Effects of Plyometric, SAQ and traditional training on sprint, agility, jumping passing and shooting performance in young soccer players

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ABSTRACT

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The purpose of this study was to perform an 8-week intervention program in order to provide a recommendation of the most suitable training program for young soccer players for improving sprint performance, agility and jumping parameters (strength and power). The participants used in this project were boys aged between 14-16 years old from Jyväskylän Komeetat Ry (soccer club in Jyvaskyla). 33 players in total took part in the study. The following subject information was recorded; age (years), weight (kg), height (cm), circumference of the thigh (cm) and years of training. The different groups included; a speed, agility and quickness group (SAQ, n= 11), plyometric group (PG, n=12), and control group (CG, n=10). Players were randomly assigned into each group according to their Pre-test results in the 30meter sprint, Agility and multiple 5 bound (MB5) test. The 2 experimental groups had 2 sessions per week lasting 30-45 minutes per session. At the same time players in the control group continued with traditional soccer training. During each testing period the following measurements were taken in the laboratory; Isometric leg press and Countermovement jump (CMJ). The Multiple 5 Bounds (MB5) Test) and the 30meter sprint with 10m acceleration phase were measured on a running track. The Finish FA agility tests (without the ball), passing test and shooting test took place on soccer pitch. The SAQ group significantly improved their absolute and relative strength levels in the isometric leg press ($p<0.001$) from pre to post. The Plyometric Group were the only group to significantly improve their performance in the MB5 ($p<0.05$) from pre to post. The control group significantly improved their performance in the CMJ ($p<0.05$), however they were the only group to get significantly slower in the 30m Sprint ($p<0.05$) post measurements.

The hypothesis for this study was that the plyometric group and SAQ group will achieve better improvements in performance compared to the control group that performed traditional soccer training. It is satisfactory to have two substituted sessions if the aim is to produce improvements in sprinting performance.

Key Words: Plyometrics, SAQ, traditional training, young soccer.

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LIST OF ABBREVIATIONS

SAQ- Speed, Agility and Quickness group

PG- Plyometric Group

CG- Control Group

CMJ- Countermovement jump

MB5- The Multiple 5 Bounds

PT- Plyometric training

PHV- Peak height velocity

ST- Strength training

PT- Plyometric training

SSC- Stretch shorting cycle

COD- Change of Direction

BMI- Body max index

CoT- circumference of thigh

BW- Body weight

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1 INTRODUCTION

Professional soccer players on average perform 700 turns, 30-40 sprints which occur every 90 seconds lasting 2-3 seconds, 30-40 tackles and jumps during a 90 minute game (Bloomfield et. al., 2007 & Mohr et. al., 2003). These types of results are not known for young soccer players however, explosive actions are an important feature for all soccer players.

Plyometric training (PT) has been proven to improve explosive strength, agility, jump height and sport specific performance. The main reason is because PT activates the stretch-shorting cycle (SSC) mechanism. The SSC can be best described as the lengthening of a muscle (eccentric phase) prior to an immediate shortening of a muscle (concentric phase). PT is mostly used when training athletes from pre puberty to late puberty due to the fact that testosterone levels in this age group are low. The low testosterone levels affect the ability of young soccer players to building muscle mass and thus neural adaptations are easier to focus on (Sohnlein et. al., 2014). There is very little information available for young adults for improving sprint performance. This means that strength and conditioning coaches have to refer to the only general recommendation of a program and duration which was derived from a meta-analysis that included adults, adolescent and pre-puberty athletes. The recommendation is a program lasting 10 weeks with 18 high intensity sessions consisting of 80 jumps per session (Saez de Villarreal et. al., 2012).

Sprints in soccer are usually not in straight line but include several changes of direction. Therefore, speed, agility and quickness (SAQ) should be useful in training all the components of soccer. Quickness refers to reaction speed, acceleration speed and running speed. A typical SAQ session aims to improve explosive movements. Acceleration, maximum speed and agility have been found to have significant correlations but they are considered unique and should be trained separately. Previous studies have shown that short term (3 weeks) agility training program improve agility test results in young players (Jullien et. al., 2008). A study by Milanovic et al (2013) showed that SAQ training leads to improvements in lateral agility with and without the

ball in young soccer players but no improvements occurred with linear movements (Milanović et. al., 2013).

The purpose of this study is to perform an 8 week intervention program in order to provide a recommendation of the most suitable training program for young soccer players for improving sprint performance, agility, jumping parameters (strength and power) and shooting performance.

2 MATURATION PERIODS OF YOUNG SOCCER PLAYERS

The development process differs for every person and this cannot be rushed. Adolescence usually begins around the age of 13 years old and ends at around the age of 18 years old. This is a time when many changes occur in a person's body. It is important to take note of the cut-off date which differs from sport to sport but for soccer the cut-off date is in the summer. Cut-off date is what is used to determine what age group a player will play under. The cut-off date is a certain time of year, for soccer it is the 1st of January but this changes for sport to sport. Players born before the 1st of January are excluded.

In the older age groups (16–18 years), age and body size differences between high- and low- level players were reduced and not significant (Malina et. al., 2007). Physical strength has been shown to have an effect on kicking, tackling and withstanding a tackle (Reilly et al, 2000). This is a major factor in sports such as rugby were physical strength is one of the biggest parts of the game. A skill such as the hand off when used effectively can make a player stand out from the rest, especially by a physically stronger child between the ages of 11-14 years old. Many coaches believe that physical strength in soccer is not as important because a skilled player is much more valuably to the team compared to a fast, powerful and agile player. However, in underage sport size is a significant factor which can affect the success of a young athlete. Those who stand out due to their size, speed and power have a greater chance to get noticed. Being noticed can enhance the player's chances of being selected for development squads, which in turn leads to better coaching and development of their skill (Malina et al, 2007).

A study by Malina et al. (2000) showed that the skeletal age and chronological age are equivalent in males aged 11-12 years old. Skeletal age is the development of a person bone in years. Chronological age is the number of years a person has lived; it starts from when the person is born. Between 13-14 years chronological age is closely related and at 15-16 years skeletal maturation starts to dominate soccer within Portuguese and young Mexican soccer players. The different stages of development within adolescent boys needs to be recognized (Malina et al., 2004), and opportunities need to be provided for smaller and later maturing talented boys during adolescence (Malina, 2000). There is no direct correlation between a person being taller and heavier with an increase in skill level. The size difference plays a small role between the ages of 13-15 but as boys approach maturity in late adolescence, usually aged between 16-18 years the early maturity is no longer apparent and in some cases it has been reversed (Malina et al., 2007 & 2005). The different development stages of an athlete are shown in table 1.

Table 1: Athlete Development (Balyi et al. 2014)

1. Active start	0-6 years old
2. Fundamental Stage	Both Males 6 to 9 & Females 6-8
3. Learn to train	Males 9-12 & Females 8-11
4. Train to train	Males 12 to 16 years old / Females 11 to 15 years old
5. Training to compete	Males 16 to 23 years old/ Females 15 to 21 years old
6. Training to win	Males 19 year + / Females 18 years +
7. Retirement & active for life	Can enter at any age

2.1 The development of young soccer player

The development of a good young soccer player involves developing multiple different skills. It is not only important to develop ones technique but there are many different aspects to be taken into consideration. In order for a player to be able to compete at the highest level possible they have to be well rounded at every discipline. The different parameters required from a player who wishes to play at a high professional level are, soccer-specific technical and tactical skills, along with physical and psychological characteristics (Gonaus et al. 2012, Reilly et al. 2000). Here are a few examples that authors have suggested to be required in order to reach the top playing level; technical skill, (Gonaus et al. 2012, Vestberg et al. 2012) tactical minded, (Gonaus et al. 2012), speed (Gonaus et al. 2012, Vestberg et al. 2012), agility (Jovanovis et al. 2011), endurance capacity (Vestberg et al. 2012) and power (Jovanovis et al. 2011, Dardouri et al. 2013). Certain parameters are harder to develop than others. All the previous physical parameters can be developed with extensive training but the technical and tactical aspects of the game are somewhat more difficult to teach to young populations.

Size is found to have particular importance in the selection process within team sports. Tall players have been found to have a particular advantage in certain positions within soccer (Reilly et al, 2000). Out of 65 players examined it was found that the majority of the tallest players were either goalkeepers or central defenders. The positions where the fittest players resided were the midfielders and fullbacks (Reilly et al, 2000). Below in figure 1 the Peak height velocity (PHV) is shown. PHV is the period when the growth rate is at its maximum (Balyi et al. 2014 and Lloyd & Oliver 2014). This is the best indication that the focus of training should be on aerobic and strength development. Males should begin strength training 12-18 months after PHV women should begin straight after PHV (Balyi et al. 2001). As previously mentioned, athlete development should take place as follows Fundamental (age 6/7 until 9/10) Train to Train (age 10/11 until 13/14), Train to Compete (age 14/15 until 17/18) and Train to Win (age 18-19 until 21-22). Girls (12 +/- 1 year old) reach Peak Height Velocity (Balyi et al 2014) at an earlier age compared to boys (14 +/- 1 year old) but similarly it occurs during the stage train to train.

