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Correlation of lower extremity muscle endurance and agility in male elite football players

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Abstract
Background: The ability to perform intense exercise is declined towards the second half of the game, as well as immediately after the most intense periods of the game such as during sprinting, jumping, etc. Suggesting that these actions may be particularly sensitive to fatigue development and injury risk. These data underline the importance of muscle endurance as an important component of fitness in football players. The frequent alteration of activities, numerous accelerations and decelerations, change of directions, and execution of various technical skills during a play contribute to higher injury rates in elite football players. Unpredictable events like twisting, and pivoting occur very commonly but there is a dearth of literature evaluating these fast components.
Subjects and Methods: The correlational study consists of 43 male elite football players. Subjects were recruited through convenient sampling. They were screened as per inclusion and exclusion criteria. Agility was evaluated using the agility t-test. The best of three readings were taken. Followed by the warm-up protocol of 10 minutes was administered for the squat test. Lower extremity muscle endurance was checked using the squat test.
Results: The moderate negative correlation was found between lower extremity muscle endurance and agility duration ($r = -.456$, $p<0.001$) that is as endurance decreases the performance of agility also reduces thereby increasing the t-test duration.
Conclusion: The study concluded that there is moderate negative correlation between lower extremity muscle endurance and agility in male elite football players. As lower extremity muscle endurance increases, agility also improves thereby reducing the time required to complete agility t-test.

Keywords: Agility, elite, football, fatigue, lower extremity muscle endurance

Introduction

Football is the most popular sport in the world and a high intensity team sport that requires a good amount of physical fitness. Footballers are also required to maintain high levels of aerobic and anaerobic conditioning, strength, Agility, muscle endurance and foot eye coordination [1]. From kinesiological analysis, football is contact sport with high physical demands. It is a game which requires very fast body movements which is determined by situations within the game such as ball movement, opposing team players position and teammate movements [2].

Fitness components are qualities that athletes must develop to physically prepare for sports. All of the fitness components exist to some degree in most sports but developing certain combinations is important [3]. There are health related components which includes cardiopulmonary endurance, flexibility, muscle strength, muscle endurance, and body composition. On other hand we have skill related fitness components which include Agility, coordination, balance, speed, power, reaction time.

Agility is the player’s ability to perform a rapid whole body movement with change of velocity or direction in response to stimulus [4]. Agility in team sports does not comprise only the ability of changing the direction of movement, but also the capability to anticipate the movement of the opponent, read and react to specific game situations. Agility is graded according to two independent qualities [23].

Change of direction of speed and reactive agility. Change in direction of speed and movement is change according to predetermined pattern whereas reactive agility is change in direction in response to external stimulus. For example, goalkeeper passing a ball in opposite direction to mid-fielders serves to be an example of reactive agility, whereas, a goalkeeper ready in stance to prevent a predetermined goal pattern serves to be an example of rapid change in speed and direction requirements of agility. Elite players perform numerous changes in direction during a game in preplanned and unplanned scenarios depending upon ball movements and team players positions. In such unpredictable scenarios player movements are often performed rapidly with little or no control over body segments [2].

Adult elite football players cover 8 to 14 km during an official match, of which 1.5 to 3.3 km are performed at high-intensity. However, the ability to perform intense exercise is declined towards the second half of the game, as well as immediately after the most intense periods of the game such as during sprinting, jumping etc. Suggesting that these actions may be particularly sensitive to fatigue development and injury risk. These data underlines the importance of muscle endurance as an important component of fitness in football players [5].

Studies evaluating fatigue in football players mainly attribute it to Hamstring injury, adductor strain, quadriceps injury, ACL tears, Ankle sprains etc. [6]. Lower limb injuries are the most common type of injury in football and most of these (66%) are non-contact injuries. Unpredictable events like twisting, pivoting occurs very commonly but there is a dearth of literature evaluating these fast components mainly that of predictive and reactive agility components. Owing to this, warm up protocols today are designed around and highly centred on stretching and passive lengthening of muscles but missing the key components of unpredictable injuries occurring during the game.

