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Investigatıon Of the Relationship Between the Cardiovascular Measured Durıng the Football Matchplay and The Performance Parameters In Young Elıte Football Players

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ABSRACT
The aim of this study is to investigate the relationship between the cardiovascular and performance parameters measured during the football matchplay of young elite football players. A total of 20 football players (age: 15.5238±5; height: 179.7143±5; weight: 69.8095±6) competing in the U16 and U17 development leagues participated in the study. The data received from the Polar Team Pro-2 units placed on the chest areas of the participants before an official matchplay were transferred to the computer with the help of bluetooth and recorded as the first half and the second half during a matchplay. Internal and external load values were determined during the matchplay. Statistical analyzes of the obtained data were carried out in the SPSS 22 package program. Mean, standard deviation, minimum and maximum values were given as descriptive statistics in the study. Spearman correlation test was performed to determine the relationship between the load values realized during the matchplay. In the study, the relationship between exercise load score and cardio load score, the relationship between heart rate regions and heart rate percentages, the relationship between heart rate regions and exercise load score, the relationship between heart rate regions and total distance, average speed and maximum speed were examined as first half and second half. As a result of the study, it was determined that there is a relationship between cardiovascular and performance parameters measured during the matchplay in young elite football players.

Keywords: Football player, Cardiovascular, Performance.

1. INTRODUCTION

The principles of excellence in performance-based sports are primarily physical. On the other hand, the development and evaluation of physical performance is an area where sports science continues to strive (Nalçakan, 2001). Compared to other sports today, football has the highest popularity in many respects, and many parents are referring their children to football. This led to a more direct involvement of children in football over the next few years (Taşkın et al., 2015). The training process of football, which is largely dependent on physical and motor development, consists of systematic and planned processes to improve athletic performance. Physiological and metabolic adaptations occur in the player during these processes (Gamble, 2006; Issurin, 2010; Kiely, 2012.) Therefore, coaches and sports researchers are constantly looking for reliable methods and strategies to identify and comply with these adaptive responses (Kölling et al., 2015; Lambert and Borresen, 2010).

In order to get maximum performance from the players and to benefit from them for a longer period of time; it is seen that the concept of monitoring training load has emerged at the point of fatigue caused by the frequency of training and matchplay on players, being able to effectively evaluate whether the recovery is at the desired level after fatigue, making training plans accordingly, protecting the health of the players and taking measures that can reduce the risk of possible injury (Bartlett et al., 2017).

In recent years, training and matchplay load tracking has become popular in modern football science. Training load measurements can be categorized as internal or external. Internal training loads are defined as the relative biological (both physiological and psychological) stressors applied to the player during training or matchplay. Measures such as heart load, blood lactate, oxygen consumption, and perceived difficulty levels (AZD) are often used to evaluate internal load. On the other hand, external training loads are objective measurements of the work performed by the player during training or matchplay and are evaluated independently of their internal loads. Common external load measurements are power output, speed, acceleration, time-motion analysis, global

positioning system (GPS) parameters, and accelerometer-derived parameters (Bourdon et al., 2017; Gabbet, 2016).

Objective measures of internal and external load data allow coaches and football players to plan training and recovery strategies used during tight schedule periods (Borressen & Lambert, 2009). Training progress is the result of the interaction of external and internal loads applied to players during the training periodization (Impellizzeri, et al., 2004). The acute and chronic changes that occur as a result of training are the result of the player's increasing internal load over a period of time. For this reason, it is of great importance to measure the internal load and determine its effects (Vanrenterghem et al., 2017). Although physiological adaptations are determined by the internal load, these data can be obtained in a more practical way by determining the external load. External load is usually evaluated by determining distances and time performed in speed categories (Manzi et al., 2014). This method is generally considered for practical matters. This is because sprint, speed, and endurance training data are simple to interpret and may not require consideration of definitions of acceleration calculations that would often require the use of non-sustainable tools (Osgnach et al., 2010; Carling et al., 2012). Therefore, it provides the opportunity to determine the relationships between the internal and external load values of the training, to evaluate the training in detail and accurately, to make a preliminary determination, to plan and to follow the development of the players (Castillo et al., 2016; Burgess, 2017; Bartlett et al., 2017).

