shows the distribution of Improvement Index according to Age, with a relatively normal distribution. Figure 4 through 9 (Appendix B) represent individual athlete date across each of the test procedures: Agility Test ($\bar{x} = 3.04$, SD = 2.14), 10 Yard Sprint ($\bar{x} = 5.07$, SD = 2.34), Upper Extremity Ball Toss ($\bar{x} = 10.25$, SD = 8.89), Broad Jump ($\bar{x} = 5.21$, SD = 6.97), Standing Vertical ($\bar{x} = .94$, SD = 1.09) and Two-Step Vertical ($\bar{x} = 1.60$, SD = .97). These statistics can also be compared to data collected from the AMP Summer 2009 program (Appendix C).

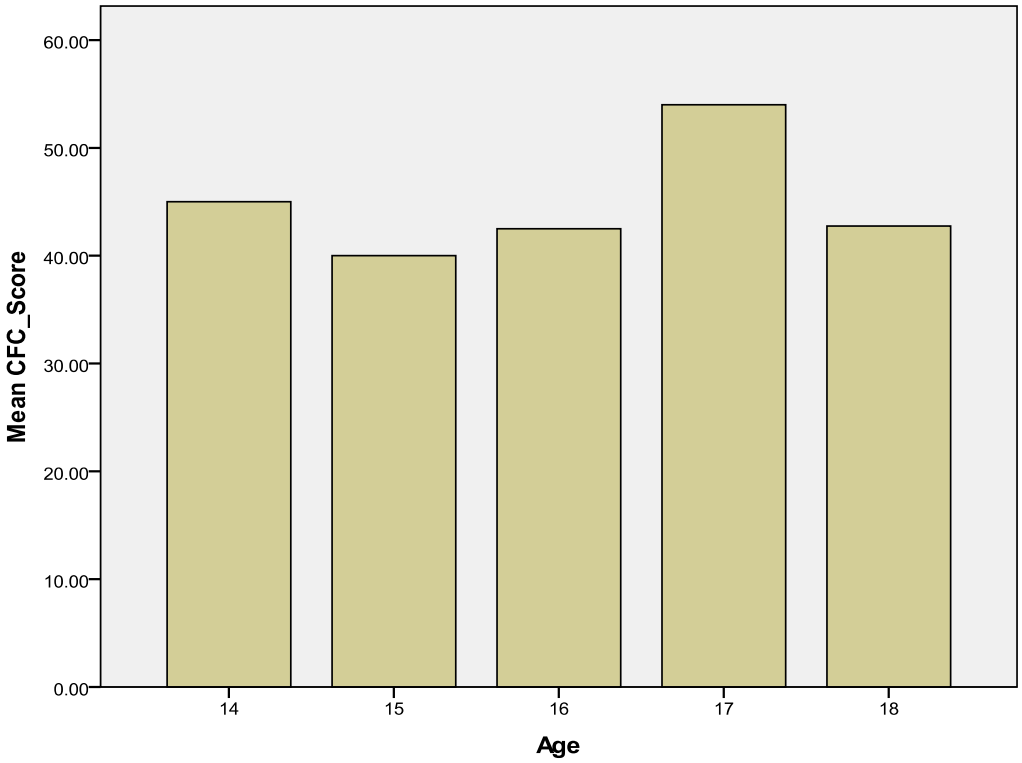

Figure 1 – Mean CFC Score According to Age of Athlete

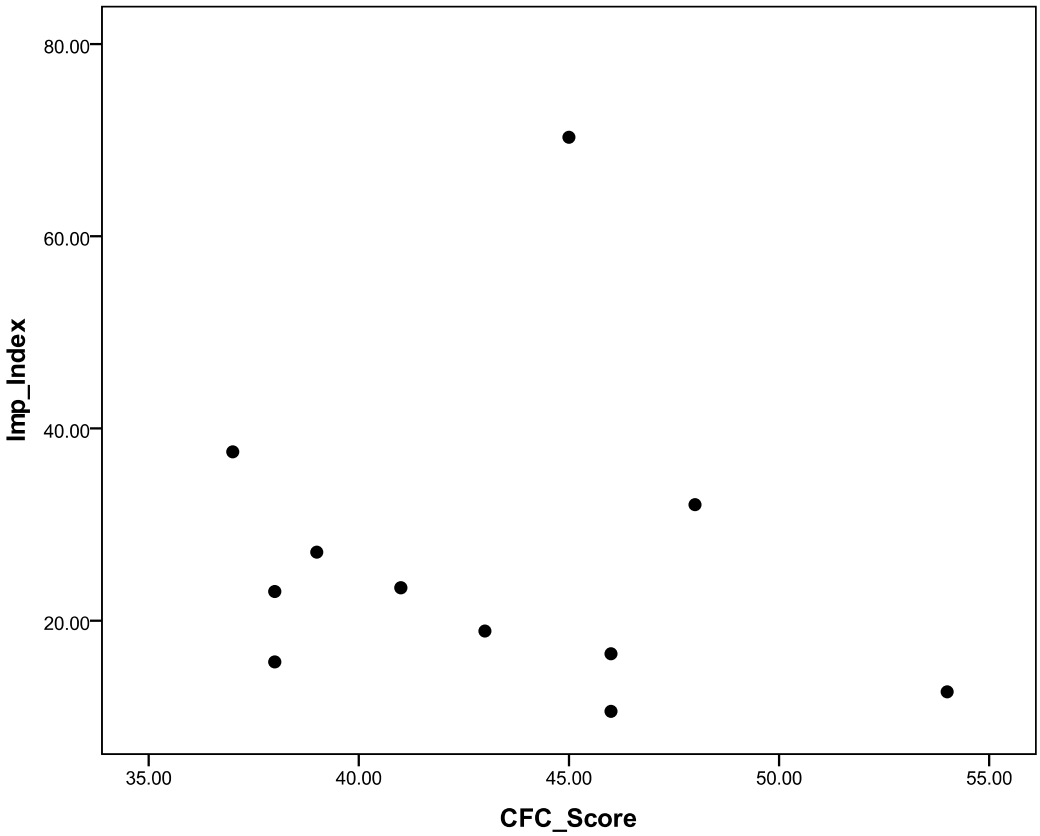

Figure 2 – Distribution of Individual Athlete Improvement According to CFC Score

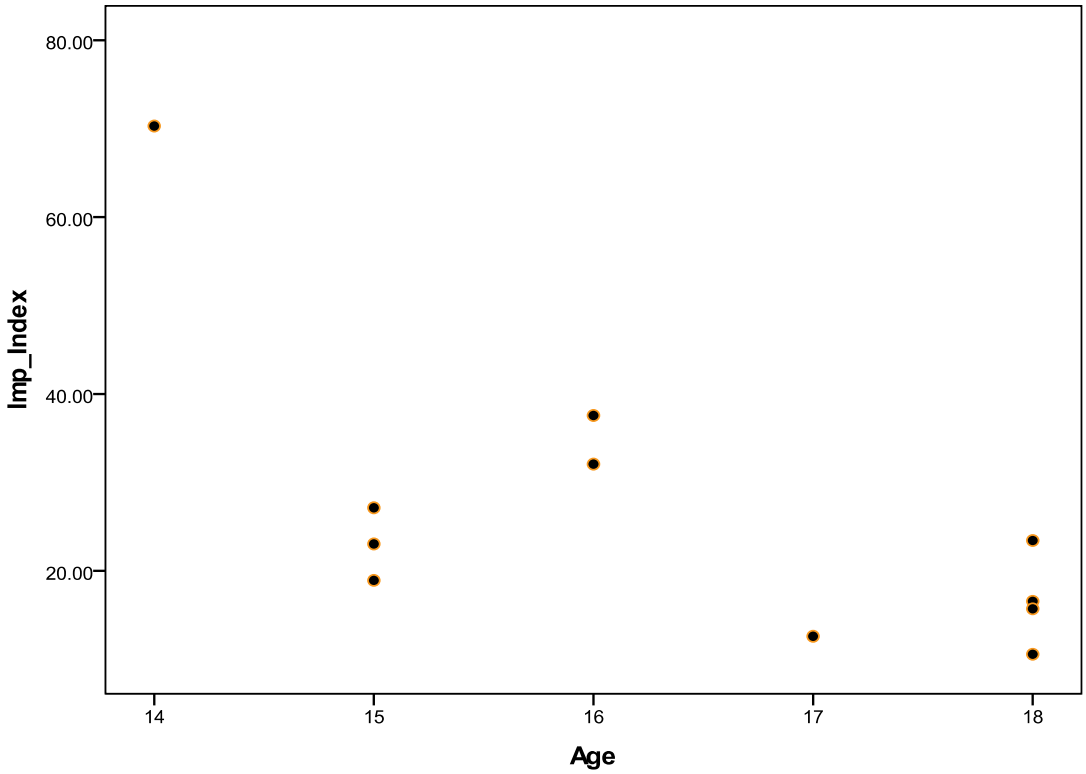

Figure 3 – Improvement Index According to Age of Athletes

Discussion

As shown in Table 2 (Appendix B), there is no significant relationship between CFC score and Improvement Index ($p > 0.05$). This can also be shown in Figure 2 as the distribution of Improvement Index according to CFC score does not allow for a linear line of regression to represent the data, and therefore CFC score cannot be said to be predictive of improvement in performance. This may be due to the ability of adolescents to accurately measure their consideration of future consequences. Rappange et al. noted that "several authors have found that young adolescents are less able to foresee consequences…and less able to conceptualize risks and benefits of their actions" (2009). While previous studies have noted lower CFC scored across adolescents, the mean scored in this study was 43.1, indicating that the athletes generally considered their long term outcomes more than the immediate consequences of their actions. No significant correlation between CFC score and Improvement Index data would indicate that there are multiple factors which contribute to the performance of the athlete, both during the six weeks of training, and during testing procedures. Traits measured by CFC scale did not show to be predictive of level of improvement after six weeks of plyometric training program, therefore situational or external factors must impact how the athlete performs during training, and therefore is represented by testing results.

The verbal feedback given by coaches during each session is used to instruct, reward, and correct athletes in their performance of each exercise throughout the program. Magill defines a verbal cue as " a short, concise phrase that serves to 1) direct the performer's attention to regulatory conditions in the environmental context or 2) prompt key movement components of skills" (Magill, p.326). Combined with demonstration, verbal cues provided the most direct way for the coaches to instruct an athlete's performance for correct biomechanical safety and efficiency. Magill notes a study by Masser (1993) in which verbal cues during performance were assessed, demonstrating that cued participants "maintained their acquired skill three months after practice"(p.327). Using this principle, the coaches aimed to cue the athletes to develop the most biomechanically safe and efficient body position throughout each exercise, with the objective that the athlete will perform the skill with the correct body position in the future without requiring the same verbal cues. Both the timing and the quantity of verbal instruction given may influence how an athlete performs a skill. Too much information given about performance makes it difficult for the athlete to direction their attention to the area of the skilled required to improve performance of that skill. Short, concise cues allow the athlete to process minimal amounts of information before performing the skill, and distraction is limited. Prinz developed the action effect hypothesis which states that "actions are best planned and controlled by their intended effects" (Magill, p.320). The intended outcome was primarily the focus of the verbal cues given to athletes, particularly during jumping and bounding exercises in which outcomes could be easily identified (e.g. Jump as high as you can) rather than focusing on the process of the skill. Both concurrent and terminal feedback was used to provide athletes with information about their performance of skills, with more informational feedback given after skill performance to allow the athlete to prepare for the next trial. The final aspect of feedback given to the athletes was visual feedback, either through a video recording or using a

mirror while running on the high speed treadmill. While video recording was only used towards the end of the six week program, a mirror positioned in front of the high speed treadmill allowed the athlete to see how they were running, and how the responded to the verbal cues given by the coaches during running tasks. The athlete was able to see their change in body position in response to cues such as “arms at 90 degrees” given by the coaches, and this form of visual augmented feedback was used during each running task on the high speed treadmill.