Despite the evident progress of sport medicine, better sport equipment, training grounds, improved recovery methods and increased awareness of fitness protocols in athletes, Non-contact muscular injuries represent a prevalent problem [2].

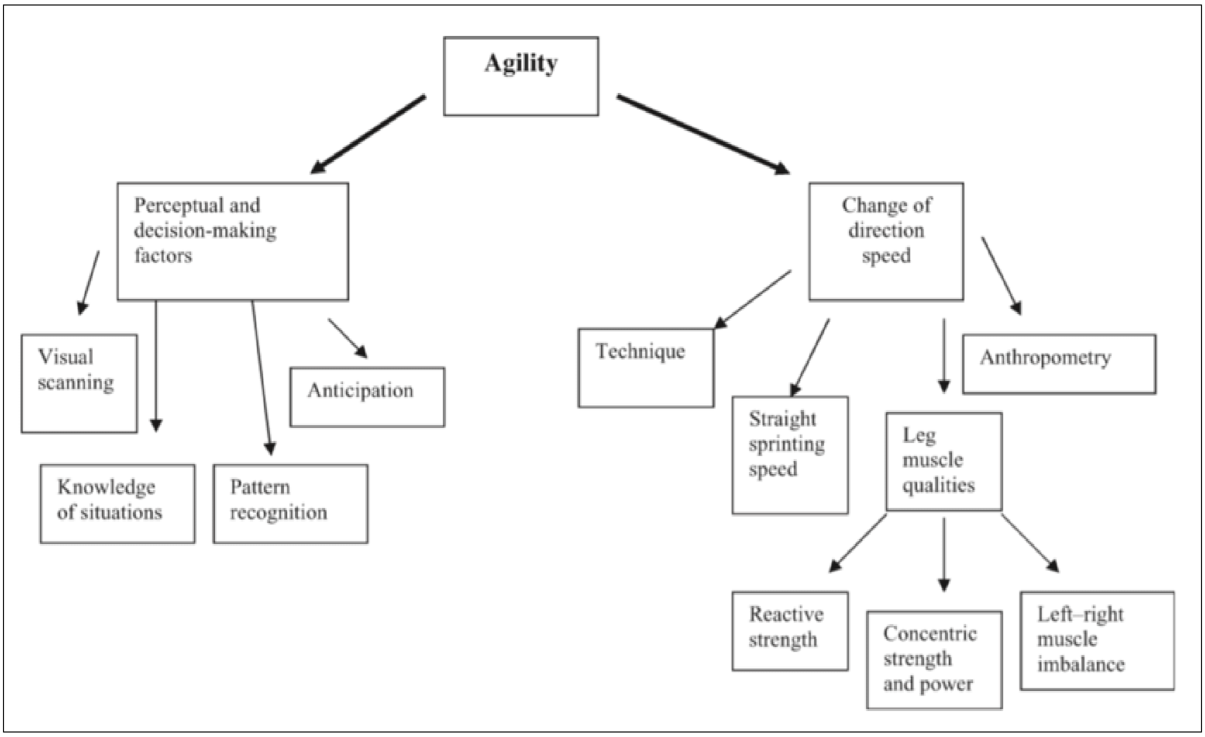
Therefore this current study is undertaken with a view of evaluating the lesser known components of fitness like agility and lower extremity muscle endurance in football players. Agility is evaluated using Agility T test whereas lower extremity muscle endurance is assessed using squat test.

Correlation if found between these components then the findings can be useful in formulating warm up and fitness protocols in football players. Agility and muscle endurance if found to be lacking in football players then it can be trained to avoid further injuries, to better prepare them for events of unpredictability and to improve game performance in players. These two components can be the baseline training recommendation in Elite football players to reduce the risk of injuries and to improve their performance.

Operational definitions

Elite football players

For the purpose of this study, Elite football players are defined as the one who play the football for minimum 4 days / week for consecutive 2 or more than 2 years.