The aim of the study is to determine the parameters obtained from cardiovascular and performance measurements of young elite football players during the football matchplay and to determine their relationship with each other.

2. METHOD

2.1. Participants

A total of 21 volunteer football players from 2 different categories who are living in Ankara, Turkiye, who train regularly 4 days/1.5-2 hours a week and who are with a mean age of (15.523±.511), height of (179.71±5.29), body weight of (69.80±6.25), and playing in the U16 - U17 development leagues were included in the study. Before the matchplay, the players continued their normal sleeping and eating patterns. The matchplays took place during daylight hours.

2.2. Data Collection Tools and Data Collection

In the study, cardiovascular (internal load); heart rate levels, exercise load, cardio load, heart rate percentages, time spent in heart rate zones, performance (external load); running distances, maximum speed values, average speed values of football players in U16 - U17 development leagues in Ankara in Turkey in a matchplay held in Ankara province were determined as internal and external load values as a result of the data obtained from the Polar Team Pro2 device positioned on the chest areas of the football players participating in two different official football matchplays.

Polar Team Pro2 units have been positioned in the chest areas of the players to keep track of the values of young elite football players' cardiovascular (internal load); heart rate levels, heart rate zones, exercise load score, cardio load score, performance (external load); running distances, average speed, maximum speed, attacks, positive and negative acceleration during an official matchplay. Data from Polar Team Pro2 units were acquired simultaneously with the Polar Team Pro app (App Store, Finland) of the iPad Pro (Apple INC., USA) tablet computer equipped with Bluetooth 4.2" technology.

2.3. Analysis of Data

Statistical results in this study were calculated using the SPSS 22 package program. In the study, mean, standard deviation, minimum and maximum values as descriptive statistics have been revealed as a result of the analysis of the obtained data. In order to determine the relationship between the load values during the football matchplay, the Spearman correlation test and the findings of the relationship are included.

3. FINDINGS

While the average age of the football players participating in the study is 15.52±51, their height is measured as 179.71±5.29, and their body weight is 69.80±6.25. (Table.1) The age range of the participants in the research is between the ages of 15-16. While the height range of the football players participating in the research varies between 171 and 191 cm, it varies between 60 and 82 kilograms on a weight basis.

Table 1. Descriptive Statistics of Age, Height and Body Weights of Young Elite Football Players Participating in the Study

Variables	N	Mean ± SD	Min.	Max.
Age	20	15,52±,51	15	16
Height (cm)	20	179,71±5,29	171.00	191.00
Weight (kg)	20	69,80±6,25	60	82

Table 2. Investigation of Internal Load Values of Young Elite Footballers in the First Half and Second Half of the Official Matchplay

		N	Min.	Max.	Mean	SD
HR Min	First Half	20	58,00	159,00	133,2000	22,31025
	Second Half		33,00	151,00	112,1500	30,72505
HR Average	First Half	20	154,00	194,00	174,8000	10,59096
	Second Half		148,00	183,00	164,1000	10,23359
HR Max	First Half	20	183,00	209,00	194,9500	8,04249
	Second Half		179,00	230,00	193,4500	12,80409
HR Min %	First Half	20	29,00	80,00	66,8500	11,22626
	Second Half		17,00	76,00	56,2500	15,44046
HR Average %	First Half	20	77,00	97,00	87,7000	5,25257
	Second Half		74,00	92,00	82,2000	5,18703
HR Max %	First Half	20	92,00	105,00	97,5500	3,94001
	Second Half		90,00	115,00	97,0500	6,34512
Zone 3	First Half	20	0	29	6,57	8,146
	Second Half		1	32	10,92	8,061
Zone 4	First Half	20	3	33	18,66	8,188
	Second Half		6	30	18,79	8,223
Zone 5	First Half	20	1	36	17,74	12,755
	Second Half		0	31	8,76	9,234
Training Load Score	First Half	20	100,00	182,00	134,9000	25,37902
	Second Half		100,00	182,00	134,9000	25,37902
Cardio Load	First Half	20	79,00	158,00	117,9000	25,25220
	Second Half		27,00	142,00	94,2000	30,50729

HR: Heart Rate; Zone 3 : 3 o'clock in the HR area; Zone 4: 4 o'clock in the HR zone; Zone 5: 5 o'clock in the HR zone