Figure 3 shows the negative correlation between Age and Improvement Index (r = -.672). While the difference in improvement between 15 to 16 years and 18 year olds was relatively small, there may be a number of reasons for this difference. While a larger sample size may be needed to draw stronger conclusions from this, the hormonal effect of puberty onset will impact the development of strength and growth, and therefore influence the extent to which male and females around the age of 15 are able to perform differently over the course of six weeks. Ingle et al. (2005) reviews training and detraining of pubertal boys, noting “susceptibility to the onset of circulating androgens during resistance training” as a reason for changes in performance among boys aged 12 and 13 over a 12 week program. The hormonal increase experienced by boys during puberty around the age of 15 maybe account for developments in strength due to testosterone, while females aged around 18 may have completed puberty and therefore will not be experiencing the increase in androgenic hormones that they did age 13 or 14. Training load for youths using plyometrics has been studied (Lundin, 1987), citing that “maturation and experience compound the problem of determining training loads”. The use of the athlete’s own body weight during plyometric exercises such as jumps, squats, push-ups, and hops eliminates the use of weight bearing exercises during pubertal growth and development. Frequency, intensity, and duration of plyometric training exercises are measured using foot contacts, to allow for adequate recovery between exercises and to cautiously prevent harmful overload. Chu recommends that beginners range from 60 to 100 contacts per session, intermediates from 100 to 150 low intensity and 100 moderate intensity, and advanced athletes may range from 150 to 200 moderate intensity foot contacts, on two to three days of the week (2004). Sessions were structured to allow for 48 hours between sessions to provide adequate recovery time after plyometric exercises. Consideration must also be given to initial levels of the athletes prior to beginning the six week program. Athlete with high initial levels, who performed well during pre-testing, will have been closer to their performance ceiling that those athletes who had lower initial levels of performance during pre-testing. Athletes with lower initial levels had more area to reach their performance ceiling than those athletes who were already performing at a high level at week one of the program.

The neuromuscular changes caused by a plyometric program have been extensively studied for a number of populations, in a number of sport settings. Programs combining strength and agility training with injury prevention techniques are thought to be the most beneficial types of programs to train athletes. Lephart et al. (2005) and Chimera (2005) both investigated ACL-prevention type programs for female athletes, using EMG data to measure muscle activation difference following a six or eight week program. Both studies found significant increases in EMG data for the quadriceps, hip abductors and adductors

and hamstrings. The principle of motor recruitment must be employed during training to produce long term changes in motor unit recruitment, refining motor pathways in the activation of more motor units for gross motor skills such as jumping and running. Gains in muscular strength may be attributed to these neural adaptations, including synchronization, recruitment, and rate of coding. Willmore, Costill, and Kenny (2008) note describe these components "Strength gains may result from changes in connections between motor neurons located in the spinal cord, allowing motor units to act more synchronously, facilitating contraction, and increasing the muscle's ability to generate force" (2008, p.206). The collaboration of more motor units when performing a task utilizes the capabilities of more muscle fibers, and therefore stronger contraction. Rate of coding may also explain changes gains in strength, and is described as the increase in frequency of stimulation of a motor unit over time which then causes "a state of tetanus" with peak muscular force (Wilmore et al. 2008, p.206). The continuous activation of particular motor units experienced during plyometric routines and sport-specific tasks in the six week program may account for any strength gains shown during testing. The basis of these neural adaptations in response the plyometric training is the speed on impulse conduction throughout the central nervous system to the muscle fibers. The neural signals from the higher centers of the brain, particularly motor cortex and cerebellum, are passed through the spinal cord to reach muscle fibers, making up motor units. The rate at which these impulses are conducted determines the timing of the motor response made by synchronization and recruitment of motor units for the task. The exercises and routines used over the six week training program were designed to improve this conduction by continuously practicing and repeating various reaction movements which were relatable to both the post-testing procedures, and the sports which the athletes will compete in.

The principle of specificity was applied using several prescribed exercises (Appendix A) including agility exercises which encouraged multiple changes of direction running at high speed, jumping and landing techniques relatable to basketball and volleyball, and bounding exercises which replicated skill components used in track and field events. Lephart et al. also measured vertical ground reaction force during landing on two feet, finding no significant difference after a plyomteric program. However, Cronin, Bessel and Fkinn (2008) found that augmented feedback reduced vertical ground reaction force during landing phase of a jump. From this we can say that it is possible to reduce the vertical force produced when landing on two feet with augmented feedback, which was used during this plyometric program. The principles behind plyometrics would show that repetition of correct landing techniques combined with appropriate feedback could decrease vertical ground reaction force during landing phase of a vertical jump, therefore minimizing the risk of knee injury experienced with large reaction forces and an unstable knee joint. Chimera discusses this with reference to the use of force plates to measure landing force. "Motion and force plate data after plyometric training revealed that trained females had lower landing forces when compared to untrained males" (2005). Further studies in this area, particularly with injury prevention objectives such as ACL prevention, should include the use of force plate instruments to accurately measure vertical ground reaction force during landing phase of jumping.

