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THE IMPORTANCE OF STRENGTH AND POWER ON KEY PERFORMANCE INDICATORS IN ELITE YOUTH SOCCER

ABSTRACT

The purpose of this investigation was to examine the importance of strength and power in relation to key performance indicators (KPI's) within competitive soccer match play. This was achieved through using an experimental approach where fifteen subjects were recruited from a professional soccer club's scholarship squad during the 2013/14 season. Following anthropometric measures, power and strength were assessed across a range of tests which included the squat jump (SJ), countermovement jump (CMJ), 20 metre (m) sprint and arrowhead change of direction test. A predicted 1-repetition maximum (RM) was also obtained for strength by performing a 3RM test for both the back squat and bench press and a total score of athleticism (TSA) was provided by summing z-scores for all fitness tests together, providing one complete score for athleticism. Performance analysis data was collected during 16 matches for the following KPIs: passing, shooting, dribbling, tackling and heading. Alongside this, data concerning player ball involvements (touches) was recorded. Results showed that there was a significant correlation ($p < 0.05$) between CMJ ($r = 0.80$), SJ ($r = 0.79$) and TSA ($r = 0.64$) in relation to heading success. Similarly, a significant correlation ($p < 0.05$) between predicted 1RM squat strength and tackle success ($r = 0.61$). These data supports the notion that strength and power training are important to soccer performance, particularly when players are required to win duels of a physical nature. There were no other relationships found between the fitness data and the KPI's recorded during match play which may indicate that other aspects of player's development such as technical skill, cognitive function and sensory awareness are more important for soccer-specific performance.

Key Words: Physical fitness, match play, tackling, heading

INTRODUCTION

Success within professional soccer is underpinned by several key factors. It has been suggested that psychological, physical, technical and tactical skills all play a role in creating the elite individual and team (8,13,16). Where physical demands are concerned, players are required to endure large volumes and varieties of stress during match play. It has been reported that players cover a mean distance of 10,714 metres (m) per game (4) during which time, multiple sprints of varying distances (18), and changes of direction (approximately 1,200-1,400 times per game) occur (3). It has also been reported that from a sample of 271 professional players competing in the Norwegian football league, 7.8% head the ball over 20 times per match, with 37.1% heading the ball 6-10 times (31). Furthermore, it has been noted that teams finishing higher within the league table show enhanced physical qualities, inclusive of larger aerobic capacity (40), greater back squat strength (40), increased repeat sprint ability (27), and increased performance during jump testing (1). However, there is a paucity of data pertaining to strength and power profiles of elite players with the majority of literature focused on physiological qualities such as aerobic capacity. Regardless, it would appear that a wide spectrum of aerobic and anaerobic qualities are required to optimise a player's physical readiness to perform.

Although increased physical attributes are linked to higher performance, it is important to remember that technical skills (also referred to as key performance indicators [KPI's]) such as passing success/accuracy is also vital to soccer success (12). These skills may not be influenced by increased fitness; however, there appears to be limited research assessing the association between the two. Aerobic fitness has previously been linked to increased passing success (19,26,30). Previous studies have demonstrated a reduction in passing accuracy of 41% after the first half and 60% at the end of the second half (26), possibly due to fatigue becoming more of a prominent factor. It was also reported that those who showed greater decrements within passing accuracy following fatigue simulation also scored lower on the intermittent yoyo recovery test (26). Further studies have also shown that higher levels of fatigue lead to a decrease in both passing (19) and kicking accuracy (30). However, caution must be made when using this evidence as the aforementioned studies make use of fatigue simulation alongside a passing test to analyse a cause and effect relationship. These methods may not represent the true picture when studying findings during actual competitive match play. Further to this, although dribbling requires players to control the ball at speed whilst also quickly changing direction to evade an opponent, previous research could find only low to moderate relationships between dribbling ability and players' speed and agility qualities (11). Finally, strength and power have anecdotally been linked to heading and tackling success. Following strength and plyometric training, torque around the knee joint within a kicking position (similar to that of a tackle)

was seen to be increased by up to 13.6% (25). Similarly, both vertical jump height and levels of maximal strength have been reported as essential to heading performance (15,20,24), with players who display superior jumping ability having the potential to produce headers with greater ball velocity (20).

It can be seen that physical fitness plays a key role within these aspects of soccer performance; therefore, it is prudent to assess the impact that fitness can play upon enhancing these technical skills. As previously described, the current literature surrounding fitness and the success of technical skills places particular focus upon superior aerobic capacity. Furthermore, technical skills have also been mentioned alongside strength and power, however, this link within the current literature appears to be somewhat modest. To the authors' knowledge, no research to date has aimed at assessing if those displaying higher levels of strength and power are more successful within these movements during match play when competing with an opponent. Therefore, the purpose of this research was to further develop an understanding of how players' physical fitness scores relate to performance indicators during match-play. Particular emphasis will be placed upon the role strength and power can play upon heading and tackling success as there appears to be a distinct gap within the current research surrounding soccer performance.