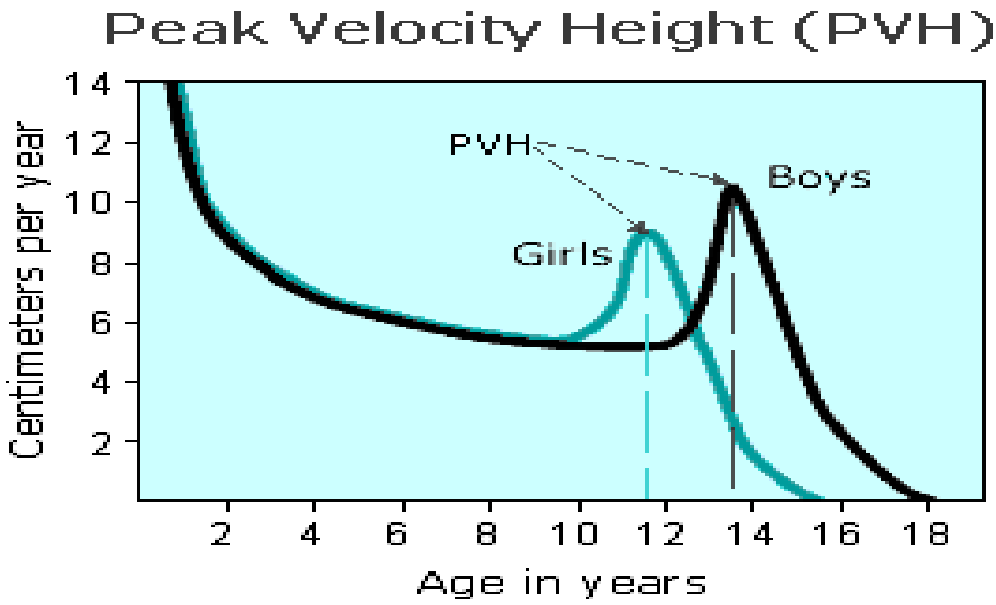

Figure 1: Peak Height Velocity (Balyi et al 2014) Athlete development differs from girls and boys. Girls (12 +/- 1 year old) reach at an earlier age compared to boys (14 +/- 1 year old).

2.2 Anthropometrics and body composition

A person's body size can influence, from a very young age, where they are going to play on the pitch. In relation to soccer it has been noticed that usually goalkeepers and defenders are bigger than midfielders (Reilly et al., 2000).

Conflicting findings have been produced by Hencken & White (2006) that do not concur with those of previous studies that focused on the anthropometric characteristics of elite soccer teams. For many researches Reilly et al. (2000) was the main source of reference regarding to anthropometrics of soccer players. They found that relative heterogeneity in body size is a characteristic of elite soccer teams, so anthropometric differences were therefore expected between playing positions. Previous studies (Reilly et al., 2000) have reported significant differences in a variety of anthropometric characteristics, most notably stature and body mass, perhaps suggesting that these variables denote a morphological optimization within soccer. All previous studies apart for the most resent one have suggested that midfielders are preferably lighter in body mass so they can move more freely. It has been suggested that defenders are usually

taller and heavier with less body mass. However the only conflicting study by Hencken & White (2006) found that positions were not significantly different from each other in total mass, fat mass, muscle mass, residual mass and lean body mass.

Figure 2 shows the different curves of systematic growth. What follows are the descriptions for each of the curves. The Genital curve indicates hormonal maturation. The General curve shows the growth of the different systems of the body such as the lungs and heart. Neural Curve shows that 95% of the central nervous system is developed by the age of 7. Lymphoid curve shows the immunological tolerance and the level of resistance to infection (Vänttinen et al. 2013 &Balyi et al. 2014).

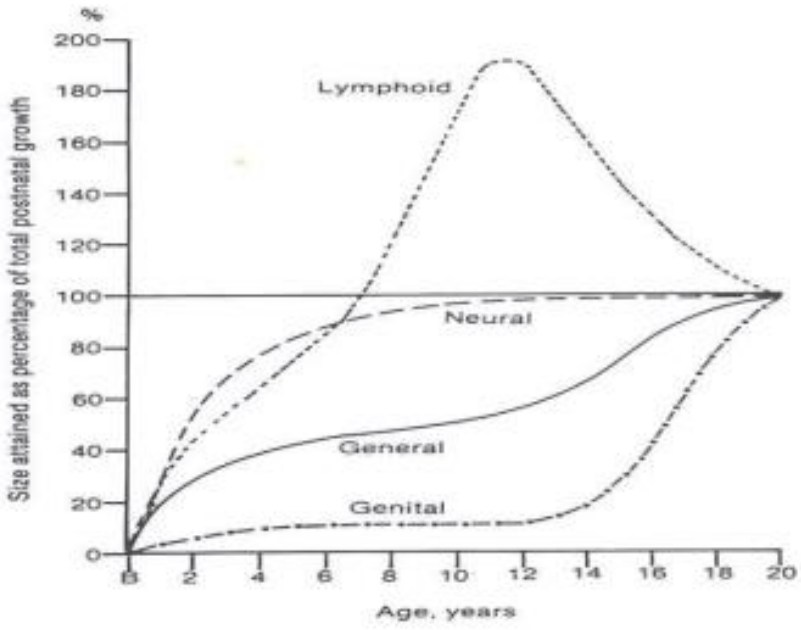

Figure 2: Scammon's curves of systematic growth (Scammon 1930)

2.3 Critical periods

It is important to train specific qualities at specific ages during adolescence. It has been shown that at a certain age, an individual can learn and improve certain qualities to their best standard. The main emphasis should be on speed and speed related strength training at the age of 13. At ages 14-15, the main emphasis should be on speed, strength and aerobic endurance training. At ages 16-17, the focus should be on speed strength

and aerobic endurance training. Finally at ages 18-19, the main focus should be on aerobic endurance, speed endurance and maximal strength training. These age ranges give an indication of what the training should be like for adolescents at different age levels. (Balyi, 2001)

3 SOCCER TRAINING FOR YOUNG PLAYERS

Soccer training has changed dramatically over the years. For the young player nowadays training specificity has progressed hugely over the years. The idea of a young player going out to kick a ball around a field is long gone. Young academies follow a strict plan for developing young soccer players, which are continuously changing from year to year and also from club to club. The timing of when and how players begin to acquire a new skill is viewed as a very important aspect of how the young of today should be trained. As they say, "timing is everything!" Figure 3 shows the many intermittent movements during a game. A players training regime should be tailored to improving the most important parameters that distinguish the top-class player from the moderate players. Top-class players were found to perform more high-intensity actions and sprinting, 28% and 58%, respectively, compared to the moderate players (Mohr et al. 2003).

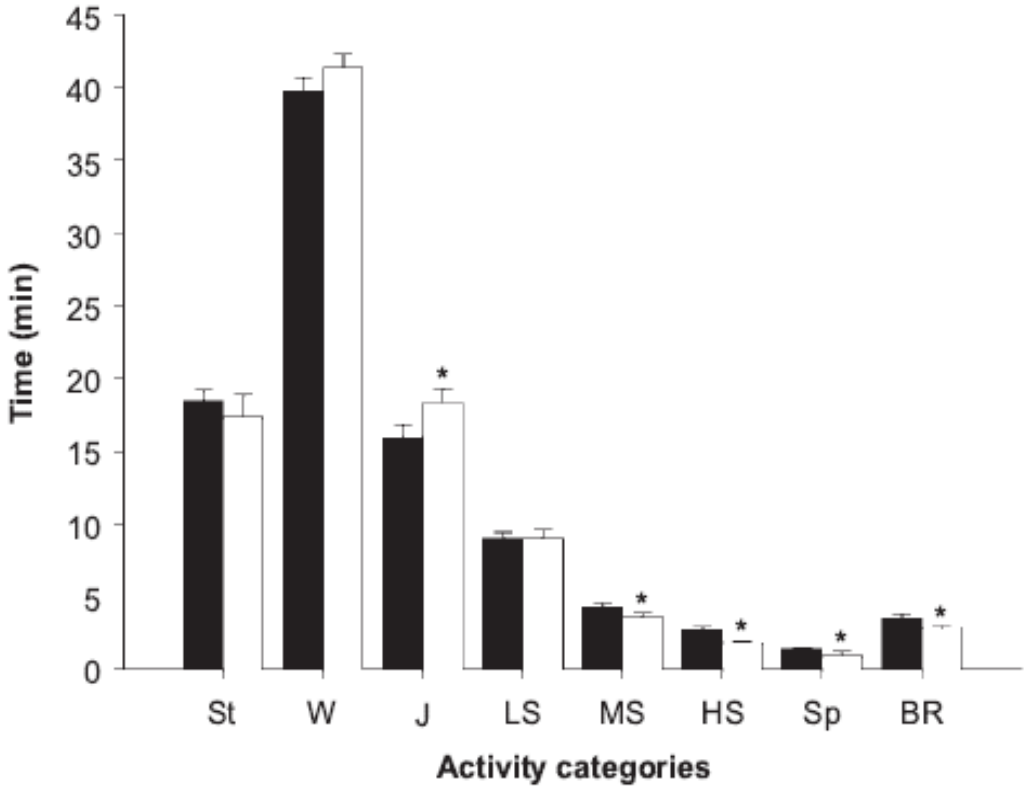

Figure 3: Locomotor categories for top-class players (■) and moderate players (□) during a soccer game expressed as total time (mean±sx). * Significant difference (P <

0.05) between groups. St =standing; W=walking; J= jogging; LS, MS and HS= running at a low, moderate and high speed, respectively; Sp= sprinting; BR=backwards running (Mohr et al. 2003).

3.1 Traditional soccer training

Basic soccer training consists of 10-15 minute warm-up which consists of dynamic stretching, light running and movement to prepare the body for playing the game. Once the warm-up is over the coach will begin with some technical and tactical training. For example a passing drill could be carried out for 15 – 20 minutes. Once this is over a position game may be performed which will then progress into the full game (Gatz 2009).

The term traditional training is used nowadays to describe soccer training done with the ball such as 2 vs 2 small game. Previous studies have suggested that regular soccer training that incorporates short sprints help contribute to speed development (Michailidis et. al., 2013).

3.2 Predictors of Success

Talent identification is much harder in team sports compared to individual sports because there is usually an outcome measure which determines the best athlete (Reilly et al, 2000). In athletics and swimming the best athlete is often decided by the fastest time. Players need to be self-motivated and confident in their own ability. Not being chosen because of smaller body size or stature can have a negative effect on a person's confidence. This might lead to drop out from a sport before they get the chance to develop fully. It has been found that being relatively younger may not always have a negative effect (Gladwell 2008). The individual sports where the Relative age effect (RAE) has been researched in is Gymnastics, Tennis and Swimming and it has been found not to have as large an effect compared to team sports. The term RAE is define as the chronological age differences between individuals within annually age grouped cohorts (Barnsley et al., 1985)

By performing soccer training young adolescents are at an advantage over their peers who are non-active. Studies have shown that muscle mass is greater in adolescent soccer players who perform soccer training compared to their non-active counterparts. This was indicated by muscle CSA seen via Ultrasound. Also the strength level is greater in the competitive active soccer players (Hoshikawa et al. 2013). It has been suggested that height, weight and BMI could be used to characterise players into their favoured position of playing by looking at their anthropometrical characteristics (Zalai et al. 2015). This recent finding agrees with previous research by Reilly et al. (2000) and Malina (2000).

