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The effects of plyometric training with additional weight applied to football athletes-students on some physical and physiological features and chronic muscle damage

Los efectos del entrenamiento pliométrico con peso adicional aplicado a los atletas-estudiantes de fútbol sobre algunas características físicas y fisiológicas y el daño muscular crónico

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Resumen

Se aplican varios programas de entrenamiento para mejorar muchas características físicas y fisiológicas de los atletas durante el entrenamiento. El objetivo de este estudio fue investigar el efecto del entrenamiento pliométrico con peso adicional sobre el rendimiento físico y los hallazgos de daño muscular en jugadores de fútbol-estudiantes.Se recogieron pruebas de rendimiento físico y muestras de sangre de los estudiantes-deportistas (hombres 23,41 ± 3,2 años) tanto de los grupos de muestra como de control en la primera semana del estudio (tercera semana del campamento preparatorio) y en el último entrenamiento de la duodécima semana. Durante el estudio, se aplicaron programas de entrenamiento pliométrico al grupo de peso adicional (AWG) (% 1 del peso corporal) y grupo sin peso adicional (AG). Se aplicaron programas de entrenamiento de fútbol estándar al grupo de control. Al final de la primera y duodécima semana, se aplicaron las pruebas de IMC y porcentaje de grasa corporal de los jugadores junto con las pruebas físicas de lanzadera, yoyo, salto vertical, salto horizontal, agilidad y pruebas de rendimiento de velocidad. También se tomaron muestras de sangre para verificar los marcadores de control de daño muscular (CK y LDH; p>0.05). De acuerdo con los resultados de las pruebas realizadas al final de los entrenamientos pliométricos de la primera y la duodécima semana en el grupo con grupo de peso adicional (AWG), prueba de lanzadera, el yoyo y el salto horizontal aumentaron significativamente, mientras que el rendimiento en esprint, el IMC y las pruebas de rendimiento de grasas se redujeron significativamente. Los resultados de la prueba del grupo sin peso adicional (AG) fue; aumento significativo pruebas físicas de lanzadera yoyo y salto vertical mientras que una disminución significativa en el rendimiento del sprint y el porcentaje de grasa Al final de los entrenamientos pliométricos de doce semanas, no se ha observado daño muscular en (AWG), CK pre entrenamiento (229,00 ± 155,25) y valores posteriores al entrenamiento (242,33 ± 193,67) (P = 0,861) y valores de LDH pre-entrenamiento (169,75 ± 40,85) y post-entrenamiento (174,33 ± 39,12). Como resultado del estudio, el rendimiento físico de los jugadores-atletas-estudiantes de fútbol aumentó con el entrenamiento pliométrico de 8 semanas con pesos adicionales (volantes, yo-yo, pruebas faciales, pruebas de botar el balón con el pie izquierdo y derecho). No se encontró daño muscular (CK y LDH) en los resultados de laboratorio. Cuando se evalúan estos resultados; Si bien el entrenamiento pliométrico con pesas adicionales aumentó el rendimiento físico, no causó daño muscular.

Palabras clave

Pliometría; peso adicional; estudiantes-deportistas; ejercicio físico.

Abstract

Various training programs are applied in order to improve many physical and physiological characteristics of athletes during training. The aim of this study was to investigate the effect of plyometric training with additional weight on physical performance and muscle damage findings in football player-students. Physical performance tests and blood samples of the

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athlete-students (male 23.41 ± 3.2 years old) were collected both from sample and the control groups at the first week of the study (third week of the preparatory camp) and at the last training of the twelfth week. During the study, plyometric training programs were applied to the additional weight group(AWG) (%1 of the body weight) and no additional weight group (AG). Standard football training programs were applied to control group. By the end of first and twelfth week, players' BMI and body fat percentage tests were applied together with the physical tests of shuttle, yoyo, vertical jump, horizontal jump, agility and sprint performance tests. Blood samples were also taken to check muscle damage control markers (CK and LDH, p>0.05). According to the results of tests performed at the end of first and twelfth weeks' plyometric trainings on group with additional weight group (AWG), shuttle, yoyo and horizontal jumping were found to be significantly increased, while sprint performance, BMI and body fat performance tests were significantly decreased. The test results of the group without additional weight (AG) was; significant increase in shuttle, yoyo and vertical jump while significant decrease in sprint performance and fat %. By the end of twelve week plyometric trainings, no muscle damage has been observed in (AWG), CK pre-training (229,00 ± 155,25) and post training values (242,33 ± 193,67) (P=0,861), and LDH pre-training (169,75 ± 40,85) and post-training (174,33 ± 39,12) values. As a result of the study, the physical performances of football players-athletes-students increased with 8-week plyometric training with additional weights (shuttle, yo-yo, face tests, ball dribbling left and right foot tests). No muscle damage (CK and LDH) was found in laboratory results. As per the evaluated results; while plyometric training with added weights increased physical performance, it did not cause muscle damage.

