Academic Journal of Science and Technology
ISSN: 2771-3032 | Vol. 12, No. 2, 2024

Study of the Relationship Between Specialised Physical Fitness and Repeated Sprinting Ability in University Football Players

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Abstract: Objective: To explore the relationship between specialised physical quality and repeated sprinting ability of university football players, and to provide theoretical basis for improving repeated sprinting ability and sports level of university football players. Methods: 29 athletes from the Chizhou University varsity football team were selected as test subjects using the method of intentional sampling to measure their specialised physical fitness and repeated sprinting ability, and Pearson correlation analysis and linear regression analysis were used to explore the relationship between specialised physical fitness and repeated sprinting ability. Results: The YO-YO test, 5*25 m run, 30 m run and T-run had different degrees of positive or negative correlation with RSA_{best} and RSA_{mean} in the specialised physical fitness. 67.4% of the maximal recurrent sprinting ability could be explained by the YO-YO test, 5*25 m run, 30 m run and T-run; 61.2% of the average recurrent sprinting ability could be explained by the YO-YO test, 5*25 m run and 30 m run. 61.2% of average repeated sprinting ability. Conclusion: Specialised physical fitness of university football players is related to repeated sprinting ability, and improving specialised physical fitness is conducive to enhancing repeated sprinting ability of football players.

Keywords: Universities; Football Players; Specialised Physical Fitness; Repeated Sprinting Ability.

1. Introduction

Football is a competitive team sport with high demands on both skills and physical fitness. During the game, in order to complete the reasonable technical and tactical, athletes need to have strong sprinting speed, change of direction, acceleration and deceleration, and confrontation ability[1]. Repeated sprint ability (RSA) is the ability of an player to complete more than 2 consecutive sprints (<10s) without full recovery (<60s)[2]. It is often manifested during repeated sprints by acceleration, deceleration and turning movements[3]. It can reflect the comprehensive physical fitness of football players. At the same time, the specialised physical fitness of football is also the basis for completing the technical and tactical and obtaining excellent performance, which is mainly divided into five aspects: endurance, strength, speed, flexibility and sensitivity[4]. Each specialised physical fitness is independent and unified, which restricts and affects the overall ability of the player.

Football-specific physical fitness and RSA are more similar in terms of physical requirements and applicable scenarios, and their relationship has attracted the attention of scholars. Perroni et al. showed that RSA and endurance are correlated in young football players[5]. Negra showed that repeated sprint training had a significant effect on the speed in football players[6]. Brocherie et al. showed a strong correlation between RSA and lower limb strength and speed in football players[7]. Brocherie et al. Although these studies show that there is some correlation between RSA and football specialised physical fitness, most of the studies have not conducted systematic research on the overall football specialised fitness, and the relationship between each specialised physical fitness and RSA is not very clear.

Seven ministries and commissions, including the Ministry of Education, have jointly issued the Action Plan for the Construction of Eight Systems of National Youth Campus Soccer, which aims to consolidate and improve the institutional system of campus football and promote the modernisation of the governance system and governance capacity of campus football[8]. However, compared with the construction of campus football at the basic education stage, the development of high-level sports teams in colleges and universities is lagging behind. This study adopts the method of intentional sampling to investigate the players of the varsity football team of Chizhou College, and quantitatively analyses the relationship between specialised physical fitness and RSA through empirical research, to provide theoretical and practical bases for the targeted development of training plans for university football players.

2. Research Methodology

2.1. Objects of Study

With the players of the varsity football team of Chizhou University as the testers, excluding those who were injured and could not participate in the test, the final inclusion of the population was 29, including 11 freshmen, 13 sophomores, and 6 juniors, with the age of 20.28±1.066 years old, and all the subjects had an informed understanding of the present study, voluntarily signed the informed consent form, and were able to take the initiative to cooperate with the completion of the test actively.