There a many different physical attributes that have a role in soccer but this literature review will envelop the importance of sprinting ability, jumping performance and agility. Young players sprinting ability is an early indication if they have potential to play at the top level. Researchers have suggested that sprinting ability is one characteristic that is extremely difficult to improve (Gonaus et al. 2012, Vestberg et al. 2012). Agility is another very important aspect of determining how successful a player will eventually be (Jovanovis et al. 2011) and power is a critical component in both of the above mentioned parameters (Jovanovis et al. 2011, Dardouri et al. 2013).

Technique and tactical attributes form the basics of a good soccer player. Soccer Associations (FA) in nearly all the countries over the world provide coaching courses that take into account the importance of teaching young players the necessary knowledge to play the game in the most effective/efficient way possible. Some players are more likely to be technically and/or tactically better than others due to their opportunities to practice (Reilly 2000).

Technique takes into account a player's skill level in regards to shooting, passing, dribbling, heading the ball and first touch. These components can all be developed with deliberate practice. It takes 10,000 hours to become an expert at a skill, which is why players need to be dedicated to perfecting their personal skill level (Gladwell 2008).

Tactical ability has to be taught to the young players by an enthusiast coach who is familiar with how the game should be played. In the basic coaching courses, coaches get the knowledge of how to teach their young aspiring players.

4 STRENGTH TRAINING (ST)

A season in soccer is considerably long therefore long lasting periods use a non-linear periodization model. ST for soccer is typically broken up into 4 phases; off-season for building functional strength, early pre-season for building Maximal Strength, late Pre-season for building Muscular power and strength endurance and finally in-season where Maintenance is the main objective. A combined muscular strength and power training should be put in place to develop a young soccer player's explosive performance, such as vertical jump, shooting power and 30m sprint, and this can also lead to improved aerobic endurance (Wong et al. 2010).

Strength training takes dramatic affect during the initial phase. After 100 days of resistance training the cross-sectional area of muscle increases by 23% and maximal strength can increase up to 91.7%. There is a direct correlation of strength per unit cross-sectional muscle area (Ikai et al. 1970). The timing of when an athlete should begin strength training is very important, players should start strength training when they are 16 years old but before this they should learn the proper techniques and develop motor control. Strength training is essential in order for an athlete to continue developing into a world class player. Strength training should be accompanied by SAQ and/or plyometric type training in order to elicit the best results. Following this type of complex training player will increase their maximal running speed, acceleration, jumping ability, increase the force in kicking, tackles and headers and help prevent injuries (Hickson 1980). At the end of this section table 2 summarise all the different resistance training methods that will be covered in this section.

4.1 Hypertrophy training

During strength training the eccentric phase (3 seconds) is slow and the concentric phase (2 seconds) is slightly faster. The muscle tissue brakes down greater during the eccentric phase, therefore when trying to increase body mass many strength and conditioning coaches suggest performing very slow movements eccentrically. Hypertrophy training is not the main cause of concern to a soccer player because the

general physique is lean. This is important to achieve a base line training level for the season as it progresses. A good foundation will assist the athlete during the later stages of a training program. The importance of periodization becomes very evident as the season progresses (Kraemer & Hakkinen 2002).

4.2 Maximal strength

Maximal strength training is essential when the main goal is to develop an athlete's 1 rep max (1RM). The general protocol is to perform this training with very little reps along with many sets, leaving large rest time in between sets. This type of heavy resistance training leads to the recruitment of type II and type I muscle fibers (Kraemer & Hakkinen 2002). This is not the most beneficial type of training for soccer players due to the fact that lifts can take a considerable amount of time which is not very soccer specific. This is useful to develop during the pre-season training. Essentially lifting heavier weights compared to body mass ratio will lead to a faster athlete.

4.3 Explosive strength

Explosive power can be developed in many different ways by using heavy, moderate and light weights. During strength training Polymeric training should be used additionally to weight lifting in order to develop explosive power. The goal for an athlete is to produce a great amount of force during a short amount of time. The fast twitch composition of the muscles is the main indication of an athlete's potential (Hakkinen et al. 1985). This is one of the reasons why explosive power is more important than maximal strength for soccer players. Examples of some exercise are; snatch, clean and jerk and clean. An athlete's ability to perform explosive movements is affected when endurance training is carried out concurrently (Hickson 1980).

4.4 Strength Endurance training / anaerobic strength endurance

Strength endurance training is important for adolescent soccer players. Endurance training in early childhood and during the early stages of adolescence is essential for building a strong base on which to plan endurance training later on. During the early stages of adolescence the soccer player's body has the ability to recover effectively from short exercises lasting less than ten seconds. In short exercises the lactic acid levels do not significantly increase. However, since the body's ability to get rid of lactic acid has not fully developed, the exercises that build high lactic acid levels should be avoided. At the later stages of adolescence, it is important to include endurance exercises that build a good foundation for the future (Balyi et al. 2014).

Resistance training in conjunction with aerobic and anaerobic training can improve performance in endurance sports (Taipale et al. 2014). One of the most popular forms of training muscle endurance is by carrying out a circuit. This type of training helps the athlete to perform repeated high intensity movements. Ideally the trainer should incorporate soccer specific movements into the circuit making it attractive to the players.

Table 2: Resistance Training protocols (Kraemer & Hakkinen 2002)

Training Methods	Sets x Reps	Load (% of 1RM)	Duration (seconds)	Recovery (minutes)
Maximal strength	4-6 x 1-3	80-100%	0.5-1.5 sec	3-5 min
Hypertrophy	3-5 x 6-12	60-80%	2-3 sec	1-2 min
Explosive strength	4-6 x 5-10	30-60%	0.2-1 sec	3-5 min
Endurance strength	4 x 15-30	0-30%	1sec	0.30-1min

5 ENDURANCE TRAINING

Endurance training is a very important component of soccer's training regime for adolescent players. The aerobic and anaerobic systems play a major role. The breakdown of the systems can be seen in table 3 comparing soccer with other sports. Endurance training is important for adolescent soccer players. Early childhood and the early stages of adolescence is when a person's endurance capacity can be developed the most. It is essential to build a strong base on which to plan endurance training later on. During the early stages of adolescence the body has the ability to recover effectively from short exercises lasting less than ten seconds. In short exercises the lactic acid levels do not significantly increase. At this stage the body's ability to get rid of lactic acid has not fully developed, and therefore, exercises that cause the accumulation of lactic acid should be avoided. At the later stages of adolescence, it is important to include endurance exercises that build high lactic acid levels in the body (McArdle et al. 2007 & Reilly et al. 2007)

Table 3: Sports on the aerobic energy system and average as well as highest VO2max scores in those sports (Wilmore et al. 2008).

Elite Athletes	VO2max (ml.kg.min)	Aerobic / Anaerobic (%)
Cross-country skiing	65-96	95 / 5
Cycling	62-74	90 / 10
Rowing	60-72	90 / 10
Running	60-85	85 / 15
Soccer	54-68	70 / 30

5.1 Aerobic Fitness

From previous papers published it is evident that there are a number of different parameters that have been used to predict an athlete's aerobic performance. The aerobic energy system utilizes proteins, fats and carbohydrates (glycogen) for resynthesizing ATP. Exercises lasting more than 3 minutes use the aerobic energy system (Fox et al.

1981). Research has found that there are 5 main powerful predictors of aerobic fitness; Maximal Oxygen uptake (VO_{2max}), Exercise Economy, Interaction between VO_{2max} and Economy, Lactate Threshold and Oxygen Uptake Kinetics (Jones et al. 2000). VO_{2max} is used to determine an athlete's capacity to perform sustained exercise for a period of time. It is measured by the volume of oxygen one can consume while exercising at their maximum capacity. VO2max is the maximum amount of oxygen in millilitres, one can use in one minute per kilogram of body weight (Wilmore et al. 2008). It is not evident that VO2max has a direct relation with outcome performance, there is a 5% error within the VO2max test procedure and when testing elite athletes the changes are as little as 0.1, 0.2 or even 0.3% (Kiely 2011) Therefore VO2max should not, on its own, be used as a method to test for performance enhancement. Exercise economy has been defined as the oxygen uptake required at a given absolute exercise intensity (Conley, et al. 1980). It is determined by measuring the steady-state consumption of oxygen (VO2) and the respiratory exchange ratio (Saunders, et al. 2004). Literature suggests that biomechanical factors are likely to contribute to better economy in any runner (Anderson, 1996).

5.2 Anaerobic Fitness

Professional soccer players on average perform 700 turns, 30-40 sprints which occur every 90 seconds lasting 2-3 seconds, 30-40 tackles and jumps during a 90 minute game (Bloomfield et. al., 2007 & Mohr et. al., 2003). Figure 4 shows the distribution in low-intensity running (jogging, low-speed running and backwards running), high-intensity running (moderate- and high-speed running) and sprinting during the first and second half for top-class and moderate players. These short lasting bouts of high intensity indicate that the anaerobic system needs to be trained in conjunction with the aerobic energy system. For these short bouts of high intensity activities ATP (adenosine triphosphate) is used as the main source of energy (Reilly 2007). The total duration of sprinting is very low meaning that the utilisation of this time is extremely important (see figure 4).