Key words

Plyometric; additional weight; athlete-students; physical exercise.

Note: This study is an excerpt from author's doctoral this sertation titled "The effects plyometric training performed with additional weight football players on some physical and physiological features and chronic muscle damage

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Introduction

The aim of plyometric training is to reach maximal strength and to improve the ability of speed with the strength gained during activities performed within a specific speed close to maximal plyometric studies are vital for the development of sportive performance in football players who use speed, agility and strength together. Muscle strength is needed in all activities without the ball such as jumping, sprint, agility, tackles including intense contact and in all activities with the ball (Eniseler, 2010; De Hoyo et al., 2016; Armstrong, & Greig, 2018). A good performance for athletes in a team, with a strong ethical climate, leads to an increase in team quality and athlete performance, as well as the success of the team (Eratlı Şirin et al.,). Besides these dynamics, the most important dynamic that enhances performance is the form of training applied to athletes.

Football competitions are tougher and more aggressive than the past, and they have higher intense. The number of games played by football players have increased compared with the past. Therefore, in today's football, players need strength and endurance more. In studies conducted on injury in football, it has been reported that while 7% of the injuries were hamstring (hind leg) injuries (Srámek et al., 2000; Gabbe, et al., 2002; Buckthorpe,et al., 2019).

This rate has been reported to increase to 12-17% today (Bailey et al., 2007).In studies conducted in English leagues, it is estimated that the cost of injury in a season exceeds hundred (100) million sterling. Therefore, various studies have shown that reaching a developed physical capacity with strength training reduces the risk of injury in football players (Eniseler, 2010; Pfirrmann, et al., 2016; Prien et al., 2018; Ekstrand et al., 2020).

Researchers stated that exercises which include eccentric contractions are stated to be effective in preventing hamstring muscle injuries by improving hamstring strength. It is stated that plyometric training is an effective method especially in developing muscle strength and power specific to football (Eniseler, 2010; Dias et al., 2021; Rydså &Vanden 2020).

With the rules of the game renewed and updated every year, football has begun to be played faster and with higher tempo. The priority of coaches is to have player profiles with the best endurance features who can maintain their existing capacity at highest level during

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the game. Players who use their physical strength in the best way, who do not get tired easily and who can rest and recover quickly are needed in football (Küçük &Tarakci, 2018; Armstrong & Greig, 2018; Zemková, 2016; Greig & Naylor, 2018; Mann et al., 2016;Paul, D.J, Gabbett, T.J. & Nassis, G.P., 2016; Vogler et al., 2017).

In game analysis on elite football players, researchers have shown that they ran for about 10-12 km during a game and made 1200 independent moves and sudden turns every 3-5 seconds (such as interfering with the ball by sliding for 30-40 meters and jumping, more than 700 turns and 30-40 m sprint sprints) (Iaia et al., 2019; Pojskic et al., 2019).

Plyometric studies have played an important role in many studies applied to develop the muscle groups used especially when performing movements that require high speed and strength with and without ball. Studies have shown that plyometric workout improves physical performance characteristics such as speed, agility and anaerobic capacity and strengthened muscle groups decrease the risk of injury (Cigerci, 2017).

Although plyometric training is a method commonly used in various branches by many trainers and conditioners in speed, explosive power, explosive reaction and dynamic movements, it is known that this training causes muscle damage and muscle injury (Twist & Roger 2015; Yepes et al., 2020).

There are different views in literature about plyometric training causing muscle damage (Hyldahl & Hubal, 2014; Lovering, et al., 2009).