Table 3. Investigation of External Load Values of Young Elite Footballers in the First Half and Second Half of the Official Matchplay

		N	Minimum	Maximum	Mean	Standard Deviation
Running Distance	First Half	20	2554,00	6301,00	4865,3000	830,46760
	Second Half		981,00	6091,00	4162,2500	1362,88486
Average Speed	First Half	20	3,20	8,60	6,6550	1,24286
	Second Half		3,50	6,60	5,4450	1,00445
Maximum Speed	First Half	20	25,00	41,90	29,1800	4,14305
	Second Half		24,20	42,90	28,7500	3,89757
Attacks	First Half	20	11,00	78,00	40,3000	15,42418
	Second Half		5,00	69,00	35,8000	17,35572
ACC 1	First Half	20	8,00	55,00	27,2000	12,15947
	Second Half		2,00	54,00	23,8000	12,69729
ACC 2	First Half	20	21,00	96,00	58,9000	16,35430
	Second Half		18,00	88,00	51,2500	19,03701
ACC 3	First Half	20	153,00	226,00	192,8000	22,54959
	Second Half		66,00	275,00	193,5500	57,91689
ACC 4	First Half	20	92,00	237,00	180,5000	38,83636
	Second Half		46,00	267,00	157,4500	56,53362
DCC 1	First Half	20	91,00	173,00	124,0000	24,05914
	Second Half		48,00	183,00	114,7500	33,13747
DCC 2	First Half	20	150,00	273,00	199,6500	31,93624
	Second Half		66,00	274,00	196,0000	66,36978
DCC 3	First Half	20	26,00	75,00	52,2000	11,09101
	Second Half		66,00	274,00	196,0000	66,36978
DCC 4	First Half	20	7,00	68,00	33,3500	13,90295
	Second Half		5,00	60,00	28,7000	13,52619

Table 4. An Investigation of the Relationship Between the Exercise Load Score and the Cardio Load in the First Half of Official Matchplay of Young Elite Footballers

Variables	n	r	p
Exercise load score	20	,959	,000
Cardio load			

*p < .05; **p < .01
When Table 4 is examined, a significant positive correlation was found between the first half exercise load score and cardio load (r = ,960 p<.01).

Table 5. An Investigation of the Relationship Between the Second Half Exercise Load Score and the Cardio Load in the Official Matchplay of Young Elite Footballers

Variables	N	r	p
Exercise load score	20	,932	,000
Cardio load			

*p < .05; **p < .01
When Table 5 is examined, a significant positive correlation was found between the second half exercise load score and cardio load (r = ,932 p<.01).

Table 6. Investigation of the Relationship between the Heart Rate Percentages and Heart Rate Zones in the First Half of the Official Matchplay of Young Elite Footballers

		Zone 3	Zone 4	Zone 5
Minimum Heart Rate Percentage	r	-,433	-,234	,344
	P	,057	,322	,138
	N	20	20	20
Average Heart Rate Percentage	R	-,949**	-,677**	,980**
	P	,000	,001	,000
	N	20	20	20
Maximum Heart Rate Percentage	R	-,819**	-,680**	,940**
	P	,000	,001	,000
	N	20	20	20

Zone 3 : 3 o'clock in the HR area; Zone 4: 4 o'clock in the HR zone; Zone 5: 5 o'clock in the HR zone; *p < .05; **p < .01

When Table 6 is examined, the relationship between the first half heart rate percentages and heart rate zones is investigated. There was no significant difference between the minimum heart rate percentage and zone 3 (r = -.433 p>.05), zone 4 (r = -.234 p>.05) and zone 5 (r = .344 p>.05) beat zones. While a significant negative correlation was found between average heart rate percentage and zone 3 (r = -,949 p<.05) and zone 4 (r = -,677 p<.01) beat zones, a positive and significant relationship was found between zone 5 (r = .980 p<.01) beat zone. While a significant negative correlation was found between the maximum heart rate and zone 3 (r = -,819 p<.05) and zone 4 (r = -,680 p<.01) beat zones, a positive and significant correlation was found between zone 5 (r = ,940 p<.01) beat zone.