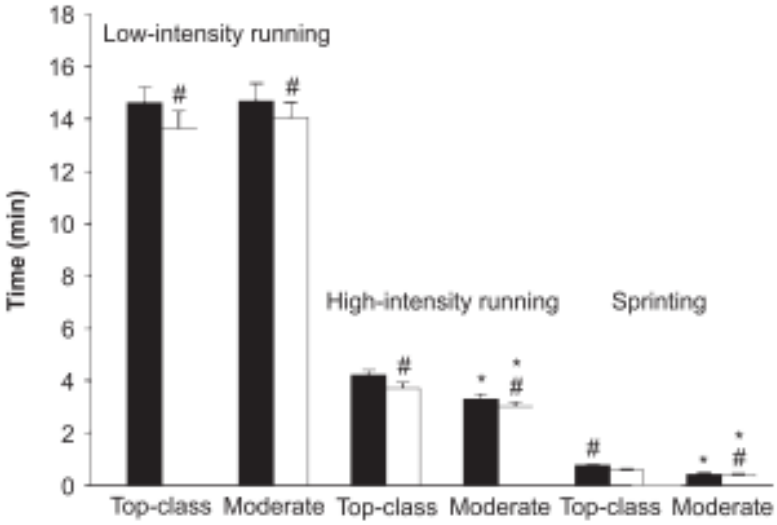

Figure 4: Time spent in low-intensity running (jogging, low-speed running and backwards running), high-intensity running (moderate- and high-speed running) and sprinting during the first (■) and second half (□) for top-class and moderate players (Mohr et al. 2003). # indicates significant difference ($P < 0.05$) between first and second half. * means significant difference ($P < 0.05$) between top-class and moderate professional players.

6 PLYOMETRIC TRAINING

There are three types of muscle action; eccentric, isometric and concentric action. An eccentric action or negative work is when the muscle lengthens under tension, such as when a player has to decelerate. Isometric or static hold occurs when the muscle is staying at the same length generating tension and there is little or no movement at the joint. In a dynamic movement this becomes known as the transition phase. When the muscle shortens under tension this is referred to as a concentric action or positive work (McArdle et. al., 2007). The muscle contains muscle fibers made up of two opposing proteins called actin (thin protein filaments) and myosin (thick protein filaments) which work together to form cross-bridges. Cross-bridges work together to perform work and cause motion (Chu et. al., 2013 & McArdle et. al., 2007). There are two types of muscle fibers; type I which are slow and type II which are fast. Explosive training such as plyometric training normally results in the recruitment of fast twitch muscle fibers which are essential to perform actions as fast as possible. Muscle fibers are recruited by activating motor neurons which together are referred to as motor units. The more motor units recruited the greater amount of contractile force can be produced (McArdle et. al., 2007). The aim of plyometric training is to increase performance by increase efficiency of force production.

This type of training involves jumping and bounding type activities accompanied with resistance training, in order to attain the best results. Söhnlein et al (2014) have given recommendations about the duration of a short term PT program in young soccer players. Their recommendations have proved to be controversial in light of other similar studies (Saez de Villarreal et. al., 2015). According to Söhnlein et al (2014) 2 PT sessions per week may be efficient to improve sprint performance. This study indicates that after 4 weeks considerable improvements are noticed. However, the greatest achievements were attained after a 12 week period, but there was no significant change in performance during the final 4 weeks. In some cases you may need to continue for up to 16 weeks of certain parameters such as the 20m sprint performance. This was controversial at the time because prior to this finding it was recommended that plyometric training should take place 3-4 times per week (Saez de Villarreal et. al., 2015).

6.1 Stretch shorting cycle (SSC)

To improve a person's jumping ability, SSC exercises have demonstrate considerable enhancement in performance with increased force at a given shortening velocity (see figure 5) (Komi, 2000). Therefore plyometric exercises, such as hopping and bounding, could be brought into a players training regime in the hope of improving their working mechanics. Developing a person's SSC characteristics can improve speed, as muscle fibers are recruited faster and more efficiently, and also endurance capabilities because the onset of fatigue sets in later because movement economy improves becoming more efficient (Harrison, et. al., 2004).

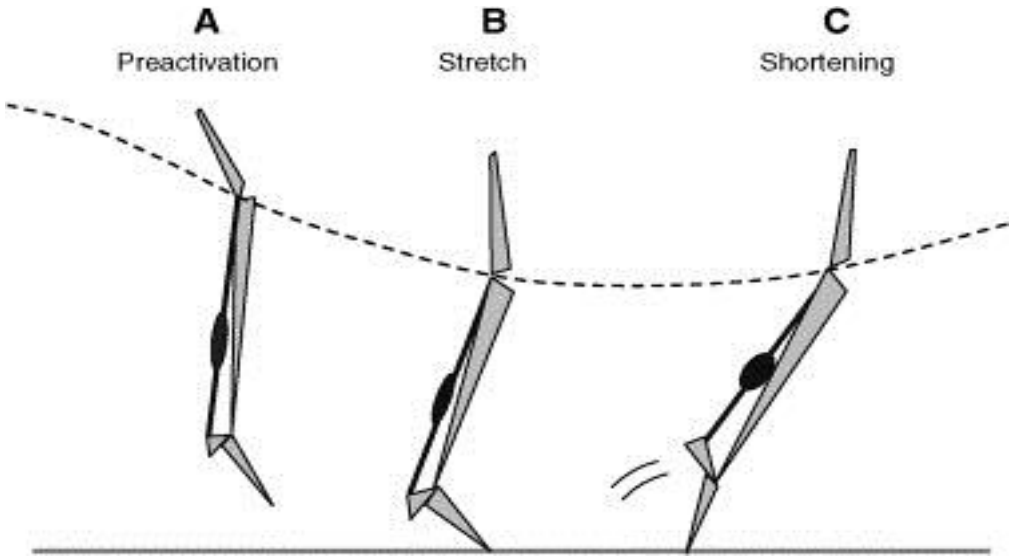

Figure 5: When contact takes place with the ground considerable impact loads occur from human walking, hopping and running. This requires pre-activation from the lower limb extensor muscles before the ground contact to make them ready to resist the impact (A) and the active braking phase (B). The stretch phase is followed by a shortening (concentric) action (C) (Komi, 2000)

Plyometric training (PT) has been proven to improve explosive strength, agility, jump height and sport specific performance (Michailidis et al. 2013). The main reason is because PT activates the stretch-shorting cycle (SSC) mechanism. The SSC is when the muscle is lengthened (eccentric phase) and then immediately after the lengthening the muscle is shortened (concentric phase) (McArdle et al., 2007; Komi 2000). PT is mostly used when training athletes from pre puberty to late puberty due to the fact that

testosterone levels in this age group are low. Due to the low testosterone levels at this age the ability for building muscle mass is limited and thus, neural adaptations should be the main focus of training (Söhnlein et al 2014).

There is no general recommendation available for young adults for improving sprint performance. Strength and conditioning coaches must therefore refer to the only general recommendation of a program and duration which were derived from a meta-analysis that included adults, adolescent and pre-puberty athletes. A pervious article suggests that 6 weeks of plyometric training consisting of one session per week leads to significant improvements in the traditional agility test known as the T-test, Illinois Agility Test and force production (Miller et al. 2006). This was one of the first papers to the author's knowledge that showed improvements in agility tests after a plyometric intervention. The recommendation is a program lasting 10 weeks with 18 high intensity sessions consisting of 80 jumps per session. There is a high trainability in preadolescent soccer players as has been shown by Michailidis et al. (2013) that a 12 week plyometric program leads to better improvements in squat jump (SJ), drop jump (DJ), countermovement jump (CMJ), single leg jump (SLJ), multiple 5-bound hopping (MB5), leg strength and sprint time, compared to normal soccer practice.

6.2 Slow and fact SSC

Slow (>0.25) SSC-type plyometric exercises are used to improve the initial acceleration phase (0-10m) (Delecluse et al. 1995). The ground contact time lasts longer than 0.25s and this type of movement involves large movements at the joints (Söhnlein et al. 2014). Fast (<0.25) SSC-type plyometric exercises improve the second acceleration phase (10-30) and maximal velocity phase (30m) (Delecluse et al. 1995). Less than 0.25s ground contact times generally involve smaller movement at the joints (Söhnlein et al. 2014). Typical sessions consist of 3-5 sets and 6-16 reps of each exercise (starting at 3 sets working up to 5 sets). The numbers of jumps\contacts start at around 90 and increase up to 180 over an eight week period. Number of ground contacts/jumps and jump type will dictate the session intensity. When good technique is mastered then the athlete should slowly and steady progress onto the next progression level. Landing mechanics and technique are factors that should be perfected before progression or

increase in intensity are considered. A jump mat can be used to determine an athlete's ability to utilize their SSC ability. It has been shown that 30, 60 or 120 seconds rest in between sets result in similar improvements (Ramírez-Campillo et. al., 2014). From the safety perspective and benefit of the athlete it should be noted that a good strength foundation should precede any plyometric work.

7 SPEED, AGILITY AND QUICKNESS (SAQ)

Speed, agility and quickness (SAQ) is used to improve reaction speed, change of direction, co-ordination, balance and neuromuscular activity, (Brown et al. 2005). This training method is becoming the most common protocol to train soccer players. This type of training program touches on developing all the different movement patters required within soccer. Sprints in soccer are usually not in straight line but include several changes of direction. Therefore SAQ should be useful to train all the components of soccer. Previous studies have shown that power, speed and quickness can be improved with SAQ training but not agility with and without the ball. This type of training only leads to improvements in lateral agility but no improvements occur with linear movements. Therefore, specific benefits can be achieved with SAQ training. Consequently, speed (linear direction), agility and quickness should be considered as separate motor abilities (Milanović, et al. 2013).

The term speed has a number of different meanings but in this case it is defined as the maximum velocity. Agility is important in most team sports which demand that the athlete be agile in order to make small, fast and precise movements. Quickness refers to reaction speed, acceleration speed and running speed. A typical SAQ session attempts to improve explosive movements that are essential for speed, agility and quickness (Milanović et al 2014).

7.1 Velocity

An athlete's maximum velocity is achieved after 30 meters of high intensity running. It has been suggested that sprint performance is characterised into 3 phases; (a) initial acceleration phase (0–10 m), (b) secondary acceleration phase (10–30 m), and (c) maximal velocity phase (after 30 m) (Delecluse et al. 1995). The 30m sprint test isn't very soccer specific but it is still necessary to assess all 3 phases of sprinting. After the implementation of a 12 week SAQ intervention program the participants improved significantly in all the tests (sprint with 180^{o} turns, sprint 4x5m, slalom test with ball,

slalom test, sprint with 90^{o} turn with ball and sprint with 90^{o} turns) carried out except for sprinting forward and backward (see table 4) (Milanović, et al. 2013).

