ORIGINAL ARTICLE

The effect of plyometric training on competition period muscle damage in amateur footballers

Tayfun Şirin[ABCDE]

Department of Coaching Education, Faculty of Sport Science, Kahramanmaras Sutcu Imam Universty, Turkey

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

Abstract

Background and Study Aim The aim of this study is to investigate the effect of plyometric training on the damage muscle in amateur footballers.

Material and Methods The research group consists of 19 footballers with an average age of 23.41 ± 3.2. In addition to football training, the research group received a plyometric training program from the third week of the preparation period (two days a week) to the sixth week of the competition period (one day a week). Blood samples were taken in the sixth week of the competition period, before and after the training and on the day of the competition. CK activity was determined in sera obtained from centrifuged blood. It was analyzed with the Roche Diagnostic kit on an Integra (800-Roche) biochemistry device. Tests used: Vertical Jump Test; 30 m. Sprint Test; Illinois Agility Test; Flexibility Test. Statistical analysis were performed by t-test, according to normality test in SPSS 10.0 package program.

Results The blood samples taken before and after the training were compared with creatine kinasevalues. It was seen that there was an increase and this increase returned to normal on the match day. In 30 meters sprint tests and Iliniois tests, significant reductions were found ($p<0.05$). While a significant difference was detected in the pre- and post-tests, pre-training and match day, no significant difference was found in CK values ($p>0.05$).

Conclusions Based on the results of this study, it can be recommended to reduce the intensity of the training to be done after the plyometric training due to the high CK value in the blood. It can be said that plyometric studies can play an important role in improving the performance of footballers.

Keywords: muscle damage, football, plyometrics, training

Introduction

The improvement of the football team performance and the personal performance of the footballers have caused an increase in the total distances run during a match each year. The rule that prevents the side shots from being played inside the penalty area has been changed. The players, who go back and forth between two goalposts at a distance of 60-70 m, had to increase their performance, physical and physiological strength by going back and forth between two goalposts at a distance of about 90m, at different speeds, together with the change of this rule. The success of the team and the continuity of the match of the footballers increased the physical and physiological load under these conditions, and thus the risks of serious injury increased. With the intense match traffic and the intensity of the national matches, football has started to be played faster and more paced with the updated game rules. That the players are free from injury, their performance is always at the highest level, playing matches with the same team skeleton and continuing the season have always been the first priority of the coaches. Having a football player profile that can maintain the existing capacity at the highest level during the match and has the best endurance characteristics has been the first priority of the coaches [1-3]. Athletes who use their physical strength best, who do not get tired easily, who can rest quickly and who can recover, are tried to be included in the transfer lists by paying astronomical prices, especially by European clubs with huge budgets [4-6]. In the analyzes made on the footballers playing in the national teams, it was found that they ran a distance of approximately 10-12 km during the match, this distance increased every year with the further development of their training models. And it was also found that footballers tried to do of approximately 10 difficult and combined movement out of 1200 independent movements in every 3-5 seconds. It has been revealed by the researches made by scientists that they try to run forward and backward by sprinting 30-40 m to the opponent and the ball, and perform more than 700 movements that require speed, agility and skill [7, 8]. Football matches are tougher, more aggressive and have higher intensity compared to previous years. The number of matches played by footballers today has also increased compared to the past. Therefore, in today's football, footballers need more strength and endurance. In the studies on football injuries, it is reported that while hamstring (back leg) injuries

doi:10.15561/20755279.2022.0104

[9] constitute 7% of football player injuries, this rate has increased to 12-17% today [10]. In the studies conducted in the English leagues, it is estimated that the cost of injury in a season exceeds one hundred (100) million pounds. For this reason, various studies show that footballers reach an improved physical capacity with strength training, which also reduces the risk of injury [11].

Hamstring injury is the most common type of injury in football [12 -15]. There are many potential risk factors for hamstring injuries, such as age, athlete's position, previous hamstring injury, musculature, fatigue, flexibility and strength. Injuries in the hamstring group of muscles are usually seen in two joints as a result of sudden and excessive contraction of the muscles. These are hip flexion and knee extension [16]. Eniseler [11] reported that it is important to develop the hamstring muscle group, so that injuries that may occur can be prevented and that it will make an important contribution to football player performances during the match, and he hasalsoreported that pliomeric training is an indispensable part of football training. He stated that by improving hamstring strength with eccentric contraction, hamstring muscle injuries are reduced and the highest efficiency is achieved with plyometric training, especially in such football-specific exercises. For this reason, plyometric training is an indispensable element in transforming the strength gained into football-specific power.

