A Retrospective Analysis of In-Season Conditioning

Author: Daria Volker

Kinesiology and Integrative Physiology – Winter 2018

Dr. Bryant Stamford

Table of Contents

A Retrospective Analysis of In-Season Conditioning

Chapter One

Introduction

Soccer is a game played by two teams of eleven players with a spherical ball that the players kick up and down the field. The field shape is a rectangle with dimensions of 80 by 120 yards and has a goal that stands 8 by 24 feet at both ends of the field. Each goal is surrounded by an 18-yard box, which is the area where the goalie alone is permitted to use his/her hands. The ball may not be touched with the hands or arms during play by the rest of the players on the field. The objective of the game is to score goals by kicking or heading the ball into the opposing goal. It is played by 250 million players in over 200 countries and dependencies, making it the most popular sport in the world.

There are 4 general positions on the field that an individual can play: goalie, defender, midfielder, or forward. Each position has a specific task that contributes to the team objective of winning games. Goalies protect the goal and stop the other team from scoring. They are also responsible for organizing their team and making sure their teammates are doing what they are supposed to be doing. Goalies are confined to their goal box because that is the area where they are permitted to use their hands. Once they step out of the 18-yard box, they are just like every other player on the field and they can no longer use their hands to defend the goal. Defenders are the last line of defense before the ball gets to the goalie. The job of the defense is to stop the offensive attack of the opposing team and distribute the ball to the midfield or forwards once the ball has been won back from the opposing team. Midfielders are the glue of the team, which means that are the link between the defense and the offense. The responsibility of the midfield is to aid in the offensive attack to try to score on the opposing team, as well as aid the defenders when the opposing team is attacking the defensive goal. Midfielders typically have the freedom to run everywhere on the field; they are not confined to a specific segment of the soccer field. Forwards are the attacking line of the team and their job is to score goals. Forwards are also the first line of defense when the ball is lost in the team's offensive third of the field. This means that they are the players that are closest to the opponent with the ball and must immediately put pressure on the opposing team when their own team has lost possession. (9) Generally, the forwards play on the attacking half of the field where they are expected to score goals. Only on rare occasions do they find themselves in the defensive third.

Soccer is a game that requires a lot of knowledge and field experience to be a successful player. However, in addition to knowing the game and making the right decisions with the ball, a player must also be physically fit in order to be most productive. Soccer is fast-paced and demands a great deal of running. The players are constantly moving in all directions: forwards, backwards and laterally. Combining this physical knowledge with the knowledge of the different positions, there can be hypotheses drawn about what makes a player great at their position and why a specific type of physique plays a certain position, which will be discussed later.

In theory, all players on the team (excluding goalies) should have the same level of physical fitness because they all participate in the same activities and running drills at practice. However, to those who have previous soccer experience, it seems that there are general trends of differing types of fitness amongst the distinct positions. For example, it seems that midfielders can constantly run for extended periods of time, but they tend to not be fast sprinters. On the opposite end of the spectrum, defenders tend to be extremely fast, yet they cannot constantly jog for long periods of time without fatiguing quickly.

For this study, the term "fitness" refers to a full test battery (specifically including aerobic capacity, flexibility, body fat percentage, agility, reaction time, sprint speed, power, and distribution of fast and slow twitch muscle fibers) that will measure the athlete's ability to perform well in her sport. Every sport requires different physiological attributes in order for a player to be successful. For example, basketball players must have a large vertical jump and great baseball batters must be able to generate a large amount of power. However, most sports require more than one physiological attribute to be successful. In order for a basketball athlete to be a great player, they must be agile, aerobically fit, anaerobically fit, powerful, and strong all in addition to being able to jump high. In a study done by Nicholas M. Stone and Andrew E. Kilding, it was found that team field sports (such as soccer) require a well-developed level of aerobic fitness. (19) However, when it was compared to other sports such as basketball, it was found that soccer players spend considerably more amount of time performing low intensity movements as opposed to medium intensity movements. In order to get a better understanding of what fitness for soccer players means in this study, each fitness variable will be explained below.

Aerobic capacity is defined as a measure of the ability of the heart and lungs of an exercising individual to get oxygen to the working muscles to be used during the metabolic process. Aerobic capacity can be assessed by measuring maximum VO_2 uptake, which is the measurement of the maximum amount of oxygen that an individual can utilize during intense, or maximal exercise. The higher an individual's VO_2 max is, the more aerobically fit they are. VO_2 max can be improved with training. In a study conducted by Andrew P. Bacon, it was found that the most efficient way to improve VO2 max is interval training (2). Therefore, if a soccer player is looking to improve their aerobic capacity, one of the best ways to do it is to interval train. This is valuable information because it means that a player can be developed and trained to increase their physiological attributes to fit a certain soccer position, which would be midfield in this case. According to a study done by Dr. Christine Mermier, Ph.D., female soccer players from Texas A&M University had VO_2 max scores of 44.87±4.61 ml/kg/min in their post-season fitness testing. (11) This information will be useful while collecting data from the Hanover College Women's soccer players because it will serve as a reference point. The data collected from the women of Texas A&M will be helpful when creating hypotheses about which position on the field should have the highest aerobic capacity, which should most likely be the midfield.

The next variable is flexibility, which is defined as the range of motion of human joints or the ability of the joints to move freely. It also refers to the mobility of the muscles, which allows for more movement around the joints. Just like aerobic capacity, flexibility can be improved with training. In a study conducted by Dan Wallin, it was proven that an athlete can stretch trained three times a week with a modified contract-relax method and improve muscle

flexibility. (23) Flexibility is important for all athletes, regardless of their sport, because of its possible link to injury reduction.

Body fat percentage is a measurement of the amount of fat mass in an individual's body and is important physiological trait for athletes of all sports to be aware of. (12) Body fat is important for some necessary bodily functions (such as reproduction for women) but when individuals accumulate too much excess body fat, it can become a problem. Excess fat in relation to lean body mass can greatly increase an average person's risk of cardiovascular disease, diabetes, atherosclerosis, and much more. For athletes, excess body fat decreases performance in sports that involve a lot of movement and cardiovascular work, especially soccer. The more mass a person has to carry around that isn't contributing to muscular contraction needed to propel the body forward, the slower and less efficient the person will be.

Agility is defined as the ability to move and change direction quickly and easily, which is extremely applicable for soccer. Soccer requires athletes to be able to sprint full speed, decelerate quickly, and change direction constantly. On average, a player will turn 50 times throughout a match with many of those turns occurring in crucial seconds of the game, such as goal scoring opportunities. Agility uses a combination of strength, power and neuromuscular coordination and it takes many hours practice and training to refine the skill. (22)

Reaction time is defined as the ability to respond quickly to a stimulus. It important in many sports because of the importance of reacting quickly to a stimulus on the field. For example, baseball players must have an outstanding reaction time. Batters need to be able to determine when if and when they will swing their bat to hit the ball off of a pitch that is thrown to them. Fielders must also be able to react to the ball once it is hit from the batter because they only have a few seconds to get to the ball and throw it to first base to make the out. In soccer, goalies must have quick reaction times as well because they must be able to block the opponent's shot.

Speed is the ability to move quickly across the ground when running. Soccer is a game that is made up of brief periods of intense activity (such as sprinting) followed by short periods of rest or active recovery. In a study by Marcin Andrzejewski and his colleagues, they conducted research to analyze the sprinting activities of professional soccer players using Amisco Pro, which is a computer system that analyzes player movements while they play a game. The statistical analysis revealed that the average number of straight sprints a player makes in a game was 11.2 plus or minus 5.3, with 90% of those sprints lasting less than 5 seconds. (1) The study also found that the forwards covered the longest sprint distance during a game, which aligns with what the researcher will be hypothesizing. If a player is struggling with speed, it can in fact be improved with training. In order to increase an individual's speed, a combination of sprint, plyometric, and weight lifting will make one faster. Speed is a product of how much power and force an individual can produce. (4) Therefore, by increasing the force of muscular contractions, one can increase their speed.

Power the ability to exert a maximal force in as short a time as possible, as one would see in accelerating, jumping and throwing. (5) Power is not to be confused with strength, which is the maximal force you can apply against a load. Power is proportional to the speed at which a person can apply this maximal force. This becomes relevant in soccer when a player kicks a ball

for a clearance out of the defensive third of the field or when a forward shoots the ball to try to score. The amount of force they can produce in a short amount of time and apply it to the ball is what will determine how far the ball will travel and with what velocity it will travel with. Power can be increased by increasing one's strength with resistance training and plyometric drills.

The last portion of the definition of "fitness" for this study is the distribution of fast and slow twitch muscle fibers. It is generally accepted that muscle fiber types can be broken down into two main groups: slow twitch (Type I) muscle fibers and fast twitch (Type II) muscle fibers. (13) The fast twitch fibers can then be further broken down into Type IIa and Type IIx fibers (13); but for the purpose of this study, the two groups that will be dealt with are the slow twitch and fast twitch only. Slow twitch muscle fibers are aerobic in nature, resistant to fatigue, and generate low amounts of force. On the other hand, fast twitch muscle fibers are anaerobic in nature, are more powerful, but fatigue extremely quickly. (16) Whether or not a person can change their muscle fiber types or distributions is a hot topic for debate right now. Many people believe that an individual's muscle makeup cannot be changed, and that people naturally gravitate towards sports in which their athletic ability matches the physiologic demands. For example, Olympic athletes tend to fall into sports that match their genetic makeup. (25) Olympic sprinters have been shown to possess about 80 percent fast twitch fibers while those who excel in marathons tend to have 80 percent slow twitch fibers. (16)

After discussing all of the physiologic attributes and how they relate to soccer, it is clear to see that hypotheses can be drawn relating soccer position to the different fitness variables. If the hypotheses (discussed below) are proven to be correct, then it would make sense to have the programming for off-season training of the soccer team reflect those findings. The training should vary by position in order to hone and develop physiological attributes needed for each position.

Therefore, this study was conducted to examine if there were significant physical differences between the players of distinct positions on the soccer field. Another question that was answered by this study was the question: does the soccer position make the individual fit in order to fit the position needs? Or do particular individuals play certain positions on the field because of the fitness attributes they already possess?

Statement of Purpose

To determine if soccer position influences:

- Aerobic capacity
- Flexibility
- Body fat percentage
- Agility
- Reaction time
- Sprint speed
- Power
- Distribution of fast-twitch and slow-twitch muscle fibers

Significance of the Study

Professional Significance

This study was conducted to answer the question: does soccer position affect physiologic profile? It is evident that there are varying levels of fitness amongst different sports. For example, a basketball player will most likely be more physically fit than a golfer. What is less noticeable is the differences of fitness amongst players of the same sports team. If the results of the study indicate that there is a significant difference in the physiologic profiles of players of different positions, then the idea that their off-season training should vary comes to mind. Would a basketball player be trained the same way that a cross country skier is trained? Of course not. They do not have the same physiological demands for their sports. Therefore, why would players of the same soccer team, but of different positions, be trained the same way if they have different athletic needs to be successful?

During the winter term, the Hanover College Women's soccer team has off-season conditioning and lifting. In order to truly give the athletes a better edge, they must be participating in training that will benefit them specifically in the field position that they play. The results of this study assisted the trainer and coaches to better understand what each player needs to be doing to prepare for the upcoming soccer season.

Personal Significance

Personal reasons for conducting this study are because I have played soccer my entire life and have had multiple discussions with teammates throughout the years about the different physical demands of positions on the field. I have grown up training at least 3 (usually more) days a week for the sport that I love. While training with the various teams that I have been a part of throughout my life, I have noticed that some training drills seem harder than others. When I thought deeper into it, I noticed that the drills I personally enjoyed more were the drills that pertained specifically to my position. For example, I find possession activities to be the most fun and physically demanding. In a soccer match, I play midfield and my job is to possess and distribute the ball around the field while constantly being in motion. It makes sense that I would find the most enjoyment in a possession activity at practice. On the other hand, teammates who play forward do not find the possession drills as fun because they are constantly having to move and there is no direction in which to score goals. These differences have always stood out to me and I have always wanted to conduct a study to test if my hypotheses about the physiologic profiles was correct. If I can find that there are significant physiologic differences between positions played on the field, then developing a training program for my directed study will be greatly enhanced. Developing a workout regimen that caters to each position would be a more effective method than broadly training everyone on the team the same.