METHODS

Experimental Approach to the Problem

In order to further understand the impact of physical fitness upon soccer-specific performance, a fitness testing battery deemed suitable for soccer (34), was conducted. Furthermore, match performance data was also required to ascertain success rates for all player KPI's which had previously been identified within the literature and consisted of: passing, shooting, heading, tackling and dribbling (10,32) and ball involvements or 'touches' during match play. This data collection would then enable links to be made between physical fitness and match performance across 16 competitive matches. All fitness testing data was collected as routine practice as part of the squad's annual fitness testing battery.

Subjects

A total of 15 male, outfield players (5 defenders, 6 midfielders and 4 strikers) from the club's scholarship squad (age: 16-18 years; mass: 77.9 ± 7.9 kg; height: 179.9 ± 6.5 cm), volunteered to

participate in this study. During the season the club participated at level 5 of the English football league system, with the scholarship squad competing within the Youth Alliance League. Players were approached by the researcher within his role at the club and were informed of the study intentions. All players had a minimum of two year's resistance training experience within a structured strength and conditioning programme. Furthermore, any players who were injured during the time of the fitness testing battery were removed and subsequently any data pertaining to that individual was deleted. Informed consent was gained from all players, as well as from the parent or legal guardian for any player under the age of 18, and from the soccer club with further ethical approval sought and gained from the London Sports Institute Research and Ethics Committee, Middlesex University.

Procedures

The players performed the following battery of fitness tests at the clubs training ground, with a grass training pitch and gym facilities utilised for the testing. Testing took place at the end of the pre-season period. The surface and weather conditions were dry and warm to enable maximal effort and minimum risk during tests conducted outside. Anthropometrics (height and body mass) including body fat percentage were measured using skinfold callipers (Harpenden Skinfold Callipers, West Sussex, UK) and calculated using the ISAK seven site method of calculation (14). This involved taking skinfold measurements at the following sites: triceps, biceps, subscapular, supraspinale, abdominal, thigh and calf. Testing took place over two separate days with a specific warm up chosen for the jump, sprint, and agility tests on day 1. A jump mat (Just Jump system) and electronic speed gates (Brower TC Timing system, Salt Lake City, Utah, USA) were utilised to capture the data for jump and sprint tests and players were afforded two practice trials before the commencement of data collection where three trials were conducted. Best scores were used for subsequent data analysis. Specific gym-based warm ups were provided on day 2 for the back squat and bench press in line with NSCA warm up suggestions for 1 repetition maximum (RM) testing (6). It should be noted that all players were previously familiar with all tests and exercises as they were conducted as part of the club's routine fitness testing battery each year.

Fitness Testing Battery

Squat jump (SJ) and Countermovement jump (CMJ). During the squat jump the players were required to place hands upon hips, squat to 90 degrees, and pause for three seconds before being instructed to jump. This removed the stretch shortening cycle component in order to test concentric jump

capacity alone (7,21). The hands were required to remain on the hips during the entire jump as arm swing is reported to have a significant effect on take-off velocity (7). Legs were required to remain fully extended during the flight phase of the jump (21). For the CMJ, subjects were required to keep their hands on their hips for the entire jump and utilise a pre-squat to a self-selected depth followed by a maximal effort vertical jump (21). Legs were again required to remain fully extended during the flight phase of the jump (21). Any deviation from the outlined specifications resulted in that trial becoming void and another attempt was given after a 60-second rest period. It is important to note that during jump testing only jump height values were recorded. The fitness testing battery included both jump tests in order to assess each players ability to utilize the stretch shortening cycle (SSC), with a larger CMJ relative to SJ suggesting better SSC ability (7,21).

Arrowhead agility test (AAT). Players were required to run the test course, outlined in Figure 1, turning each direction (initial right or left) independently, i.e., with a rest period before the next trial. Players started between the two start cones and followed the path of the black line as outlined in Figure 1. The same procedure was conducted for the opposing direction with trials alternated for each direction. Players were given 3-minutes rest between each trial to allow for adequate recovery. The best score for each direction was then added together to form one total score for the arrowhead test.

*** INSERT FIGURE 1 ABOUT HERE ***

20m sprint. The players were required to make a 20m maximum sprint from a standing start, with the front foot positioned 50cm behind the start line. Players initiated the start of each trial, with the time being recorded from when they broke the beam from the electronic timing gates. A cone was placed 5m behind the finish line in order to encourage the players to continue sprinting through the line. Each player was provided with 3-minutes rest between trials in order to maximize recovery.

Back squat and bench press (3RM). A 3RM test was conducted to provide a prediction for absolute maximum totals due to players' inexperience at conducting 1RM protocols, which have also been shown to be inaccurate with a comparable sample (29). Previously validated equations were used to determine 1RM totals (17), with absolute predicted values used for subsequent data analysis. For the back squat, players were required to reach a parallel depth as a minimum requirement (defined as the quadriceps reaching parallel to the floor). For the bench press, players were required to lower the bar and lightly touch the chest before fully extending the elbows in order to complete a

successful lift. Both of these were closely monitored for deviations by the primary researcher. If three repetitions were not successfully achieved, players were provided with 5-minutes rest before another attempt was given. A total of three attempts at any one load was allowed before taking the previous successful total as the player's 3RM value.