Plyometric studies have an important place in many studies applied to develop the muscle groups used especially when performing high speed and power movements with and without the ball. It has been shown that plyometric studies especially improve physical performance (speed, quickness, agility, anaerobic capacity) [17]. Although plyometric exercises in various branches are used by many trainers and performance developers as a common working method used for speed, explosive power, explosive reaction and eccentric muscle control in dynamic movements, it is known that these exercises cause muscle damage and muscle injuries [18 - 20]. The first signs of damage immediately after exercise are decreased strength and loss of function. The damage to the muscle is more prominent after an unadapted exercise, depending on the intensity and volume of the exercise [21]. If the training is unusual or very intense, the muscles can be damaged and take time to return to normal. A suitable recovery is needed according to the intensity of the training. For these reasons the muscle damage experienced is called training-related muscle damage [22]. Creatine kinase (CK), the enzyme that determines muscle damage, increases in serum during muscle damage. An increase in the level of CK in the serum is an indicator of muscle tissue damage [23 - 25]. It is known that in muscle damage that occurs after training, the blood CK value increases depending on the race, gender, age and exercise type of the individual. The rate of clearance from blood values varies according to the lymph flow of the person and the severity of the damage. At the end of the 24 hour period following the exercise, the creatine kinase concentration, which reaches its highest value, starts to decrease at the end of 48 hours and returns to its pre-exercise level after 72 hours [26, 27]. Eryılmaz et. al. [28] found damage in CK and lactate dehydrogenase (LDH) levels in blood samples taken after 30 m repetitive sprint training. It can be said that this may be due to the fact that the fatigue level of the athletes is at the highest level when the training scope of the athletes is increased

In the light of the literature research, the purpose of this study is to determine whether the footballers carry the risk of injury after the plyometric training applied starting from the preparatory period in amateur footballers. The aim is to compare the blood samples taken before and after plyometric training with the creatine kinase values, to see if they carry the risk of injury and if there is a risk, to help investigate how much it affects the match day.

Material and Methods

Participants.

19 athletes (age 23.41 ± 3.2 years) who are both amateur footballers and students in the faculty of sports sciences without any injury or disease constitute the sample of the research (see table 1). Football players were given three predetermined plyometric training forms, the difficulty level of which was predetermined and repeated in each training. In this experiment, informed consent was obtained from all participants. All procedures were in accordance with the 2021 Declaration of Helsinki. This study was approved by Kahramanmaraş Sütçü İmam University Ethics Committee for research on human participants (2021/02).

Table 1. Anthropometric characteristics of the participants

Variables	Plyometric Group Mean±SD
Age (year)	23.41 ± 3.2
Height (cm)	169 ± 0.19
Weight (kg)	64.0,6± 7.12
BMI	21.02 ± 8.11

Research Design

In the 6th week of the competition period, just before and immediately after the training, blood samples were taken by the health personnel under hygienic conditions and transferred to a private hospital laboratory. CK activity was determined in sera obtained from centrifuged blood. It was analyzed with the Roche Diagnostic kit on an Integra (800-Roche) biochemistry device.

Vertical Jump Test

Before the jump, athletes try to reach the highest point on the previously marked wall with bare feet, body in an upright position and one arm stretched and the last contact point is determined. Without moving, the athlete just shrinks, tries to jump up with two feet and the end point touched is marked. The end point touched by jumping is recorded. The best of the three attempts is taken. Vertical jump test is one of the most used tests in measuring strength and explosiveness [29].

30 m. Sprint Test

The test battery developed to measure the speed performance of footballers includes players' passing a distance of 30 meters with the fastest speed by spending maximum effort. During the trials, the photocell was placed at meters 0 and 30meters. The athlete started 1 m behind the photocell. The athlete's values at the end of meters 30 were recorded. The best of the two trials was evaluated. Reliability coefficient was found as α = .74 for 30 m sprint [30].

Illinois Agility Test

The limits were determined with funnels placed on the corners of the area with a width of 5 meters and a length of 10 meters where the test would be performed and the athletes' departures and returns were directed with arrows drawn on the floor. The area where the test would be performed was divided in two longitudinal parts. Four funnels with a distance of 3.3 meters were placed on the mid line. The athletes started the test from one meter behind the photocell when they felt ready. Two trails were performed by taking rest and recovery into consideration, and the best result was evaluated [31].