Delimitations

The study was conducted with a total of 13 subjects: 3 forwards, 4 midfielders, 4 defenders, and 2 goalies. The subjects were members of the Hanover College Women's Soccer team and the data was collected within 3 weeks of the fall soccer season ending (the first week immediately following season end was be a rest week to let any nagging injuries and soreness heal). Theoretically, this yielded the best results because the athletes were in the best physical shape for their position after season had concluded. Another reason for conducting the tests in the postseason is to ensure that the athletes were not sore when the tests were conducted, and that testing did not interfere with colligate games. This ensured that the most accurate data was collected.

The independent variable of the study was the soccer position that the test subject played. The dependent variable of the study was the factors that were tested: aerobic capacity, flexibility, body fat percentage, agility, reaction time, sprint speed, power output, and distribution of fast-twitch and slow-twitch muscle fibers.

Aerobic capacity was measured by utilizing the Submaximal Bruce Protocol Treadmill Test. Subjects were required to walk on the treadmill at an incline for 12 minutes.

Flexibility was measured by using a goniometer to measure the degrees of the range of motion in joints of the lower extremity. Measurements were taken of the hip, knee, and ankle joints.

Body fat percentage was measured using the BodPod, which is an Air Displacement Plethysmograph (ADP) that uses whole body densitometry to determine body composition. The device showed how much lean mass a person had in comparison to how much fat mass they had.

Agility of the subjects was measured using the T-Test. The T-test measured the agility of an athlete by requiring the athlete do forward, lateral, and backward movements.

Reaction time was measured using the ruler drop test. Typically, the test is conducted by the subject catching the ruler between digits 1 and 2 of the hand when the ruler is dropped. However, since the soccer utilizes mainly the lower extremity, the test was conducted using the feet instead of the hands to catch the ruler.

Sprint speed was measured using the 40-yard dash test. Each subject sprinted 40 yards as fast as possible while the researcher and an assistant both timed the subject. The average of the two timers was used as the subject's score on the test.

Both the power output and distribution of fast and slow-twitch muscle fibers of the quadriceps and hamstrings were measured using the Humac Norm Cybex Machine. The power output was measured by performing 5 repetitions at a speed of 60 degrees per second with maximum exertion by the subject on all 5 reps. The muscle fiber distribution was measured by performing 50 repetitions at a speed of 180 degrees per second of maximum effort. Once the test had concluded, the researcher took the peak torque scores from the first 3 and the last 3 reps and plugged it into an equation to estimate the percentage of fast-twitch and slow-twitch muscle fibers in both the quadriceps and hamstrings of the right and left legs.

Testing was conducted on 3 days. Day 1 consisted of data being collected for height, weight, body fat percentage, reaction time, flexibility, and estimation of fast twitch and slow twitch muscle fibers. Day 2 consisted of data being collected for agility, sprint speed, and power output. Day 3 was the predictive VO_2 max test on the treadmill. The tests were spaced out enough so that the subject could exert maximum effort on all tests without feeling fatigue.

Limitations

Although the study is controlled, there are some weaknesses that cannot be eradicated. The first problem with the study was the sample size of athletes being tested. There was only 13 total subjects and they were all from the same team. To get more reliable results, many more subjects should be recruited, and they should be randomly picked from colligate teams across the United States. Since the subjects only come from one team, the results of the study will only be able to tell information about that team specifically. Therefore, the results cannot be projected to be true about other colligate women's soccer teams. Another problem with a small sample size is that the results can be skewed easily with an outlier. Very small samples tend to undermine the internal and external validity of a study, but it is all that the researcher can do for the scope of this study. (6)

For both the T-test and 40-yard dash, the researcher and an assistant timed the subjects with stopwatches. The average was then taken of the two stopwatch timers and that score was recorded for the subject. This was done because the technology to have exact timing is not available.

Assumptions

It is assumed that all subjects will give their best effort on all tests. The tests are set up in an order that should allow for maximum effort to be exerted on every test. It is also being assumed that all subjects will follow the pre-test protocol. Failure to do so would skew the results of the testing and therefore render the study inaccurate.

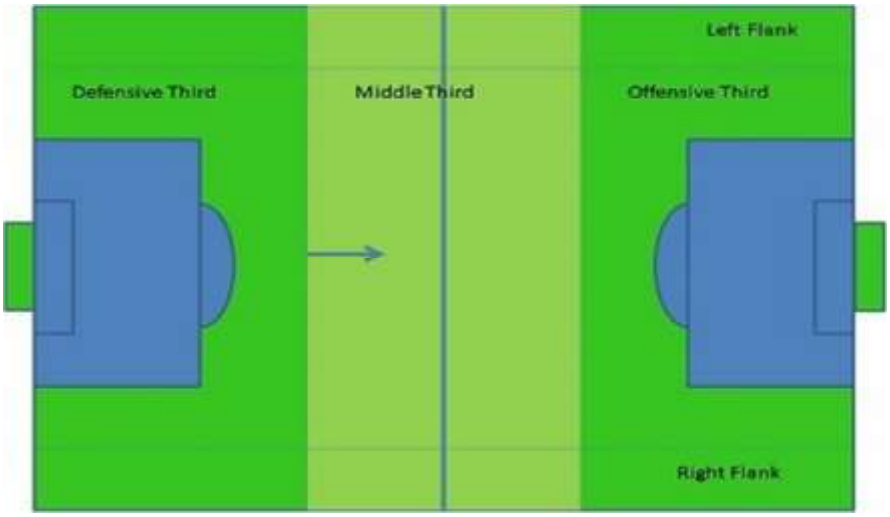
Regarding the testing equipment, all machines used for fitness assessments were tested for reliability by collecting initial pilot data prior to collecting data for the study. It is then assumed that the equipment gave reliable and viable results for the fitness assessments. The researcher explored all possible equipment that could be used in the study and came to the conclusion that the Cybex, BodPod, and a treadmill would be the best machines to utilize. They have been proven to provide the best and quickest results for power output and muscle fiber type distribution, body composition readings, and predicting VO_2 max, respectively.

Hypotheses:

1. Midfielders will demonstrate the highest VO_2max.
2. Goalies will demonstrate the lowest VO_2max.
3. Midfielders will demonstrate the most flexibility.
4. Defenders will demonstrate the least flexibility.
5. Goalies will demonstrate the highest percentage of body fat.
6. Midfielders will demonstrate the lowest percentage of body fat.
7. Midfielders will demonstrate the highest agility.
8. Forwards will demonstrate the lowest agility.
9. Goalies will demonstrate the fastest reaction time.
10. Forwards will demonstrate the slowest reaction time.
11. Defenders will demonstrate the fastest sprint speed.
12. Goalies will demonstrate the slowest sprint speed.
13. Defenders will demonstrate the most power.
14. Midfielders will demonstrate the least power.
15. Midfielders will possess the most slow-twitch muscle fibers.
16. Forwards will possess the most fast-twitch muscle fibers.

Definition of Terms

1. *Offensive Third*: section of the field where the team in possession is shooting on their opponent's goal
2. *Defensive Third*: section of the field where the team is defending their goal against the opponent's offensive attack



3. *Agility*:
    a. Accepted Definition: ability to move quickly and easily
    b. Operational Definition: ability of a player to move side to side quickly and efficiently

4. *Aerobic Capacity/VO_2:* a measure of the ability of the heart and lungs to get oxygen to the muscles
5. *VO_2 Max*: measurement of the maximum amount of oxygen that an individual can utilize during intense, or maximal exercise. Measured in mL/kg/min
6. *Flexibility*
    a. Accepted Definition: range of motion of joints or the ability of the joints to move freely. It also refers to the mobility of muscles, which allows for more movement around the joints
    b. Operational Definition: range of motion measured by goniometer of the hip, knee, and ankle joints
7. *Body Composition*: describes the percentages of fat, bone, water and muscle in the human body
8. *Body Fat Percentage (BFP)*: the total mass of fat divided by total body mass; body fat includes essential body fat and storage body fat. Essential body fat is necessary to maintain life and reproductive functions.
9. *Percent Lean Mass*: total mass of bone, muscle, and other non-fat entities in the human body divided by the total body mass
10. *Strength*: the ability to carry out work against a resistance. It is the maximal force that can be applied against a load
11. *Power*: the ability to exert a maximal force in as short a time as possible, as in accelerating, jumping and throwing implements. Power is proportional to the speed at which maximal force can be applied
12. *Speed*
    a. Accepted Definition: the rate at which someone or something is able to move or operate
    b. Operational Definition: for this study, speed will refer to straight sprint speed of an individual and their score on the 40-yard dash
13. *Fast Twitch Muscle Fibers:* Anaerobic. Types of muscle fibers that produce a lot of force, but fatigue very quickly.
14. *Slow Twitch Muscle Fibers:* Aerobic. Types of muscle fibers that produce weaker contractions, but for extended periods of time without fatigue due to high mitochondrial content

Chapter Two

Background Research and Related Literature

Part I: Background Research

Introduction

A large portion of this study deals with the aerobic and anaerobic metabolic pathways, which includes the phosphocreatine system, glycolysis, Krebs cycle, and electron transport chain. These three energy systems work together to ensure that there is a constant supply of energy (in the form of ATP) for the activities that are performed throughout the day. Cell metabolism lays the foundation for many of the fitness attributes that will be tested in this study. Cell metabolism can be expanded into fast and slow twitch muscle fibers, which can be turned into strength and power, and from there, speed can be brought into the picture. These are the topics that will be discussed in the background section.

Cell Metabolism

The first energy system to be discussed is the phosphocreatine system, also known as the creatine phosphate system. This system is anaerobic, which means that it does not require oxygen to create ATP (Adenosine Triphosphate). This energy system provides immediate energy through the breakdown of high-energy phosphates that are stored in the muscles. If this energy system is 'fully stocked' it will provide energy for maximal intensity, short duration exercise for between 10-15 seconds before it fatigues (15). This system is typically used most often in sports such as track field events (ex: shotput, discus, long jump, etc.). However, the PC system is used in all exercise, regardless of the intensity, as the initial energy source for activity. It is only the primary source of energy for high intensity sports, such as field events. (15)

The next metabolic system is glycolysis, which is also anaerobic and does not require oxygen. Glycolysis takes place in the cytoplasm inside the cell. The process starts with a glucose molecule and transforms it into 2 pyruvate molecules while giving off 2 ATP molecules. (8) This is where anaerobic respiration ends. It yields only 2 ATP, but the ATP can be produced extremely fast. This concept will be useful later in the study when analyzing the difference between fast and slow twitch muscle fibers in athletes. Once the 2 pyruvate molecules have been produces from glycolysis, they would then be transported to the Krebs cycle inside the mitochondria if oxygen is available. (8) If oxygen is not available, then they would be sent into the lactic acid cycle. The lactic acid cycle will not be discussed for the purposes of this study

If oxygen is available, then 2 pyruvate molecules are then transported to the Krebs cycle and converted into acetyl coenzyme A (acetyl CoA). The Krebs cycle takes place inside the matrix of the mitochondria, which is the middle of the mitochondria. This cycle yields a net gain

of 2 ATP per glucose molecule. (13) Although the Krebs cycle doesn't provide much energy, it does yield several molecules of NADH and $FADH_2$, which are two molecules will be the needed in the third step of aerobic respiration. The third step (electron transport chain) produces the majority of the ATPs made during cellular respiration.

The final stage of aerobic metabolism is the electron transport chain, which takes place in the inner mitochondrial membrane. This is also the step where oxygen finally comes into play and what makes this pathway the "aerobic" pathway. The NADH and $FADH_2$, which are made during the Krebs cycle, initiate the electron transport chain. These two molecules transport electrons down through a chain of reactions by converting ADP to ATP. In this process, the NADH loses its hydrogen and creates a hydrogen concentration gradient across the inner membrane of the mitochondria. The NADH is then turned into NAD^+, which is then recycled and reused again in glycolysis. The free hydrogen is then combined with oxygen molecules at the end of the chain to make water. (14) The entire electron transport chain yields about 32-34 ATP molecules, which puts the grand total for aerobic respiration at 36-38 ATP per one glucose molecule. (13) (14)

Summary

The body depends on the metabolic systems to produce and provide energy to power all of the systems that are necessary to sustain life. Without ATP, the body would have no fuel source to keep important processes, such as breathing and organ function, going. Together, aerobic and anaerobic metabolism produce enough energy to meet the demands of the human body. The concept of anaerobic and aerobic metabolism is related to the study because athletes use the different systems to perform their sport activities. Metabolism is especially important for soccer players because of the different aerobic and anaerobic demands from each position on the field. This all becomes more pertinent when it is related to muscles and the fiber types.