Key Performance Indicators

Information regarding individual match performance was gathered from the first 16 completed matches of the 2013-14 season; the team's record during this time was 11 wins, 1 draw and 4 losses. Matches were recorded using a single camera system, positioned upon a gantry above the halfway line (35). The footage was then analysed using Dartfish™ software, through a tagging system which has been previously used in team sport environments (35). This enables each KPI to be tagged to the individual player performing the action so that total match actions, including success and failure, can be recorded. In order to reduce inter-operator variability, one performance analyst analysed all 16 matches with a previously determined coefficient of variation (CV) of <5%; thus, consistency was deemed acceptable. In order to be included within the analysis, players must have completed a minimum of 20 minutes playing time. This time frame was chosen as it matched those utilized by the club for match analysis, and is similar to those used within previous soccer research (22).

Upon collection of the data, the skills performed were divided by total playing time for each player i.e., total number of passes performed/total amount of time on pitch (minutes). This enabled the elimination of bias when comparing physical qualities to the amount of a certain skill performed. KPI's success was calculated as a percentage (such as percentage of tackles won from those attempted). These data are presented as average per player across the 16 match period. Definitions for each term are outlined in Table 1 and were adapted from Opta™ which is commonly used within a professional soccer setting (23).

*** INSERT TABLE 1 ABOUT HERE ***

Statistical Analysis

Normality ($p > 0.05$) was determined via the Shapiro-Wilk test and reliability of fitness testing procedures was calculated via the CV, standard error of the measurement (SEM) and intraclass correlation coefficient (ICC) with absolute agreement. Acceptable ICC's were considered ≥ 0.75 ,

whilst CV's of < 5% were considered highly reliable (2,33). For normally distributed data, Pearson's correlations were run to assess relationships between fitness test scores and soccer-specific KPI's, with correlations ≥ 0.5 only considered for this study due to the small sample size. These relationships were also compared across the different playing positions. However, due to the small sample size respective to each position, percentage differences were also used for subsequent analysis. Furthermore, Cohen's *d* effect sizes were calculated to ascertain the magnitude of difference across playing positions concerning the success of each KPI and were interpreted in line with suggestions by Rhea (28), where values <0.35 = trivial, 0.35-0.8 = small, 0.8-1.5 = moderate, and >1.5 = large. Finally, a total score of athleticism (TSA) was calculated which is produced by firstly calculating the Z-score for each parameter of fitness. This gives an indication of how each player performed in comparison to the squads mean. These Z-scores are then added together to provide the TSA which allows players to be ranked according to their overall levels of fitness in comparison to their teammates (33). This score was also used to compare to match performance data.

RESULTS

All data was deemed to be normally distributed ($p > 0.05$) and both absolute (CV and SEM) and relative (ICC) reliability were deemed acceptable where appropriate (Table 2). It should be noted that only tests that were performed with multiple trials (SJ, CMJ, 20m and Arrowhead) reported reliability statistics. Pearson's correlations indicated that heading success was significantly ($p < 0.05$) correlated to both SJ height ($r = 0.79$), CMJ height ($r = 0.80$) and TSA ($r = 0.64$). It is important to note that player height played no role in a player's ability to beat an opponent to head the ball ($p > 0.05$). A significant correlation was also observed between absolute predicted 1RM back squat ($r = 0.61$) and tackle success. Once the players were delineated into their playing positions, heading success was seen to be significantly correlated to SJ ($r = 0.91$; $p < 0.05$) amongst the defenders. A further significant correlation was also seen between tackle success and absolute predicted one repetition maximum back squat ($r = 0.88$; $p < 0.05$) amongst the strikers. No other significant relationships were noted.

*** INSERT TABLES 2-6 ABOUT HERE ***

DISCUSSION

The aim of this study was to identify the relationship between physical characteristics and KPI's performed during soccer matches. The results of this study demonstrate a relationship between strength and power performance and the success rates of winning headers and tackles within 16 soccer matches. All other KPI's demonstrated no relationship to physical fitness parameters.

The study results show a direct relationship between both SJ and CMJ height with a player's ability to successfully head the ball. This is a finding that had been previously supported within the literature which states that vertical jump height, generated through explosive strength, is a key factor in successfully heading the ball (15, 20, 24). This is of little surprise as the literature further explains that player take-off when attempting to jump for the ball closely matches that of the CMJ (24). It should be reinforced that during this study only headers where two opposing players left the ground, and were in direct physical competition with each other, were included for the analysis. Therefore, a player's ability to generate greater distances from the ground when jumping clearly gives them a distinct advantage when competing with an opponent for the ball. Despite the logical notion that taller players are better suited to winning aerial battles, this study found that height appeared to provide no comparable advantage. With that in mind, there may be a window of opportunity for shorter players to overcome this issue by participating in training to improve jump performance. Consequently, both strength and power training are likely to aid in improving jump capacity, with exercises such as squats, deadlifts, Olympic lift derivatives, and jump training itself, all likely to enhance jump performance (24).

