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*THE EXAMINATION OF RELATIONSHIPS BETWEEN LOWER EXTREMITY MUSCLE STRENGTH, VERTICAL JUMP AND ANAEROBIC POWER PARAMETERS IN FEMALE FOOTBALL PLAYERS

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Abstract

The purpose of this study is to examine the relationships between lower extremity muscle strength, vertical jump and anaerobic power parametres in female footballers. The participants of study were consisted of 23 women footballers (n=23, age=17.17±1.19 years, height=160.46±5.96 cm, weight=54.23±8.73 kg) playing football at 3rd Women's League of Turkish Football Federation. The height of the athletes were measured using a stadiometer. Body weight were measured by using body composition analyzer. Lower extremity strength ability were measured by using isokinetic dynamometer. Vertical jump height were measured by using mat and imaging device. Anaerobic power and capacity ability were measured by using bicycle ergometry. Statistical analysis of data obtained at the study was done by using statistic packet programme. Shaphiro Wilk was applied for normality test of data. Multiple Regression Analaysis was applied to determine the relations between independent and depended variables and meaningfulness value was accepted as $p<0.05$.It was found that when the effect of lower extremity muscle strength on anaerobic power and anaerobic capacity were examined, variables of ndom. 180º/sc extension and dom. 60º/sc flexion have been being seen to have a meaningfull effect ($p<0.05$). Variables of lower exremity strength on vertical jump height were detected not to have a meaningfull effect ($p>0.05$). Consequently, it was determined that the relationship between isokinetic strength of lower extremity extensor muscle groups and vertical jump, anaerobic power in female soccer players increased at high angular velocity values. Also, it could be said that the relationship between isokinetic strength of lower extremity flexor muscle groups and vertical jump, anaerobic power decreased depend on increase of angular velocity.

Key words: Football, Lower Extremity Strength, Vertical Jump, Anaerobic Power, Anaerobic Capasity.

INTRODUCTION

Because of its form, football is based on aerobic/ anaerobic power and endurance, and muscle power performance (Canüzmez et al. 2006). Strength performance is one of the determiners in football as well as in other branches of sports. Many studies which are related to strength and performance relationship are found in the literature. Malliou et al. (2003), did a study on professional football players who were in the preparation stage; and they found a statistically significant relationship between isokinetic knee strength performance in the angular velocity of 60˚/sec and 180˚/sec and vertical jump performance. Özdemir (2014), a statistically significant difference is observed in parameters of $MaxVO_2$, anaerobic power, vertical jump, flexibility, 20 m speed, pass and shot accuracy in the experimental group in the study of evaluating the effects of 8-week strength training on some physiological, motoric, technical parameters, which is applied in addition to football training in the preseason preparation stage.

Even though aerobic and anaerobic metabolisms are used together, it is known that the energy is mostly obtained from aerobic metabolism. During the competition, the ratio of low-intense actions is more than high-intense actions, yet the quality of short-time anaerobic actions such as sprint, acceleration/deceleration, and fast change of directions affect the result of the game (Bangsbo, 2007). It is known that important attack actions and most of the activities that affect score occur in an anaerobic environment even though the percentage of the energy obtained from anaerobic metabolism is low. It has been determined in the studies that the actions that determine the result of the competition are carried out using the anaerobic energy system (Reilly et al. 2000).

There are many different parameters that affect sportive performance, success; and they are particular to a branch of sports. Athletes success depends on how they improve their motoric skills and technique-tactics skills which are particular to their branch. Especially for football, athletes lower extremity strength performance is extremely important. There are some studies that show the relationship between isokinetic muscle strength and anaerobic power parameters, which are essential elements to determine performance in football. Yet, the number of studies conducted with female football players is limited. The purpose of this study is to examine the relationships between lower extremity muscle strength, vertical jump and anaerobic power parametres in female footballers.

METHODS

Study Type

This study is made by using the relational method which is one of the quantitative research methods to analyze the interrelation of two or more variances.

Study Group

This study is made with 23 female football players which are certified and actively represent Ordu in Turkish Football Federation 3rd League. Before the study, athletes were informed about the content of the study; and they were involved in the study on a volunteer basis. It was paid attention that athletes did not have any injuries/diseases. So in this way, data obtained by the study would be correct, and no health problems would occur. The study was made according to the Declaration of Helsinki.

Table 1. Descriptive Data of Female Football Players

	n	$\bar{X}$	SD	Min.	Max.
Age		17.17	1.19	16.00	19.00
Body Weight (kg)	23	54.23	8.73	43.30	81.90
Body Height (cm)		160.46	5.96	149.00	174.00

Research Design

Before the study, the group was divided into two groups, and the measurements were done two days apart. The groups were measured on different days and they were verbally and practically explained the tests. Measurements were done at the same time of the day because of biological rhythm. Field tests were performed on synthetic football pitch. Laboratory measurements were performed in Ordu University Sport Science Research Laboratory. Before the tests, athletes height and weight were measured. The first isokinetic strength test, and Wingate anaerobic power test, and the vertical jump test were applied after two days. Vertical jump tests were done in synthetic pitch.