Training may lead to damage in muscles if it is unusual or too intense and it may take time to return to normal; the degree of muscle damage and recovery time may differ depending on the intensity of training and for these reasons, the resulting muscle damage may be termed training-related muscle damage (Paulsen et al., 2012).

Injuries of various sizes in the skeletal muscle tissue, injuries caused by impact and strain are also called muscle damage; depending on the degree of damage, loss of isometric strength, speed and flexibility in athlete performance may occur (LaStayo et al., 2003).

Eryılmaz et al., (2019) reported that although athletes are accustomed to exercise in training program, when training intensity and volume are suddenly increased, the damage can be observed more severely and therefore long term performance loss can be experienced.

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The aim of this study is to examine whether plyometric exercises with additional weight, one of the training parameters performed to increase individual and team performances of players during the preparation period or competition period, have an effect on muscle damage.

Material and Methods

Participants

Thirty-six students, who are football players and (mean ± SD,male 23,41 ± 3.2 age, height 177.33 ± 6.4 cm, mass 73,19 ± 10,11 kg) have experience of resistance exercises, voluntarily participated in the present study.

These players were grouped in three with randomization method. 12 players who were applied plyometric training with additional weight formed the first experimental group (additional weight group), 12 players who were applied plyometric training with their own weight without using additional weight formed the second experimental group (no weight group) and 12 players who had their standard football training formed the third experimental group (Control group). The study was conducted in accordance with the guidelines of the revised Helsinki Declaration and the ethical approval with the protocol number of 2018/08 from the Faculty of Medicine, Kahramanmaras Sutcu Imam University.

Biochemical analysis

Venous blood samples were taken from the football players before plyometric training at the first training in the first week of plyometric training program (third week of preparation camp) and the last training of week 8 in the training area under hygienic conditions by two experienced nurses in order to find out the effect of plyometric training with additional weights on muscle damage. The blood samples taken were sent to Kahramanmaraş Sütçü İmam University Faculty of Medicine, Biochemistry Laboratory and were analysed. CK-CKMB activity was analysed in serums obtained from centrifuged blood with Roche Diagnostic kit in Integra (800-Roche) biochemistry device.

Statistical analysis

In the analysis of the research data, the arithmetic means and standard deviations (SD) of the pre-test and post-test values of the Additional Weighted Group (EAG), Unweighted

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Group (AG) and Control Groups (KG) were calculated. According to the normality test, the Paired Sample T-Test was used for the data showing normal distribution. The level of significance was determined as $p < 0.05$. All analyzes were performed using the IBM SPSS Statistics 20.

Protocol

As per the experimental protocol, all football players in the study were applied a training program including previously determined standard football technique and tactics for 6 days a week. After the second week of preparation period, in addition to standard football training program, plyometric training program was applied to the first experimental group (additional weight group) by using additional weight of 1% of body weight, and to the second experimental group (no-weight group) without using any additional weight. The program was designed as 1 day and 20 minutes a week for 8 weeks. The third group (Control group) was applied only the standard football training program (Table 1).

Considering the recovery period, plyometric training was terminated at least three days before games. In the first week training, barrier height and height in all jumping movements did not exceed 15 cm. From the third week of the preparation period to the end of the 10th week, 3 complementary movements were determined and applied from a total of 14 basic movements (Table 2) each week (2 days in a week during preparation period and 1 day in a week during competition period).

Table1.Study design of the groups AWG; Additional Weight Group, NWG; No weight group, CG; Control group,

Design	Groups		
Group / Number of footballers	Experimental Group 1 (AWG) / n=12	Experimental Group 2 (NWG)/ n=12	Experimental Group 3 (CG)/ n=12
Number of weekly trainings	6 days	6 days	6 days
PlyometricTraining Period/Rest period (sec)	20 min / 1:10sec	20 min/ 1:10sec	–
Plyometrictraining	Weeks 3-11	Weeks 3-11	_
Physical pre-tests/Post-tests(Week)	first and twelfth weeks	first and twelfth weeks	first and twelfth weeks
PhysicalperformancePre-tests/Post-tests (Week)	first and twelfth weeks	first and twelfth weeks	first and twelfth weeks
Blood valuesPre-tests/ Post-	first and twelfth	first and twelfth	first and twelfth

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tests (Week)	weeks	weeks	weeks

The design of 8-week Plyometric training program was developed by the researcher.