Flexibility Test

The upper surface of the sit and reach box, which has a length of 35 cm, width of 45 cm, height of 32 cm with an upper surface length of 55 cm and width of 45 cm, is 15 cm further than the surface on which the feet rest. 0-50 cm measurement ruler is indicated with 5 cm parallel line intervals on the upper surface. After the athletes warm up, they sit with their bare feet soles under the 15 cm shorter part of the test table and they reach forward as far as possible with the hands in front of the body without bending the knees. The best of the two attempts is determined in cm [32].

Predetermined standard football training programs were applied to all athletes in the study 5-6 days a week during the preparation and competition period. Pre-training, post-training and matchday blood samples were taken at the sixth and sixth week of the preparation phase and competition period (see table 2).

Table2. Footballers plyometric work design and tests

Group / Number of footballers	Research Group (n=/19)
Number of Football Practices per Week	5 Day
The Beginning of Plyometric Trainings	Preparation Period III. week
Plyometric Training Preparation Period Number of Weekly Work	2 Day
Plyometric Training Competition Period Weekly Number of Work	1 Day
Plyometric Training Time / Rest Time (sec)	20min / 1:10sec
Performance Pre-Tests	Preparation period III. week
Performance Post –Tests	Preparation period VI. week
CK Pre-workout First test	Competition Period VI. week
Second test after CK Training	Competition Period VI. week
CK Final Test	Competition Period VI. week

The design of the Plyometric Training program was developed by the researcher.

12 plyometric movements, which are thought to improve agility, speed and power, were applied to the footballers within the standard football training program (see table 3).

Plyometric training Program

They completed the plyometric training program applied to footballers by performing sprint movements with a change of direction, varying between 2 and 6 meters, two days a week during the preparation period and once a week during the competition period (table 4).

Statistical Analyses

Data analysis was performed by the SPSS software version 22.0 program. Data were expressed as mean ± standard deviation (ss). The t test was used to determine the differences between groups. Variances were found to be homogeneous for all protocols. Significance level was interpreted according to $p<.05$, $p<0.1$ and $p<.001$.

Results

According to table 5 after the plyometric training, in the pre-test and post-test values of the footballers. In 30 meters sprint tests and Iliniois tests, significant reductions were found ($p<0,05$). Significant increases were found in vertical jump and flexibility values ($p<0,05$).

Pre, Pre-training, Post, Post-training

According to table 6 comparing the pre-test and post-test blood values of the plyometric training

Table 3. Plyometric movements applied to footballers

1st Plyometric Movement	One legged side over barrier (OLSB)
2 d Plyometric Movement	Ankle hops (AH)
3 d Plyometric Movement	Sid hope over barrier (SHB)
4 th Plyometric Movement	Lateral bounding (LB)
5 th Plyometric Movement	One leg bounding (OLB)
6 th Plyometric Movement	Standing long jump (SLJ)
7 th Plyometric Movement	Splitsqut Jumps(SJ)
8 th Plyometric Movement	LandingTecnique(LT)
9 th Plyometric Movement	TuckJums(TJ)
10th Plyometric Movement	Standing long jump lateral (SLJL)
11th Plyometric Movement	Standing long jump lateral Sprint (SLJLS)
12 Plyometric Movement	Standing long jump with barrier jump (SLJBJ)

OLSB = one legged side over barrier; AH = ankle hops ; SHB = sid hope over barrier; LB = lateral bounding; OLB = one leg bounding; SLJ = standing long jump; SJ = splitsqut jumps; LT= landing technique; TJ= tuck jumps; SLJL = standing long jump lateral; SLJLS = standing long jump lateral sprint; SLJBJ= standing long jump with barrier jump.