7.2 Agility and/or Change of direction

Change of direction (COD) has sometimes been used as another name for agility but recently they have become acknowledged as different performance abilities. Agility has been defined as a whole body rapid movement with change of velocity or direction in response to a stimulus (Sheppard & Young, 2005). Agility is performance in a changeable environment such as a match. On the other hand COD takes place in a pre-planned environment, such as the traditional T-test. In the future these traditional agility tests may become known as change of direction speed (CODs) tests.

It has been studied that short term (3 weeks) agility training program can improve agility test results in young players (Jullien et al. 2008). This shows the importance of training specificity. Lateral agility has been found to improve with SAQ training (Milanović, et al. 2013) and linear agility has been found to improve with additional plyometric training (Söhnlein et al. 2014 & Saez de Villarreal et. al., 2012). It has also been shown that a player's agility can be significantly improved when the athlete is 18 years old. Previously it was considered that the majority of development occurs at 16 years old (Milanović, et al. 2013).

7.3 Reaction speed

Reaction speed is associated with the term "Quickness" (Brown 2005). Quickness is an essential part of soccer because during a game players have to perform short sprints every 4-5 second. These short sprints can include moving into an advanced position or tracking the movement of an opponent (Bloomfield et. al., 2007 & Mohr et. al., 2003). Being that millisecond faster than your opponent is the difference from winning and losing possession. When developing an athlete's quickness it is important to avoid using pre-planned agility exercises as this prevent the athlete from developing their

reaction speed (Milanović, et al. 2013). A way to incorporate this into a drill is to use different colour cones and the player runs to the colour cone that the coach calls our or the coach can simply show with hand signals which direction the player should run.

Table 4: Below shows the results achieved after a 12 week SAQ intervention. * and ** indicate significant difference ($p < 0.05$ and $p < 0.01$ respectively) between initial and final testing (Milanović, et al. 2013). The control group failed to produce any significant improvement.

	Experimental group (n = 66)		Control group (n = 66)	
	Initial	Final	Initial	Final
Sprint with 180° turns	7.40 (.33)	7.29 (.35) **	7.46 (.35)	7.49 (.36)
Sprint with backward and forward running	7.84 (.39)	7.74 (.39)	7.76 (.41)	7.80 (.43)
Sprint 4x5 m	5.93 (.38)	5.86 (.39) **	6.04 (.35)	6.07 (.34)
Slalom test with ball	10.93 (1.11)	10.67 (1.06) **	10.95 (1.21)	11.24 (1.23)
Slalom test	7.83 (.74)	7.77 (.76) *	7.85 (1.06)	7.95 (1.13)
Sprint with 90° turns with ball	9.92 (.60)	9.67 (.58) *	9.85 (.64)	9.91 (.65)
Sprint with 90° turns	7.83 (.51)	7.67 (.48) *	7.72 (.63)	7.75 (.65)

8 PURPOSE OF THE STUDY

The purpose of this study was to perform an 8 week intervention program in order to provide a recommendation of a suitable training program for young soccer players for improving sprint performance, agility, strength and jumping parameters (strength and power).

Research questions and Hypothesis for this study

1. What training protocol best enhances jumping power, speed and agility in young soccer players?

Hypothesis 1: Plyometric training leads to improvement in vertical jump height and linear speed.

Plyometric training improves speed and jumping but not change of direction (Sohnlein et. al., 2014).

Hypothesis 2: SAQ training leads to improvement in lateral agility

Speed, agility and quickness (SAQ) training improves agility performance with and without the ball (Milanovic et. al., 2013).

Hypothesis 3: Plyometric and SAQ training benefit young soccer players in a similar manner.

A variation in training can lead to improvements in performance.

2. Are two substituted plyometric and/or SAQ training session enough to observe changes in the results between the groups?

Hypothesis 4: Are two substituted plyometric and/or SAQ sessions for traditional training session enough to achieve improvements in the performance parameters measures.

9 METHODS

9.1 Study Design

Recruiting and group stratification: Recruitment was done by contacting soccer clubs in the Jyväskylä region who might be willing to participate in the study. The target group was 14-16 year old healthy boys who are part of a soccer club. Players were randomly assigned into a group according to their Pre-test results in the 30meter sprint, Agility and multiple 5 bound (MB5) test.

Inclusion criteria: Attending a minimum of 80% of the total session along with the pre and post measurements fully completed.

Physical Training: The goal of the training was to improve speed, agility and power of the lower extremities.

Plyometric training sessions consisted of a mixture of maximal and explosive strength training for both the lower extremities. Each session consisted of 2-4 sets by 6-8 reps 6 plyometric exercises, 3 slow (>0.25) SSC-type such as squat jumps, hurdle jumps, ect. And 3 fast (<0.25) SSC-type plyometric exercises, such as the 2-footed ankle hoop, single leg hop, ect. Jumps were performed in one plan of direction (upward/downwards and forward/backwards). The number of contacts increased from 72 to 128 until week 6 and then became to taper off. Traditional core exercises will be included as they are a typical part of training programs for all athletes.

SAQ training sessions included multidirectional sprints/ diagonal movements. These sessions comprised of 4-8 repetitions of 3-6 exercises. The type of drills included were 15-yard (triangle) turn drill, z- pattern run, Mirroring player, etc. The time off was maintained the same between the experimental groups.

Control group preformed traditional soccer training such as technical skills and moves (easy/difficult), position games (small/big, 2 vs. 2 offensive and 2 vs. 2 defensive and tactical games with various objectives.

Intervention schedule:

Week -1 - Familiarization sessions

Week 0 - pre testing

Week 8 - Post testing

Schedule for the measurements:

Each testing period subjects will have 2 days of testing 48 hours before the first training session and 48 hours after their final training session. The testing protocol was usually broken up into two days. Day 1 consisted of sprint and jumps and day 2 consisted of agility tests and any endurance tests (Moore et al. 2005, Ferrete et al. 2014).

Day 1

- Isometric leg press.
- Jumping performance; Countermovement Jump (CMJ) and Multiple 5 Bounds (MB5) Test.
- Speed tests; 30meter sprint with 10m acceleration phase also measured. (Infrared photocells gates).

Day 2

- Agility tests (without the ball); Finnish FA agility test
- Passing drill to test skill level.
- Soccer specific testing: shooting velocity.

9.2 Measurements

9.2.1 Anthropometrics:

Age (years), years of training, height (cm), weight (kg), BMI (kg/m^2) and circumference of thigh (cm) were recorded.

9.2.2 Isometric leg press:

Subjects sat into the chair. An electromechanical isometric leg press extension device (designed and manufactured by the Department of Biology of Physical Activity, University of Jyväskylä, Finland) was used to measure maximal bilateral isometric strength and average force over the first 500 ms of the maximal bilateral isometric strength measurement in a horizontal leg press position. The participants' knee angle was 107°, while the hip angle was 110°. Participants were instructed to produce force "as fast and as hard as possible" for approximately 3 s. Participants performed at least three maximum voluntary contractions (Häkkinen et al., 1998). If the maximum force during the last trial increased more than 5% from the previous trial, then an additional trial was performed. The best performance measured in Newtons was used for statistical analysis.

9.2.3 CMJ

Subjects performed the CMJ on a force plate with hands on their hips and feet shoulder with apart. A force platform (Department of Biology of Physical Activity, Jyväskylä, Finland) was used to measure maximal dynamic explosive force by CMJ (Komi & Bosco, 1978). Participants were instructed to stand with their feet approximately hip-width apart with their hands on their hips. Participants were then instructed to perform a quick and explosive countermovement jump on verbal command so that knee angle for the jump was no less than 90°.

9.2.4 MB5

5 jumps were performed and the total distance covered was measured. From a standing position with both feet on the ground, participants tried to cover as much distance as possible with 5 forward jumps by alternating left and right leg contacts. This test has been recommended for the measurement of lower-limb muscle power instead of the vertical jump test and is considered to be soccer specific (Sohnlein et. al. 2014). The horizontal distance between the starting line and the heel of the rear foot was recorded

to the nearest 1 cm using a tape measure. For all the jumping tests the best of the three trials was chosen for further investigation.

9.2.5 Sprint test

Subjects started 0.70m behind the photocells and they were allowed to start whenever they wished and instructed to push off their front leg. There were 3 sets of photocells; one at 0m, second at 10m and the third at 30m. 2 minutes rest between trails was allowed.

9.2.6 Agility tests

When preforming the agility test the players preformed the test without the ball. A total of 3 trails were timed and the best was used for the statics analysis. 3 minutes rest between tests was allowed.

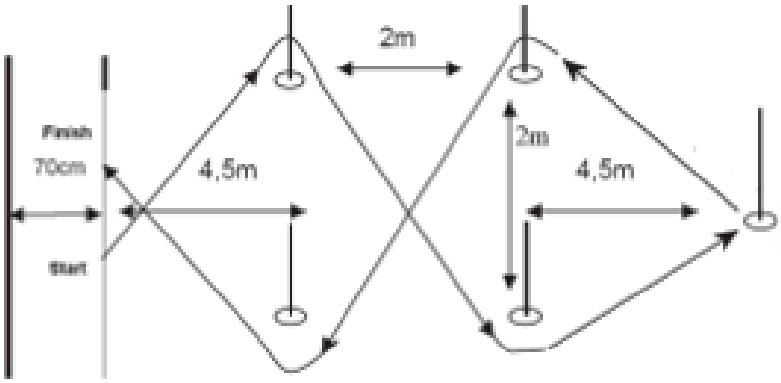

Figure 6: Finnish FA agility test

9.2.7 Passing drill

The passing test layout included two cones 6 m apart from each other and 2 m wide passing walls placed 7 m apart from the cones. Performance time started when a player kicked the soccer towards the wall. Then the player repeated the cycle: pass - receive rebound - dribble between cones - pass to the other wall. The performance ended when

the 10th pass hit the passing wall. Five of the passes were given with the right foot and five with the left foot. One successful performance, which was always achieved by the fifth attempt, was required in the test (see figure below). Every player had at least 3 trials each.