Plyometric Training Program

Plyometric Training Program to be applied to the football players was applied starting from the third week of the preparation period, for two days a week with two days of interval during the preparation period, during the competition period (considering the recovery periods of the football players), three days before competition, one day per week, immediately after warm up and before the main period. Starting from the third week of the preparation period, the players were asked to complete the program with sprint movements with distances varying between 2 and 6 meters.

Design of the Study

All football players in the study were applied a training program including previously determined standard football technique and tactics for 6 days a week in a total of 36 weeks during a season, including preparations and interval camps. Plyometric training program, which was to be applied to the first experimental group (additional weight group) by using additional weight of 1% of body weight and to the second experimental group (no-weight group) without using additional weight within the traditionalf football training program to be applied after the preparation period, was designed as 1 day and 20 minutes a week for 10 weeks. The third group (Control group) was applied only the traditionalf football technical training program (Table 1).

Considering the recovery period, plyometric training was terminated at least three days before games. In the first week training, barrier height and height in all jumping movements did not exceed 15 cm. For 10 weeks from the third week of the preparation period to the end of the 8th week, 3 complementary movements were determined from a total of 14 basic movements (Table 2), in every training which would include plyometric exercises, the barrier heights used for these movements and the intensity of movements were continued by increasing the intensity with predetermined rates.

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Testers

Sit up test

It is a system which requires the athlete to cover the same distance in less time with periodical intervals against time within a distance of 20 meters. It starts with the signal sound; the speed between the sets, which is slow at the beginning, continues by increasing every 10 seconds. The participants who moved from the starting point with the sound of the stimulus reached the finish with the sound of the second stimulus and went back to the starting point with the third stimulus sound. The athlete who could not reach the start and finish line with the stimulus sound twice in a row in this spiral was eliminated from the test (Tamer, 2000).

Yo-Yo Intermittent Recovery Test

It is used to determine the capacity of football players to repeat high intensity runs in relation to the maximal participation of the aerobic system (Bangsbo et al., 2008).It is grouped in two as 1 and 2 according to the degree of difficulty. Yoyo1 is a test that requires higher effort than yoyo2. It is one of the important physical tests in determining athletes' aerobic capacity. There is a 5 second rest break with certain second intervals at the end of 20 m and at 5 meter rest area for a short time. It is a system which requires the athlete to cover the same distance in less time with periodical intervals against time within a distance of 20 meters. It starts with the signal sound; the participant needs to be at 20 m. before the signal sound. Otherwise, the test is terminated (Krustrup et al., 2003).

Vertical Jump Test

Jump meter was used to measure and collect data during the test. The belt of the jump meter is fitted to the waist of the players and players were asked to jump three times. Best scores were recorded. The first measure was taken in the second week of the preparation period while the last measure was at the end of week eight (Miller, 2012).

Horizontal Jump Test

Athletes jump behind the marked line on the floor with two feet to the farthest point

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they can reach with all their strength. The last contact point while jumping and the last point of contact are measured in meter as distance (Miller, 2012).

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 and 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.

10 m, 20 m, 30 m Sprint Test

The test battery developed to measure the speed performance of football players includes players' passing a distance of 10.20.30 meters with the fastest speed by spending maximum effort. During the trials, the photocell was placed at meters 0 and 10,20,30. The athlete started 1 m behind the photocell. The athlete's values at the end of meters 10, 20 and 30 were recorded. The best of the two trials was evaluated. Reliability coefficient was found as $\alpha = .74$ for 30 m sprint.

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, the best result was evaluated (Kızılet et al., 2010).

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Dribbling with ball and slalom test

The athletes dribbled between 5 slalom rods placed one meter apart starting from a distance of 1 meter from the starting point. Two trials were made for each leg. Four minutes of breaks were given between the trials. The time used for a trial was recorded by the electronic photocell placed at the beginning of the setup. When the subject lost the ball, the test continued until two successful trials were completed. The average of two successful trials was evaluated (Haaland & Hoff, 2003).

Body Fat Percentage Measurement

Body fat percentage of the football players was measured with an electronic scale (Tanita TBF 300 Body Analysis Device, Japan) with a precision of 0.1 kilogram (kg).