2.2. Test Methods

2.2.1. Repeated Sprint Proficiency Testing

The RSA test was selected from the Sports Training Assessment System (SWIFT, developed in Australia)[9]. The RSA test consists of six 40m sprinting groups (6*40m) with a 20s interval between each group, the player first performs a sprinting run, and this performance is used as the contrast value; the official test starts after a 5min rest, if the player's

repeated sprinting time in the first test is greater than 2.5% of the contrast value, the test is stopped immediately, and the player rests for 5min and then performs the test again. RSA test indexes include RSA_{mean}, RSA_{best} , RSA_{dec} . A stopwatch records the time of each return run[10]. RSA_{dec} is calculated as follows:

$$RSA_{dec}=\frac{RSA_{mean}-RSA_{best}}{RSA_{best}} * 100.$$

2.2.2. Basis of Selection and Testing of Specialised Physical Qualities

Wang pointed out that football-specific physical fitness refers to the specialised abilities of players in specialised sports on strength, speed, endurance, agility and flexibility et al.[11]. The related study showed the specialised physical fitness of university football players through 30m run, standing long jump, out-of-bounds ball throw, 5*25m test and Illinois sensitive run[12]. On the other hand, Wang showed the performance of university men's high-level football team through seated forward bending, Yo-Yo test, 5*25m test, T-run, chin-up, standing long jump and 30m run[4], combined with previous studies, the selected tests of this specialised physical fitness indicators are shown in Table 1.

Table 1. Indicators for the assessment of specialised physical qualities of football players

Level 1 indicators	Level 2 indicators	Level 3 indicators
specialised flexibility	flexibility	sit-up-and-bend (physical exercise)
specialised endurance	aerobic endurance	Yo-Yo testing
	anaerobic endurance	5 x 25m test
specialised sensitivity	sensitivity	T-run
specialised strength	Upper body strength	chin-up (physical exercise)
	Lower limb strength	standing long jump
specialised speed	displacement speed	30m run

2.2.3. Data Analysis

A database was set up for analysis using SPSS 26.0, and all continuous variables were expressed as mean ± standard deviation ($\bar{X}$± SD). Pearson correlation was used to analyse the correlation between specialised physical fitness and RSA, with 0.2<|r|<0.4 being a low correlation, 0.4≤|r|<0.6 being a moderate correlation, and 0.6≤|r|<0.8 being a high correlation[13]. The results of specialised physical fitness were used as independent variables and RSA as dependent variable, and two models were used for linear regression analysis. Model 1: A univariate linear regression analysis was used to regress each independent variable on RSA individually and explore the effect of each independent variable on RSA. Model 2: Multiple stepwise regression was used to regress the independent variables on RSA by placing them in the model simultaneously. The test level was p=0.05.

3. Results

3.1. Correlation Analysis Between Each Specialised Physical Fitness and Repeated Sprinting Ability

Table 2 showed that the correlation between each specialised physical fitness and RSA. chin-up, sit-up-and-bend and standing long jumps had no correlation with RSA, and all the tests had no correlation with RSA_{dec}. The YO-YO test had a moderate negative correlation with RSA_{best} and RSA_{mean} (p<0.05). 5*25m run had a high positive correlation with RSA_{best} and RSA_{mean} (p<0.01). 30m run had a moderate positive correlation with RSA_{best} and RSA_{mean} (p<0.01). T-run had a moderately positive correlation with RSA_{best} (p<0.05).

Table 2. Pearson's correlation between each specialised physical fitness and repeated sprinting ability

	RSA_{best}	RSA_{mean}	RSA_{dec}
Chin-up	-0.364	-0.275	0.294
Sit-up-and-bend (cm)	0.33	0.297	-0.204
Standing long jump (cm)	-0.016	-0.101	-0.135
YO-YO test(s)	-0.425*	-0.443*	0.156
5 * 25m run(s)	0.686**	0.676**	-0.306
30m run(s)	0.598**	0.583**	-0.268
T-run(s)	0.459*	0.354	-0.365

Note: **indicates that the difference is highly significant *at* $p \leq 0.01$; *indicates that the difference is significant at $0.01< p \leq 0.05$.