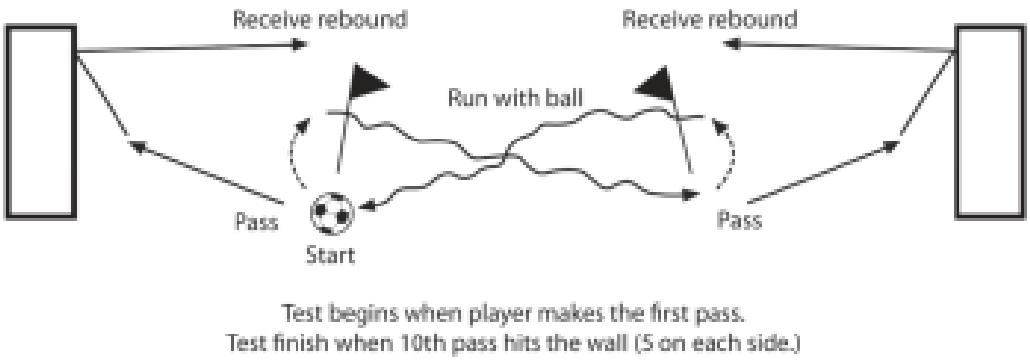

Figure 7: Passing test used in the study

9.2.8 Shooting velocity and accuracy test:

Players performed a maximal velocity instep place kick to a stationary ball. A ball with a standard International Federation of Association Soccer size and inflation was kicked from 11 meters toward a target 1.5 x 1.5 meters. The players were asked to approach the ball at a speed of their choosing and shoot the ball as hard as possible. The first 3 shots that hit the target were recorded; each player had 1 minute rests in between trails. Ball speed was measured using a radar gun (Sports Radar, The Stalker Pro II, Sarco Oy, Helsinki, Finland) located 4 meters behind the spot kick, held by a person standing on a chair and pointed toward the target according to the instruction manual.

9.3 Training intensity

Firstbeat team analysis was used to measure training intensity over the 8 weeks. Each player had his own belt and had to make sure it was working before the start of the training session. Only the first 30-45 minutes of each training session was recorded, because this was when they were broken into their experimental groups.

9.4 Statistical Analyses

Firstly the data was checked for normality. All dependent variables were normally distributed according to the Shapiro-Wilk test and the Levene's test was used to make sure there was no violation of homogeneity of variance.

A One-way ANOVA (time X group) was carried out to analyse if there were any significant changes between the 3 groups in the parameters measured. A paired sample t-test was used to analyse if there were any within group differences. There were no significant between group differences. It should be noted that one subject from the Control group was unable to complete the post agility, passing and shooting tests.

10 RESULTS

10.1 Subject information

Subjects were aged between 14-15 years old (SAQ group 14.5±0.5, Plyometric Group 15±0.6 and Control Group 14.9±0.3) and have training in soccer for at least 5 years ((SAQ group 7.1±1.7, Plyometric Group 7.58±1.9 and Control Group 7.6±1.96). Players were randomly divided into groups dependent on their Pre-test results in the 30meter sprint, Agility and multiple 5 bound (MB5) test.

There were no statistical differences between the SAQ group and the PT Group. However the Control group was statistical different from both groups in weight (Group 1; per=0.009, post=0.007 & Group 2; per=0.005, post= 0.006) and circumference of thigh (CoT) (Group 1; pre p=0.01, post p=0.003 & Group 2; pre p=0.013, post p=0.005) (table 5).

There was no interaction between weight measurement points ($F(2.30)=0.683$, $p=0.513$). A significant main effect was found for measurement ($F(1.30)=25.971$, $p<0.001$) and for group ($F(2.30) = 7.211$, $p=0.003$). That was also a significant main effect for CoT measurement ($F(1.30)=39.84$, $p<0.001$) and group ($F(2.30)=7.288$, $p=0.003$). All groups significantly increased ($p<0.01$) their CoT from pre to post measurements.

10.2 Countermovement jump (CMJ)

The Control group were the only group to significantly ($p<0.05$) improve from pre to post measurements in the CMJ (table 6).

Table 5: Subject information **(**Mean±SD)

	SAQ Group (n=11)		PT Group (n=12)		Control Group (n=10)	
	Pre	Post	Pre	Post	Per	Post
Age (years)	14.5±0.5	-	15±0.6	-	14.9±0.3	-
Years of Training	7.1±1.7	-	7.58±1.9	-	7.6±1.96	-
Weight (kg)	60.53±6.6#	61.51±6.5#	59.91±10.2#*	61.63±10.4#*	72.89±9.3*	74.25±8.9*
Height (cm)	177.78±6,9	178,6±6,7	174.57±8.4	175.98±8.7	180.76±5.8	181.02±5.9
BMI	19.09±1.2#	19.22±1.3#	19.58±2.5#	19.79±2.5#	22.34±3.1	22.71±3*
CoT (cm)	48.57±2.7#	49.63±2.6#**	48.87±4.8#	49.98±4.6#**	53.95±3.7	55.56±3.8**

* $p<0.05$, ** $p<0.01$ & *** $p<0.001$, refers to significant differences between Pre and Post.

# $p<0.05$, significant difference with the control group.

10.3 Isometric leg press

The SAQ group significantly improved in the isometric leg press ($p<0.001$) while the control group significantly improved ($p<0.05$) their isometric strength. The plyometric also improved their isometric, however, it was not significant ($p=0.71$). A significant main effect was found for measurement ($F(1.30)=6.62$, $p<0.015$). When body weight is taken into account only the SAQ group maintain improve relative to their size (fig. 8).

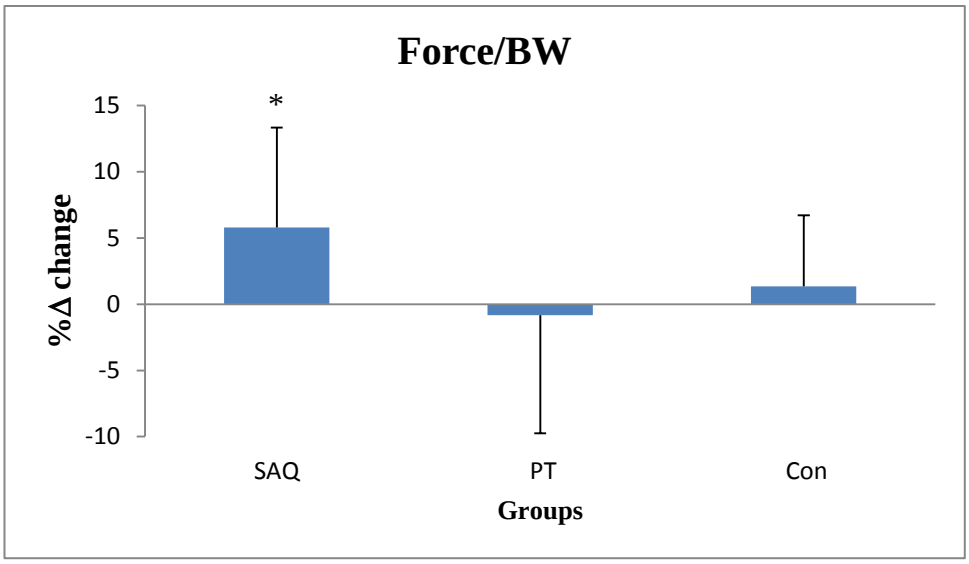

Figure 8. Relative changes in strength/body weight expressed as delta percentage change. *p≤0.05, (mean ±SD).

10.4 30meter sprint

No main effect was found for measurement ($F(1.30)=0.23$, $p=0.637$) or for group ($F(2.30)=1.87$, $p=172$) regarding to the 30 meter sprint. However, the only noticeable change was that the control group became significantly slower ($p=0.02$) from pre to post in the 30meter sprint the other two groups got a little bit faster (fig. 9).

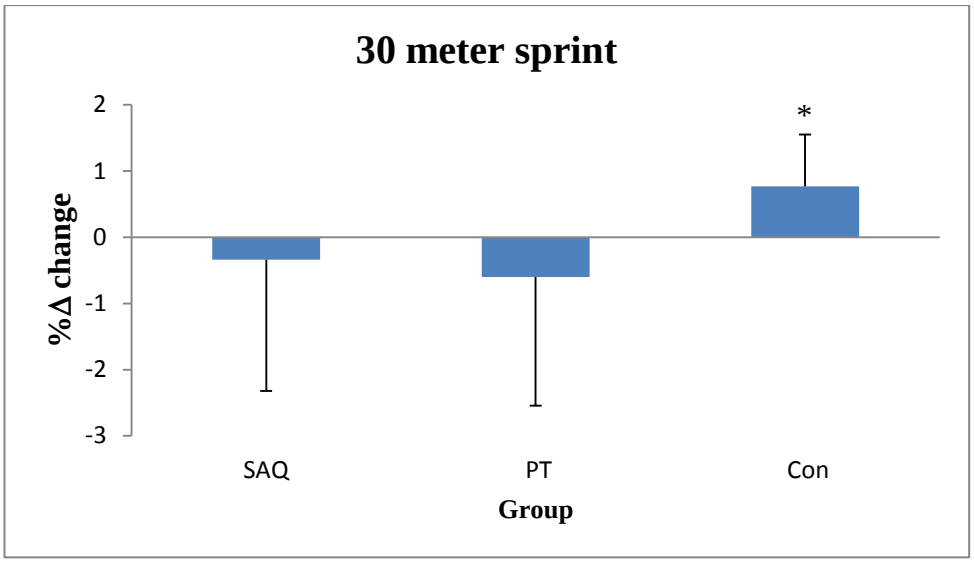

Figure 9: Relative changes in 30meter sprint time performance. *p≤0.05, (mean ±SD).

10.5 Multiple 5 Bounds (MB5) Test

A significant main effect was found for measurement ($F(1.30)=7.17$, $p<0.012$). The plyometric group were the only group to significantly improve their MB5 ($p<0.05$) (fig 10.).