Body Mass Index

Body Mass Index of the football players was measured with an electronic scale (Tanita TBF 300 Body Analysis Device, Japan) with a precision of 0.1 kilogram (kg).

Table 2. Plyometric Exercises

1	Landing Technique; Free fall on the ground with double feet from 15 cm. Box
2	Tuck Jumps; Pulling feet to chest by jumping with two feet
3	Split squat Jumps; Jumping up, landing
4	Ankle hops; Straight up, repetitive jumping without bending the legs
5	Side hops over barrier; Jumping left and right with double feet over 15 cm barrier
6	One legged side over barrier; Jumping left with one foot over 15 cm barrier
7	Standing long jump; Jumping forward and away by standing with two feet
8	Standing long jump lateral Sprint; Jumping forward and away by standing with two feet, 3m. Sprint to the right with fall
9	Standing long jump lateral Sprint; Jumping forward and away by standing with two feet, 3m. Sprint to the right with fall
10	Standing long jump with barrier jump; Jumping forward and away by standing with two feet, climbing over 45 cm barrier
11	One leg bounding; Bounding right, left and forward with one foot
12	Lateral bounding; Bounding with one foot from 15 cm. long 7 barriers standing with intervals of 30 cm
13	Drop froze; Landing from 45 cm barrier and standing on double toes for 1-2 seconds
14	Standing triple jump over barrier jump; Long step forward, passing over 45 cm. barrier to the other side without touching(https://www.youtube.com/,2020).

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Table 3. 8-week Plyometric Training Program Applied

Season	Week/day		Plyometric Exercises	Set	Number of repetitions	Rest between sets (sec)
Preparation Period	1		-	-	-	-
	2		-	-	-	-
	3	Tuesday	4	3	6	1:5
			2	3	8	1:7
			1	3	6	1:5
		Thursday	4	3	6	1:5
			6	3	8	1:7
			5	3	8	1:7
	4	Tuesday	6	3	8	1:7
			5	3	8	1:7
			3	3	10	1:8
		Thursday	5	3	10	1:8
			1	3	10	1:8
			8	3	10	1:8
	5	Tuesday	8	3	12	1:10
			9	3	12	1:10
			10	3	12	1:10
		Thursday	6	3	12	1:10
			7	3	12	1:10
			14	3	12	1:10
Competition period	6		12	3	12	1:10
			10	3	12	1:10
			8	3	12	1:10
	7		9	3	12	1:10
			10	3	12	1:10
			11	3	12	1:10
	8		11	3	12	1:10
			9	3	12	1:10
			10	3	12	1:10
	9		9	3	12	1:10
			10	3	12	1:10
			14	3	12	1:10
	10		13	3	12	1:10
			10	3	12	1:10
			9	3	12	1:10

This program was developed by the researcher. Days of the week were shown as coded:Tuesday:1; Thursday;2;

Results

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As per table 4, when pre test and post test results of the players are compared, NWG players have demonstrated the most development (Pre; 88,25^{a} ± 10,95, Post; 94,00^{a} ± 12,24). Additionally, NWG players have also demonstrated the most development according to pretest and posttest results of Yoyo2 (Pre; 40,25^{a} ± 5,44, Post; 42,58^{a} ± 4,88).

When both groups' protest and posttest results of 10m sprint (Pre; 1,70^{b} ± 0,07, Post; 1,66^{b} ± 0,07) and 20m sprint tests (Pre; 2,87^{b} ± 0,18, Post; 2,83^{b} ± 0,17) were compared, the most development was demonstrated by AWG players. As per the 30m sprint (Pre; 4,18^{a}± 0,05 Post; 4,12^{ab} ± 0,06) and right foot dribbling (Pre; 11,97^{ab} ± 1,46 Post; 11,05^{b} ± 1,17) pre-test and post-test comparison, the most development was demonstrated by NWG. According to the pre-test and post-test results of left foot dribbling (Pre; 11,10^{b} ± 1,57 Post; 10,40^{b} ± 0,88), AWG was the group demonstrating the most development. As per the analysis of other test results, no significant difference was found between pre-test and post-test results of vertical jump, flexibility, horizontal jump, Illinois agility, BMI, body fat percentage tests (p>0.05).