3.2. One-way Linear Regression Analyses of Each Specialised Physical Fitness and Repeated Sprinting Ability

One-way linear regression analyses of each specialised physical fitness and RSA_{best} were performed, with the independent variables being the YO-YO test, 5*25m run, 30m run and T-run and the dependent variable was RSA_{best}. Table 3 shows the regression analyses of the independent variables with RSA_{best}. The YO-YO test (F=6.58, p=0.016), 5*25m run (F=23.953, p<0.001), 30m run (F=15.008, p=0.006), and T-run (F=7.189, p=0.012) had significant or highly significant affect with RSA_{best}. The YO-YO test, 5*25m run, 30m run, and T-run explained 18.1%, 47%, 35.7%, and 21% of the RSA_{best}, respectively. wit, impact coefficients of 0, 0.13, 0.532, and 0.298. Except for the YO-YO test had an impact coefficient of 0. The regression equation of the independent variables with the dependent variable were RSA_{best}=0.13 * "5*25m run" + 2.939, RSA_{best}=0.532 * "30m run" + 5.059 and RSA_{best}=0.298* "T-run" + 3.87.

One-way linear regression analyses of each specialised physical fitness and RSA_{mean} were performed, with the independent variables being the YO-YO test, 5*25m run and 30m run and the dependent variable was RSA_{mean}. Table 3 shows the regression analyses of the independent variables with $_{mean}$. YO-YO test (F=5.965, p=0.021), 5 x 25m run (F=22.71, p<0.001) and 30m run (F=13.882, p=0.001) had significant or highly significant affect with RSA_{mean}, YO-YO test, 5*25 m run and 30 m run explained 19.6%, 45.7%, and 34% of RSA_{mean}, respectively, with impact coefficients of 0, 0.107, and 0.431. Except for the YO-YO test, the regression equations of the independent variables with the dependent variables were RSA_{mean}=0.107 * "5*25m run" + 4.079 and RSA_{mean}=0.431 * "30m run" + 5.838.

Table 3. One-way linear regression of each specialised physical fitness against repeated sprinting ability

Dependent variable	Constants and independent variables	B-value	standard error	beta value	t	*P*	R-square	F
RSA_{best}	constant	7.741	0.157		49.314	0.000	0.181	5.965
	YO-YO test(s)	0.000	0.000	-0.425	-2.442	0.021		
	constant	2.939	0.906		3.243	0.003	0.470	23.953
	5∗25m run(s)	0.130	0.027	0.686	4.894	0.000		
	constant	5.059	0.598		8.454	0.000	0.357	15.008
	30m run(s)	0.532	0.137	0.598	3.874	0.001		
	constant	3.870	1.307		2.962	0.006	0.210	7.189
	T-run(s)	0.298	0.111	0.459	2.681	0.012		
RSA_{mean}	constant	8.033	0.129		62.097	0.000	0.196	6.580
	YO-YO test(s)	0.000	0.000	-0.443	-2.565	0.016		
	constant	4.079	0.763		5.344	0.000	0.457	22.710
	5∗25m run(s)	0.107	0.022	0.676	4.766	0.000		
	constant	5.838	0.505		11.571	0.000	0.34	13.882
	30m run(s)	0.431	0.116	0.583	3.726	0.001		

3.3. Multiple Linear Regression Analysis of Specialised Physical Fitness and Repeated Sprinting Ability

Multiple linear regression analyses were performed for each specialised physical fitness and RSA_{best}, with the independent variables being the YO-YO test, 5∗25m run, 30m run and T-run and the dependent variable was RSA_{best}. Table 4 showed that the regression analysis of the independent variables with RSA_{best}, the four independent variables explained 67.4 percent of RSA_{best}, i.e., the model fit was 67.4 percent and the linear regression model (F=12.399, p<0.001) was significant. Among the four independent variables, YO-YO test (p=0.241) and T-run (p=0.068) were not significant with RSA_{best}, with impact coefficients of 0 and 0.154, respectively; 5*25m run (p=0.001) and 30m run (p=0.034) were significant with RSA_{best}, and the impact coefficients of were 0.089 and 0.266, respectively. Except for YO-YO test, the regression equation of the independent variables with the dependent variable is RSA_{best}=0.089 ∗ "5*25m run" + 0.266 * "30m run" + 0.154 ∗ "T-run" + 1.502.