When analysing the biomechanics and demands of heading it has been highlighted that strength around the pelvis, neck, back and stomach alongside jump approach and body jack-knife movements are all important (15, 20, 24). Due to the vast amount of demands and levels of intra-muscular co-ordination placed upon the athlete when competing for a header it is no surprise that those individuals displaying greater overall athleticism are able to be more successful within this skill (15, 20, 24). This is evident within the results as those with higher TSA scores were also those displaying greater heading success. This further justifies the use of the TSA as a method for reporting upon fitness test results, especially when interpreting data with large groups of athletes.

Surprisingly, the TSA did not correlate to any other KPI's and the reason for this may lie within the athlete's sensory motor skills (36,37). It has been reported that higher skilled players are more effective at visually scanning their opponents; thus, able to better respond to different patterns of play (36,37). Consequently, this can result in greater anticipation of an opponent's movement and more accurate decision making skills (36). For example, an attacker may have superior speed and

change of direction ability than a defender; however, this does not automatically dictate success when aiming to dribble past the defender due to their opponents enhanced ability to recognise postural cues (36). Therefore, well designed S&C programs may be able to provide athletes with greater levels of athleticism to perform these skills; however, if the athlete has not developed the required sensory skills, their greater physical prowess may not give them a competitive advantage.

Oftentimes, lower limb strength in the form of maximal back squat training has been recommended within soccer strength and conditioning programmes due to its positive impact upon jump height, sprint speed and change of direction performance (39). However, to the authors' knowledge, the role strength can play in physical battles for the ball in soccer has not been formally demonstrated. The results of the present study show a significant correlation between lower limb strength, in the form of a predicted 1RM squat, and a player's ability to successfully win tackles. It stands to reason that in a physical duel that requires an individual to overcome the force of an opponent, the athlete displaying greater levels of lower body strength would be successful. Anecdotally, this study shows no evidence that upper body pushing strength increases tackle success. Therefore, it is recommended that lower body strength training is prioritised over upper body training, which may indirectly improve a player's tackling ability.

When assessing relationships across the different playing positions, only two significant correlations were reported. These were SJ and heading success amongst defenders ($r = 0.91$; $p < 0.05$), and predicted 1RM back squat and tackle success amongst the strikers ($r = 0.88$; $p < 0.05$). However, when analysing this data using percentages the same positive effect of jump height upon heading success was demonstrated. Midfielders and strikers both displayed greater jump height than the defenders (SJ: 4.5 and 9%, CMJ: 5.5 and 8% respectively), whilst also winning 11% more headers. However, tackle success did not follow a similar trend. Perhaps somewhat expectedly, defenders won 4% more tackles than midfielders and 18% more than strikers, despite demonstrating smaller predicted 1RM back squat scores (2% vs midfielders and 6% vs strikers). However, caution should be used when analysing the positional data due to the small sample sizes within each group. Furthermore, the percentage differences within the physiological measures between the groups appear to be relatively small (< 10%). As such, this makes the findings of the present study pertaining to positional differences for strength and power and their relationship to KPI's difficult to conclude. When represented through Cohen's d effect sizes, differences were trivial to moderate (Table 6). Amongst the KPIs that showed correlations to strength and power (i.e., heading and tackle success), moderate effect sizes were noted for tackle success, with defenders winning more than strikers. Similarly heading success also demonstrated moderate effect sizes, with both midfielders and strikers winning a greater amount than defenders. As expected, strikers displayed greater shot

success than both midfielders and defenders, with midfielders also showing greater success than defenders, all with moderate effect sizes.

This research showed no further correlations between physical fitness and the other identified KPI's; passing, shooting and dribbling. This appears to be in agreement with the current literature that analysed KPIs from real match data. It has previously been reported that during match play of a French Ligue 1 team, no correlation was found between passing accuracy and the deterioration in physical performance (5). This was despite the authors acknowledging that player's physical performance had deteriorated by virtue of shorter distances covered and less high speed running performed (5). The most likely reason that the strength and conditioning coach cannot affect the aforementioned three skills is because there are several other variables that contribute to their success. The literature states that a high level of cognitive function and motor skill acquisition is required to perform these skills successfully (12, 38). This is highlighted by the fact that during a passing test, execution time improved by 18% and skill execution time (time combined with accuracy) by 32% from age 10 to 18; due to the amount of time players spend in practice and training (12). Time in practice is often reported as the single most important factor in motor skill development, with considerable time in training required to enhance a player's skill capacity (38). This is shown within the difference in hours spent in practice by those performing at different levels of the sport. Those who are elite level performers spend 9322 hours in practice compared to amateurs who experience 5079 hours at 18 years into their careers (9). Therefore, if this amount of time in practice is required to develop these skills it is highly unlikely that just increasing a player's physical fitness is going to further enhance a player's ability to perform them.