Table 4.Anova/Tukey Analysis results for Physical performance "Pre and Post Test"

Variable	Measure	AWG $\bar{X}$±s n=12	NWG $\bar{X}$±s n=12	CG $\bar{X}$±s n=12	F	p
Sit-up	Pre-test	91.25^{a} ± 14.07	88.25^{a} ± 10.95	72.25^{b} ± 9.39	9.241	0.001*
	Post-test	95.50^{a} ± 16.11	94.00^{a} ± 12.24	71.58^{b} ± 8.46	13.422	0.000*
Yoyo2	Pre-test	43.00^{a} ± 4.47	40.25^{a} ± 5.44	32.50^{b} ± 10.56	6.620	0.004*
	Post-test	44.16^{a} ± 2.79	42.58^{a} ± 4.88	32.41^{b} ± 9.98	11.132	0.000*
Flexibility	Pre-test	25.20^{b} ± 3.77	23.58^{b} ± 2.46	24.25^{b} ± 1.60	1.043	0.362
	Post-test	25.58^{b} ± 3.53	23.79^{b} ± 2.64	24.00^{b} ± 1.65	1.555	0.226
Vertical jump tests	Pre-test	2.77^{a} ± 0.13	2.65^{ab} ± 0.11	2.59^{b} ± 0.11	6.742	0.004*
	Post-test	2.78^{a} ± 0.12	2.68^{ab} ± 0.11	2.59^{b} ± 0.12	6.971	6.744
Horizontal jump tests	Pre-test	2.58^{b} ± 0.09	2.57^{b} ± 0.06	2.57^{b} ± 0.08	0.101	0.900
	Post-test	2.60^{b} ± 0.09	2.57^{b} ± 0.05	2.58^{b} ± 0.09	0.343	0.711
10 m. sprint	Pre-test	1.70^{b} ± 0.07	1.68^{b} ± 0.07	1.82^{a} ± 0.07	11.814	0.000**
	Post-test	1.66^{b} ± 0.07	1.67^{b} ± 0.06	1.82^{a} ± 0.07	18.521	0.000**
20 m. sprint	Pre-test	2.87^{b} ± 0.18	2.96^{b} ± 0.10	2.90^{b} ± 0.13	1.072	0.352
	Post-test	2.83^{b} ± 0.17	2.93^{b} ± 0.08	2.91^{b} ± 0.13	1.801	0.032*
30 m. sprint	Pre-test	4.09^{b} ± 0.09	4.18^{a} ± 0.05	4.18^{a} ± 0.09	4.425	0.020*
	Post-test	4.05^{b} ± 0.10	4.12^{ab} ± 0.06	4.19^{a} ± 0.08	7.346	0.002*
Right foot dribbling	Pre-test	10.92^{b} ± 1.97	11.97^{ab} ± 1.46	12.53^{a} ± 0.63	3.751	0.034*
	Post-test	10.65^{b} ± 1.68	11.05^{b} ± 1.17	12.41^{a} ± 0.70	6.467	0.004*
Left foot dribbling	Pre-test	11.10^{b} ± 1.57	12.80^{b} ± 3.04	13.72^{b} ± 0.94	0.981	0.383
	Post-test	10.40^{b} ± 0.88	10.84^{b} ± 1.19	13.53^{a} ± 0.91	33.892	0.000*
İllinois	Pre-test	17.04^{b} ± 0.96	16.55^{b} ± 0.62	16.46^{b} ± 0.94	1.605	0.216

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agility	Post-test	$16.23^{b} \pm 0.67$	$15.87^{b} \pm 0.61$	$16.39^{b} \pm 0.75$	1.847	0.174
BMI	Pre-test	$24.18^{b} \pm 2.80$	$22.49^{b} \pm 2.75$	$23.90^{b} \pm 3,78$	0.992	0.381
	Post-test	$23.71^{b} \pm 2.70$	$22.49^{b} \pm 2.80$	$23.90^{b} \pm 3.78$	0.711	0.496
Body fat percentage	Pre-test	$7.57^{b} \pm 3.10$	$5.86^{b} \pm 2.93$	$7.95^{b} \pm 6.08$	0.803	0.455
	Post-test	$6.37^{b} \pm 2.78$	$6.77^{b} \pm 2.88$	$7.95^{b} \pm 6.08$	0.454	0.636

Values of additional weight (AWG), No-weight (NWG) and Control groups (CG), Pre; Pre- -test , Post;Post--test ,