Muscle Fiber Anatomy

Muscles are responsible for the movement of the human body. There are about 700 named muscles and they make up roughly half of a person's body weight. Each of these muscles is an individual organ made up of skeletal muscle tissue, blood vessels, tendons, and nerves. For the purpose of this study, the aspect that will be focused on is the skeletal muscle tissue and the types of muscle fibers that make up that tissue.

Before explaining the types of muscle fibers, the anatomy of skeletal muscles must first be discussed. Skeletal muscles consist of multiple layers of soft tissue bound by connective tissue. The connective tissue attaches skeletal muscle to the bones of the skeleton and transmits the force of a contraction to the moving part of the body. The multiple layers of connective tissue also ensure that the force of the muscular contractions doesn't rip apart the body. (13) The outermost layer of connective tissue is called the epimysium and it encompasses fascicles. Fascicles are made up of skeletal muscle fibers that are surrounded by the perimysium

connective tissue layer. Finally, each skeletal muscle fiber is made up of myofibrils (or single muscle cells) that are surrounded by the endomysium connective tissue layer. (13) Each muscle cell has multiple nuclei and mitochondria. The number of mitochondria are what gives a muscle fiber its characteristics of either fast or slow twitch, which will be discussed next.

Muscle Fiber Types

There are 2 main classes of skeletal muscle fibers: slow-twitch (Type 1) and fast-twitch (Type 2). The fast-twitch class can then be broken down further into fast-twitch fibers (Type 2x) and intermediate-twitch fibers (Type 2a). The fibers are divided up based on their biochemical and contractile properties.

Type 1 fibers are the aerobic muscle fibers in humans because they contain large numbers of mitochondria, which is where aerobic respiration takes place. These fibers are also extremely efficient. At any given work rate, the slow-twitch fibers will require less energy to get the job done. These fibers also have a high resistance to fatigue and are surrounded by more capillaries than the fast-twitch fibers. However, slow-twitch fibers do not produce as much force as the fast-twitch fibers because they have a slower shortening velocity and have less actin and myosin cross-sectional area. (13) (16) These fibers are most useful in sports that require a lot of endurance work, such as marathons and cross-country skiing.

The next fiber type are the Type 2 fibers. The first type is the Type 2x fibers, which are also known as the fast-twitch fibers. These fibers have a small number of mitochondria and a lower resistance to fatigue than slow-twitch fibers. (16) However, they contain more glycolytic enzymes than slow-twitch fibers which gives them a higher capacity for anaerobic metabolism. These fibers also generate the highest power output of all the fiber types. These fibers are most helpful in power sports or events such as sprinting or shotput. Type 2a fibers are considered to be the intermediate fibers because they have properties of both fast and slow-twitch fibers. (13) Intermediate fibers will not be focused on for this study.

Whether or not a person can change their muscle fiber types or distributions is a hot topic for debate right now. Many people believe that an individual's muscle makeup cannot be changed, and that people naturally gravitate towards sports in which their athletic ability matches the physiologic demands. For example, Olympic athletes tend to fall into sports that match their genetic makeup. Olympic sprinters have been shown to possess about 80 percent fast twitch fibers while those who excel in marathons tend to have 80 percent slow twitch fibers (16).

Summary

The concept of muscle fiber anatomy and how that affects the muscle fiber type becomes important when training athletes. This can all be related back to the idea of soccer players of different positions potentially having different muscle fiber type distributions. (24) If the midfielders constantly run for longer periods of time than the other positions, then it is possible that they would have more slow twitch muscle fibers than the other positions. This concept will be tested in this study.

Power and Strength

Power is one of the fitness attributes that will be tested in this study. Power is defined as the ability to exert a maximal force in as short a time as possible, as one would see in accelerating, jumping and throwing. (21) (5) Power is proportional to the speed at which a person can apply maximal force. Coordination is another aspect that must be factored into power. The more efficient an individual is at performing a task, the faster and more forceful they can be.

Strength is defined as the amount of force a muscle, or group of muscles, can exert against an external load. (21) (5) An individual can increase their strength in two different ways: increasing the amount of motor units recruited or increasing the number of motor units. A motor unit is defined as one motor neuron and all of the muscle fibers it stimulates. Therefore, motor unit recruitment refers to the activation of additional motor units to accomplish an increase in contractile strength in a muscle. This is usually the first step in gaining strength. Once the maximum number of motor units are recruited, that is when an individual begins to create more muscle fibers to gain strength. (21) In order to accomplish either way of gaining strength, one must test their muscular limits. The body will never grow and adapt if it is not pushed to do something it could not do before. An example of this would be lifting weights and increasing the weight or number of repetitions every week.

Power relates to the study because the power output of the quadricep muscles will be measured in the study using the Cybex machine. A soccer player must have a powerful kick to be successful, whether that be a forward shooting on goal or a defender clearing the ball out of their defensive end of the field. It is an important quality to possess for all players.

Speed

Speed is a scalar quantity and is defined as the rate at which an object covers a defined distance. (4) The faster a person can sprint set distance, the better their overall speed is. Therefore, if a person can increase the rate of their muscular contractions, that would in turn increase their force, which would then increase their speed at which they move their muscles (ex: legs). Therefore, by increasing the force of muscular contractions, one can increase their speed.

Summary

Strength, power, and speed are all interrelated. To increase one's overall speed, they must increase the rate at which they move their legs. In order to do this, one must increase the rate at which the muscle fibers contract to move the leg faster. To increase the rate of muscle fiber contractions, they must increase the force at which the fibers contract. Therefore, by increasing the muscular contraction force, you can increase the overall sprint speed of an individual.

Part I Overall Summary

ATP is the energy currency of the body and it is used for every process needed to sustain life. As the body begins to move and exercise, the demand for ATP increases and the metabolic systems come into the picture to produce the needed energy.

The first system that is utilized is the anaerobic phosphocreatine system, which provides quick energy for a short period of time. If the energy demand is greater than what the phosphocreatine system can provide, then energy is produced through glycolysis in the cytosol of the cell. From there, the pyruvate that is formed during glycolysis either goes to the aerobic Krebs cycle or to the anaerobic lactic acid cycle. For aerobic respiration, the pyruvate is brought into the mitochondria and converted to acetyl CoA. From there, it is ran through the Krebs cycle to form NADH+, which is sent to the electron transport chain to produce approximately 36-38 ATP for the body to use.

The number of mitochondria in a muscle cell is one of the main determining factors of what type of muscle fiber it is. There are 3 main types of muscle fibers: Type I, Type IIa, and Type IIx, which stand for slow-twitch, intermediate-twitch, and fast-twitch, respectively. these fiber types are a large determining factor of how an athlete will perform in a sport. Developing the fiber types that the individual has will lead to success in athletics.

Fiber types lead into strength, which in turn determines the amount of power one can generate. Power can then be developed into the overall sprint speed of an athlete. All of attributes are connected to one another. For example, if an athlete is found to have predominately slow-twitch muscle fibers, it can be projected that they will have a low power output because slow-twitch muscle fibers do not produce a lot of force. If the athlete has a low power output, they will most likely not have a fast sprint speed because power is part of the equation to determine sprint speed. Therefore, by measuring a few of the basic fitness levels of the soccer athletes for this study, it should give a general idea of how each player will perform on subsequent fitness tests in the study.

Part II: Related Literature

Introduction

In this section, each hypothesis was reviewed either supported or refuted with research studies. A brief overview was provided for each study. The subsequent paragraph will then explain how it related to each hypothesis and why it is important to the study.

Hypotheses: Aerobic Capacity

- Hypothesis #1: Midfielders will demonstrate the highest VO_2 max.
- Hypothesis #2: Goalies will demonstrate the lowest VO_2 max.

Supportive Research

1. Stone, Nicholas M., and Andrew E. Kilding. "Aerobic Conditioning for Team Sport Athletes." *Sports Medicine*, vol. 39, no. 8, 2009, pp. 615–642., doi:10.2165/00007256-200939080-00002.

There are many different training methods that have been proven effective to improve one's VO_2 max. Within this reference, the researcher conducted a meta-analysis of many different training programs that utilize various techniques to improve athlete's aerobic capacity. The researcher categorized the training programs and studies into 3 sections: traditional, classic, and sport-specific. What they found was that sport-specific training to improve VO_2 max was the most effective method.

2. Walker, Scott, and Turner, Anthony,M.Sc, C.S.C.S. "A One-Day Field Test Battery for the Assessment of Aerobic Capacity, Anaerobic Capacity, Speed, and Agility of Soccer Players." *Strength and Conditioning Journal*, vol. 31, no. 6, 2009, pp. 52-60, *Physical Education Index*

In this study, the researchers were explaining the uses and benefits of conducting one-day field test batteries for soccer players. The test battery included tests for aerobic capacity, anaerobic capacity, speed, and agility of soccer players. The importance of this study is in its practicality. It is very difficult logistically to get one athlete to a proper physiological testing laboratory and next to impossible to get the entire team. Therefore, the researchers felt the need to come up with a well-rounded test battery that will help them to assess each player's physical fitness. What they found was that sports-specific field tests are better suited, compared with laboratory tests, for these goals because of the simplicity and lack of equipment, making them popular with both coaches and players.

3. Dabney, Upton, and Butler, Mike. "*The Predictive Ability of the YMCA Test and Bruce Test for triathletes with Different Training Backgrounds.*" Emporia State Research Studies, Vol. 43, no. 1, pp. 38-44. (2006)

The purpose of this study was to examine the predictive ability of two max VO_2 tests (the YMCA Cycle Test and the Bruce Protocol Treadmill Test) and to examine the effect of different training backgrounds of triathletes (emphasizing either cycling, running, or swimming) on the predictive ability of the tests. For the study, 14 triathletes (ages 19 to 41) with training backgrounds in one of three triathlon areas participated. Training background was defined as having significant competitive history in either swimming, cycling, or running. The results indicated that both tests underestimate max VO_2 by about 14% and that there is a specificity effect. This means that cyclists got better predictions from the cycling test (YMCA) and runners got better predictions from the treadmill test (Bruce).

Summary

All three research studies support hypotheses 1 and 2 because they stress the importance of VO_2 for soccer players. Each study went into detail on how it can be evaluated for soccer players and what was the best way to increase aerobic capacity. Task specificity is a large factor that needs to be addressed when selecting tests to implement in the test battery. By using all of this information, the researcher made educated hypotheses on what position would have the highest aerobic capacity and what position would have the lowest.

Hypotheses: Flexibility and Body Fat Percentage

- Hypothesis #3: Midfielders will demonstrate the most flexibility.
- Hypothesis #4: Defenders will demonstrate the least flexibility.
- Hypothesis #5: Goalies will demonstrate the highest percentage of body fat.
- Hypothesis #6: Midfielders will demonstrate the lowest percentage of body fat.

Supportive Research

1. Nikolaidis, Pantelis T. "Physical Fitness in Female Soccer Players by Player Position: A Focus on Anaerobic Power." National and Kapodistrian University of Athens, Athens, July 2014.

In the study listed above, the researchers examined the relationship between player position and physical fitness, with an emphasis on anaerobic power, anthropometric characteristics, body composition, and somatotype. There were 54 subjects for the study and they were split up amongst 4 different groups based on the position they play: forwards, midfielders, defenders, and

goalies. The subjects completed a series of tests including BMI, sit-and-reach test, physical working capacity at a heart rate (HR) of 170 bpm (PWC170) on the cycle ergometer, force-velocity test, Wingate anaerobic test, and isometric muscular contraction tests. What they found was that there were differences between player positions in; body composition (highest body fat percentage in goalkeepers) and flexibility (lowest score in goalkeepers).

This study helped the researcher make educated guesses on what positions would have the most and least flexibility, as well as what positions would have the highest and lowest body fat percentages. It supports hypotheses 3, 4, 5, and 6 because it goes into detail on the importance of flexibility and body fat percentages for athletes. With this information combined with the researcher's knowledge of soccer, the researcher hypothesized which position would have the highest and lowest values for the two variables. In addition, it also proved that the researcher did not want to utilize the sit-and-reach test because it is only reliable when comparing an individual's data to themselves. It is not applicable to compare data from different individuals on that test because factors such as limb length can skew the data. This influenced the researcher to find an alternative way of measuring flexibility of the athletes.

Hypotheses: Agility and Sprint Speed

- Hypothesis #7: Midfielders will demonstrate the highest agility.
- Hypothesis #8: Forwards will demonstrate the lowest agility.
- Hypothesis #11: Defenders will demonstrate the fastest sprint speed.
- Hypothesis #12: Goalies will demonstrate the slowest sprint speed.