Multiple linear regression analyses were performed for each specialised physical fitness and RSA_{mean}, with the independent variables being the YO-YO test, 5*25m run and 30m run and the dependent variable being the RSA_{mean}. Table 4 showed that the regression analysis of the independent variables with RSA_{mean}, the three independent variables explained 61.2% of RSA_{mean}, i.e., the model fit was 61.2 percent and the linear regression model (F=13.157, p<0.001) was significant. Among the three independent variables, YO-YO test (p=0.108) was not significant with RSA_{mean}, with a coefficient of influence of 0. 5*25m run (p=0.001) and 30m run (p=0.036) were significant with RSA_{mean}, with coefficients of influence of 0.078 and 0.263, respectively. Except for YO-YO test, the regression equation of the independent variables with the dependent variable is RSA_{mean}=0.078∗ "5*25m run" + 0.23 ∗ "30m run" +4.221.

Table 4. Multiple linear regressions of specialised physical fitness and repeated sprinting ability

Dependent variable	Constants and Independent Variables	B-value	standard error	beta value	T	p	R-square	F	p
RSA_{best}	constant	1.502	1.161		1.293	0.208	0.674	12.399	<0.001
	YO-YO test(s)	0.000	0.000	-0.152	-1.202	0.241			
	5 x 25m run(s)	0.089	0.025	0.471	3.619	0.001			
	30m run(s)	0.266	0.118	0.298	2.249	0.034			
	T-run(s)	0.154	0.081	0.236	1.909	0.068			
RSA_{mean}	constant	4.221	0.751		5.62	0.000	0.612	13.157	<0.001
	YO-YO test(s)	0.000	0.000	-0.221	-1.666	0.108			
	5 x 25m run(s)	0.078	0.022	0.493	3.573	0.001			
	30m run(s)	0.23	0.104	0.311	2.214	0.036			

4. Discussion

Specialised physical fitness and RSA are very important to the physical fitness and competitive performance of football players. Taking Chizhou University as an example, the results showed that football-specific physical fitness and RSA have positive or negative correlation of medium to high degree. Meanwhile, the specialised physical fitness can affect RSA.

In the correlation analyses, the YO-YO test, 5*25m run, 30m run and T-run were positively or negatively correlated to varying degrees on RSA_{best} and RSA_{mean}. The YO-YO test has been widely used as a specialised aerobic endurance test in football players. It has 20m distance is the same as RSA test, which football players face when dribbling to break through, sprint, chase the opposing player and tackle the ball in a game[14]. Research has shown that training interventions can improve RSA while improving YO-YO test scores[15, 16]. The 5*25m run was used as a test to assess anaerobic endurance.[4] The 5*25m run as a measure of anaerobic endurance is consistent with anaerobic energy metabolism in terms of time of energy supply[17]. KEIR et al. found that the values of blood lactate were similar between the repeated sprint test and the anaerobic endurance test[18]. KORAL et

al. showed that sprint interval training improved performance in the 30m run and RSA[19]. The 10m run and 30m run both are speed tests. Luo et al. found that repetitive sprint training improved the performance of the 10m run and RSA_{mean}[20]. DI et al. showed that agility and RSA are also correlated[21], training can improve the agility and RSA of players[22, 23]. The above studies showed that football-specific physical fitness has a significant correlation with RSA, but chin-up, standing long jumps and sit-up-and-bend did not. Chin-up as a test index of upper limb strength, while the test of repeated sprinting ability is mainly based on lower limb strength, and there is a difference from the analysis of technical movements. Strength is divided into maximal strength, speed strength and strength endurance[24]. According to the characteristics of energy metabolism, the test of repeated sprinting ability is based on anaerobic energy supply and is more in line with the characteristics of power endurance. Standing long jump is in line with the characteristics of speed strength, which may be the reason why chin-up and standing long jumps are not significantly correlated with RSA. TURKI-BELKHIRIA et al. showed that dynamic stretching training can improve the flexibility of the hip joint, but it cannot improve RSA[25]. It is evident that flexibility is not significantly related to RSA.