Each of the five NATP standard exercises used for testing were selected to most accurately measure changes in performance based upon the exercises prescribed according to the Ortho Montana protocol over the six week course. Figure 4 shows each individual athlete's change performance on the agility test between week one and week six of the program. Three athletes showed between 5% and 7% increases in performance. Comparative norms (Appendix C, Figure 1) show distribution across age and gender. The agility exercises (Appendix A) were designed to incorporate safe biomechanics for changing direction at high speeds, while making changes in direction optimally efficient during performance. Verbal cues were used by coaches to correct technique, with emphasis on 1) lowering center of gravity, 2) multiple small, fast steps during deceleration when approaching point of change of direction, and 3) acceleration in new direction after turning. The agility test used (10 yard shuttle) used two changes of direction. Brughelli et al. (2008) analyze change of direction (COD) tests as well as their components, "Each COD requires a braking force followed by a propulsive force, which in turn may increase the importance of eccentric-concentric force capability of muscle and endurance as the number of turns increases". This shows that eccentric-based plyometric exercises will aid an athlete's ability to change direction by allowing safe deceleration and force absorption across the knee joint, followed by acceleration by generation of force in a different direction. Brughelli et al. also note that correlations between agility test performance and "straight sprinting speed" are minimal; as more changes in direction over shorter distances does not correlation with straight sprinting speed. Because of this, other types of training methods were incorporated into the program to improve straight sprinting speed. Both straight sprinting speed and change in direction are important aspects of the majority of sports played by young athletes.

Figure 5 shows the improvement in 10 yard sprint times for each athlete, with two athletes improving by over 8% (Appendix B, Figure 5) This is a greater improvement than is normally seen after completing the six week program (Appendix C, Table 1). A high speed treadmill was used for HIIT (high intensity interval training) with emphasis on correct running biomechanics when sprinting. Due to the high number of track and field athletes participating in the program, this became an important component of training as the high speed treadmill allowed them to run at very high speeds, for short durations, on inclined, declined, and flat surfaces. Cues given to the athletes during this training emphasized 1) running on toes, 2) driving the knees high, 3) maintaining strong posture, 4) using arms at 90 degrees to assist running, and 5) bringing the lower leg down rather than out in-front during flight, before next stride. This component of training was not included in testing procedures, due to the possible risk of injury during pre-testing when athletes have limited experience with running at high speeds. The short, intense bouts of sprinting utilized the ATP-PCr energy system to allow the athletes to perform at a high intensity for up to 15 seconds (Wilmore et al., 2008, pg. 51). Variations of this training were used, such as inclined and declined surfaces, which changed the demand placed on the muscles, as well as the duration of each exercise bout. Athletes were instructed to run for as long as they could at each speed, with the overload principle used to gradually increase the percentage of maximum speed on each repetition duration a session (Appendix A). Generally, athletes would be capable of running for between five and seven seconds before failing, due to the lack of oxygen availability to the muscles by

performing at such a high intensity for a short period of time. While HIIT allowed each athlete to practice and correct their sprinting biomechanics, other forms of sprint training were used in relation to the 10-yard sprint test. 'Lean-Fall Runs' (Appendix A) incorporated both reaction and movement time with sprint exercises. Using the principle of specificity, these exercises emphasized 1) reaction time to auditory stimulus, 2) Utilization of the stretch-shortening cycle (SSC), 3) importance of first step taken by lead foot, and 4) using correct biomechanics emphasized during HIIT on high speed treadmill. This type of training also incorporated sport-specific exercises such as 'block starts' which related to those athletes competing in track events. The effects of plyometric exercises on running economy have also been studied. Bonacci et al. (2009) note that "explosive resistance training and plyometrics…aims to enhance the ability of muscles to generate power through the SSC. The SSC utilizes the ability of soft tissues to sore and return elastic energy, thus reducing energy expenditure". The neuromuscular adaptations seen through plyometric training were also found to improve running economy, Paavolainen et al. (1999), as repeated intense exercise and utilization of the SSC were found to produce "a significant improvement in 5k run performance (3.1%), running economy (8.1%)…and velocity over a 20m sprint (3.4%)". This shows that not only running-specific training exercises may improve running economy and sprint time, but other plyometric exercises contribute to the ability of muscles and to store energy to improve sprint time.

Upper body strength and agility exercises were also incorporated into the six week program (Appendix A), primarily with variations of push-ups and ladder exercises emphasizing 1) explosive power, and 2) muscular strength. Figure 6 shows the range of improvement across the athletes for the upper extremity ball toss, with two athletes improving by over 20% between pre-test and post-test (Appendix B, Figure 6). Vossen et al (2000) studied the differences between a dynamic push-up training program and a plyometric push-up training program, using the same upper extremity ball toss to measure these differences. Results showed that the plyometric group "experienced significantly greater increases than the DPU group" when performing the upper extremity ball toss. The biomechanical specificity of the plyometric push-up compared to the dynamic push-up would suggest more significant improvement using this testing, as the explosive forward push required replicates the way in which plyometric push-ups would be performed. In the same study, PPU were compared to DPU for a 1RM medicine ball chest press, with "no significant differences between the 2 groups for this measure". This again suggests that when compared for overall muscular strength capabilities, plyometric push-ups may have no significant benefit over dynamic push-ups. It is worth noting that the majority of the participants were training for sports which do not have emphasis on upper body strength, however increases in upper body strength were targeted to also contribute to improvements in core strength and stability.

Three different tests were used to measure variations of jumps and lower body power. Figure 7 (Appendix B) shows changes in broad jump performance between pre-test and post-test results, with one athlete scoring significantly higher than the other athletes (22.45%) and two athletes scoring lower during post-testing (1.15% and 1.32%). Possible reasons for the large level of improvement seen in athlete number 11 could be that they

did not perform to their full capability during pre-testing, and had unfamiliarity with the broad jump procedure. Another possibility would be that due to the lower age of the athlete, they saw vast improvement in both their lower body power and ability to coordinate their body more efficiently to perform the jump, after the six week program. Decreases in performance across this test were small and not significant enough to be attributed to loss of lower body power or jump capabilities. Therefore these decreases may simply be contributed to foot placement during landing phase of the broad jump, or fatigue after performing vertical jump testing prior to broad jump test. Two athletes improved by around 10%, indicating increases of around seven or eight inches. This size increase may be attributed to an increase in lower body power. Two types of vertical jump were also measured: standing vertical and two-step vertical (Appendix B, Figure 8, 9). Two athletes showed improvement of around 3% on the standing vertical jump, indicating improvement of 2.5 to 3 inches. This level of improvement using the VERTEC® instrument, 4 to 6 vanes, could represent a significant improvement, attributable to increases in lower body power. One athlete decreases their score on the standing vertical jump (.83%). This small decrease, two vanes on the VERTEC®, may also be attributed to fatigue after performing other tests such as the broad jump or agility run. This may not be uncommon in older athletes (Appendix C, Figure 5). Results from the two-step vertical jump can be used with the standing vertical data to make comparisons for each participant across the two related skills. In general athletes performed better on the two-step vertical than on the standing vertical, only one athlete showed the same level of improvement on both tests, and the athlete who showed a decrease in performance in the standing vertical improved by over 1% on the two-step vertical.

The changes in performance seen across the three jumping tests support the principle of specificity in the foundation of the jumping and bounding exercises used over the six weeks (Appendix A). Emphasis of verbal cues during these exercises was directed towards 1) landing softly on toes, 2) aligning the knees, hips, and ankles 3) maintain posture and use arms for balance, 4) generate as much power from the legs to jump as high as possible. Variations of jumps included squat jumps, single legs jumps, bounding for height, landing on one or two feet, and jumping for distance. A study by Chimera et al. (2004) used a six week training program of similar exercises with college-age female athletes. Results indicated “improvements in vertical-jump height and sprint speed”. The repetition of the eccentric loading phase during the jump and bounding exercises forced the athletes to refine muscle recruitment and firing patterns in the quadriceps, hamstrings, gluteals, and calf muscles. Isokinetic data recorded by Wilkerson et al. (2004) after plyometric training of female basketball players showed that plyometirc training “increased the performance capability of the hamstrings”, and may demonstrate differences in hamstring and quadricep strength in relation to ACL injuries. EMG data recorded by Chimera et al. showed increases in adductor muscle activation during “preparatory phases of landing” after the six plyometric program, possibly contributing to knee stability. Comparison of standing vertical and two-step vertical results would indicate differences performance between two relatable skills. The two-step vertical involved jumping off of the dominant leg after producing momentum with a previous step. This transition during momentum phase replicated a number of bounding and

jumping exercises used, as well as single-leg isolation exercises. While the vertical jump replicated various exercises used, including squat jumps, the momentum component would predict improved performance on the two-step vertical. Two athletes decreased their level of improvement from the standing vertical to the two-step vertical jump, possibly due to fatigue.