2. Materials and methods

2.1 Study Design: Correlation Study

2.2 Study Setting: Football Clubs in and Around Nashik

2.3 Sampling Method: Convenient Sampling

2.4 Sample Size: 43

2.5 Study Participants: Elite Male Football Players

2.6 Inclusion criteria

- Male Elite Football Players
- Having 2 Years Of Experience
- Males Above 18 Years Of Age

2.7 Exclusion criteria

- Females
- Amateur Footballers
- Subjects with History of Any Lower Limb Musculoskeletal Injury in Past One Year.
- Subjects with History of Lower Limb Fracture.

- Subjects With History of Any Surgeries
- Subjects with Any Neurological Impairments.
- Subjects with Cardio-Respiratory Insufficiency.

2.8 Materials Used
- 4 Cones
- Stopwatch

2.9 Outcome Measures
- Agility T test [4, 13]
- Squat test [7, 8, 9, 15]

3. Results
The moderate negative correlation was found between lower extremity muscle endurance and agility duration (r= -.456, $p<0.001$) that is as endurance decreases the performance of agility also reduces thereby increasing the t test duration.

Discussion
The purpose of this study was to find out if there exists a correlation between lower extremity muscle endurance and Agility in elite male football players.

In this study 43 male elite football players were recruited by means of convenient sampling. Agility was evaluated using Agility T test. Best of three readings were taken and mean was calculated. Warm up protocol of 10 min was administered before squat test. Participants performed squat test for lower extremity muscle endurance.

All the participants participating in study were male above 18 years of age. In this study we noted the mean age of participants was 24.88372 (±11.73154). The average years of experience was 7.0348 (±7.930).

On applying Shapiro-Wilk's test ($p<0.05$) and a visual inspection of the histogram, Q-Q plots and Box plots showed that data obtained from agility t test and squat test was not normally distributed.

For correlation between Lower extremity muscle endurance and Agility, by applying Spearman's correlation the r value of -0.456 was obtained with P value of <0.05 which is statistically significant. Thus, suggesting moderate negative correlation that is as endurance decreases the performance of agility also reduces thereby increasing the T-test duration.

In this study we aimed to find out if there exist a correlation between lower extremity muscle endurance and agility in male elite football players. We used Agility T test as a outcome measure to evaluate agility. Paule *et al.* (2000) said that the T-test appears to be highly reliable and measures a combination of components, including leg speed, leg power, and agility, and may be used to differentiate between those of low and high levels of sports participation [18].

To evaluate lower extremity muscle endurance we used squat test. Vaara, Jani *et al.* (2012) said that the repeated squat test measures the performance of the knee flexor and extensor muscles [8].

Some previous studies published by Amrinder Singh *et al.* researching to determine the effect of a 6-week agility training program on lower limb isometric strength and fatigue index in Indian taekwondo players found that there is significant improvement in game performance after 6 weeks of agility training in Indian taekwondo players. Significant changes ($p<0.05$) in group 1 (agility training group) were observed in All the variables tested. No significant changes/decline in performance was found in group 2 group (control group) [20]. This program significantly improved the performance and may be implemented as a regular part of the training schedule.

Further, Raouf Hammami, *et al.* in 2017 analyzed the associations between Change of Direction, Balance, Speed, and Muscle Power in Prepubescent Soccer Players. The results of this study illustrate the importance of developing balance and muscle power to enhance change of direction performance in pre-pubescent soccer players [24].

Zlatan Bili´ *et al.* in their study in 2023 investigated the effect of exercise-induced fatigue on change of direction performance. Among Young Male Tennis Players. They underwent a standardized physiological load protocol using the "300-m running test" which consists of consecutive runs for 15 shares of 20 m (15 × 20). Prior to and after the protocol, they performed a pre-planned change of direction T-test and serve precision test. Results showed significant increase of time in the T-test after the fatigue test protocol. These findings indicate that increase in exercise induced fatigue impairs change of direction performance [22].