There are some limitations to this study that should be acknowledged. Firstly, GPS technology was not available due to financial restrictions at the club, meaning that metrics concerning total distance and high speed running could not be analysed in relation to both KPI's and physical fitness data. Similarly, equipment such as force plates would have allowed for increased metrics such as peak force and impulse to be quantified rather than simply having an outcome measure of jump height. Furthermore, such additional jump metrics such as take-off velocity have been reported within the literature as important to successful heading performance (15,20,24); therefore, this too may have further enhanced the understanding between jump performance and heading success. Also, it may have been valuable to have data pertaining to the total time in possession for each match, as a significant match to match variation may have allowed for a greater understanding between KPI performance and a player's physiological characteristics. Finally, the small sample size made it difficult to make accurate comparisons when assessing differences between playing positions and the effect this may have upon the relationship of performance variables and KPI's. This may be of

even larger significance when we consider that, due to both the tactics of the team and the number of them within the playing squad, strikers often played less game time than any other position. This may lead to a skewing within the data set.

In conclusion, it can be seen that success in soccer is reliant upon several performance variables. Within this population of athletes, superior strength and power qualities have been shown to positively impact successful heading and tackling performance. Based upon this study, success within other soccer KPI's cannot be attributed to levels of strength and power. These data suggest that factors such as motor skill development, cognitive function and sensory motor skills may all play a more important role within their development.

PRACTICAL APPLICATIONS

The results from the present study highlight the importance of developing lower body strength and power which may enhance jumping and tackling performance. Whilst this is likely considered a logical perspective for a sport such as soccer, few studies have highlighted the impact this can have on soccer-specific performance. With that in mind, strength exercises such as bilateral and unilateral squats and deadlifts, and power exercises such as Olympic lifting derivatives and jump training should be a priority for soccer athletes. However, other soccer-specific skills such as passing and dribbling would appear to not be affected by the strength and power capabilities of players. It is likely that these are associated with greater cognitive skills which may be better served through specific training such as small-sided games.

REFERENCES

1. Arnason, A, Sigurdsson, SB, Gudmundsson, A, Holme, I, Engebretsen, L and Bahr, R. Physical fitness, injuries, and team performance in soccer. *Med. Sci. Sports Exerc.* 36: 278–85, 2004.
2. Atkinson, G and Nevill, AM. Statistical methods for assessing measurement error (Reliability) in variables relevant to sports medicine. *Sports Med.* 28(4): 217-238, 1998.
3. Bangsbo, J. Time and motion characteristics of competition soccer. In: *Science of Football* (vol 6). Reilly, T and Korkusuz F, eds. London, UK: Routledge, 1992. pp. 34-40, 1992.
4. Bradley, PS, Sheldon, W, Wooster, B, Olsen, P, Boanas, P and Krustup, P. High-intensity running in English FA Premier League soccer matches. *J Sports Sci.* 27: 159–68, 2009.
5. Carling, C and Dupont, G. Are declines in physical performance associated with a reduction in skill-related performance during professional soccer match-play? *J Sports Sci.* 29: 63–71, 2011.
6. Harman, E and Garhammer J. Administration, scoring and interpretation of selected tests. In: *Essentials of Strength Training and Conditioning* (3rd ed). Baechle, TR. and Earle, RW, eds. Champaign, IL: Human Kinetics, 2008. pp. 250–273.
7. Harman, EA, Rosenstein, MT, Frykman, PN and Rosenstein, RM. The effects of arms and countermovement on vertical jumping. *Med. Sci. Sports. Exerc.* 22: 825-833, 1990.
8. Helgerud, J, Engen, LC, Wisloff, U and Hoff J. Aerobic endurance training improves soccer performance. *Med. Sci. Sports Exerc.* 33: 1925-1931, 2001.
9. Helsen, WF, Starkes, JL and Hodges, NJ. Team sports and the theory of deliberate practice. *J. Sport. Exerc. Psych.* 20: 12-34. 1998.
10. Hughes M, Caudrelier T, James N, Redwood-Brown A, Donnelly I, Kirkbride A, Duschesne C. Moneyball and soccer - an analysis of the key performance indicators of elite male soccer players by position. *J Hum Sport Exerc.* 7(2): 402-412, 2012
11. Huijgen, BCH, Elferink-Gemser, MT, Post, W and Visscher, C. Development of dribbling in talented youth soccer players aged 12-19 years: a longitudinal study. *J Sports Sci.* 28: 689–98, 2010.
12. Huijgen, BCH, Elferink-Gemser, MT, Ali, A and Visscher, C. Soccer skill development in talented players. *Int. J. Sports Med.* 34: 720-726, 2013.
13. Impellizzeri, FM, Marcora, SM, Castagna, C, Reilly, T, Sassi, A, Iaia, FM and Rampinini, E. Physiological and performance effects of generic vs specific aerobic training in soccer players. *Int. J. Sports Med.* 27: 483-492, 2006.