Of the previous studies using the CFC scale, few have been applied to health and medicine. O'Connor et al. (2008) used the CFC scale to analyze the relationship between CFC score and the amount of "hypertension awareness" information participants read. Results showed that those with a high CFC score "spent twice as long reading the additional hypertension information after reading the loss frame information". These results may give some indication to the actions taken by those with high or low CFC scores in a health intervention setting. The current study used a different format, assessing the relationship with one's consideration of future consequences and their physical performance over several weeks. Because there have been no previous studies of the same format, further studies must be done to determine the validity of the use of the CFC scale in this type of exercise-performance setting. Verbal cues given to athletes directed their attention to immediate outcomes of their performance, and so measurement of consideration of future consequences at this time would represent a 'state' CFC rather than the trait measured by the original CFC scale. The 'state' CFC being low would indicate the athlete's intent to 'perform this skill correctly' focusing on immediate outcomes, while the trait CFC measured by the scale could be high for the same athlete. It is this paradigm that may make the CFC scale invalid for young populations in a performance based setting.

Future Studies and Conclusions

Future studies in this area would aim to target an older population, as the CFC scale has been more widely used by adults and has accepted validity and reliability for this population. Similar design could be used for older participants, taking into account adjustment of norms in performance of the five test exercises. For more detailed quantitative analysis, kinematics variables could be analyzed during running and jumping exercises, particularly for injury prevention participants, to quantify levels of improvement more accurately. The use of high speed camera recordings would allow for measurements of knee and ankle angles during pre-test and post-test phases of a program, which could provide additional information when assessing level of athlete improvement. Previous studies of plyometric programs have used EMG data and force plate instruments to measure levels of performance, and again this would contribute to a higher level of analysis of performance. In terms of the study design, any future study would aim to use a larger sample size, and equal numbers of male and female participants to make gender-specific comparisons. While the 'Improvement Index' proved a simple way to correlate the level of athlete improvement with CFC score, the lack of validity of this measure must be taken into account. Future studies would aim to find a more valid, accepted measure, although the 'Improvement Index' was effective for this study.

Although participant's consideration of future consequences did not prove to be predictive of their level of improvement over the six week program, the plyometric program produced improvement across the five testing skills for all participants. These results show that the extent to which a young athlete considers future outcomes does not predict how much they will improve in their performance after participating in a training program. The combination of the age of the participants and the verbal cues given as part of the training program prevented the participants from accurately assessing possible outcomes. Because of this, the CFC scale may not be appropriate to use for exercises based training programs in which emphasis constantly placed on the immediate outcome of skill performance, unless future studies with older populations show that adults are able to more accurately assess outcomes of their actions. Alternative trait measurements, such as extroversion or neuroticism, could be measured to more accurately distinguish the personality types of athletes when assessing improvement in exercise-related skills as a result of a structured training program.

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Appendix A

WEEK 1

Monday:

- Testing

Wednesday:

- Introduction Day:
    a. **<u>PAL Progression</u>**: Posture-Arms-Legs
       Lean, Fall, Run Progression
       Good for all level of athletes
       (To emphasize acceleration, have athletes perform partner sprints after PAL)
    b. Introduce athletes to the high speed treadmill
    c. Short shuttle run (agility):
        - Consist of various directional changes
        - Teaches athletes how to control body movement in a small area

Friday:

- Treadmill day
    a. First day that the athlete are put through a specific protocol on the treadmill.

- Introduction to lower and upper body plyometrics
    a. 10 different exercises
        - ~100 ft touches total

    b. 5 different exercises
        - Reps depend on athletes strength and training status
            1. Novice, intermediate, or advanced athlete

WEEK 3

Monday:

- Lower and upper body plyometrics
    a. 8 different exercises (LB)
        - 110-120 ft touches

    b. 4 different exercises (UB)
        - Using med ball

- Treadmill day (Work day)

Wednesday:

- Agility day
    a. Various of exercises using ladders and cones

Friday:
- Treadmill day (Speed day)
- Lower and upper body plyometrics
    a. 6 different exercises (LB)
        - 110-140 ft touches depending on the athletes training status

    b. 4 different exercises (UB)
        - ~ 80 reps

Week 6

Monday:

- Treadmill day (Work day)

- Lower and upper body plyometrics

    a. 7 different exercises (LB)
        - ~140 + ft touches

    b. 3 different exercises (UB)
        - ~80 + reps

Wednesday:
- Agility

Friday:
- Test out top speed on treadmill

Appendix B

Table 1 – Descriptive Statistics of CFC Score and Improvement Index of Athletes after a 6 Week Plyometric Program

	N	Minimum	Maximum	Mean	Std. Deviation
Imp_Index	11	10.57	70.30	26.1727	16.76987
CFC_Score	11	37.00	54.00	43.1818	5.23103
Valid N (listwise)	11				

Table 2 – Pearson's Correlation Between CFC Score and Improvement Index of Athletes After a 6 Week Plyometric Program

		CFC_Score	Imp_Index
CFC_Score	Pearson Correlation	1	-.121
	Sig. (2-tailed)		.724
	N	11	11
Imp_Index	Pearson Correlation	-.121	1
	Sig. (2-tailed)	.724	
	N	11	11

Table 3 – Paired Correlation Results Between Gender, Improvement Index, CFC Score and Age of Athletes after a 6 Week Plyometric Program

		N	Correlation	Sig.
Pair 1	Age & CFC_Score	11	.169	.619
Pair 2	Gender & Imp_Index	11	.275	.413
Pair 3	Gender & CFC_Score	11	.662	.026
Pair 4	Age & Imp_Index	11	-.672	.023