Table 7. Investigation of the Relationship Between Heart Rate Percentages and Heart Rate Zones of Young Elite Footballers in the Second Half of the Official Matchplay of Young Elite Footballers

		zone3	zone4	zone5
Minimum Heart Rate Percentage	r	-,269	,364	,404
	p	,251	,115	,087
	N	20	20	20
Average Heart Rate Percentage	r	-,748**	,093	,861**
	p	,000	,698	,000
	N	20	20	20
Maximum Heart Rate Percentage	r	-,484*	,232	,749**
	p	,031	,326	,000
	N	20	20	20

Zone 3 : 3 o'clock in the HR area; Zone 4: 4 o'clock in the HR zone; Zone 5: 5 o'clock in the HR zone; *p < .05; **p < .01

When Table 7 is examined, the relationship between second half heart rate percentages and heart rate zones is investigated. There was no significant difference between the minimum heart rate percentage and zone 3 (*r* = -,269 p>.05), zone 4 (*r* = ,364 p>.05) and zone 5 (*r* = ,404 p>.05) beat zones. While a significant negative correlation was found between the average heart rate percentage and the zone 3 (*r* = -,748 p<.01) beat zone, a positive significant correlation was found between the zone 5 (*r* = ,861 p<.01) beat zone. No significant relationship was found with the zone 4 (r = .093 p>.05) beat zone. While a significant negative correlation was found between maximum heart rate and zone 3 (*r* = -,484 p<.05) beat zone, a positive significant correlation was found between Zone 5 (*r* = ,749 p<.01) beat zone. No significant correlation was found with the zone 4 (r = .326 p>.05) beat zone.

Table 8. Investigation of the Relationship between Heart Rate Zones and Total Distance, Average Speed and Maximum Speed in the First Half of the Official Matchplay of Young Elite Footballers

		Total Distance	Maximum Speed	Average Speed
Zone 3	r	-,505*	0,75	-,657**
	p	,023	0,753	,002
	N	20	20	20
Zone 4	r	-,238	,215	-,393
	p	,313	,362	,087
	N	20	20	20
Zone 5	r	,570**	,159	,585**
	p	,009	,504	,007
	N	20	20	20

Zone 3 : 3 o'clock in the HR area; Zone 4: 4 o'clock in the HR zone; Zone 5: 5 o'clock in the HR zone; *p < .05; **p < .01

When Table 8 is examined, the relationship between the first half heartbeat zones and the total distance, maximum speed and average speed is investigated. While a significant negative correlation was found between Zone 3 beat zone and total running distance (r = -.505 p<.05) and average speed (r = -.657 p<.01), no significant relationship was found with maximum speed (r = 0.215 p>.05). There was no significant relationship between Zone 4 beat zone and total running distance (*r* = -,238 p>.05), maximum speed (*r* = ,404 p>.05) and average speed (r = -, 397 p>.05). While a significant negative correlation was found between Zone 5 throwing zone and total running distance (r = -.570 p<.01) and average speed (r = -.585 p<.01), no significant relationship was found with maximum speed (r = ,504 p>.05).

Table 9. Investigation of the Relationship between Heart Rate Zones and Total Distance, Average Speed and Maximum Speed in the Second Half of the Official Matchplay of Young Elite Footballers

		Total Distance	Maximum Speed	Average Speed
Zone 3	R	,017	,251	,087
	P	,945	,287	,714
	N	20	20	20
Zone 4	R	-,095	-,445*	-,177
	P	,631	,049	,455
	N	20	20	20
Zone 5	R	,047	-,035	-,225
	P	,895	,882	,340
	N	20	20	20

Zone 3 : 3 o'clock in the HR area; Zone 4: 4 o'clock in the HR zone; Zone 5: 5 o'clock in the HR zone; *p < .05; **p < .01

When Table 9 is examined, the relationship between the second half heartbeat zones and the total distance, maximum speed and average speed is investigated. There was no significant relationship between Zone 3 beat zone and total running distance (r = ,017 p>.05), maximum speed (r = ,251 p>.05) and average speed (r = ,087 p>.05). While there was no significant relationship between Zone 4 beat zone and total running distance (r = -.095 p>.05) and average speed (r = -, 177 p>.05), a negative significant relationship was found between

maximum speed (*r* = -,445 p<.05). There was no significant relationship between Zone 5 throwing zone and total running distance (*r* = ,047 p>.05), maximum speed (*r* = -,035 p>.05) and average speed (r = ,340 p>.05).