14. International Standards for Advancement in Kinanthropometry. *International Standards for Anthropometric Assessment*. ISAK. 2001.
15. Kristensen, LB. Investigation of segmental characteristics in powerful soccer heading. *ISBS Symposium*. 409-412, 2002.
16. Le Moal, E, Rue, O, Ajmol, A, Ben Abderrahman, A, Ali Hammami, M, Ben Younis, O, Keksi, W and Zouhal, H. Validation of the Loughborough Soccer Passing Test in young soccer players. *J.Strength Cond. Res.* 28: 1418-1426, 2014.
17. Le Suer, DA, McCormick, JH, Mayhew, JL, Wasserstein, RL and Arnold, MD. The accuracy of predication equation for estimating 1-RM performance in bench press, squat and deadlift. *J. Strength Cond. Res.* 11: 211-213, 1997.
18. Little, T and Williams, AG. Specificity of acceleration, maximum speed, and agility in professional soccer players. *J. Strength and Cond. Res.* 19: 76–78, 2005.
19. Lyons, M, Al-Nakeeb, Y and Nevill, A. Performance of soccer passing skills under moderate and high intensity localised muscle fatigue. *J. Strength Cond. Res.* 20: 197-202, 2006.
20. Marcolin, G and Petrone, N. A method for the performance evaluation of jumping headers in soccer. *ISBS Symposium*. 2006.
21. Markovic, G, Dizdar, D, Jukic, I and Cardinale, M. Reliability and factorial validity of squat and countermovement jump tests. *J. Strength Cond. Res.* 18: 551-555, 2004.
22. O'Donoghue, PG. Time-motion analysis of work-rate in English FA Premier League soccer. *International Journal of Performance Analysis in Sport* 2(1): 36-43, 2002.
23. Opta, 2013. *Opta's event definitions*. Available at: <http://www.optasports.com/news-area/blog-optas-event-definitions.aspx> [Accessed February 1, 2014]
24. Paoli, A, Bianco, A, Palma, A and Marcolin, G. Training the vertical jump to head the ball in soccer. *Strength Cond. J.* 34: 80-85, 2012.
25. Perez-Gomez, J, Olmedillas, H, Delgado-Guerra, S, Royo, IA., Vicente-Rodriguez, G, Ortiz, RA, Chavarren, J and Calbet, JAL. Effects of weight lifting training combined with plyometric exercises on physical fitness, body composition and knee extension velocity during kicking in football. *Appl. Phys. Nutri. Met.* 33: 1-10, 2008.
26. Rampinini, E, Impellizzeri, FM, Castagna, C, Azzalin, A, Bravo, DF and Wisloff, U. Effect of match-related fatigue on short-passing ability in young soccer players. *Med. Sci. Sports Exerc.* 40: 934–942, 2008.

27. Rampinini, E, Sassi, A, Morelli, A, Mazzoni, S, Fanchini, M and Coutts, AJ. Repeated-sprint ability in professional and amateur soccer players. *Appl. Phys. Nutri. Met.* 34: 1048-1054, 2009.
28. Rhea, M.R. Determining the magnitude of treatment effects in strength training research through the use of effect size. *J. Strength Cond. Res.* 18: 918-920. 2004.
29. Ritti-Dias, RM, Avelar, A, Salvador, EP and Cyrino, ES. Influence of previous experience on resistance training on reliability of one-repetition maximum test. *J. Strength Cond. Res.* 25: 1418-1422, 2011.
30. Rostgaard, T, Marcello Iaia, F, Simonsen, DS and Bangsbo, J. A Test to Evaluate the Physical Impact on Technical Performance in Soccer. *J. Strength Cond. Res.* 22: 283–292, 2008.
31. Straume-Naesheim, TM, Andersen, TE, Dvorak, J and Bahr, R. Effects of heading exposure and previous concussions on neuro-physiological performance among Norwegian elite footballers. *Brit. J. Sports Med.* 39 (Supp 1): i70-i77, 2005.
32. Taylor, JB, Mellalieu, SD, James, N, and Shearer, DA. The influence of match location, quality of opposition and match status on technical performance in professional association football. *J. Sports Sci.* 26: 885-895, 2008.
33. Turner, A. Total score of athleticism: a strategy for assessing an athletes athleticism. *Prof. Strength Cond.* 33: 13-17, 2014.
34. Turner, A, Walker, S, Stenbridge, M, Coneyworth, P, Reed, G., Birdsey, L, Barter. P and Moody, J. A testing battery for the assessment of fitness in soccer players. *Strength Cond. J.* 33: 29-39, 2011.
35. Waldron, M., Worsfold, PR., Twist, C and Lamb, K. The relationship between physical abilities, ball carrying and tackling among elite youth rugby league players. *J Sports Sci.* 32(6), 542-549, 2014.
36. Ward, P and Williams, AM. Perceptual and cognitive skill development in Soccer: The multidimensional nature of expert performance. *J. Sport Exerc. Psych.* 25: 93-111, 2003.
37. Williams, AM and Davids, K. Visual search strategy, selective attention, and expertise in Soccer. *Res. Quart. Exerc. Sport.* 69: 111-128. 1998.
38. Williams, A. M. and Hodges, N.J. Practice, instruction and skill acquisition in soccer: Challenging tradition. *J. Sport Sci.* 23: 647-650. 2005.