Supportive Research

1. Walker, Scott, and Turner, Anthony,M.Sc, C.S.C.S. "A One-Day Field Test Battery for the Assessment of Aerobic Capacity, Anaerobic Capacity, Speed, and Agility of Soccer Players." *Strength and Conditioning Journal*, vol. 31, no. 6, 2009, pp. 52-60, *Physical Education Index*

In this study, the researchers were explaining the uses and benefits of conducting one-day field test batteries for soccer players. The test battery included tests for aerobic capacity, anaerobic capacity, speed, and agility of soccer players. The importance of this study is in its practicality. It is very difficult logistically to get one athlete to a proper physiological testing laboratory and next to impossible to get the entire team. Therefore, the researchers felt the need to come up with a well-rounded test battery that will help them to assess each player's physical fitness. What they found was that sports-specific field tests are better suited, compared with laboratory tests, for these goals because of the simplicity and lack of equipment, making them popular with both coaches and players.

This relates to my study because of the concept of simplicity in administering these tests. The idea for the T-Test came from this study and the importance of testing agility for soccer athletes was proven by this study. Rapid activity often occurs in crucial seconds of the game and can be the difference between scoring and conceding a goal. With this fact being known, it is important that the athlete be able to move as quickly as possible in those crucial moments of the game, which is why agility is such an important factor to be considered.

Hypotheses: Reaction Time

- Hypothesis #9: Goalies will demonstrate the fastest reaction time.
- Hypothesis #10: Forwards will demonstrate the slowest reaction time.

Refuting Research

1. Klicka, John, et al. "VIDEO GAMES FOR THE IMPROVEMENT OF REACTION TIME AND HAND EYE COORDINATION IN COLLEGE FOOTBALL PLAYERS." *Journal of Undergraduate Kinesiology Research*, vol. 2, Dec. 2006, file:///C:/Users/Valued%20Customer/Downloads/kins474klickaetal.fall2006.pdf.

The purpose of the study was to see if action video games could improve hand-eye coordination and reaction time in collegiate football players. There were 16 subjects in the study and half of them participated in playing videogames for a week while the other half did not. All subjects participated in 3 tests at the beginning and end of the study. The three tests included: Ruler-drop test, pop can test, and the online reaction test. The results of the study showed that there was no significant evidence for improved reaction time and hand-eye coordination with video game playing. However, the researchers cited previous studies that had shown slight improvements in hand-eye coordination and reaction time by playing video games in other studies. Therefore, it was concluded that there is still potential for improvement, but the study would need to be conducted for longer than a week.

This study was useful in developing the test protocol for hypotheses 9 and 10. In the study, the tests that were conducted were utilizing the hands, which was specific to football because the hands are the primary body part that are used in the game. Soccer players primarily use their feet; therefore, the researcher used the principle of task specificity to adjust the ruler drop test to measure the primary lower extremity muscle groups. This gave the best results to test soccer players for hypotheses 9 and 10.

Hypotheses: Power Output

- Hypothesis #13: Defenders will demonstrate the most power.
- Hypothesis #14: Midfielders will demonstrate the least power.

Refuting Research

1. Nikolaidis, Pantelis T. "Physical Fitness in Female Soccer Players by Player Position: A Focus on Anaerobic Power." National and Kapodistrian University of Athens, Athens, July 2014.

In the study listed above, the researchers examined the relationship between player position and physical fitness, with an emphasis on anaerobic power, anthropometric characteristics, body composition, and somatotype. Due to the physiological demands of match play, which includes many high-intensity activities of short duration (e.g. shooting, passing, sprinting, jumping), anaerobic power is important for soccer performance. There were 54 subjects for the study and they were split up amongst 4 different groups based on the position they play: forwards, midfielders, defenders, and goalies. The subjects completed a series of tests including BMI, sit-and-reach test, physical working capacity at a heart rate (HR) of 170 bpm (PWC170) on the cycle ergometer, force-velocity test, Wingate anaerobic test, and isometric muscular contraction tests. What they found was that there were no significant differences between the groups for anaerobic power. However, the findings might be used as reference data by coaches and trainers to identify talent, select players, and monitor training.

This relates to the study being conducted because it highlighted the importance of task specificity when conducting tests. For example, Nikolaidis utilized all cycle ergometer protocols to test the anaerobic power of the soccer athletes. Soccer is a sport that involves high amounts of running, not cycling. Cycling does not require the subject to support their entire body weight whereas running on a treadmill does. Therefore, the data in the study could be skewed if the researcher does not choose the tests carefully.

Hypotheses: Distribution of Fast-Twitch and Slow-Twitch Muscle Fibers

- Hypothesis #15: Midfielders will possess the most slow-twitch muscle fibers.
- Hypothesis #16: Forwards will possess the most fast-twitch muscle fibers.

Supportive Research

The study was conducted to see if the muscle fiber compositions of athletes from different sports reflected the physiologic demands of their sport. What they found was that athletes of endurance sports had predominately slow-twitch muscle fibers while athletes of power sports had predominately fast-twitch muscle fibers. From this data, the belief that muscle fiber type can predict athletic success gained more credibility.

From this study, the researcher could predict which position would have the most fast-twitch muscle fibers and which position would have the most slow-twitch muscle fibers based on the aerobic demands of the different positions. It is predicted that midfielders will possess the most slow-twitch muscle fibers because of how much they are constantly running during games. The same thought process can be applied for the other positions as well: the other 3 positions should be predominately fast-twitch because their positions require more speed/power rather than endurance running.

Part II Overall Summary

Research showed a vast majority in support of each hypothesis, especially surrounding the topic of aerobic capacity. 3 articles proved how important VO_2 max was in determining an athlete's fitness and helped shape the hypotheses on which position would have the highest and lowest values. Two of the most pertinent research studies found were directly aligned with the study I conducted.

The first one was the study done by Nikolaidis titled "Physical Fitness in Female Soccer Players by Player Position: A Focus on Anaerobic Power." was an extremely useful research study. The study that he and his coworkers conducted aligned greatly with the goals of my study. For example, the 4 positions that were used in his study were the same positions that were used in my study. Therefore, the data I collected could be compared with the data in which he collected. He also gave very useful information in regard to testing battery for flexibility, body fat percentage, and power output, which was utilized in the early stages of mapping out this study.

The second important study found was the study conducted by Scott Walker titled "A One-Day Field Test Battery for the Assessment of Aerobic Capacity, Anaerobic Capacity, Speed, and Agility of Soccer Players." Just like the study conducted by Nikolaidis, this study gave reliable test battery ideas for the testing of this study.

The present study aims to add information to the question of whether differences in physical fitness exists between positions.

Chapter Three

Methodology

Protocol

The study was conducted with a total of 13 subjects: 3 forwards, 4 midfielders, 4 defenders and 2 goalies. The subjects are members of the Hanover College Women's Soccer team and the data was collected within 3 weeks of the fall soccer season ending. Theoretically, this yielded the best results because the athletes were in the best physical shape for their position after season had concluded. Another reason for conducting the tests in the postseason was to ensure that the athletes were not sore when the tests were conducted, and that testing did not interfere with colligate games. This made sure that the most accurate data was collected.

Testing was conducted on 3 days. Day 1 consisted of data being collected for height, weight, body fat percentage, reaction time, flexibility, and estimation of fast twitch and slow twitch muscle fibers. Day 2 consisted of data being collected for agility, sprint speed, and power output. Day 3 consisted solely of the Submaximal Bruce Protocol Treadmill Test to predict the VO_2 max of the subjects. Tests were spaced out enough so that the subject could exert maximum effort on all tests without feeling fatigued.

Procedures

The independent variable of the study was the soccer position that the test subject plays. The dependent variable of the study were the factors being tested: aerobic capacity, flexibility, body fat percentage, agility, reaction time, sprint speed, power output, and distribution of fast-twitch and slow-twitch muscle fibers.

Aerobic capacity was measured by utilizing the Submaximal Bruce Protocol Treadmill Test to predict VO_2 max. All subjects completed 3 levels (3 minutes per level or until subject reaches steady state heartrate. Estimated 9 minutes total) of differing workloads:

1. 1.7 mph at 10% grade
2. 2.5 mph at 12% grade
3. 3.4 mph at 14% grade

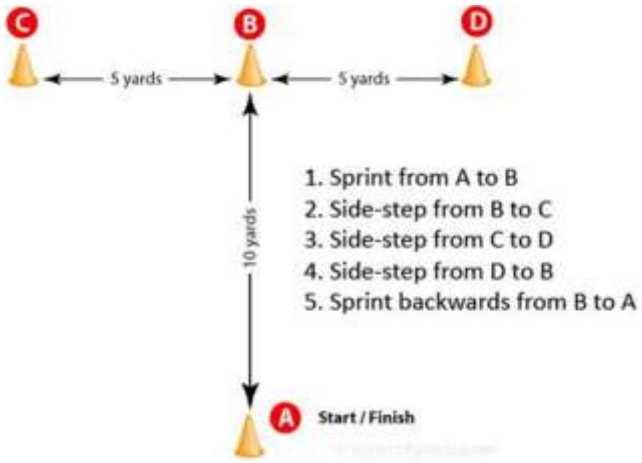
The heartrates were then put into the ACSM metabolic equation for walking to determine the gross VO_2 max. The equation is: VO_2 ($mL * kg^{-1} * min^{-1}$) = (0.1 * S) + (1.8 * S * G) + 3.5 $mL* kg^{-1}*min^{-1}$.

Flexibility was determined using a goniometer to measure the range of motions in the lower extremity joints. Measurements were taken of the hip, knee, and ankle joints. The best score was the score that was used for analysis.

Body fat percentage was measured using the BodPod, which is an Air Displacement Plethysmograph (ADP) that uses whole body densitometry to determine body composition. The device showed how much lean mass a person has compared to how much fat mass they have.

This test was conducted because body fat percentage is important to most athletes. The more lean-body mass a subject has, the faster/stronger the subject is in their respective sport.

Agility of the subjects was measured using the T-Test. The T-Test measured the agility of an athlete by requiring the athlete to move forwards, backwards, and laterally. The researcher set up cones in the formation of a T. The researcher and an assistant both timed the subject as the subject completed the test and the average of the two times was recorded as their score. The best score was the score that was used for analysis.



Reaction time was measured using the ruler drop test. Typically, the test is conducted by the subject catching the ruler between digits 1 and 2 of the hand when the ruler is dropped. However, since the soccer utilizes mainly the lower extremity, the test was conducted using the feet instead of the hands to catch the ruler. This will involve larger muscle groups including (quadriceps, sartorius, hip adductor muscles, etc.), which are all muscles that are heavily used when playing soccer. There is no normative data on this type of variation of the test, but it is not needed since the data is going to be compared amongst the 13 test subjects only. To make sure that all subjects have their feet the exact same distance apart, they put their feet on the outside of the researcher's fingers, which was exactly 3 inches apart. There were 3 trials and the median score was the score that was used for analysis.

Sprint speed was measured using the 40-yard dash test. Each subject sprinted 40 yards as fast as possible while the researcher and an assistant both timed the subject. The average of the two timers was used as the subject's score on the test. The best score was the score that was used for analysis.

Power output was measured by utilizing the Humac Norm Cybex Machine. The Cybex machine is a machine that isolates joints and uses isokinetic exercise as the most efficient way to measure maximum output of a joint. The joint that was in use was the knee, which utilized the quadricep and hamstring muscles to extend and flex the knee, respectively. The test that was performed included 5 repetitions at a speed of 60 degrees per second with maximum exertion by the subject on all 5 reps.

The distribution of fast-twitch and slow-twitch muscle fibers was measured by the Humac Norm Cybex Machine as well. The test that was utilized consisted of the subject performing 50 repetitions at a speed of 180 degrees per second of maximum effort. Once the test had concluded, the researcher took the peak torque scores from the first 3 and the last 3 reps and plugged it into an equation to estimate the percentage of fast-twitch and slow-twitch muscle fibers in both the quadriceps and hamstrings of the right and left legs.