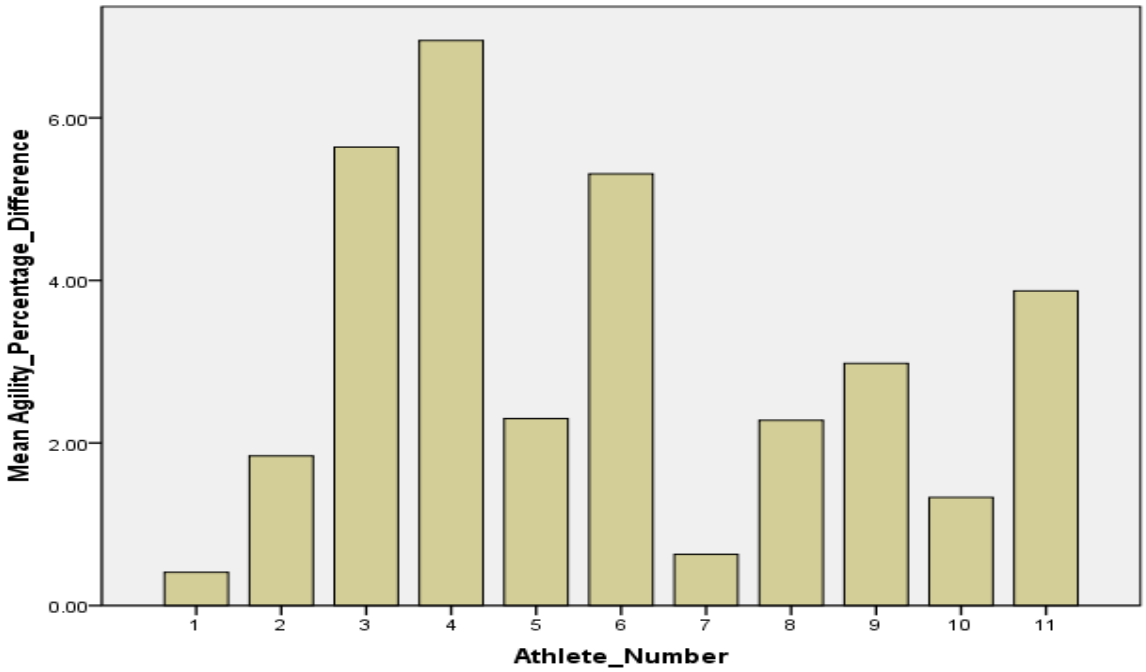

Figure 4 – Distribution of Percentage Changes by Each Athlete on Agility Test

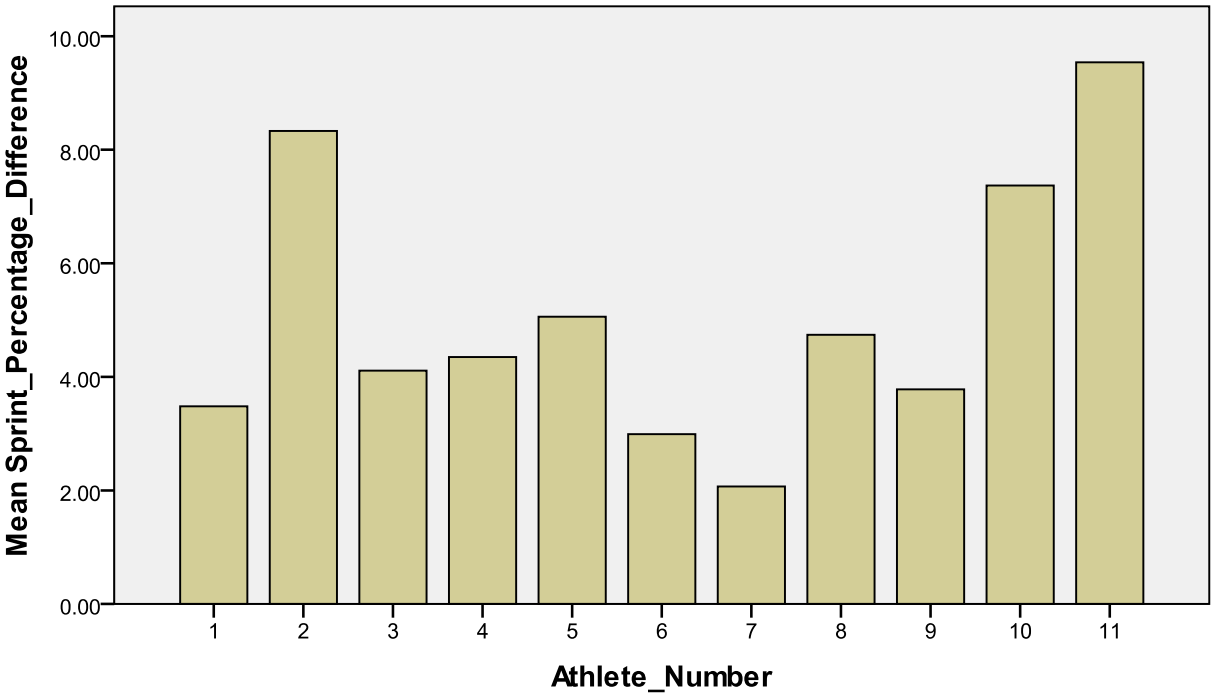

Figure 5 – Distribution of Percentage Changes by Each Athlete on 10 Yard Sprint Test

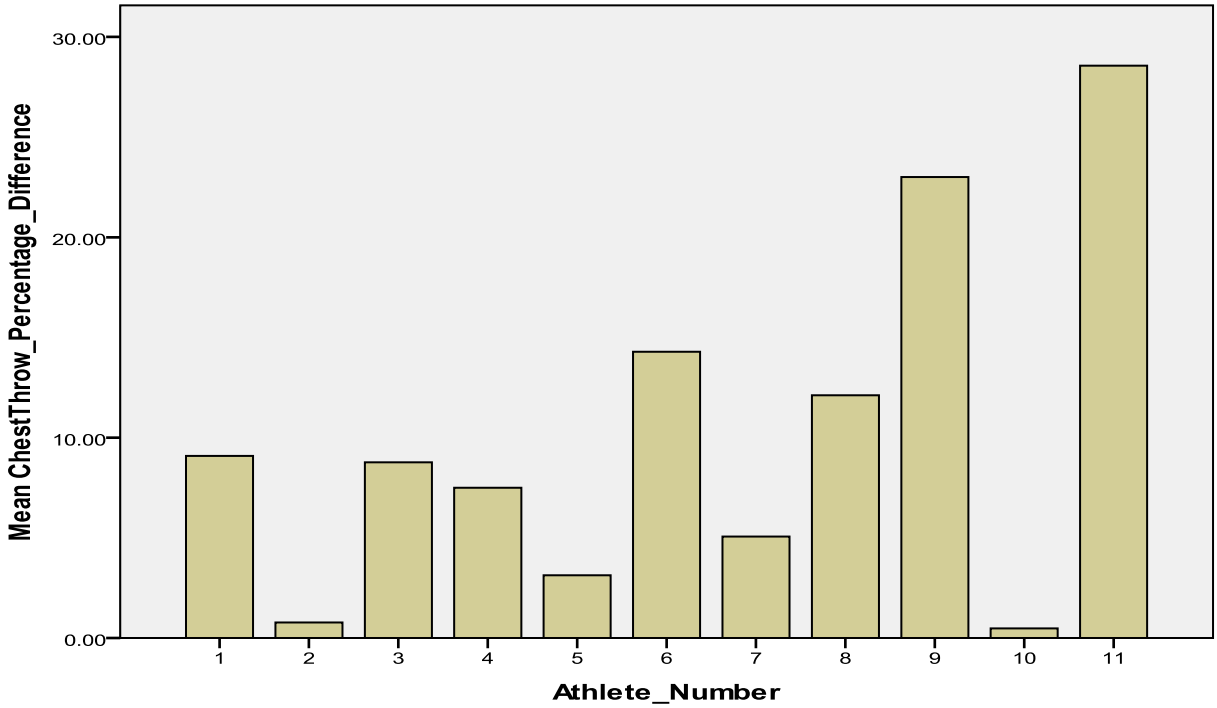

Figure 6 – Distribution of Percentage Changes by Each Athlete on Chest Throw Test