Table 10. Investigation of the Relationship Between Heart Rate Zones and Exercise Load Score, Cardio Load in the First Half of the Official Matchplay of Young Elite Footballers

		Exercise Load Score	Cardio Load
Zone 3	R	,755**	,795**
	p	,000	,000
	N	20	20
Zone 4	r	-,596**	-,546*-
	p	,006	,013
	N	20	20
Zone 5	r	,925**	,946**
	p	,000	,000
	N	20	20

Zone 3 : 3 o'clock in the HR area; Zone 4: 4 o'clock in the HR zone; Zone 5: 5 o'clock in the HR zone; *p < .05; **p < .01

When Table 10 is examined, the relationship between the first half heart rate zones, exercise load score and cardio load is examined. Considering the zone 3 beat region, a positive and significant relationship was found between exercise load score (r = .755 p<.01) and cardio load (r = .795 p<.01). While a significant negative correlation was found between zone 4 beat zone and exercise load score (r = -.596 p<.01), a positive significant correlation was found between cardio load (r = .946 p<.01). When the zone 5 beat zone was examined, a positive and significant relationship was found between exercise load score (r = .925 p<.01) and cardio load (r = .946 p<.01).

Table 11. Investigation of the Relationship between the Heart Rate Zones and the Exercise Load Score, Cardio Load in the Second Half of the Official Matchplay of Young Elite Footballers

		Exercise Load Score	Cardio Load
Zone 3	r	-,178	-,232
	p	,454	,326
	N	20	20
Zone 4	r	,426*	-,615**
	p	,034	,004
	N	20	20
Zone 5	r	,672**	,639**
	p	,001	,002
	N	20	20

Zone 3 : 3 o'clock in the HR area; Zone 4: 4 o'clock in the HR zone; Zone 5: 5 o'clock in the HR zone; *p < .05; **p < .01

When Table 11 is examined, the relationship between the second half heart rate zones, exercise load score and cardio load is investigated. Considering the zone 3 beat region, no significant relationship was found between exercise load score (r = -.178 p>.05) and cardio load (r = -.232 p>.05). While a significant positive correlation was found between zone 4 beat zone and exercise load score (r = ,426 p<.05), a negative significant correlation was found between cardio load (r = -.615 p<.01). When the zone 5 beat zone was examined, a positive and significant correlation was found between exercise load score (r = .672 p<.01) and cardio load (r = .639 p<.01).

4. DISCUSSION AND RESULT

In this study, which was carried out to determine the relationship between the cardiovascular and performance parameters measured during the football matchplay of the young elite football players participating in the study, when the heart rate per minute (HR/min) data of the players and the values obtained were examined, it was determined that while the average was 174 HR / min in the first half, it was 164 HR / min in the second half. There are studies on heart rate in the literature. Arabacı ve Pehlivan (2018), examined the heart rate variability of young football players in different types of training and the training processes in the form of warm-up, training and recovery processes in their study and determined these differences, which emerged as a result of

the tests for the warm-up-training and training-recovery differences as "quickness-agility, coordination" in the warm-up-training processes, and "quickness-agility, coordination" and "quickness-agility, matchplay" training in the training-recovery processes.

Aşçı (2016), in his study with young football players with an average age of 17±0.9, stated that the players had an average of 168 HR/min in an official football matchplay. Mortimer et al (2006), in their research on young football players playing in the U17 league, found the average value of the players as 168 KAH/min. Çetin (2018), in his study on young football players playing in the U16, U17 and U19 leagues, found the average HR/min values to be 172.17 HR/min for U16, 169.56 HR/min for U17 and 169.11 HR/min for U19. When the studies are examined, it shows similarities with the data obtained and supports it. This similarity leads to the fact that the aerobic capacities of young players are close to each other.