Table 4. Plyometric training program

Season	Weekday		Plyometric Exercises	Set	The number of repetitions	Between Set Rest.(s)	Training intensity
Preparation Period	3	Tuesd	**1st** OLSB	2	3	1:6	% 60-70
			2d AH	2	3	1:6	% 60-70
			3d SHB	2	3	1:6	% 60-70
		Thurs	**3d** SHB	2	3	1:6	% 60-70
			4th LB	2	4	1:6	% 60-70
			6th SLJ	3	4	1:7	% 80-90
	4	Tuesd	**1st** OLSB	3	4	1:7	% 80-90
			3d SHB	3	5	1:7	% 80-90
			5th OLB	3	6	1:8	% 80-90/2-3m. sprint
		Thurs	**7th** SJ	3	6	1:8	% 80-90
			8th LT	3	6	1:8	% 80-90/2-3m sprint
			9th TJ	3	6	1:8	% 100/ 2-3m sprint
Competition period	5	Wednes	**10th** SLJL	3	6	1:10	% 100/5-6m sprint
			11th SLJLS	3	6	1:10	
			12th SLJBJ	3	6	1:10	
	6	Wednes	**10th** SLJL	3	6	1:10	% 100/5-6m sprint
			11th SLJLS	3	6	1:10	
			12th SLJBJ	3	6	1:10	
	7	Wednes	**9th** TJ	3	6	1:10	% 100/5-6m.sprint with change of direction
			11 SLJLS	3	6	1:10	
			12 SLJBJ	3	6	1:10	
	8	Wednes	**10th** SLJL	3	6	1:10	% 100/5-6 m. sprint with change of direction
			11th SLJLS	3	6	1:10	
			12th SLJBJ	3	6	1:10	

“Sunday”.Tuesd = Tuesday; Thurs = Thursday; Wednes = Wednesday. *The Plyometric Training program was developed by the researcher assuming that the match days would be on

Table 5. Analysis results for physical performance "pre-test and post-test" values of footballers doing pilepliometric training.

Variable	Measure	X(n=19)	*ss*	t	p
30 m sprint	Pre	4,13	0,14	2,52	0,03**
	Post	4,11	0,08		
Vertical jump tests	Pre	2,70	0,12	1,72	0,00**
	Post	2,76	0,09		
İllinois agility	Pre	18,22	0,88	1,72	0,03**
	Post	16,99	0,72		
Flexibility	Pre	23,44	3,20	6,71	0,00**
	Post	26,57	3,66		

Pre; Pre- training, Post; Post-training

Table 6. Analysis results for "pre-test and post-test" values for variables of blood values of footballers participating in the study.

Variable	Measure	X (n=19)	ss	t	p
CK before and after training	Pre	161,63	60,74	-3,65	0,002**
	Post	228,21	62,37		
CK pre-training and matchday, before the match	Pre	161,63	60,74	0,34	0,732
	Post	156,10	29,10		

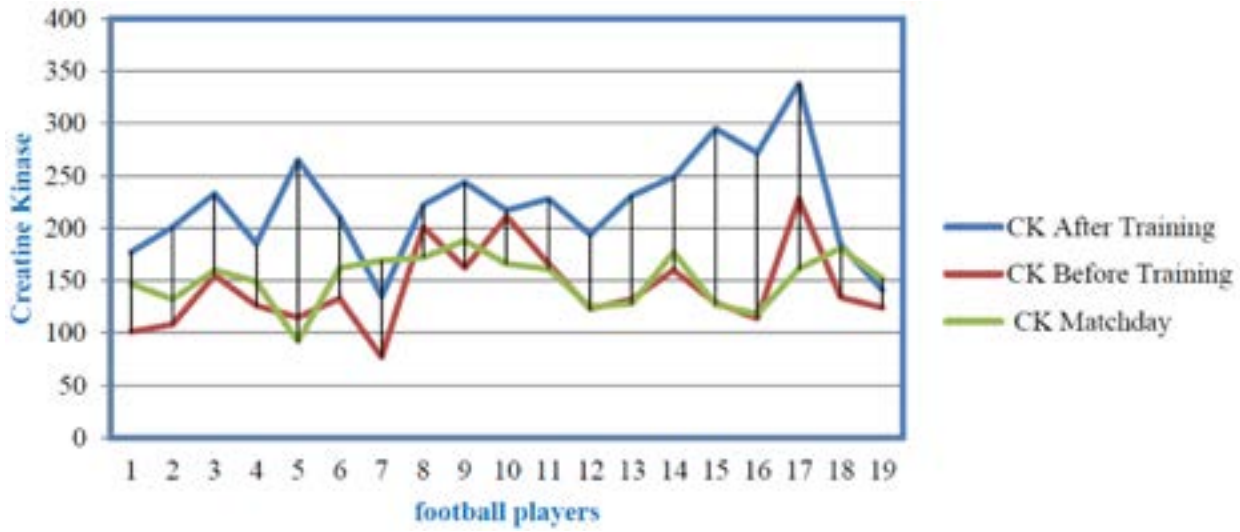

Figure1. Creatine kinase (CK) values of the players before training, after training and match day

program data, before and after training values. While a significant difference was detected in the pre- and post-tests, pre-training and match day, no significant difference was found in CK values ($p>0.05$).