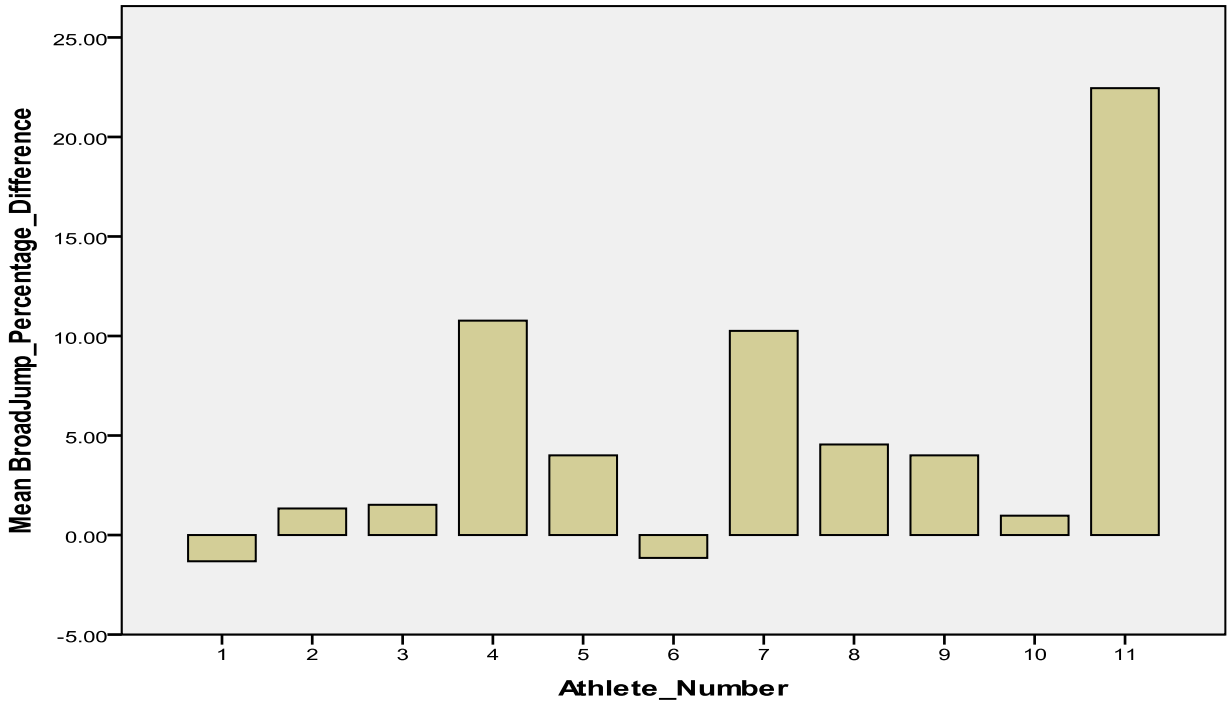

Figure 7 – Distribution of Percentage Changes by Each Athlete on Broad Jump Test

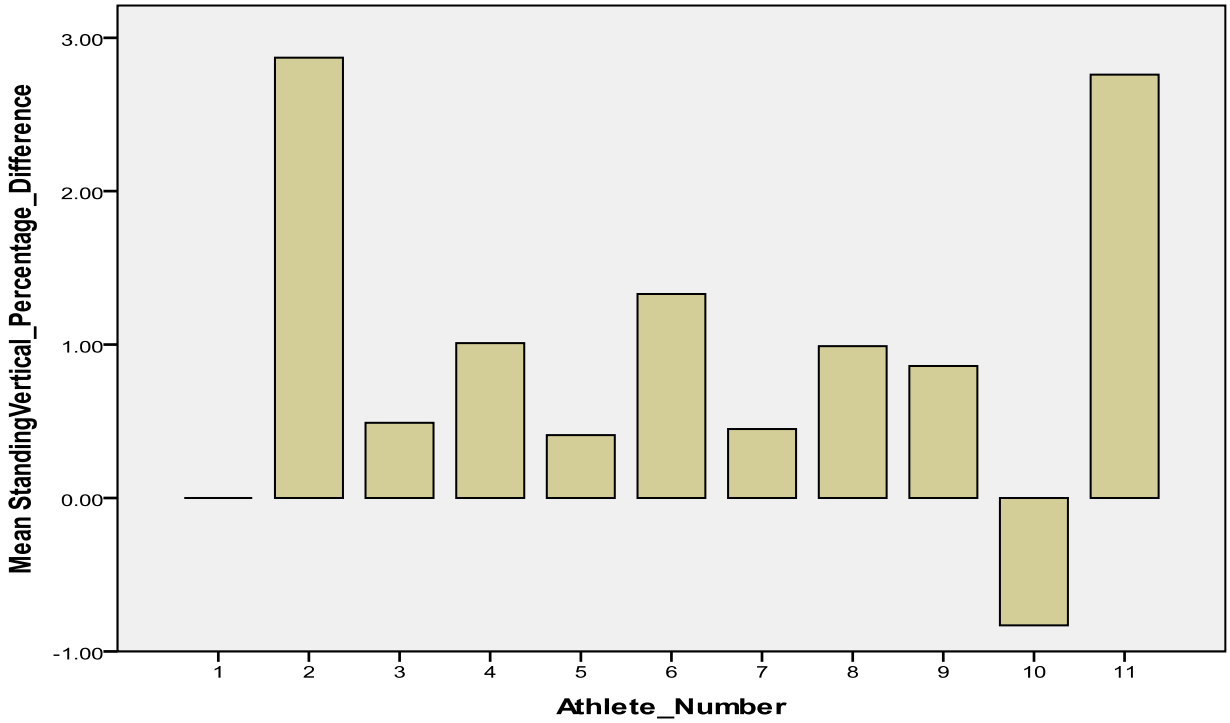

Figure 8 – Distribution of Percentage Changes by Each Athlete on Standing Vertical Jump Test

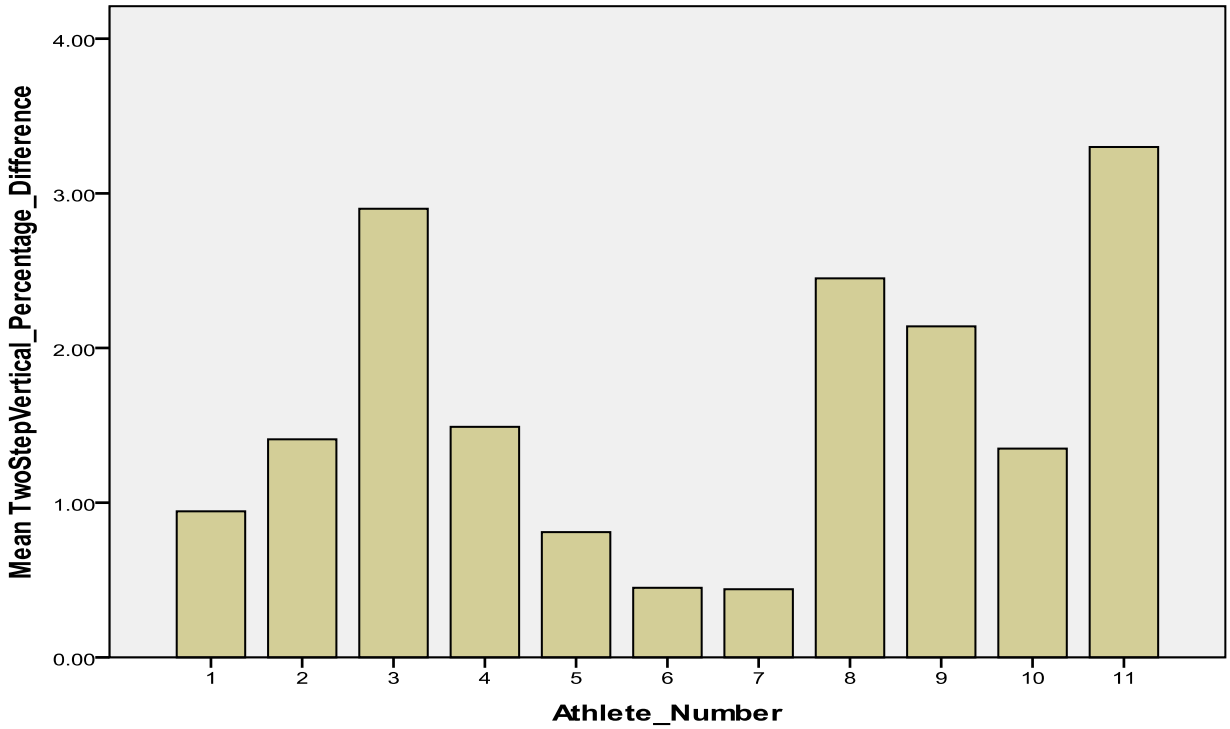

Figure 9 – Distribution of Percentage Changes by Each Athletes on 2-Step Vertical Jump Test

Appendix C

Table 1 – Descriptive Statistics for AMP Summer Program (n = 50)

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Pro_Agility_Improvement	49	-3.85	6.57	2.3141	2.30978	5.335
Sprint_Improvement	50	-3.00	7.76	2.3820	2.32751	5.417
Ball_Toss_Improvement	48	-7.41	36.84	7.9850	7.60458	57.830
Broad_Jump_Improvement	48	-5.13	39.58	4.9990	7.21546	52.063
Standing_Vertical_Improvement	48	-1.39	6.31	.6096	1.10488	1.221
Two_Step_Vertical_Improvement	47	-.51	6.22	1.0443	1.38720	1.924
Valid N (listwise)	47					