Data Collection Tools

This study has been approved in the meeting of Ordu University Clinical Research Ethics Committee on 06/13/2019 with the decision number 2019-91.

Body Weight Measurement

The bodyweight of the athletes was measured with 0,1 kg precision via Body Composition Analyzer (Jawon Body Composition Analyzer Model X-Scan plus II, Seoul, Korea) which is a body composition analysis device. They were asked to put on their sports outfits and the measurements were done in anatomic posturing on the naked feet.

Body Height Measurement

The body height of the athletes was measured with 0,1 cm precision via Stadiometer (Holtain Ltd. Crymych, UK). They were asked to stand in anatomic posturing on the naked feet, and the point at which the upper table touched the head was recorded as cm.

Isokinetic Strength Test

Athletes lower extremity strength was measured via isokinetic dynamometer (CSMİ Humac Norm, Stoughton, the USA.) Before the test, they were verbally and practically explained about the content and its application. A short dynamic warm-up was done before the test and the results were recorded in the measuring device. After adjusting the seat and dynamometer, the test protocol was applied to athletes in turn. Before starting the isokinetic strength test, athletes were allowed to have trials with 3 repetitions. They were verbally motivated during the test. Both dominant and nondominant leg measurements of the athletes were performed.

Table 2. Isokinetic Test Protocol

Angular Velocity(˚/sn)	ROM(˚)	Repetition	Rest(sec)
60 (trial)	0-90	3	10
60	0-90	5	30
120	0-90	5	30
180	0-90	5	-

Wingate Anaerobic Power Test

To determine athletes anaerobic power parameters, a bicycle ergometer (Monark Ergomedic 894E, Vansbro, Sweden) was used, and the Wingate Anaerobic Power Test was measured two days after the isokinetic power test.

The information of the athletes was recorded on the computer and then the weight of 0.075 kg of the athletes body weight was loaded into the bicycle basket. Measurements was performed after dynamic warming. When they reached maximum pedal speed, the load in the bicycle basket automatically dropped at 90 RPM, and the test started. Athletes pedaled against the weight for 30 seconds at maximum speed. Anaerobic power (peak power) which is the highest value that football players can reveal in the 30-second test, the average power that can be sustained throughout the test was determined as anaerobic capacity (average power) values and these parameters' relative (W/kg) was used in the study.

Vertical Jump Test

Vertical jump height were measured in synthetic pitch by using a vertical jump mat and electronic monitoring device (Witty, Microgate, Bolzano, Italy). Before measurement a short dynamic warm-up was done; and athletes did vertical jump for trial purposes with 2 repetitions. Athletes were measured in a complete resting status; and they did vertical jumps 3 times with 45 second-break-time. The best result was recorded. Athletes did jumping exercises with the Counter Movement Jump technique.

Statistical Analysis of the Data

Statistical analysis of the data in this study was done via SPSS statistic package software (SPSS 25.0. Armonk, NY: IBM Corp). The suitability of the data to normal distribution was checked via Shaphiro Wilk test and it was found that data had a normal distribution. The effect of isokinetic strength values on a vertical jump and anaerobic power parameters was checked via multilinear regression analysis. In multilinear regression analysis, regression models were created by determining lower extremity strength values as the independent variable, and vertical jump and anaerobic power/capacity values as the dependent variable. Variance Inflation Factor (VIF) of multicollinearities among independent variables was analyzed. According to VIF values, regression models with 2 independent variables (isokinetic force in the angular velocity of 60˚/sec and 180˚/sec) were created without isokinetic force in the angular velocity of 120˚/sec. In the correlation (r) values obtained from regression analysis, results between r=0.00-0.30 were evaluated as low-level relationship, results between r=0.30-0.70 were evaluated as medium-level relationship, results between, r=0.70-1.00 were evaluated as high-level relationship (Büyüköztürk, 2020). In interpreting the results, $p<0.05$ was accepted as the significance level.