39. Wisloff, U, Castagna, C, Helgerud, J, Jones, R and Hoff, J. Strong correlation of maximal squat strength with sprint performance and vertical jump height in elite soccer players. *Brit. J. Sports Med.* 38: 285–288, 2004.
40. Wisloff, U, Helgerud, J, and Hoff, J. Strength and Endurance of elite soccer players. *Med. Sci. Sport Exerc.* 30: 462 – 467, 1998.

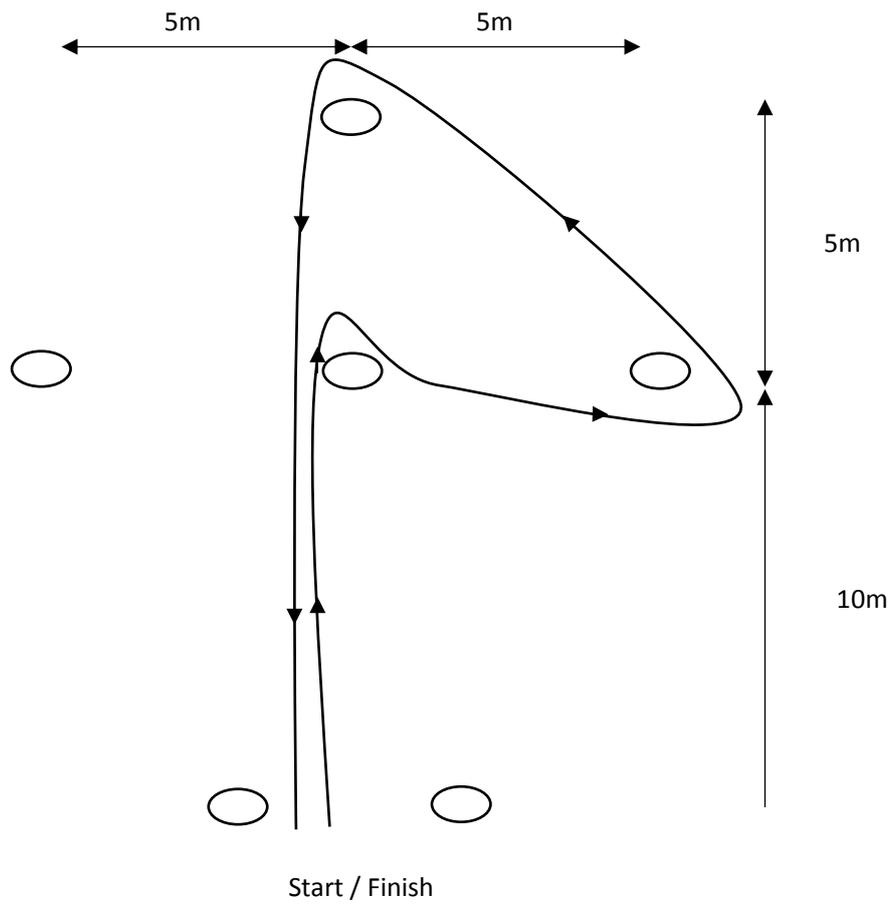


Figure 1: Outline of the arrowhead agility test

Table 1: Key Performance Indicator (KPI) definitions

Parameter	Definition
Passing	An intentional played ball from one player to another. A completed pass is one received by a player on the same team as the passer.
Heading	Where two players challenge in the air against each other. For inclusion within the present study, both players must have left the ground in an attempt to win the ball. The player who heads the ball is deemed to have won the duel.
Tackling	A tackle is defined where a player makes contact with the ball in a 'ground challenge'. If the ball is taken away from their opponent, it is regarded as a successful tackle.
Shooting	Any attempt either head or strike that is aimed towards the goal. A shot on target is classified as a goal or any shot that would have gone in if it wasn't for the intervention of an opposition player.
Dribbling	An attempt by a player to beat an opponent whilst in possession of the ball. A successful dribble is classified as when a player beats an opponent and retains possession.

Table 2: Mean fitness testing data with intraclass correlation coefficients (ICC) inclusive of 95% confidence intervals (CI), coefficient of variations (CV), and standard error of measurements (SEM – expressed in the same units as each respective test)

Testing Parameter	Mean (SD)	ICC (95% CI)	CV (%)	SEM
Body Fat (%)	8.08 (1.17)	-	-	-
Height (cm)	179.9 (6.47)	-	-	-
Back Squat (Kg)	116.13 (13.91)	-	-	-
Bench Press (Kg)	80.17 (11.45)	-	-	-
SJ Height (cm)	59 (6.09)	0.89 (0.74, 0.96)	2.0	2.02
CMJ Height (cm)	61.79 (5.96)	0.96 (0.90, 0.98)	2.0	1.19
20m Sprint (s)	2.94 (0.79)	0.82 (0.63, 0.93)	2.0	0.34
Arrowhead Agility (s)	16.03 (0.25)	0.85 (0.70, 0.94)	5.0	0.01
Kg = kilograms; cm = centimetres; s = seconds; SJ = squat jump; CMJ = countermovement jump				