The time spent by the players in the zone regions was examined in three ways as zone 3, zone 4 and zone 5. Considering the results of the research, it was concluded that the average time spent in zone 3 was 6.57, the average time spent in zone 4 was 18.66, the average time spent in zone 5 was 17.74 in the first half. However, the average time spent in zone 3 was 10.92, the average time spent in zone 4 was 18.79, the average time spent in zone 5 was 8.76 in the second half. Since football is a sports branch that contains both aerobic and anaerobic energy mechanisms, zone 3, zone 4, zone 5 heart rate zones are mainly used. It can be said that as the average heart rate of the players decreases, the time spent in zone 3 and zone 4 beats increases, due to the fact that football is a sports branch where aerobic energy metabolism is used more intensively. However, the use of maximal heart rate in zone 5 can be said to be the reason for the positive relationship. When the exercise load score obtained during the matchplay was examined, the averages of the first half and the second half were found to be 134.9000. In their study, Bucheit et al. (2010) examined the average total distance covered by young football players in different categories.

When the results of the study were examined, they reported 8436 ± 136 m for U16 and 8448 ± 135 m for U17. In another study, Vigh-Larsen, Dalgas, and Andersen (2018) stated that young football players playing in the U17 and U19 leagues covered an average distance of 10776±107 m in an official football matchplay. When the external load data of the players during the matchplay were examined, the running distance was calculated in meters and the average result was 4865.3000 m in the first half, while the average result was 4162.2500 m in the second half. When the cardio load score, which is another internal load parameter, was examined, it was found that while the first half was 117,9000, the second half was 94,2000. It is thought that the fatigue of the players during a 90-minute matchplay affects the cardio load score and the fatigue that occurs causes a decrease in the second half cardio load score. When the relationship between the internal and external load values of the players during the official matchplay was examined, a positive significant relationship was found between the first and second half exercise load points and the cardio load. This parameter, which represents how hard the cardiovascular system is during cardio load exercise, can be said that the increase in the cardiac load score positively affects the performance of the player and causes it to increase the exercise load score. Atan et al (2018) in their study on football players playing in the U18 league, reported the maximum speed reached by the players during the matchplay as 27.80 km/h for the first half of the matchplays and 29.10 km/h for the second half of the matchplays. Al Haddad, Simpson, Buchheit, Di Salvo, and Mendez-Villanueva (2015) examined the peak speeds reached by players in various young age categories. Considering the results of the research, it was reported as 26.2 ± 2.5 km/h for U16 and 26.8 ± 1.9 km/h for U17. Henderson, Cook, Kidgell and Gastin (2015) reported the average peak speed of young football players in the U18 age group during matchplays as 28 ± 2 km/h. Köse, Yıldırım and İşler (2021) stated in their study that although different physiological responses were observed during SG (Static Stretching) and DG (Dynamic Stretching) exercises performed on young football players, this difference was not reflected in the physiological and performance data of TST (Repetitive Sprint Test) applied after stretching exercises. As a result of this study, it can be said that SG (Static Stretching) or DG(Dynamic Stretching) exercises to be applied before TST (Repetitive Sprint Test) do not change performance and both stretching exercise methods can be used.

When the Yo-Yo AT1 and Yo-Yo AT2 tests were compared in the study of Bayrakdaroğlu, Can, Albaarak, and İmamoğlu (2021), it was seen that the participants covered more distance in the YoYo AT1 test. This difference is due to the higher running speed in the Yo-Yo AT2 test, and therefore, the players reaching their maximum heart rate in a shorter time. Considering the heart rate during the Yo-Yo AT1 and Yo-Yo AT2 test, it was seen that the heart rate increased as the running distances increased, and the maximum heart rate was reached in a shorter distance in the Yo-Yo AT2 test. Considering the recovery heart rate obtained at 0, 1, 3, 5, 7 and 9 minutes after both tests, it will be seen that the recovery rate in the Yo-Yo AT1 test is higher. It can be suggested that the reason for this is the higher maximum heart rate in the Yo-Yo AT2 test and the longer recovery time because the test is performed at a high running speed. Although there is no statistically significant difference between the blood lactate values at the end of the tests, it is seen that the blood lactate values at the end of the Yo-Yo AT2 test are higher.

In the light of the findings and the literature, it has been concluded that the increase in the cardiac load score, which represents the strain of the cardiovascular system measured during the football matchplay in young elite

football players, affects the performance of the player positively, and it has been revealed that there is a positive relationship between them.

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