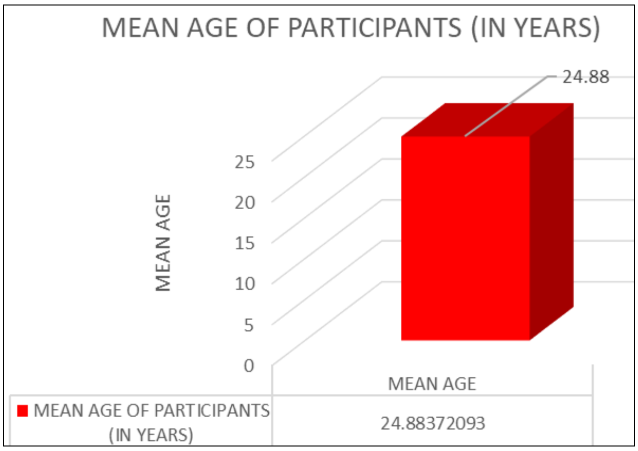
Sohel Ahmed *et al.* in their study titled, "Correlation of core stability with balance, agility and upper limb power in badminton players: a cross-sectional study" found that There is a negative correlation between core stability and agility T test. As when the level of core stability is high, the time taken for completing the agility T test is lowered that indicates the positive impact of core on agility [19].

Another study conducted by Suat Yildiz *et al.* in 2020 showed a significant correlation between agility (CS) and speed. However, there was no significant relationship between reaction time and agility (OS and CS). The important athletic skills of speed and quick change of direction were shown to have an effect on each other. It may be of benefit to add change of direction drills to training programs in order to improve the speed performance of the athletes [19].

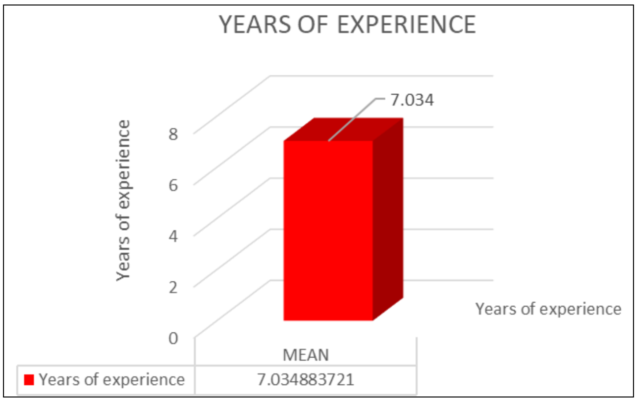
The study published by Erika Zemková *et al.* in 2010 in their article "The effect of 6-week combined agility-balance training on neuromuscular performance in basketball players" They found that a combined agility balance training has enhanced the dynamic balance. Also the ability to dose the force of muscle contraction during rebound jumps has improved. In contrast, there were no changes in reaction time and power of lower limbs [21].

Peñailillo L *et al.* suggested in study that it is important to develop muscle strength in youth soccer players to improve their acceleration, speed and agility. Considering that soccer involves frequent changes of direction, they postulated that agility would be highly related to muscle strength. However, they only had a small correlation [26].

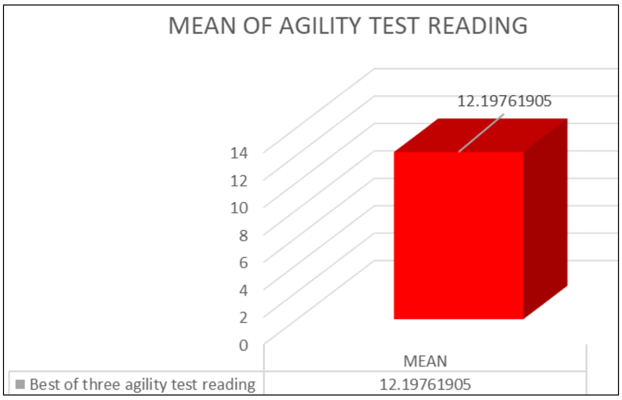
The findings from few researches do not conclusively indicate the importance of leg muscle power for change of direction of speed and therefore the value of training designed to increase leg muscle power to enhance the agility in sports remains unclear [25].