In the comparison of pre-test and post-test values of plyometric training program data of additional weight, no-weight and control groups, no significant difference was found between pre and post-tests and groups ($p>0.05$) (Table 5),

Table 5.ANOVA Analysis results for blood value variables of additional weight group

Variables	Measurement	AWG $\bar{X}\pm s$ n=12	NWG $\bar{X}\pm s$ n=12	CG $\bar{X}\pm s$ n=12	F	p
LDH	Pre-test	165,66 ± 24,60	169,75 ± 40,85	144,00 ± 37,26	1,883	0,168
	Post-test	167,66 ± 23,91	174,33 ± 39,12	145,16 ± 27,98	2,913	0,681
CK	Pre-test	178,41 ± 111,47	229,00 ± 155,25	131,91 ± 73,22	2,026	0,148
	Post-test	188,58 ± 167,91	242,33 ±193,67	130,91 ± 73,28	1,572	0,223

(AWG), No-weight group (NWG) and Control groups (CG), Pre; Pre- test , Post;Post-test

Discussion

The aim of this study is to investigate the effects of plyometric training with additional weights on some physical and physiological characteristics and chronic muscle damage of football sports students.

In the present study, of the 36 football players between 19 and 28 years of age playing in Local Amateur League , significant increases were found in the pre-training and post-training values, anaerobic strength and vertical jump tests of additional weight group (n=12) and no-weight group (n=12), while significant decreases were found in sprint tests with and withoutball, BMI and fat % values. Based on these results, it can be said that a significant part of the physical performance values mentioned above are developed more especially in football players who have plyometric training with additional weight.

In a study conducted with 26 male athletes, Rimmer & Sleivert (2000) stated that 8-week long plyometric exercises had a statistically positive effect on 40 m sprint performance In a study conducted with 25 male athletes,In their studies, Göllü (2006); Kurt(2011) found a

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statistically significant difference in the sprint values of quick strength and plyometric training and stated that this difference was in the form of a "decrease" (in other words, improvement).In a study conducted by Cigerci (2017) on young basketball players, it was concluded that 10 m sprint times of the subjects showed significant improvement in both water and land group and there was no difference in the control group.

As a result of the study, it was found that there were no significant increases in the blood tests, CK and LDH values of additional weight, no-weight and control groups; there were no significant changes in the muscle damage of football players who were trained with additional weight that was 1% of their own weight (n=12) and also their physical performance developed more when compared with the other groups.

It is stated in studies in the literature that the increase in CK and LDH levels in blood is accepted as muscle damage finding and it is expected to return to normal level within 48 and 72 hours after training (Brancaccio et al., 2007)

In addition to training and competition intensity, CK as normal value differs from person to person; the reason for this may be the fact that the permeability of muscle cells to enzymes differs between individuals. Since the muscle damage that occurs in fast-contracting muscle fibres is higher than the damage in slow-contracting muscle fibres and this brings to mind that the increase in CK amount may be associated with muscle fibre distribution (Knitter et al. 2000).

It can be said that the inclusion of plyometric training with additional weight in football training programs will help reaching more effective results in terms of performance, and it will be useful for trainers to include these in the training program in accordance with the football player's age, the content of training and the existing training period (preparation, competition period or transition period).

It can be said that performing additional weight plyometric trainings regularly will be more effective in branches in which speed, agility, promptness, jumping, anaerobic strength and aerobic strength are in the foreground when compared with the other programs.

It can be thought that the results of the present study may be a guide for studies examining how much of the amount of weight used will cause muscle damage in plyometric

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trainings with additional weight.

Based on the results of the present study, it can be said that in male football players who are insufficient in terms of sprint, vertical jump, anaerobic strength and aerobic strength, speed and agility can show improvement on the issues they are insufficient by using additional weight plyometric training exercises.

It is observed in this study that after the trainings with additional weight that is 1% of their body weight, not only player's physical performance has increased but also no muscle defect symptoms were observed. This study which was applied on amateur student players, can also be applied on sportsman from different branches (Basketball, volleyball etc.) and to the players those are performing in professional leagues. Plyometric studies can be used to develop performance if similar results are found. Increase in physical performance can be monitored with used different amounts of additional weight and muscle defect symptoms can be observed.

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