Regression analysis showed that YO-YO test, 5*25m run, 30m run and T-run can influence RSA_{best} and YO-YO test, 5*25m run and 30m run can influence RSA_{mean}. In One-way linear regression analysis, it was found that the explanatory rate of each independent variable on RSA_{best} and RSA_{mean} was less than 60%, which indicated that the respective variables can influence RSA, but the model fit was low. In the multiple linear regression analysis, the explanatory rates of the independent variables for RSA_{best} and RSA_{mean} are 67.4% and 61.2% respectively, which are greater than 60%, indicating a better model fit.

Among the effects of independent variables on RSA_{best}, the 30m run had the greatest effect, followed by T-run, 5*25m run and YO-YO test respectively. All of them showed positive relationship, among which YO-YO test and T-run were not significant. RSA_{best}, as the shortest time used in 6 times of 40m run, belonged to the displacement velocity from the point of view of the composition of athletic ability[1]. 30m run is also a displacement speed test, from the perspective of energy supply, the phosphagen system supplies energy for 6-8 seconds. During the experimental test, the time used for 20m round trip running and 30m sprint running was within 8 seconds, which was mainly supplied by the phosphagen. The T-run, as a test of agility, incorporates a sprint run, a backward run, and a left-right change-of-direction side slide during the test, which have similarities with football. 5*25m run test also contains sprinting and change of direction, which is based on the energy supply of phosphagen system and anaerobic glycolysis. It is one of the reasons that affect the RSA_{best}. The YO-YO test is a test of aerobic endurance, and oxygen is an important substance for CNS oxidation, and CNS hypoxia may have a negative effect on RSA[26]. Therefore, the results show that a 1-second improvement on 30m run was accompanied by a 0.266-second improvement on RSA_{best}, a 1-second improvement on T-run was accompanied by a 0.154-second improvement on RSA_{best}, and a 1-second improvement on 5*25m run was accompanied by a 0.089-second improvement on RSA_{best} .

Among the effects of independent variables on RSA_{mean}, compared with 5*25m run and YO-YO test, 30m run has a greater effect on RSA_{mean}. All of them are positive, among which YO-YO test is not significant. RSA_{mean} is the average time used in 6 times of 40m run. There is a certain connection between the three of them from the calculation formula of the three indexes of RSA. The results showed that a 1-second improvement on 30m run was accompanied by a 0.23-second improvement on RSA_{mean}, and a 1-second improvement on 5*25m run was accompanied by a 0.078-second improvement on RSA_{mean}. There is no correlation between the independent variables and RSA_{dec}. RSA_{dec} , as an indicator reflecting the fatigue level of players in repeated sprinting, the energy source in repeated sprinting mainly relies on the phosphagen energy supply system, and the re-synthesis of CP in the recovery process requires aerobic oxidative energy supply. So the aerobic working capacity should be an important reason for influencing the RSA_{dec}. This is inconsistent with the results, which may be related to the sample size being too small to be representative.

The study was a cross-sectional study, which could not illustrate the causal relationship. The study only used specialised physical fitness as the independent variable and did not involve morphological and physiological indicators. The small sample size of the study is a limitation, and future studies should increase the relevant indicators and exaggerate the sample size. It is suggested that future studies can intervene on specialised physical fitness of university football players to further test the causal relationship between specialised physical fitness and RSA.

5. Conclusion

From the correlation analysis between specialised physical fitness and RSA, most of the specialised physical fitness and RSA showed positive correlation. The 30m run was the most predictive of repeated sprinting ability, followed by the 5*25m run, suggesting that increasing sprint training and anaerobic endurance training with short distances during the training process of university football teams can help to improve RSA of players.

Acknowledgments

A study on the relationship between repeated sprinting ability and specialised physical fitness of university football players in Chizhou City + CZ2023ZR02.

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