Chapter 4

Results and Discussion

Aerobic Capacity

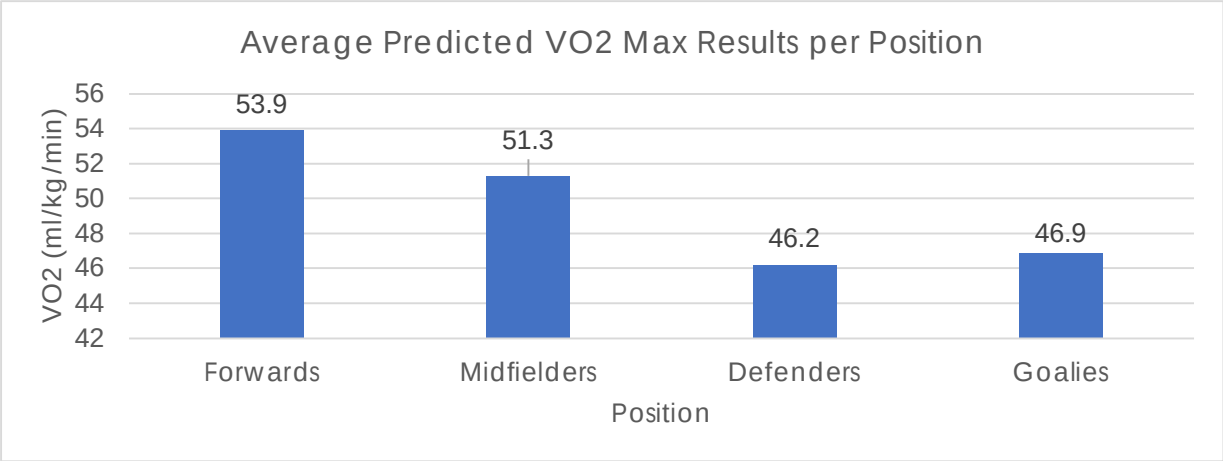


Figure 1. The average predicted VO_2 max scores for each position from the Submaximal Bruce Protocol Treadmill Test.

The graph indicates that the forwards had the highest predicted VO_2 max with an average value of 53.9 ml/kg/min, which came as a surprise to the researcher. It was hypothesized before the experiment that the midfielders would have the highest VO_2 max because their position requires them to constantly be moving since they are involved in both offensive and defensive plays on the field. The data showed that midfielders had the second highest VO_2 max out of the 4 positions with an average value of 51.3 ml/kg/min. The lowest scores were the defenders with an average value of 46.2 ml/kg/min, which was also not expected. The range of the data was from 46.2 ml/kg/min to 53.9 ml/kg/min.

Related Hypotheses:

- Hypotheses #1: Midfielders will demonstrate the highest VO_2max → Rejected
- Hypotheses #2: Goalies will demonstrate the lowest VO_2max → Rejected

It was hypothesized that Midfielders would have the highest VO_2 because of the amount of constant movement their position requires. It is possible that if anaerobic threshold were to have been assessed, then the Midfielders would have scored higher than the Forwards because of their ability to pace themselves and run constantly at a higher speed without burning out as quickly. Forwards likely scored the highest on this test because of the number of sprints they have to make during a game. They are not moving as constantly as Midfielders, but they do move substantially more than the Defenders and Goalies. Defenders and Goalies had the lowest VO_2 max scores, with Defenders being at the bottom of the list. These two positions run the least during games, therefore their aerobic capacity was not as developed as the Forwards and Midfielders.

Flexibility

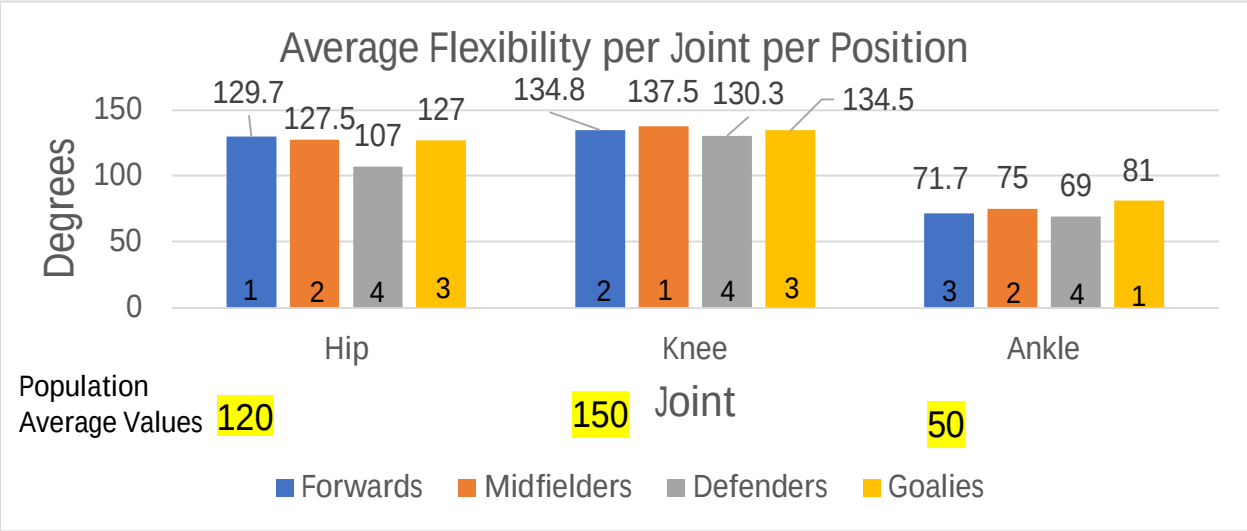


Figure 2. The average goniometer measurements for the hip, knee, and ankle joints for each position. 1-4 are the rankings from most to least flexible, with 1 being the best.

The graph above shows the average flexibility for 3 different joints of the lower extremity (hip, knee, and ankle). The position with the highest average flexibility for the hip joint (hip flexion) was the forwards with a result of 129.7 degrees of motion for hip flexion. The lowest scoring group was the defenders with a score of 107 degrees. For the knee joint in knee flexion, the midfielders had the highest range of motion (137.5) and the defenders had the lowest (130.3). For the ankle joint in plantar flexion, the goalies had the highest range of motion (81) and the defenders had the lowest (69). Overall flexibility was determined by ranking the positions 1 through 4 based on their scores. The position that had the highest total ranking score is the position that was deemed most flexible. The most flexible position were the midfielders with rankings of 2, 1, and 2 for the hip, knee, and ankle joints, respectively. The least flexible position were the defenders with rankings of 4 for all 3 joints. The population average values are provided below the graph.

Related Hypotheses:

- Hypotheses #3: Midfielders will demonstrate the most flexibility → Accepted
- Hypotheses #4: Defenders will demonstrate the least flexibility → Accepted

Midfielders demonstrated the greatest overall flexibility, which agreed with the original hypothesis. When comparing the data with accepted/average ROM scores, it was found that both hip and ankle scores were higher than the average, while knee scores were significantly lower than average. The higher hip and ankle ROMs are likely due to the kicking motion that soccer players perform regularly. To kick a ball, players must extend and flex the hip throughout the motion while also locking their ankle in plantar flexion. The lower than average knee ROM scores is likely due to the anatomical development of the calf and hamstring muscles of the players.

Body Fat Percentage

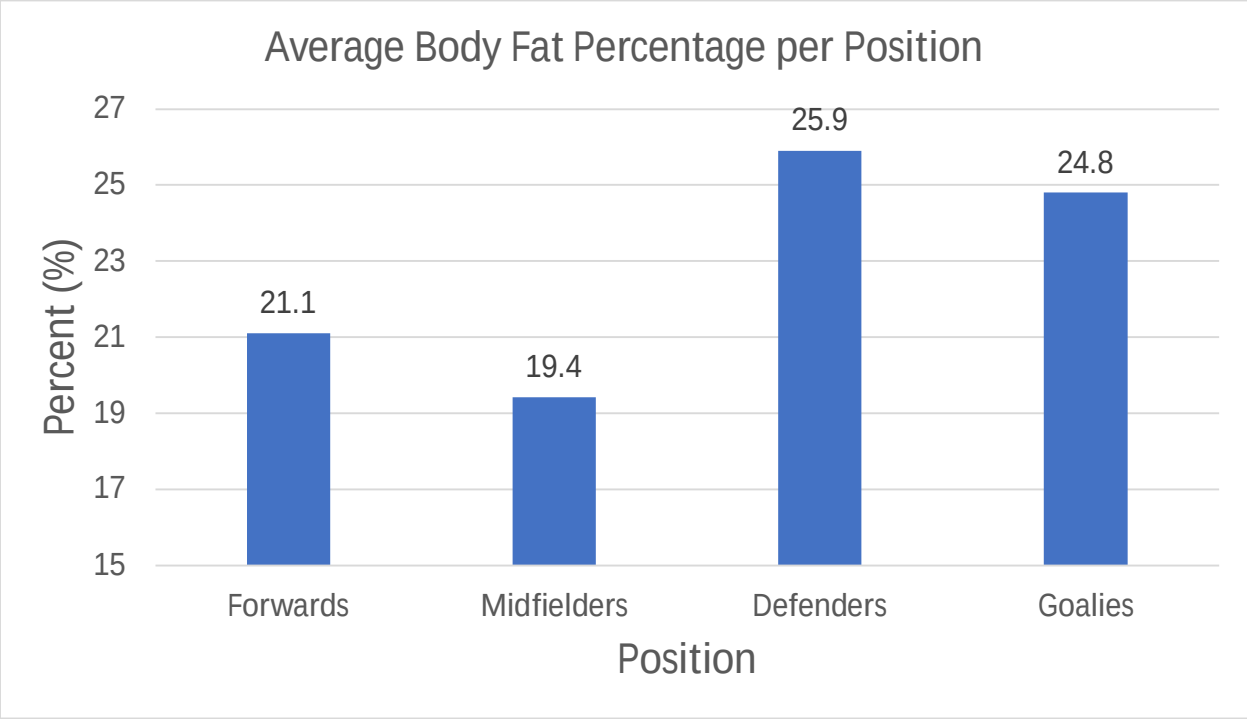


Figure 3. Average body fat percentage for each position from the BodPod.

For this fitness attribute, the lower the score (percentage), the better. There was a range from 19.4% to 25.9% body fat across the 4 positions. Midfielders had the lowest percentage of body fat with an average result of 19.4%, while defenders had the highest percentage of body fat with an average result of body fat of 25.9%. It was hypothesized prior to the study being conducted that the midfielders would have the least amount of body fat because of how much they run during soccer games.

Related Hypotheses:

- Hypothesis #5: Goalies will demonstrate the highest percentage of body fat → Rejected
- Hypothesis #6: Midfielders will demonstrate the lowest percentage of body fat → Accepted

Forwards and Midfielders had much lower body fat percentage scores than the Defenders and Goalies. This aligned with the VO_2 max scores because both Midfielders and Forwards run substantially more during games than Goalies and Defenders. The more running a person does, the more likely they are to have low percentages of body fat since excess fat is burned off with activity. Defenders demonstrated the highest percentage of body fat, which is likely due to the low subject numbers in the study. If there would have been more Goalie participants, that group would likely have had the highest percentage of body fat due to their lack of movement during games and practice.

Agility

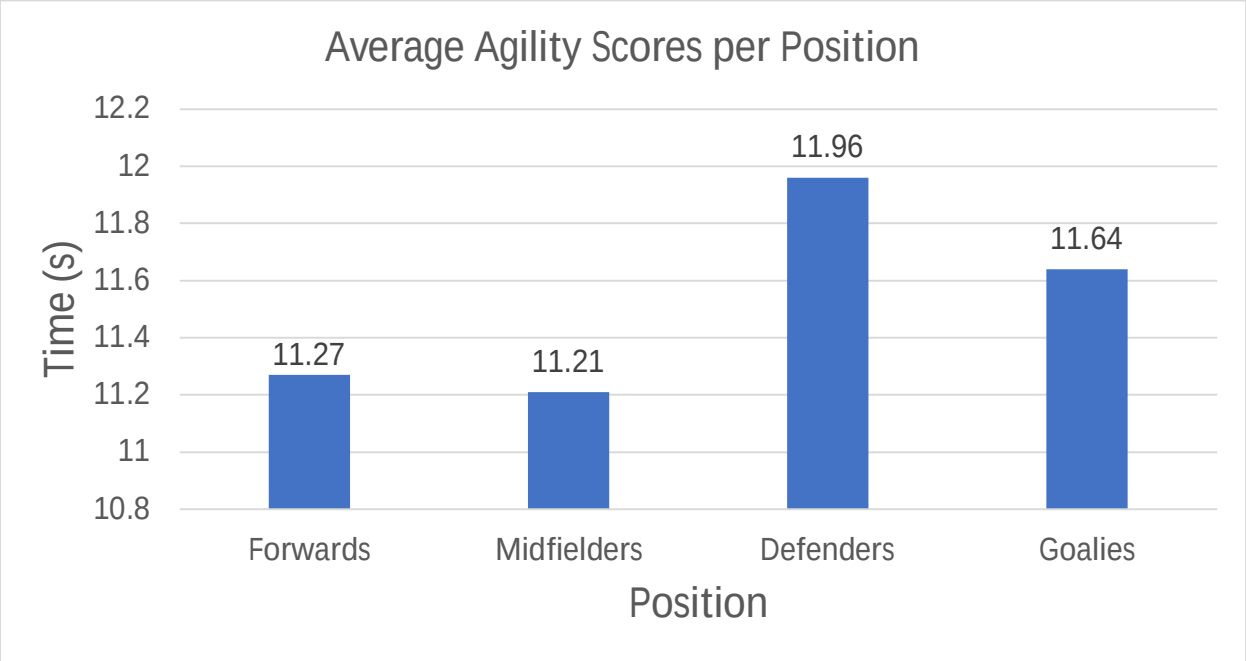


Figure 4. The average time in seconds per position on the T-Test. The best time out of the two trials for each subject was used for the position average.