Table 3: Individual Z-scores and total score of athleticism (TSA) results for each player

Player	BS	BP	SJ	CMJ	20m	Arrow	TSA
1	0.13	-0.01	0.67	0.79	0.68	1.01	3.27
2	-0.05	-0.45	-1.18	-1.27	1.69	0.38	-0.88
3	-1.12	-1.33	-0.67	-0.70	-0.58	-0.84	-5.25
4	1.90	2.17	2.25	1.97	0.93	0.89	10.11
5	0.35	0.86	-0.64	-1.54	-0.45	-0.09	-0.09
6	0.13	0.20	-0.85	-0.17	-1.34	-0.33	-2.35
7	-1.88	-1.76	0.49	1.03	1.56	2.03	1.47
8	-1.45	-0.89	-1.28	-0.69	-1.46	-1.04	-6.81
9	0.13	-0.01	0.21	0.00	-0.83	-0.33	-0.83
10	-0.23	-0.45	1.10	0.72	-0.08	-1.51	-0.44
11	-0.05	0.20	-0.02	-0.37	0.81	0.65	1.24
12	1.72	1.52	1.05	1.24	0.18	-0.73	4.98
13	0.57	-0.01	0.15	0.07	-0.08	0.61	1.31
14	-0.08	0.20	-0.18	0.04	0.18	0.65	0.81
15	-0.08	-0.23	-1.10	-1.12	-1.21	-1.36	-5.10

Table 4: Overview of the match performance data collected from 16 completed matches. Mean data presented across 16 matches

Performance Parameter	All Players n= 15 Mean (SD)	Defenders n= 5 Mean (SD)	Midfielders n= 6 Mean (SD)	Strikers n= 4 Mean (SD)
Minutes Played	866.73 (417.72)	939.8 (371.64)	931.83 (429.02)	677.75 (508.34)
Passes attempted	285.33 (193.31)	274.2 (114.2)	333.33 (265.73)	227.25 (173.2)
Pass success (%)	80.27 (3.51)	80.81 (2.95)	79.78 (4.26)	80.36 (3.84)
Tackles attempted	52.2 (43.36)	54.8 (23.21)	64.17 (63.03)	31 (23.21)
Tackle success (%)	65.4 (20.73)	71.6 (12.03)	67.83 (23.56)	54 (27.53)
Headers attempted	65.13 (55.37)	76.2 (57.47)	37.83 (23.45)	92.25 (79.47)
Heading success (%)	59.58 (12.78)	52.28 (15.88)	63.16 (10.47)	63.36 (10.52)
Shots attempted	21.2 (21.82)	3.4 (3.13)	28.67 (19.25)	32.25 (28.11)
Shot success (%)	41.64 (22.07)	26 (29.87)	43.6 (3.85)	58.25 (16.62)
Dribbles attempted	9.73 (10.25)	6.2 (3.27)	12.33 (13.74)	10.25 (11.3)
Dribble success (%)	45.98 (34.32)	47.5 (47.1)	41.92 (21.96)	50.21 (40.94)
Touches	433.6 (272.07)	414.8 (186.84)	476.33 (348.94)	393 (299.23)
Touches per minute	0.49 (0.13)	0.43 (0.08)	0.47 (0.18)	0.59 (0.08)

Table 5: Mean fitness testing data presented across the different positional groups.

Testing Parameter	Defenders n=5 Mean (SD)	Midfielders n=6 Mean (SD)	Strikers n=4 Mean (SD)
Body Fat (%)	8.1 (1)	7.95 (1.59)	8.25 (0.9)
Height (cm)	181.22 (2.09)	176.3 (6.1)	183.63 (8.96)
Back Squat (Kg)	113.4 (7.34)	115.25 (19.33)	120.88 (12.8)
Bench Press (Kg)	75.5 (6.22)	81.25 (15.63)	84.38 (9.44)
SJ Height (cm)	56.48 (5.01)	59.12 (7.75)	61.98 (4.15)
CMJ Height (cm)	59.04 (5.11)	62.45 (7.41)	64.23 (4.27)
20m Sprint (s)	2.95 (0.1)	2.96 (0.1)	2.92 (0.03)
Arrowhead Agility (s)	16.08 (0.24)	15.93 (0.27)	16.09 (0.27)
Kg = kilograms; cm = centimetres; s = seconds; SJ = squat jump; CMJ = countermovement jump			

Table 6: Comparison of KPI success using Cohen's *d* effect sizes

Performance Parameter	Defenders vs Midfielders	Defenders vs Strikers	Midfielders vs Strikers
Pass success (%)	0.28	0.13	-0.14
Tackle success (%)	0.2	0.83	0.54
Heading success (%)	-0.81	-0.82	-0.02
Shot success (%)	-0.83	-1.33	-1.2
Dribble success (%)	0.15	-0.06	-0.25
Effect size magnitude: <0.35 trivial, 0.35-0.8 small, 0.80-1.5 moderate, >1.5 large			