When figure1 is examined, when the blood samples taken and the CK values before and after the training were compared, an increase was observed, and it was seen that this increase returned to the normal level on the match day.

Discussion

In this study it was observed that there was a significant increase in CK values in pre-test and post-test results in blood tests taken from footballers aged 19-28 before and after training. However, it was determined that there was no significant difference in the pre-training and pre-match CK values of the athletes (see table 6 and see figure 1). According to the analysis results; It was seen that plyometric trainings made a significant contribution to the performances of football (see table 5). Based on these results, it can be said that plyometric studies (see Table 4) will not cause injuries on the match day, as pre-match CK values return to normal.

In addition, it is frequently reported in the literature that plyometric exercises significantly improve the performance of athletes.

Eniseler [11] and Baechle [33] defined the aim of plyometric training as reaching maximum power

and improving speed ability with the strength gained during activities performed at a certain speed close to the maximum. At the same time, plyometric exercises are very important for the development of sportive performance in footballers who use speed, agility and strength together. They state that there is muscle strength in exercises without the ball such as jumping, sprinting, agility, interventions involving intense contact, and all exercises with the ball.

Lin et al [34] investigated the effects of plyometric training and creatine monohydrate supplementation on anaerobic capacity and muscle damage in their study on 26 male athletes. As a result, they found that plyometric exercises significantly improved the development of the anaerobic capacity of the athletes, as well as their characteristics such as speed and agility.

The peak time of creatine kinase, which rises after exercise, varies depending on the intensity, type and duration of exercise. In other studies, different results were obtained regarding the peak time. It has been revealed after the researches that the CK value reaches its highest level 2 or 4 days after the exercise [22].

Kaplan [35] evaluated muscle enzymes in terms of muscle damage caused by Nordic Hamstring Exercise and Slide Board Hamstring Curl Exercise, which are eccentric exercises used in sports branches in his study on footballers. It was reported that muscle enzyme values continued to increase 3, 24 and 48 hours after exercise.

Khan et al. [36] in his study in which he examined the sprint values of footballers and the muscle damage due to them, stated that the CK value in the blood after the tests may last for 24-48 or even 72 hours. This result of the research shows parallelism with our research results.

Conclusions

Based on the results of this study, it can be recommended to reduce the intensity of the training to be done after the plyometric training due to the high CK value in the blood.

It can be said that plyometric studies can play an important role in improving the performance of footballers.

In the light of this information, the CK value in the blood may increase after a plyometric training, which may cause injury. For this reason, it is necessary to pay attention to the load that may cause injury while planning the studies after the competition period plyometric training.

It can be said that the inclusion of plyometric training programs in addition to the existing training programs of footballers can contribute to the development of physical performances such as speed, agility and changing direction at high speed, which they encounter most during the match.

Suggestions

Coaches will significantly contribute to footballers development if they include plyometric training to the current training period (preparation, competition period or transition period) by taking the football player's age, the scope of the training into consideration. It can be said that the plyometric training programs applied to this group can also be applied in teams of lower age groups by changing the number of repetitions and rest periods according to the difficulty levels and age categories. The subject of this study can also be applied in amateur footballers by considering the differences between positions. The effects of plyometric training in different branches and in different age categories, the muscle damage of players, and physical and physiological parameters can also be examined.

In different studies, changing muscle enzyme levels can be compared by changing gender or age groups. As another suggestion, this study can be applied to the sample by adding more detailed and detailed biochemical tests.

Financial support

There is no financial support.

Conflict of interest

The author declare no conflict of interest.

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Information about the author:

Tayfun Şirin; https://orcid.org/0000-0001-6305-0097; tayfunksu@gmail.com; Department of Coaching Education, Faculty of Sport Science, KahramanmarasSutcu Imam Universty; Kahramanmaraş, Turkey.

Cite this article as:
Şirin T. The effect of plyometric training on competition period muscle damage in amateur footballers. *Physical Education of Students,* 2022;26(1):27–34.
https://doi.org/10.15561/20755279.2022.0104

Received: 02.12.2021

Accepted: 26.01.2022; **Published**: 28.02.2022