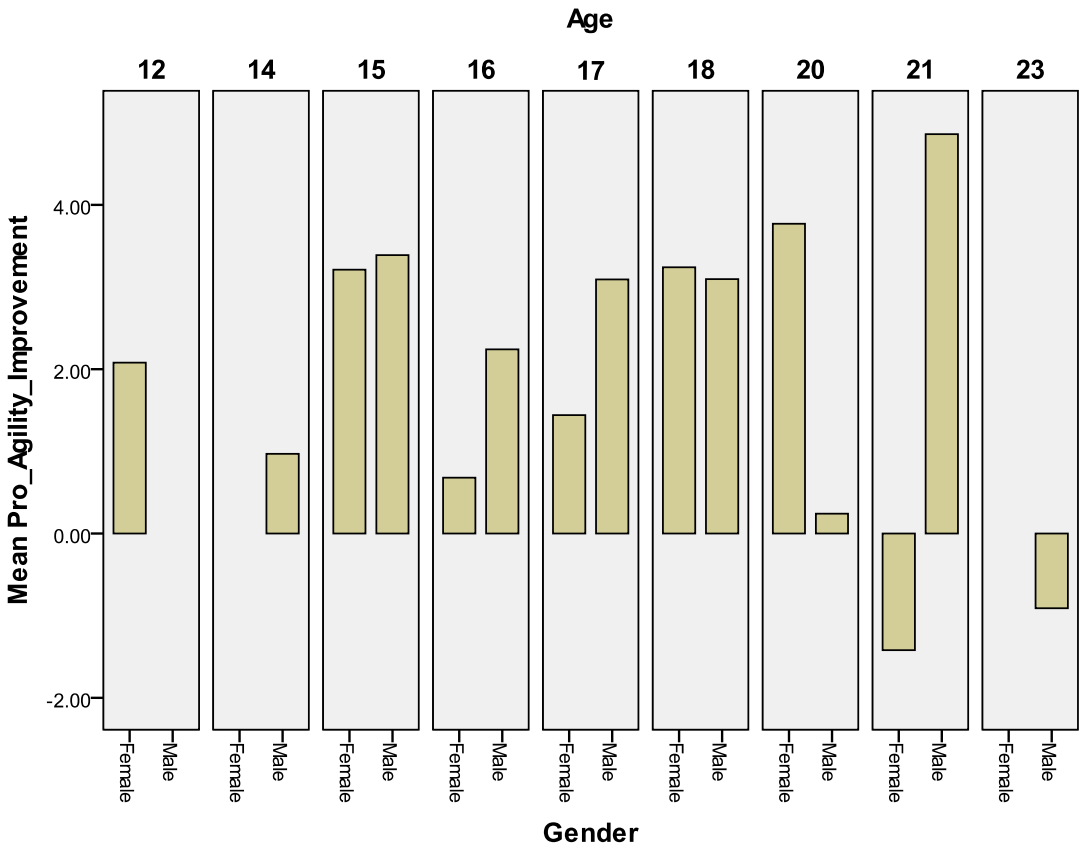

Figure 1 – Average Percentage Improvement in Pro Agility Test after 6 Weeks for Athletes in AMP Summer Program

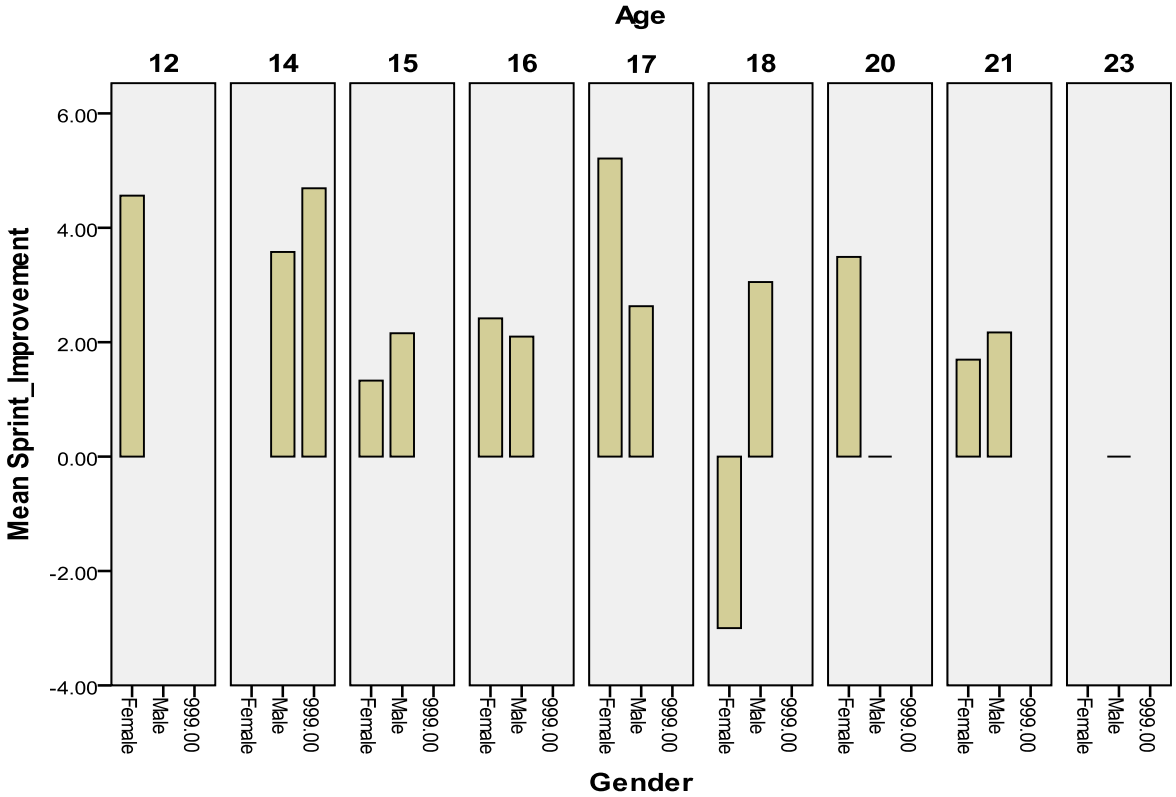

Figure 2 – Average Percentage Improvement in 10 Yard Sprint Test after 6 Weeks for Athletes in AMP Summer Program

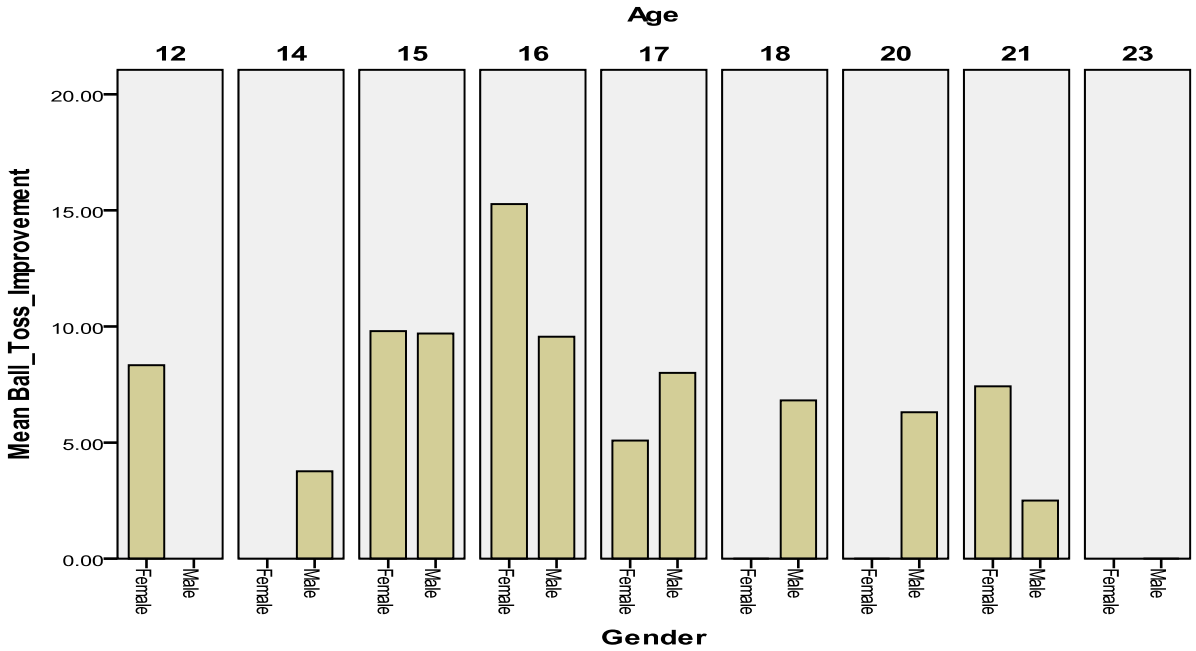

Figure 3 – Average Percentage Improvement in Upper Extremity Toss Test after 6 Weeks for Athletes in AMP Summer Program