For this fitness attribute, the lower the score, the better. The fastest times were recorded by the midfielders with an average time of 11.21 seconds to complete the T-Test. This makes sense because the midfielders are constantly changing direction very quickly since they are always under pressure from the other team. The lowest scores recorded for agility were from the defenders with a score of 11.96 seconds. The original hypothesis was that forwards would have the slowest times for agility, but this was proven wrong by the data collected. After further contemplation, the defenders having the slowest times also makes sense because they tend to sprint in straight lines when they are defending. Their position requires little change of direction.

Related Hypotheses:

- Hypothesis #7: Midfielders will demonstrate the highest agility → Accepted
- Hypothesis #8: Forwards will demonstrate the lowest agility → Rejected

Midfielders had the fastest average time on the T-Test for agility, which agrees with the original hypothesis. Midfielders play in the center of the field and must react most quickly to changing game conditions. The original hypothesis about forwards having the slowest agility time was rejected. Forwards must be agile and quick in order to beat defenders. Defenders had the slowest time. This is likely due to the fact that they often run in straight lines during games and have very little situations when they have to change direction.

Reaction Time

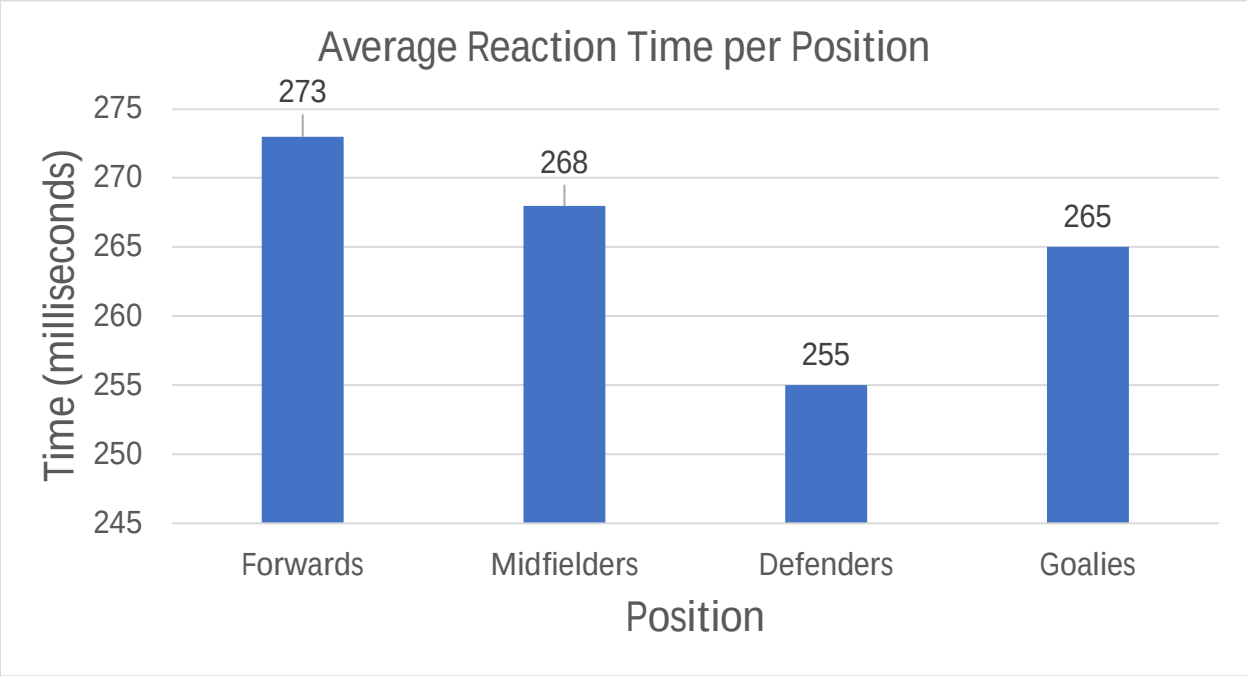


Figure 5. Average reaction time in milliseconds for each position from the ruler drop test.

For this fitness attribute, the lower the score, the better. The position that had the fastest average reaction time was the defenders with a score of 255 milliseconds. It was originally hypothesized that the goalies would have the fastest reaction time. However, after further contemplation and analysis of the data collected, it makes sense that the goalies did not have the fastest reaction time because the test was utilizing the lower extremity and not the hands. Goalies are the only position that primarily use their hands; therefore, if the test would have utilized the hands to determine reaction time, the goalies would most likely have done the best out of all 4 groups. The group that had the slowest reaction time was the forwards with an average score of 273 milliseconds.

Related Hypotheses:

- Hypothesis #9: Goalies will demonstrate the fastest reaction time → Rejected
- Hypothesis #10: Forwards will demonstrate the slowest reaction time → Accepted

Defenders had the fastest reaction time, which does not agree with the original hypothesis. This is likely due to the fact that the rule drop test was altered and participants had to catch the ruler with their feet instead of their hands. If the test had been conducted the traditional way, then Goalies would have likely scored the highest because of task specificity. Goalies are the only position on the field that uses their hands during the sport. For future studies, this should be taken into consideration and a reaction time test for both the hands and feet should be conducted. However, Defenders likely had the fastest time because they must be able to react quickly to Forwards coming at them and trying to score. Therefore, the ruler drop test with the feet was an accurate measurement for quickness of the lower extremity.

Sprint Speed

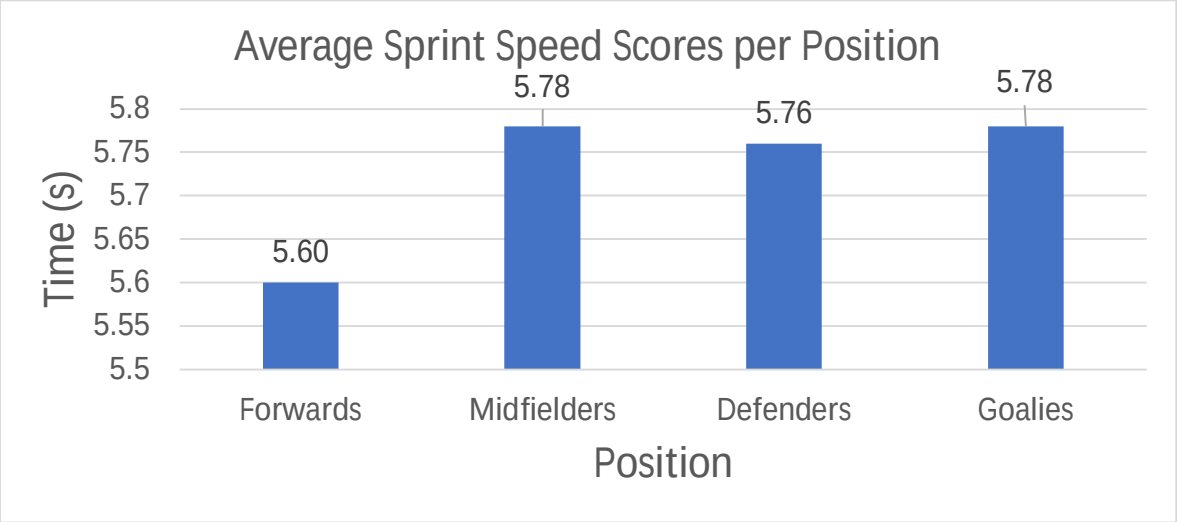


Figure 6. The average time in seconds per position on the 40-yard dash. The best time out of the two trials for each subject was used for the position average.

For this fitness attribute, the lower the score, the better. The group that had the fastest scores for sprint speed were the forwards with a score of 5.6 seconds. The forwards must be fast in order to be effective at their position because they must be able to beat defenders to score goals. The slowest group was a tie between the midfielders and the goalies with a score of 5.78 seconds. This makes sense because although midfielders run constantly and have high aerobic capacities, they do not typically have the fastest sprint speeds because that is not a requirement for their position. Goalies also have the slowest sprint speeds as well because their position does not require any sprinting or running of any form. All the data scores for the 4 positions are relatively close together with the range of scores are all within 0.18 seconds of each other. However, those slight differences in sprint speed make huge differences on the soccer field.

Related Hypotheses:

- Hypothesis #11: Defenders will demonstrate the fastest sprint speed → Rejected
- Hypothesis #12: Goalies will demonstrate the slowest sprint speed → Accepted

Data shows that Forwards had the fastest sprint speed, which does not align with the original hypothesis of defenders having the fastest sprint speed. Forwards most likely had the fastest sprint speed due to the position's demands. Forwards must be fast in order to beat Defenders in a foot race. Goalies demonstrated the slowest sprint speed, which makes sense due to the fact that they do not run often during the games. Their position requires them to make quick decisions and diving saves. Rarely does a Goalie make a sprint to a ball or to make a good save.

Power Output

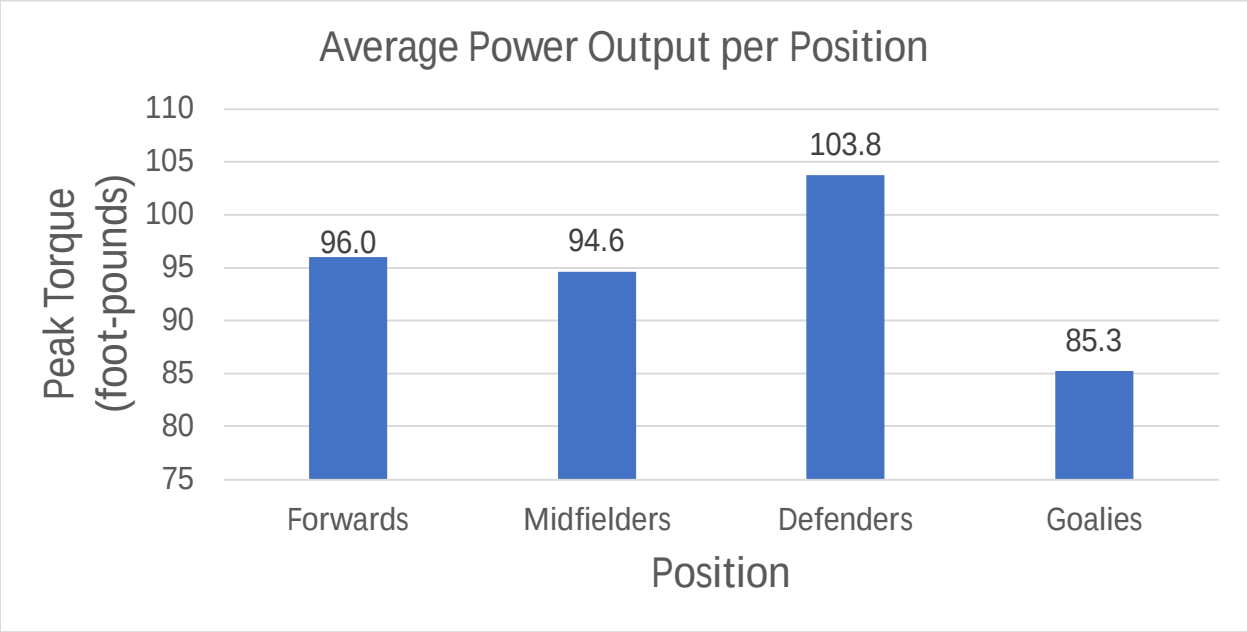


Figure 7. Average power output in foot-pounds per position from the Cybex Power Test.