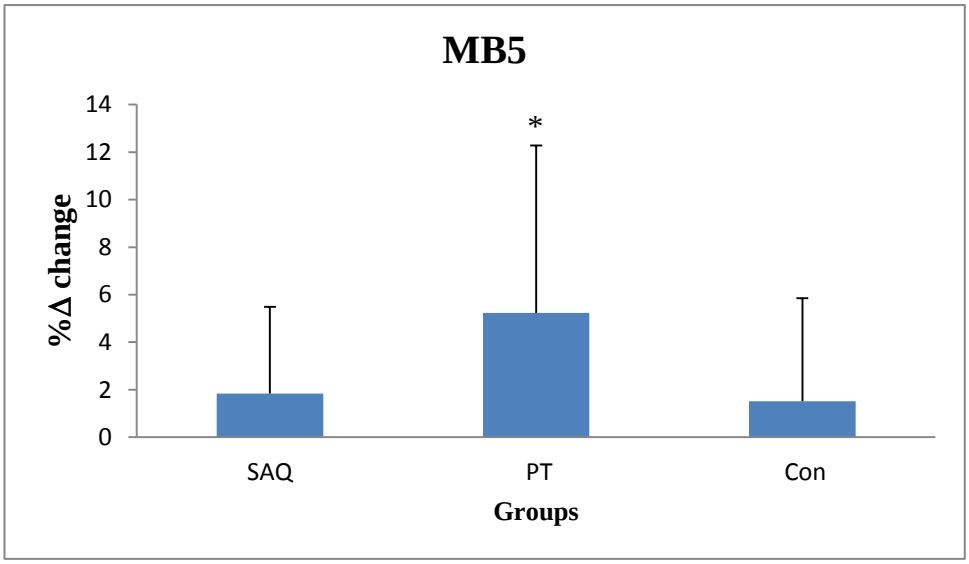

Figure 10: Relative Changes in MB5 performance. *p≤0.05, (mean ±SD).

Table 6: Absolute strength, power and performance values at pre and post measurements within the Groups (Mean±SD).

	SAQ Group (n=11)		Plyometric Group (n=12)		Control Group (n=10)	
	Pre	Post	Pre	Post	Per	Post
CMJ (cm)	27.92±4.91	27.45±3.83	27.83±4.26	28.1±4.07	27.02±2.24	**28.82±3,93***
Isometric leg press (N)	2686.75±743.9	**2884.01±771.76*****	2910.25±811.65	2945.95±714.92	2817.54±506.82	**2892±40***
Force/BW (N/kg)	44.49±10.9	**46.88±10.7*#**	48.4±10.4#	**47.5±7.2##**	38.6±5.2	38.9±5.9
RFD-max N/s (10ms)	13146±4958	12289±2765	12758±3221	13755±8353	13481±6154	11852±4265
0-10m phase	1.77±0.10	1.77±0.08	1.79±0.10	1.77±0.06	1.80±0.07	1.81±0.07
30m Sprint (s)	4.41±0.25	4.39±0.20	4.44±0.24	4.41±0.18	4.48±0.18	**4.51±0.18*↓**
MB5 (cm)	11.18±0.90	11.36±0.63	11.33±0.95	**11.85±0.78***	11.57±1.19	11.65±0.97
Agility (s)	7.10±0.15	7.17±0.22	7.11±0.23	7.12±0.25	7.32±0.34	7.34±0.41
Passing (s)	40.06±4.18	40.18±2.53	40.82±5.11	40.30±6.81	38.72±3.93	38.61±4.13
Shooting (km/hr)	87.37±8.12	85.72±5.82	85.91±6.91	**80.75±8.61****	89.47±7	88.07±5.25

* $p<0.05$, ** $p<0.01$ & *** $p<0.001$, refers to significant differences between Pre and Post measurements.

# $p<0.05$, ## $p<0.01$ significant difference with the control group.

10.6 Agility tests

There was no significant main effect change in measurement ($F(1.29)=1.98$, $p=0.170$) or group ($F(2.29)=0.45$, $p=0.642$) from pre to post in any group in the agility test.

10.7 Passing test

No significant improvements were observed in the passing test. Main effect for measurement ($F(1.29)=0.22$, $p=0.648$) and for group ($F(2.29)=0.22$, $p=0.803$).

10.8 Shooting velocity and accuracy test

There was a significant main effect present in measurement ($F(1.29)=14.080$, $p=0.001$) but not between groups ($F(2.29)=2.93$, $p=0.069$). The Plyometric group shooting speed got significantly slower ($p<0.001$) from pre to post measurements while both the other groups decreased their performance but was not found to be significant.

10.9 Correlations

By examining the percentage change in all performance parameters measured from pre to post measurements the following correlations were found.

CoT was significantly related to how well subject performed in the MB5 ($r = -0.371$, $p<0.05$). CoT had a possible trend toward significance with 30m Sprint ($r = 0,309$, $p = 0.080$) and had a clear tendency to a significant relationship with Isometric leg strength ($r=-0.334$, $p=0.057$). MB5 performance was significantly correlated with CMJ ($r = -0.348$, $p<0.05$). A significant positive correlation was observed between the changes in passing performance and the changes in Shooting speed ($r = 0.462$, $p = 0.008$). There was a significant correlation between the changes in the 30meter time and Pre 30 meter sprint time ($r = -0.28$, $p \leq 0.001$) (fig. 11).

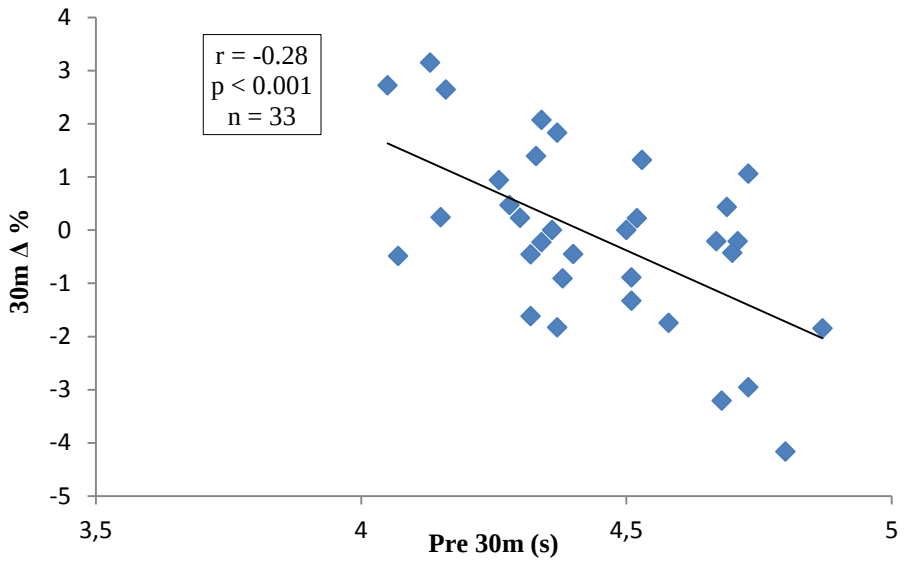

Figure 11: Correlation between Pre 30meter sprint time and percentage delta change.

Once correlations between the different measurements were reported then the correlations within the 3 groups were examined. This reveled that in the SAQ group the number of years of training and shooting performance were correlated marginally nonsignificant ($r = 0.525$, $p = 0.097$). Shooting performance and 30 meter sprint speed were also leaning towards correlation ($r = -0.542$, $p = 0.085$). Passing performance and Isometric leg strength nearly approached statistical significance ($r = -0.557$, $p = 0.085$).

In the Plyometric group the years of training ($r = -0.535$, $p = 0.073$) and how much force the subject could produce ($r = -0.539$, $p = 0.071$) were correlated nearly significantly with the 30 meter sprint. Cot ($r = 0.700$, $p = 0.011$) had a significant correlation with the performance in the 30 meter sprint. Performance in agility has a significant correlation with passing performance ($r = 0{,}677$, $p = 0.016$) (fig. 12) and shooting speed ($r = 0.680$, $p = 0.015$) while passing and shooting performance have a strong correlation ($r = 0.594$, $p = 0.041$).

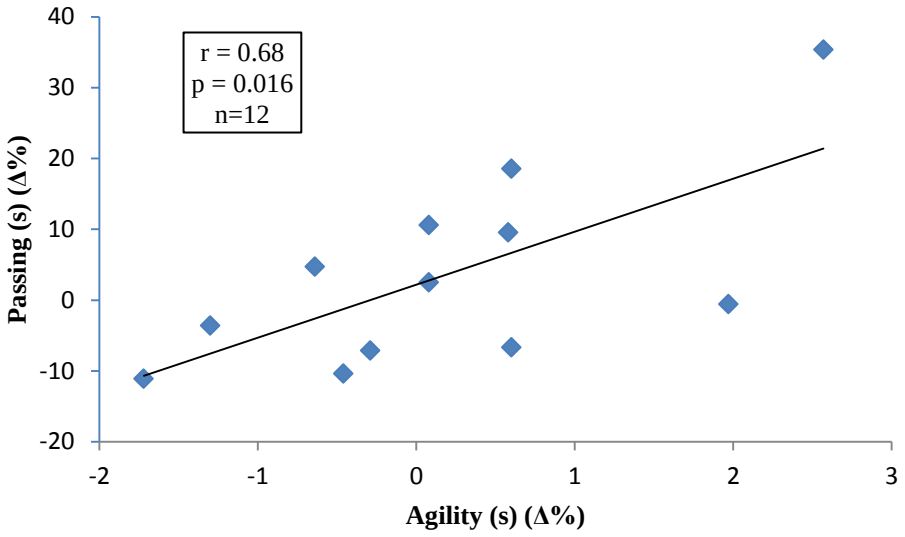

Figure 12: Correlation between the changes in Agility and the changes in passing performance between Pre and Post within the PT Group.

In the control group there was a significant correlation between the changes in the Isometric leg press and 30 meter sprint (r = 0.670, p = 0.034) (fig. 13) while it was heading towards correlation with both passing (r = -0.607, p = 0.083) and shooting (r= -0.634, p = 0.067). In this group the 30 meter sprint speed had a significant correlation with passing (r = -0.708, p = 0.033) and shooting (-0.870, p = 0.002). Passing and Shooting had a significant correlation (r = 0.905, p = 0.001) in this group. The jump height in the CMJ and the distance cover in the MB5 narrowly missed achieving significance correlation (r= -0,619, p = 0.056).