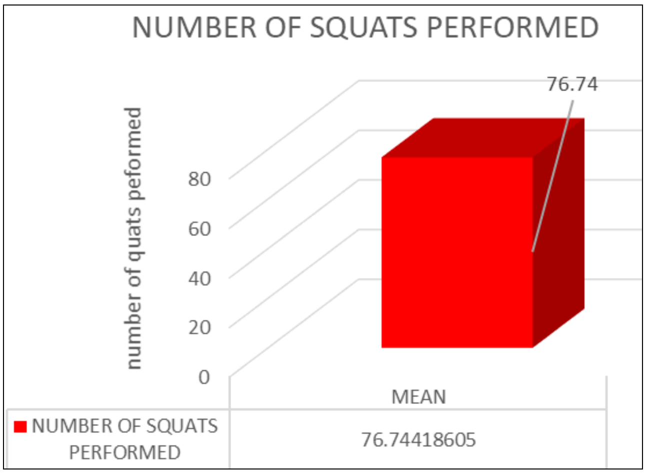
Graph 1: Mean age of participants



Graph 2: Mean of years of experience



Graph 3: Mean duration of agility test reading



Graph 4: Mean of total number of squats performed

Table 1: Variable characteristics

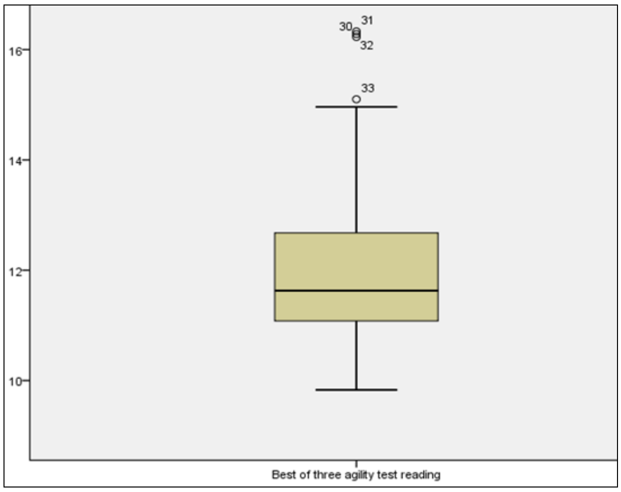
	Mean	Standard deviation
Age	24.88372	11.73154
Years of experience	7.034883721	7.930798426
Agility t test	12.19761905	2.466604703
Squat test	76.74418605	54.40942365

Table 2: Normalcy distribution for agility T test and endurance

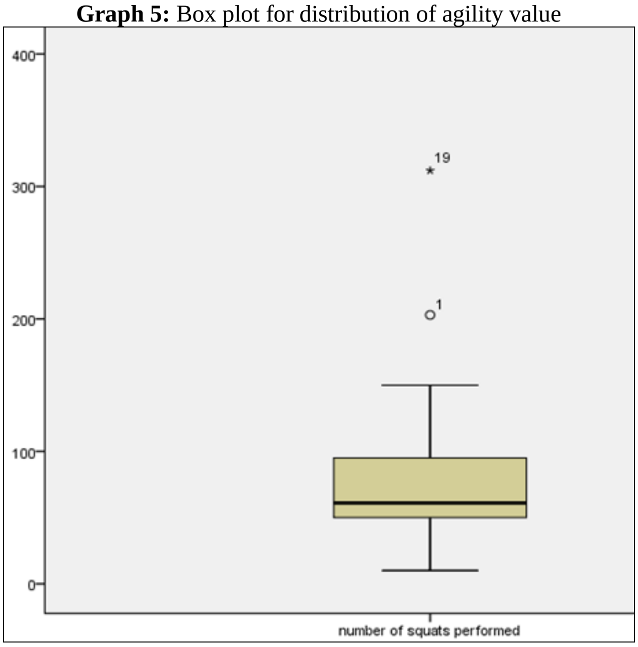
	Skewness	Standard error	Kurtosis	Standard error
Agility T test	1.245	.361	.816	.709
Squat test	2.241	.361	7.674	.709