The position with the highest power output was the defenders with a score of 103.8 foot-pounds of torque. It was hypothesized prior to the study being conducted that the defenders would have the highest power output because of their position demands on the field. Defenders have to be strong on the ball and have a powerful kick in order to kick the ball up the field away from the opposing team's offensive attack. This was proven with the data that was collected from the Cybex Machine. The lowest power output was the goalies with a score of 85.3 foot-pounds of torque. The difference between the highest and lowest values are 18.5 foot-pounds.

Related Hypotheses:

- Hypothesis #13: Defenders will demonstrate the most power → Accepted
- Hypothesis #14: Midfielders will demonstrate the least power → Rejected

As originally hypothesized, Defenders demonstrated the most power output. This is likely due to the number of times they clear the ball out of the defensive half of the field. In order to defend well, a powerful kick is needed to get the ball away from the defender's own goal. Goalies demonstrated the least amount of power, which contradicts the original hypothesis. This could be due to the fact that Goalies do not kick as often as the other positions do. In addition, they also do not kick in the same manner as the other positions either. When Goalies kick the ball, they typically punt it, not kick it from the ground.

Fast-Twitch and Slow-Twitch Muscle Fiber Distribution

Figure 8. The charts above show the average distributions of fast and slow twitch muscle fibers for each position.

The charts above indicate that there is a profound difference in the distribution of muscle fibers amongst the different positions, specifically with the midfielders. The midfield position (48.83:51.17) was the only one to be close to a 50:50 ratio of slow and fast twitch fibers. Before the experiment was conducted, it was hypothesized that the midfielders would have the highest ratio of slow twitch muscle fibers because they constantly ran the most during the soccer games. The data proved this to be true. All other positions were predominately fast twitch. Goalies had the highest percentage of fast twitch muscle fibers out of all the positions. This makes sense because their position requires them to make explosive movements (such as jumping diving, etc.) with extended periods of rest.

Related Hypotheses:

- Hypothesis #15: Midfielders will possess the most slow-twitch muscle fibers → Accepted
- Hypothesis #16: Forwards will possess the most fast-twitch muscle fibers → Rejected

It was likely that the Midfielders possessed the most slow-twitch muscle fibers because they are more aerobic-based athletes. Their position requires constant movement at an average pace, which means they must have the muscle fiber type to accommodate that demand. Goalies had the most fast-twitch muscle fibers because of their position as well. They run very little during the games while every other position has some form of running (either sprints or constant jogging). The majority of their movements include short sprints, diving, and punting the ball.

Discussion

The data from this study supports the idea that although the athletes play the same sport, different positions on the field have different physiologic demands. Traditionally, all players of the team have the same off-season training protocols, which means that all players are doing the same strength and conditioning drills, regardless of what their positional demands/needs are. This training style does not make sense if a coach wants his/her athletes to be at their peak physical shape for their position. A great example is comparing it to football: a coach would never train a quarterback and a defensive lineman the same way. Their duties on the field require different physical demands. Therefore, the athletes of the 2 positions train differently during the off-season. Why then would a soccer coach train the players on their team the same way if the position demands differ so greatly? This "train the majority" training style will only help a few players reach their peak, if any at all. Otherwise, the coach is just training his/her players to be average at their positions when it comes to fitness. The data from this study provides evidence that training regiments should be individualized based on positions so that each athlete develops what she needs to succeed at her position.

The data from this study can be applied to create a position specific training program for the off-season conditioning of the soccer athletes. Based on the data and the scores from the fitness testing, the 4 positions can be divided into 4 groups and trained separately. In a perfect world, coaches would have unlimited resources, equipment, and time to train each position individually. However, there are always limitations, whether that be at a high school with a low budget or a gym with only 1 strength and conditioning coach.

For example, in a perfect world where a training program could be developed and implemented for solely the Midfielders, the training would be a healthy mix of aerobic and anaerobic activities. Based on the data, Midfielders possessed the most slow-twitch muscle fibers out of all the positions, but they still had a slight majority of fast-twitch fibers overall. This means that they have almost an even number of fast and slow twitch fibers, which directly reflects aerobic vs anaerobic energy systems. As Midfielders, the players are required to play both offense and defense on the team for the entire game. This means that they are constantly running up and down the field which itself could measure up to a maximum of 75 by 110 meters. Consequently, Midfielders must have a high aerobic capacity along with stellar game knowledge and ball control to be able to perform well at the position.

A training regimen made up for Midfielders would include a variety of running drills but have a chief focus on increasing aerobic capacity and anaerobic threshold. Although Midfielders are primarily aerobic, they must still have the capacity to sprint quickly if the occasion arises. This means that all 3 energy systems (anaerobic, intermediate, and aerobic) must be developed. One training method that would be extremely useful for Midfielders during their off-season training is called a Fartlek run, which is a training method that combines continuous training and interval training. This training is simply defined as periods of fast running followed by periods of slower running. The individual never stops moving; they just vary their pace of movement. Both aerobic and anaerobic energy systems are targeted with this type of training. In addition, Fartlek running greatly enhances an athlete's endurance, which is directly beneficial to the Midfielders because of the amount of constant movement their position requires. This type of training can also be tailored to fit any type of sport, but it is usually found to be most useful in

sports such as soccer, lacrosse, and other sports that involve constant movement during a game. Fartlek training should be done about 1-2 times per week. Along with Fartlek training, Midfielders should also perform high-intensity interval training (HIIT). Interval training is a cardiovascular exercise strategy that alternates between short periods of intense anaerobic exercise with less intense recovery periods. These workouts are known to improve athletic capacity and glucose metabolism. The energy systems used in these workouts are typically anaerobic, which includes the phosphagen and glycolytic systems. These types of workouts should be performed 1-2 times per week as well.

On the remaining days of the week, coaches should primarily focus on agility, which was the other physical attribute that Midfielders excelled at. Agility drills consist of anything that involves numerous changes of direction at a quick pace. A few great drills are agility ladders to work on footwork and speed and circuits. The remaining physical attributes should be worked on periodically throughout training sessions as well, but it is not as necessary as aerobic capacity and agility is for Midfielders. Weight training should be incorporated into the off-season workouts for all positions as well. Once again, Midfielders should have a mix of endurance (8+ reps) and power lifts (1-3 reps and Olympic lifts) to strengthen the athletes.

The advantages to separating the players based on position-specific needs are endless. Peaking athletes for their athletic seasons is every coach's main goal during the off-season. With the data from this study, coaches will be able to improve upon their current training methods. It has been shown that any task-specific training would be more beneficial to the athletes than the traditional "one-size-fits-all" model of off-season conditioning. The best way to condition soccer athletes in the off-season is to train each position individually (or group positions based on similarities) in order to peak them specifically for their positional fitness needs.

Chapter 5

Conclusion

The findings of this study indicate there is a difference in the physiologic make up of athletes that play different positions. These findings can be interpreted and used to develop specialized training programs that are specific to each position and that position's demands. Task-specific training will allow athletes to develop the qualities needed to excel at that position. It should also be noted that while there were findings that support that the position molds the player, there is also a self-selection factor likely operating. Players with certain innate physiologic abilities self-select (choose to play) a position because they feel comfortable and are initially successful. From there, training and physical demands of the positions further mold physiologic abilities.

References

1. Andrzejewski, Marcin; Chmura Jan; Pluta, Beata; Strzelczyk, Ryszard; Kasprzak, Andrzej. "Analysis of Sprinting A ctivities of Professional Soccer Players." *Journal of Strength and Conditioning Research.*, vol. 27, no. 8, 2013, p. 2134.

2. Bacon, Andrew P., et al. "VO2max Trainability and High Intensity Interval Training in Humans: A Meta-Analysis." *PLoS ONE*, vol. 8, no. 9, 2013. *PubMed Central*, doi:10.1371/journal.pone.0073182.

3. Dabney, Upton, and Butler, Mike. "*The Predictive Ability of the YMCA Test and Bruce Test for triathletes with Different Training Backgrounds.*" Emporia State Research Studies, Vol. 43, no. 1, pp. 38-44. (2006)

4. Dawes, Jay, and Mark Roozen. "Developing Agility and Quickness: Speed." *Human Kinetics*, NSCA -National Strength & Conditioning Association, 2017, www.humankinetics.com/excerpts/excerpts/optimum-speed-gives-athletes-an-advantage

5. "Developing Power: Defining the Term Power in Strength and Conditioning." *Human Kinetics*, www.humankinetics.com/excerpts/excerpts/defining-the-term-power-in-strength-and-conditioning.

6. Faber, Jorge, and Lilian Martins Fonseca. "How sample size influences research outcomes." *Dental Press Journal of Orthodontics*, Dental Press International, 2014, www.ncbi.nlm.nih.gov/pmc/articles/PMC4296634/

7. Favero, Terence G. Ph.D. & Stoll, Kara Jackson, D.O. "Seasonal Improvements in VO2max Among Women's College Soccer Players with One-Day Per Week Aerobic Interval Training." Kinesiologia Slovencia

8. "Glycolysis." *Khan Academy*, Khan Academy, 2017, www.khanacademy.org/science/biology/cellular-respiration-and-fermentation/glycolysis/a/glycolysis.

9. Johnson, Chris. "Teaching 1st Defender without Opposition." *SoccerXpert*, SoccerXpert, 7 Feb. 2011, www.soccerxpert.com/soccerdrills/teaching-1st-defender-wo-opposition.aspx

10. Klicka, John, et al. "VIDEO GAMES FOR THE IMPROVEMENT OF REACTION TIME AND HAND EYE COORDINATION IN COLLEGE FOOTBALL PLAYERS." *Journal of Undergraduate Kinesiology Research*, vol. 2, Dec. 2006, file:///C:/Users/Valued%20Customer/Downloads/kins474klickaetal.fall2006.pdf.

11. Mermier, Christine & Legler, Allison & Barrett, Whitney & Mermier, Christine & Gateley, Ann. (2017). VO2 Maximum of College Athletes. WAS 6 was 7

12. Nikolaidis, Pantelis T. "Physical Fitness in Female Soccer Players by Player Position: A Focus on Anaerobic Power." National and Kapodistrian University of Athens, Athens, July 2014.

13. Powers, Scott K., and Edward T. Howley. *Exercise physiology theory and application to fitness and performance*. 8th ed., McGraw-Hill Higher Education, 2012.

14. PT Direct. "The Aerobic System." *PT Direct*, 2017, www.ptdirect.com/training-design/anatomy-and-physiology/the-aerobic-system.

15. PT Direct. "The ATP-PC System." *PT Direct*, 2017, www.ptdirect.com/training-design/anatomy-and-physiology/the-atp-pc-system.

16. Quinn, Elizabeth. "What Are Slow and Fast Twitch Muscle Fibers?" *Verywell*, Richard N. Fogoros, MD, 12 Oct. 2017, www.verywell.com/fast-and-slow-twitch-muscle-fibers-3120094. WAS 9 was 12

17. Riebe, Deborah, et al. "*ACSMs guidelines for exercise testing and prescription*." Wolters Kluwer, 2018.

18. Ross Tucker, The Science of Sport. "Physiology of football: profile of the game." *The Science of Sport*, The Science of Sport, 26 Oct. 2013, sportsscientists.com/2010/06/physiology-of-football-profile-of-the-game/

19. Stone, Nicholas M., and Andrew E. Kilding. "Aerobic Conditioning for Team Sport Athletes." *Sports Medicine*, vol. 39, no. 8, 2009, pp. 615–642., doi:10.2165/00007256-200939080-00002. WAS 11 was 15

20. Turner, Anthony. "Total Score of Athleticism: a strategy for assessing an athlete's athleticism." London Sport Institute, Middlesex University, London, June 2014.

21. Voza, Luann. "Define Strength, Power & Muscular Endurance." *LIVESTRONG.COM*, Leaf Group, 11 Sept. 2017, www.livestrong.com/article/115549-define-strength-power-muscular-endurance/.

22. Walker, Scott, and Turner, Anthony,M.Sc, C.S.C.S. "A One-Day Field Test Battery for the Assessment of Aerobic Capacity, Anaerobic Capacity, Speed, and Agility of Soccer Players." *Strength and Conditioning Journal*, vol. 31, no. 6, 2009, pp. 52-60, *Physical Education Index WAS 13 was 18*

23. Wallin, Dan, et al. "Improvement of muscle flexibility." *The American Journal of Sports Medicine*, vol. 13, no. 4, 1 July 1985, pp. 263–268. *Sage Journals*, doi:10.1177/036354658501300409. WAS 14 was 19

24. Zierath, Juleen R, and John A Hawley. “Skeletal Muscle Fiber Type: Influence on Contractile and Metabolic Properties.” *PLoS Biology*, Public Library of Science, Oct. 2004, www.ncbi.nlm.nih.gov/pmc/articles/PMC521732/.