10.10 Training intensity

By using the Firstbeat monitoring system we were able to monitor the training intensities of all the training groups. Once the study was complete the average Heart Rate Max of each session was examined and the control groups trained at higher intensities as you can see in table 7. The mean delta percentage difference between SAQ and control was 6.8% and the mean delta percentage difference between the

plyometric and control was 10.1%. While the difference between experimental groups it was 3.1%.

Table 7: Average HR for each group over the 8 weeks during the first 30-45minutes of the training session (mean ±SD).

Groups	**SAQ**	**PT**	**Control**
Average HR (bpm)	133±16.7	129±16.1	142±11.8*
Range (bpm)	99-168	100-165	108-178

11 DISCUSSION

The present study examined the effects of 3 different training protocols on soccer players aged between 14-15 years old. The main findings from the study were:

1. The SAQ group significantly improved their absolute and relative strength levels in the isometric leg press from pre to post.

2. The Plyometric Group were the only group to significantly improve their performance in the MB5 from pre to post.

3. The control group significantly improved their performance in the CMJ. However, it was the only group who significantly slowed in the 30m Sprint post measurements.

4. The skill level of all the players remains unchanged over the course of the 8 weeks.

11.1 SAQ training

Previous studies have indicated that additional SAQ training can improve performance in agility tests (Milanović, et al. 2013) and straight line speed (Milanović et al 2014). However, from this study the SAQ group's agility performance and sprint speed did not improve to the amount expected. It is important to note that the isometric strength improved very significantly from Pre to Post measurements. Although this is not a popular test to be performed when researching performance level of soccer players, this test is a very reliable and the improvement in the players isometric strength can only be look at as a positive outcome for the 8 weeks of training. It could be suggested that diagonal sprint training is effective to develop strength levels in soccer player's age 15 years old. A positive training effect can be produced without the use of expensive additional equipment, which is an advantage for soccer clubs and Strength and conditioning coaches. For this age group it might be enough to practice sprint training in preseason to develop lower body strength. However, if one wants to develop other performance parameters additional strength exercises and plyometric training are required. Also, without preforming efficient strength training to stabiles the joints the

likely hood of injury is increased (Faigenbaum et al. 2010). Therefore, it is highly recommend the preform proprioception exercises and strength exercises should also be performed the help prevent injury (Lauersen et al. 2014).

11.2 Plyometric training

It has been previously shown that plyometric training improved jump height and jump distance (Michailidis et al. 2013). As predicted jump height and length did improve but oddly enough the result was not significant in the CMJ whereas it was significant for the MB5. It has been suggested that the MB5 is a soccer specific test and more applicable to determine the performance level of a soccer player (Michailidis et al. 2013). Horizontal jumps maybe more soccer specific because players have to constantly jump over tackles, jump to make tackles, etc. These types of jumping tests are not as popularly used in research but they are becoming more commonly used. The reason may be that in order to have data that is comparable to previous research the tests must remain the same. Two relative new studies have used the MB5, LJ and single leg jump to examine power production (Michailidis et al. 2013& Söhnlein et al. 2014). These tests are becoming more popular to use when working with soccer players. They are more closely related to movements that occur during a soccer game. Jumping off one leg is more often the way a player jumps for the ball.

Furthermore, this result may be due to the type of training program the players completed. The start of the program did include exercise for improving jump height at the start but as the program progressed the exercises focused more on repeated jump ability in the sagittal plane. The exercise where preformed mover forward and it was difficult to emphasis jump height when suitable equipment was not available to the trainers. Soccer is a running sport and in order to increase running speed you have to improve horizontal propulsion forces and minimize horizontal breaking forces. This program was aim towards training specificity. The focus was towards plyometrics in the horizontal force production to train in a specific manor to improve speed.

There is previous evidence to suggest that performance in speed and agility can be improved by plyometric training (Söhnlein et al. 2014 & Saez de Villarreal et al. 2012).

Some studies have suggested that 8 week is not long enough to find improvement in the 30 meter sprint time (Söhnlein et al. 2104). However, in this study the 30 meter spring time did improve in the plyometric group and the SAQ group. Straight line speed improved but agility for did not change from pre- to post measurements. Although agility did not improve, there was a correlation between agility performance and passing performance, shown in figure 12. The passing test involves reactive agility, when the ball rebounds from the wall. This acts as the stimulus the player has to react to, whereas the agility test used in this study was more pre-planned change of direction which has been shown to be difficult to improve (Sporis et al. 2010). This positive correlation suggests that this type of training may be suitable for developing reactive/unpredictable agility, which is game specific.

11.3 Control Group

Previous research shows that traditional soccer training does not lead to any significant improvements in measurements of agility, jumping and speed. A complex training method may be the most favourable training strategy for improving jumping performance, sprint and agility performance. A combined resistance training program combined with plyometric training or SAQ training should be more beneficial to the athlete traditional training methods (Seitz et al. 2014).

However, the Control Group in this study mainly preformed small sided games with increasing intensity from weeks one to six. Interestingly, the Control group did improve their jump height and absolute Isometric leg press significantly. This may be due to the high intensity small games and the fact that they had to jump to compete for the ball in the air. However, they were the only group to get significantly worse in the 30 meter sprint. Therefore it can be suggested that additional SAQ training and/or Plyometric training is required to maintain or improve maximum speed. Straight line acceleration is a key performance measure when it comes to determining who can make it to the top level in soccer. From figure 11, we can see that if a player is already fast to begin with it is difficult to become faster. Once again a variation in training to develop and/or maintain a player's speed is necessary when players have surpassed their PHV.

Interestingly, there was a positive correlation between the decrease in sprint speed and the increase in the isometric leg strength (fig. 13). Furthermore, when you take into account the subjects' body weight (BW) their overall performance has decreased in the isometric leg press compared to the other groups (Table 6). The CG were bigger in size (Table 5), providing a possibly reason why they were overall stronger compared to their smaller counterpart when looking at the absolute value but unable to transform this strength into efficient power production. They may have reached their maximum maturity development already whereas the other groups still have to.

11.4 Skill development

The time to complete the passing slightly decreased in the SAQ group where it slightly improved in both the Plyometric Group and the Control Group. It is important to note that these changes were not significant which means the skill level of all the players remained at the same level over the 8 weeks of training. Therefore, performing an additional 1 hour of Plyometric training or SAQ training does not affect the skill level of boys aged 15 years old. During a 6 hour training week it is recommended to preform 1 hour of SAQ and plyometric training sessions.

There are many different physical attributes that have a role in soccer but this study concentrated on the importance of jumping performance, sprinting ability and agility. All of these affect a player's ability while playing the game. It is important for players to be able to out-jump/out-run opponents when competing for aerial duels, retrieving a loose ball, closing down an opposing player with the ball, passing a player when in position of the ball, etc. All these aspects of the game involve being able to perform well in all these physical performance tests. A coach can visually see the performance trade off on the pitch once the players are put to the real test, which is playing a game. Young players sprinting ability is an early indication if they have potential to play at the top level. Researchers have suggested that this is one factor that is extremely difficult to improve (Gonaus et al. 2012, Vestberg et al. 2012). The most commonly used sprinting tests are the 15m and the 30m speed test. This seems to vary from country to country. Researchers may carry out the same test that clubs use in their own test battery. Further research is needed to make sure this idea is correct. Agility is another

very important aspect of determining how successful a player will eventually be (Jovanovis et al. 2011). There seems to be no longer a standard agility test that all researchers use. It is evident, from a large amount of the articles, that researchers develop their own agility test or use one derived by their FA (Football association) body in their own country. The greater power performance is also a very important aspect of a soccer players overall performance (Jovanovis et al. 2011, Dardouri et al. 2013).

11.5 Training intensity

From the data gathered by the Firstbeat monitoring system it is clear to see that the control group reached higher HR max and overall average over the course of the 8 weeks (fig. 13). By examining the data collected we can only speculate that the control groups trained the aerobic system. One can only make an observation due to the absence of a VO2max test. Small sided games maybe a suitable method to train the endurance system of player aged 14-15. It would have been interesting to have performed an endurance test to see how the intervention affected their stamina. On the other hand, training intensity can be reduced when the goal of training is to improve anaerobic performance. During the study this information was useful because the intensity of the next session could be determined correctly.

11.6 Strengths and Limitations

Strengths: For a study on soccer, the number of participants was relatively high and therefore gives the study power. Usually studies have 8-10 players in a group and in this study there were up to 12 players in a group. The number of performances tests measure was also relative high and gives a good overall view of the change in performance from pre to post measurements. There was good communication between the soccer coaches and the researchers which prevented the participants from overtraining and reduced the risk injury. The stress from playing games was avoided because the intervention took place during the pre-season. Players had time to focus only on training and improving themselves as athletes.

Limitations: Some limitations of the study were that the participants were young and you cannot be sure if they follow the instructions regarding what to eat and how much the train. The participants were asked to try to eat the same food and prepare for the pre and post measurement in the exact same way but this cannot be fully controlled. On intervention day the participants were also asked to avoid any strenuous activity that may affect their performance in the session. However, this again cannot be controlled. Being unable to monitor all the external factors coming up to the time of testing may affect the reliability of the results.

12 PRACTICAL APPLICATION AND CONCLUSIONS

The present study was conducted with an amateur young soccer team and it has indicated that plyometric and/or SAQ training is required for boys aged 14-15 years old to maintain and/or improve maximum sprint speed over the course of an 8 week training period. Only two 30-45minute session was required to improve straight line speed and jumping in the horizontal plane. This frequency of training was also sufficient to maintain agility performance and vertical jump height. Teams that do not have access to specialized training equipment know that basic plyometric and SAQ training is beneficial to the young players.

To conclude plyometric, SAQ and traditional training all seem to be an effective way of training young soccer players. They are all required to attain an overall improvement in performance. For example, players in the SAQ group may have benefited more from the plyometric training. Players should be considered at as individuals and, therefore, the sessions should be individually tailored. For amateur young soccer teams that do not have the time or money to provide individual training, combining plyometric and SAQ training twice a week maybe the most suitable option or to focus on plyometric training for one session and then SAQ training for the next session maintaining a 48 hour break between the sessions.

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