Table 3: Shapro wilk test to determine normalcy

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	DF	Sig.	Statistic	DF	Sig.
Best of 3 duration of agility test	.168	43	.004	.854	43	.000
Number of squats performed	.161	43	.007	.814	43	.000



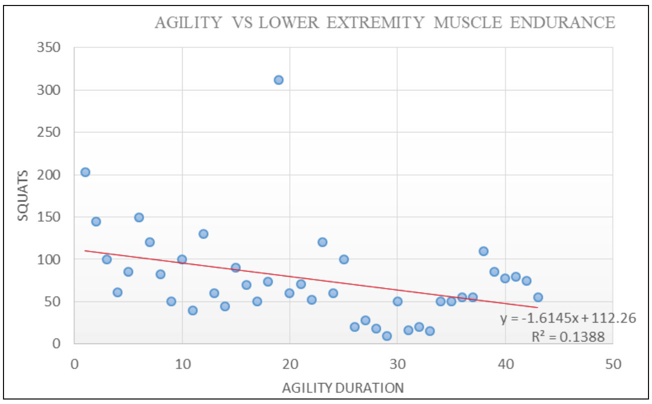
Graph 5: Box plot for distribution of agility value



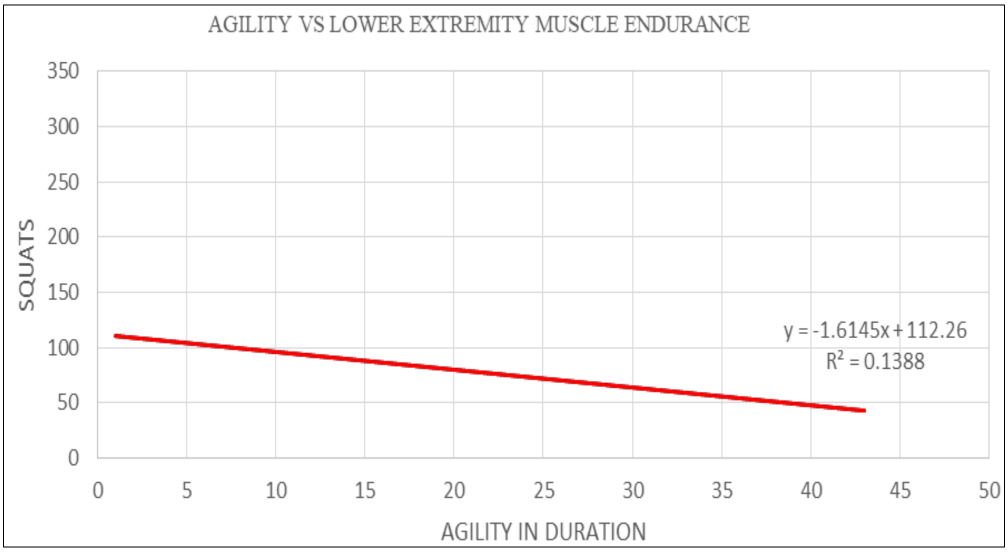
Graph 6: Box plot for distribution of number of squats performed

Table 4: Non parametric spearman's correlation

		Best of three agility test reading	Number of squats performed
Best of three agility test reading	Correlation Coefficient	1.000	-.456**
	Sig. (2-tailed)	.	.002
	N	43	43
Number of squats performed	Correlation Coefficient	-.456**	1.000
	Sig. (2-tailed)	.002	.
	N	43	43



Graph 7: Scatter plots showing correlation between agility and lower extremity muscle endurance



Graph 8: Line Graph Showing the Strength of Correlation

Conclusion

The study concluded that there is moderate negative correlation (r= -.456, p<0.001) between lower extremity muscle endurance and time taken to complete the agility t test in male elite football players. Agility is directly proportional to muscle endurance i.e. as lower extremity muscle endurance increases, agility also improves thereby reducing the time required to complete agility T-test.

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