Appendix I – Informed Consent Form

A Retrospective Analysis of In-Season Conditioning Study Consent Form

You are being asked to take part in a research study where your fitness profile will be assessed. I am asking you to take part because you are a member of the Hanover College Women's Soccer team. Please read this form carefully and ask any questions you may have before agreeing to take part in the study.

What the study is about: To determine if soccer position influences:

- Aerobic capacity
- Flexibility
- Body fat percentage
- Agility
- Reaction time
- Sprint speed
- Power
- Distribution of fast-twitch and slow-twitch muscle fibers.

What we will ask you to do: If you agree to be in this study, you will be asked to come in on 3 separate days for fitness testing. The tests will include: BodPod, ruler drop test, goniometer assessment of the lower extremity joints, Cybex machine endurance test, Cybex machine power test, T-Test, 40-yard dash, and the Submaximal Bruce Protocol Treadmill Test.

Risks and benefits:

I do not anticipate any risks to you participating in this study other than those encountered in day-to-day life.

The benefits to you include finding out what your fitness test battery results are, such as body fat percentage and sprint speed.

Your answers will be confidential. The records of this study will be kept private. We will not include any information that will make it possible to identify you in any sort of report we make public.

Taking part is voluntary: Taking part in this study is completely voluntary. If you decide not to take part, it will not affect your current or future relationship with Hanover College. If you decide to take part, you are free to withdraw at any time.

If you have questions: The researcher conducting this study is Daria Volker. Please ask any questions you have now. If you have questions later, you may contact Daria Volker at volkerd18@hanover.edu or at 513-508-3734, Bryant Stamford at stamford@hanover.edu, or Dean Jacks, PhD. Chair IRB, at jacks@hanover.edu or 812-866-7248.

You will be given a copy of this form to keep for your records.

Statement of Consent: I have read the above information, and have received answers to any questions I asked. I consent to take part in the study.

Your Signature _____ Date _____

Your Name (printed) _____

Signature of person obtaining consent _____ Date _____

Printed name of person obtaining consent _____ Date _____

This consent form will be kept by the researcher for at least three years beyond the end of the study.

Appendix II – IRB Approval

Study 2017115 approved by faculty sponsor

I

IRB-do-not-reply@hanover.edu

Mon 2/5, 1:57 PM

Daria Volker

Reply

This is a confirmation email letting you know about a change in the status of a human subjects application submitted to the Hanover College Institutional Review Board (IRB).

Study number 2017115, titled **A Retrospective Analysis of In-Season Conditioning**, listed you as

author

and the change in status is that the application has now been

approved by faculty sponsor

If you believe this is an error, please contact the webmaster for the IRB, Bill Altermatt, at altermattw@hanover.edu. The application has been submitted to the IRB. When the IRB review is complete, you will be notified by email. To review the content of the application and check on its status, you may log in at irb.hanover.edu. Remember not to begin data collection until you have received approval from the IRB. If you have any questions, plea se contact the chair of the Hanover IRB, Dean Jacks, at jacks@hanover.edu.

Appendix III – Data Tables

Aerobic Capacity

Submaximal Bruce Protocol		
Position	Subject	Predicted VO_2 max (ml/kg/min)
Forwards	Subject A	52.44
	Subject B	56.3
	Subject C	52.95
	Average	53.89666667
Midfielders	Subject D	47.81
	Subject E	47.35
	Subject F	54.14
	Subject G	55.81
	Average	51.2775
Defenders	Subject H	58.34
	Subject I	41.95
	Subject J	48.03
	Subject K	44.38
	Average	46.205
Goalies	Subject L	45.22
	Subject M	48.52
	Average	46.87

Table 1. The calculated predicted maximum VO_2 of the subjects.

Flexibility

Flexibility (Goniometer)											
Position	Subject	Side of Body	Hip			Knee			Ankle		
Forwards	Subject A	Right	130	131	131	126	127	127	77	71	70
		Left	130	128	129	129	129	127	70	74	74
	Subject B	Right	125	130	131	141	140	139	64	72	68
		Left	130	133	132	137	140	142	70	70	70
	Subject C	Right	123	122	121	136	134	136	67	63	67
		Left	126	130	130	134	132	133	67	65	70
Midfielders	Subject D	Right	122	128	131	128	131	128	78	82	85
		Left	135	130	128	137	134	135	78	85	81
	Subject E	Right	125	120	123	136	137	140	80	78	82
		Left	127	127	127	135	140	136	75	82	80
	Subject F	Right	124	126	123	139	142	144	61	61	63
		Left	134	131	125	137	137	138	63	66	70
	Subject G	Right	120	117	118	135	132	135	54	60	69
		Left	122	119	118	129	135	130	57	64	63
Defenders	Subject H	Right	108	126	120	130	134	131	73	73	70
		Left	132	121	129	136	137	140	65	76	75
	Subject I	Right	115	119	122	129	120	126	78	74	80
		Left	134	128	130	128	132	125	76	74	75
	Subject J	Right	93	91	97	124	120	115	71	65	74
		Left	99	98	100	124	128	124	61	54	64
	Subject K	Right	109	105	110	132	125	132	64	61	66
		Left	119	121	121	132	137	135	66	65	72
Goalies	Subject L	Right	126	123	125	125	130	134	84	83	81
		Left	118	121	119	130	134	136	83	80	82
	Subject M	Right	129	129	129	134	132	131	82	75	82
		Left	127	132	129	131	134	133	73	75	75

Table 2. The table above shows the raw data collected from the subjects' hip, knee, and ankle joints using a goniometer.

Goniometer							
Flexibility							
Position	Subject	Hip		Knee		Ankle	
		Left	Right	Left	Right	Left	Right
Forwards	Subject A	130	131	129	127	74	77
	Subject B	133	131	142	141	70	72
	Subject C	130	123	134	136	70	67
	Average	131	128.3333	135	134.6666	71.3333	72
	Average Overall	129.6666667		134.8333333		71.66666667	
Midfielders	Subject D	135	131	137	131	85	85
	Subject E	127	125	140	140	82	82
	Subject F	134	126	138	144	70	63
	Subject G	122	120	135	135	64	69
	Average	129.5	125.5	137.5	137.5	75.25	74.75
	Average Overall	127.5		137.5		75	
Defenders	Subject H	132	126	140	134	76	73
	Subject I	134	122	132	129	76	80
	Subject J	100	97	128	124	64	74
	Subject K	121	110	137	132	72	66
	Average	110.5	103.5	132.5	128	68	70
	Average Overall	107		130.25		69	
Goalies	Subject L	121	126	136	134	83	84
	Subject M	132	129	134	134	75	82
	Average	126.5	127.5	135	134	79	83
	Average Overall	127		134.5		81	

Table 3. Displays the best score out of the 3 trials for each joint. The best scores for each side of the body were then averaged together for each position. The average overall scores for each side of the body for each position were then averaged together to get a total score of flexibility for the body.

Body Fat Percentage

Position	Subject	BodPod	
		% Fat	% Lean
Forwards	Subject A	25.3	74.7
	Subject B	16.2	83.8
	Subject C	21.8	78.2
	Average	21.1	78.9
Midfielders	Subject D	19.6	80.4
	Subject E	13.5	86.5
	Subject F	19.5	80.5
	Subject G	25.1	74.9
	Average	19.425	80.575
Defenders	Subject H	19.7	80.3
	Subject I	22.7	77.3
	Subject J	31.4	68.6
	Subject K	20.4	79.6
	Average	25.9	74.1
Goalies	Subject L	21.8	78.2
	Subject M	27.8	72.2
	Average	24.8	75.2

Table 4. The table above indicates the percentages of lean and fat mass for each subject.

Agility

Agility (T-Test)							
Position	Subject	Trial 1			Trial 2		
		Timer 1	Timer 2	Average	Timer 1	Timer 2	Average
Forwards	Subject A	11.16	11.16	11.16	11.4	11.36	11.38
	Subject B	11.05	11.15	11.1	11.12	11.25	11.185
	Subject C	11.58	11.72	11.65	11.63	11.46	11.545
Midfielders	Subject D	11.7	11.62	11.66	11.38	11.4	11.39
	Subject E	11.36	11.4	11.38	11.25	11.4	11.325
	Subject F	11.56	11.62	11.59	11.15	11.3	11.225
	Subject G	10.92	11	10.96	10.88	10.9	10.89
Defenders	Subject H	10.59	10.51	10.55	10.58	10.7	10.64
	Subject I	11.8	11.78	11.79	11.56	11.49	11.525
	Subject J	11.62	11.65	11.635	11.74	11.68	11.71
	Subject K	12.33	12.4	12.365	12.32	12.25	12.285
Goalies	Subject L	11.43	11.58	11.505	11.46	11.38	11.42
	Subject M	11.82	11.92	11.87	12.27	12.25	12.26

Table 5. The table above shows the raw data collected from the T-Test. There were two trials conducted and two timers for each of the trials. The best score was recorded for analysis.

Reaction Time

Reaction Time (milliseconds)					
	Subject	Trial 1	Trial 2	Trial 3	Median
Forwards	Subject A	310	320	290	310
	Subject B	230	220	250	230
	Subject C	290	280	210	280
Midfielders	Subject D	270	280	260	270
	Subject E	230	270	300	270
	Subject F	260	270	290	270
	Subject G	280	240	260	260
Defenders	Subject H	240	220	250	240
	Subject I	250	270	300	270
	Subject J	260	260	260	260
	Subject K	280	250	250	250
Goalies	Subject L	250	230	240	240
	Subject M	280	310	290	290

Table 6. The table above shows the raw data collected for the ruler drop test. The median time was the time that was recorded for analysis.

Sprint Speed

Sprint Speed (40-Yard-Dash)							
Position	Subject	Trial 1			Trial 2		
		Timer 1	Timer 2	Average	Timer 1	Timer 2	Average
Forwards	Subject A	5.43	5.46	5.445	5.51	5.53	5.52
	Subject B	5.61	5.77	5.69	5.61	5.68	5.645
	Subject C	5.8	5.78	5.79	5.78	5.66	5.72
Midfielders	Subject D	5.63	5.85	5.74	5.52	5.65	5.585
	Subject E	5.79	-	5.79	5.97	5.93	5.95
	Subject F	5.67	5.75	5.71	5.72	5.61	5.665
	Subject G	6.13	6.18	6.155	6.12	6.02	6.07
Defenders	Subject H	5.5	5.25	5.375	5.27	5.31	5.29
	Subject I	5.63	5.56	5.595	5.79	5.62	5.705
	Subject J	5.85	5.73	5.79	5.78	5.74	5.76
	Subject K	6.07	6.15	6.11	5.66	5.87	5.765
Goalies	Subject L	5.53	5.77	5.65	5.46	5.51	5.485
	Subject M	6.09	6.05	6.07	6.25	6.15	6.2

Table 7. The table above shows the raw data collected from the 40-yard-dash sprint test. There were two trials conducted and two timers for each of the trials. The best score was recorded for analysis.

Distribution of Fast and Slow Twitch Muscle Fibers

Cybex Endurance							
Position	Subject	Right			Left		
		Fast-twitch	Slow - Twitch	Average Fast	Fast-Twitch	Slow-Twitch	Average Slow
Forwards	Subject A	57.38	42.62	61.83	66.28	33.72	38.17
	Subject B	54.39	45.61	55.92	57.44	42.56	44.08
	Subject C	62.06	37.94	64.26	66.46	33.54	35.74
	Average			60.67			39.33
Midfielders	Subject D	65.15	34.85	70.49	75.82	24.18	29.51
	Subject E	13.27	86.73	31.16	49.05	50.95	68.84
	Subject F	49.78	50.22	53.73	57.68	42.32	46.27
	Subject G	51.62	48.38	49.32	47.01	52.99	50.68
	Average			51.17			48.83
Defenders	Subject H	62.14	37.86	63.33	64.52	35.48	36.67
	Subject I	67.98	32.02	64.83	61.68	38.32	35.17
	Subject J	62.72	37.28	64.62	66.52	33.48	35.38
	Subject K	43.69	56.31	44.91	46.12	53.88	55.09
	Average			59.42			40.58
Goalies	Subject L	-	-	-	-	-	-
	Subject M	70.52	29.48	65.26	60.00	40.00	34.74
	Average			65.26267293			34.73732707

Table 8. The table above shows the data calculated for the fast and slow twitch muscle fiber distribution on both the left and right leg. The total average fast twitch and total average slow twitch data for the overall body composition are also shown above.