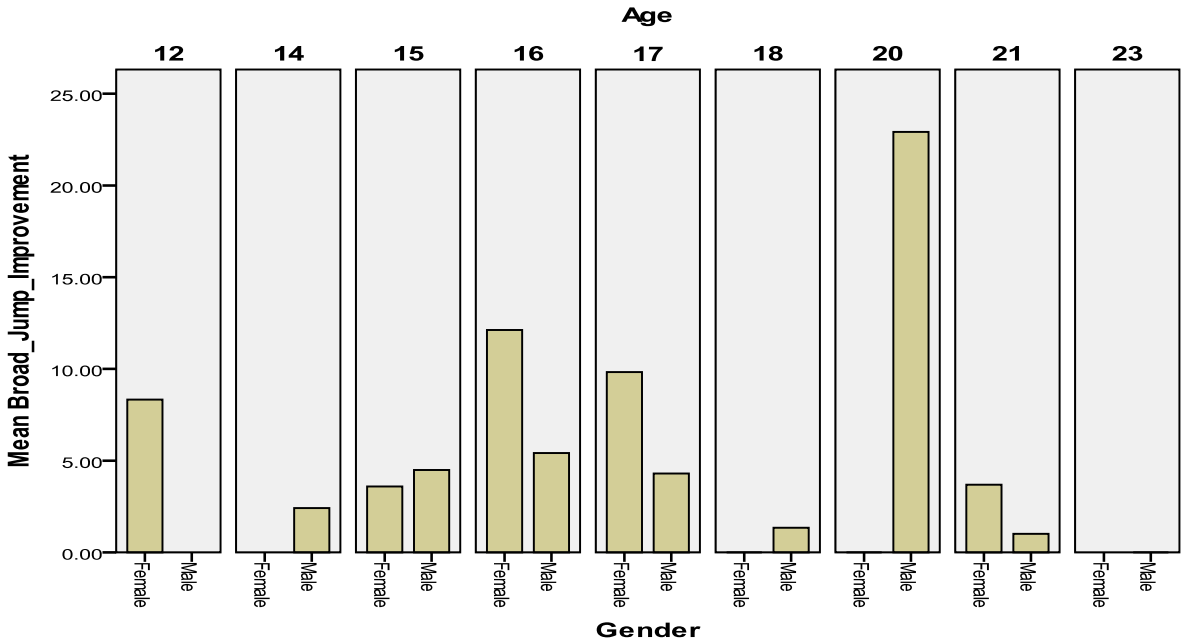

Figure 4 – Average Percentage Improvement in Broad Jump Test after 6 Weeks for Athletes in AMP Summer Program

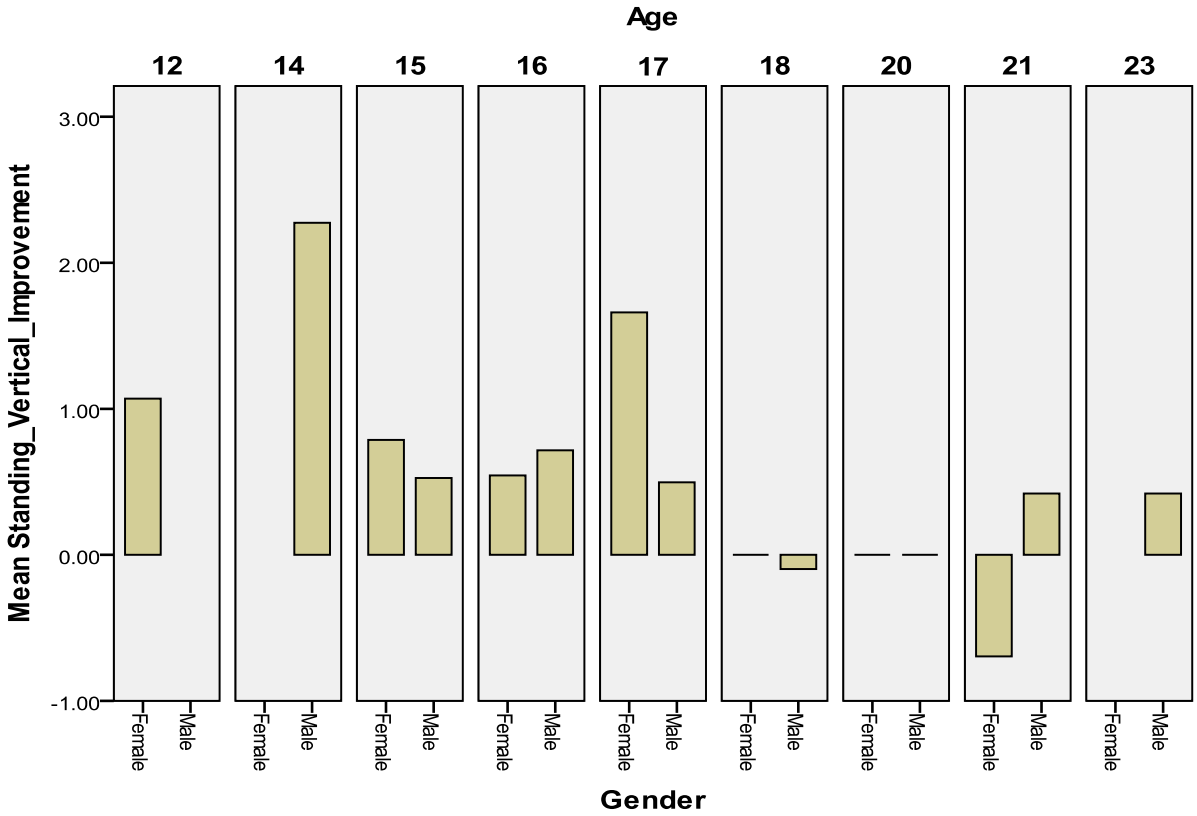

Figure 5 – Average Percentage Improvement Standing Vertical Test after 6 Weeks for Athletes in AMP Summer Program

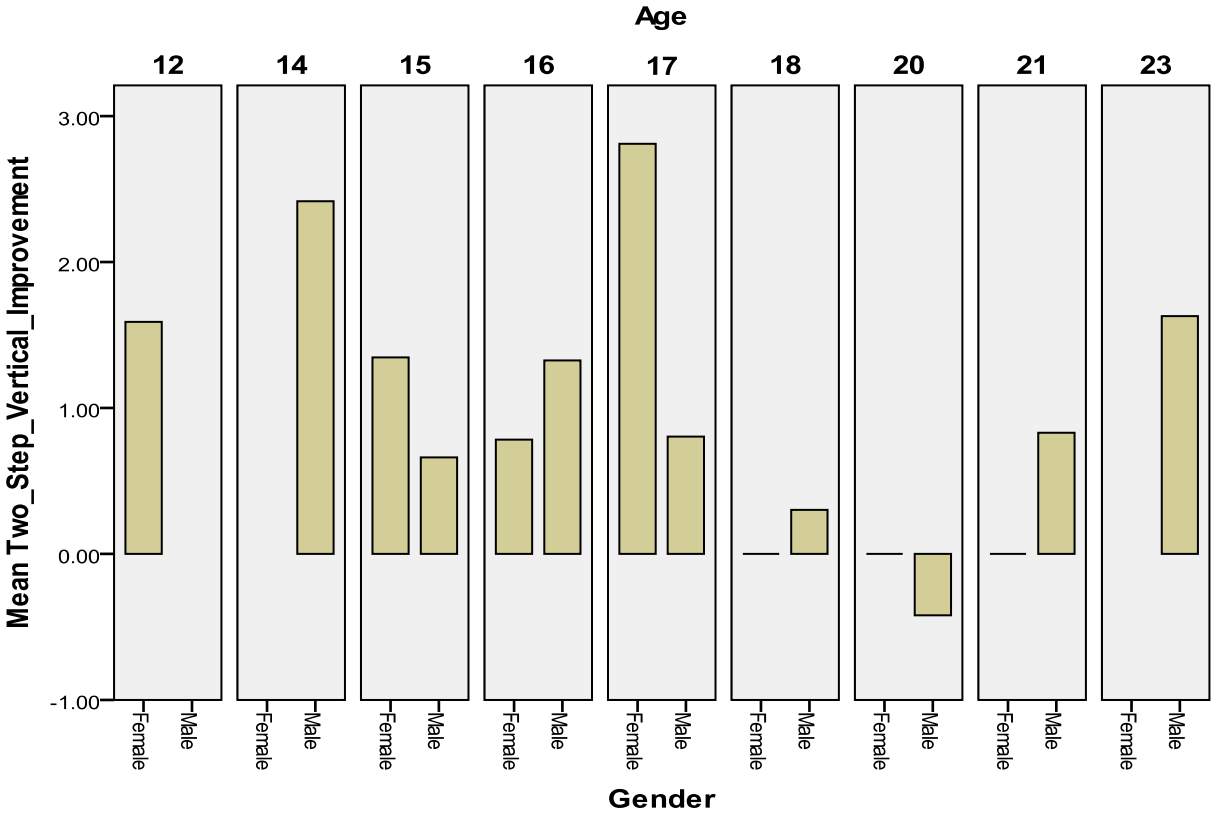

Figure 6 – Average Percentage Improvement in 2-Step Vertical Test after 6 Weeks for Athletes in AMP Summer Program