RESULTS

Table 3. The Descriptive Statistics of Lower Extremity Strength, Vertical Jump and Anaerobic Power Values in Female Football Players.

	n	X̄	SD	Min.	Max.
Dom.60˚/sn Extension (Nm)		111.91	21.03	80.00	159.00
Dom.60˚/sn Extension (PT/kg)		2.07	0.32	1.57	2.96
Dom.60˚/sn Flexion (Nm)		76.95	12.72	56.00	113.00
Dom.60˚/sn Flexion (PT/kg)		1.43	0.22	1.02	1.89
Ndom.60˚/sn Extension (Nm)		112.04	29.14	61.00	176.00
Ndom.60˚/sn Extension (PT/kg)		2.05	0.37	1.19	2.67
Ndom.60˚/sn Flexion (Nm)		75.26	16.78	42.00	123.00
Ndom.60˚/sn Flexion (PT/kg)		1.38	0.22	0.97	2.02
Dom.120˚/sn Extension (Nm)		87.39	14.38	57.00	115.00
Dom.120˚/sn Extension (PT/kg)		1.61	0.20	1.25	2.19
Dom.120˚/sn Flexion (Nm)		67.65	11.07	52.00	94.00
Dom.120˚/sn Flexion (PT/kg)		1.25	0.16	1.04	1.55
Ndom.120˚/sn Extension (Nm)		86.56	20.28	50.00	129.00
Ndom.120˚/sn Extension (PT/kg)		1.58	0.24	1.15	2.04
Ndom.120˚/sn Flexion (Nm)		67.30	13.21	39.00	100.00
Ndom.120˚/sn Flexion (PT/kg)		1.24	0.16	0.90	1.63
Dom.180˚/sn Extension (Nm)		68.86	11.74	43.00	94.00
Dom.180˚/sn Extension (PT/kg)		1.27	0.14	0.94	1.61
Dom.180˚/sn Flexion (Nm)		57.56	9.70	45.00	80.00
Dom.180˚/sn Flexion (PT/kg)		1.06	0.13	0.86	1.32
Ndom.180˚/sn Extension (Nm)		66.39	16.25	38.00	99.00
Ndom.180˚/sn Extension (PT/kg)		1.21	0.19	0.74	1.58
Ndom.180˚/sn Flexion (Nm)		57.65	10.88	34.00	83.00
Ndom.180˚/sn Flexion (PT/kg)	23	1.06	0.12	0.79	1.35
Anaerobic Power (W)		505.40	101.48	324.01	733.73
Anaerobic Power (W/kg)		9.43	1.52	6.35	13.84
Anaerobic Capacity (W)		350.86	62.41	195.38	505.64
Anaerobic Capacity (W/kg)		6.55	0.89	3.83	8.30
Vertical Jump (cm)		28.86	4.19	24.00	39.40

*Nm: Newton metre, PT: Peak tork, Dom: Dominant, Ndom: Nondominant, W: Watt.

Table 4. The Regression Analysis of Effect on Vertical Jump and Anaerobic Power of Lower Extremity Muscle Strength Parameters as Predictor Variables in Female Footballers

Dependent Variable	Model	Predictor Variable	B	Standart Error	β	t	p	r	R	R^2	Standard Error of Estimate
Anaerobic Power (W/kg)	Model 1	Constant	2.756	2.635		1.046	.308		.510	.261	1.371
		Dom.60°/sn Ext.	.593	1.466	.128	.405	.690	**.448***			
		Dom.180°/sn Ext.	4.277	3.348	.403	1.278	.216	**.505***			
	Model 2	Constant	4.120	1.617		2.547	.019		.682	.466	1.166
		Ndom.60°/sn Ext.	-1.798	.960	-.448	-1.872	.076	.237			
		Ndom.180°/sn Ext.	7.406	1.891	.937	3.916	**.001***	**.610***			
	Model 3	Constant	4.693	2.304		2.037	.055		.285	.214	1.348
		Dom.60°/sn Flex.	4.057	1.911	.597	2.123	**.046***	**.531***			
		Dom.180°/sn Flex.	-1.007	3.165	-.089	-.318	.754	**.352***			
	Model 4	Constant	4.184	2.615		1.600	.125		.421	.177	1.447
		Ndom.60°/sn Flex.	1.338	1.775	.197	.754	.460	**.366***			
		Ndom.180°/sn Flex.	3.190	3.113	.268	1.025	.318	**.392***			
Anaerobic Capacity (W/kg)	Model 5	Constant	2.243	1.453		1.543	.139		.588	.345	.756
		Dom.60°/sn Ext.	.720	.809	.265	.891	.384	**.546***			
		Dom.180°/sn Ext.	2.209	1.847	.355	1.196	.246	**.565***			
	Model 6	Constant	3.054	.985		3.101	.006		.651	.423	.710
		Ndom.60°/sn Ext.	-.381	.585	-.162	-651	.523	**.393***			
		Ndom.180°/sn Ext.	3.517	1.152	.759	3.054	**.006***	**.641***			
	Model 7	Constant	3.678	1.339		2.748	.012		.545	.297	.783
		Dom.60°/sn Flex.	2.402	1.110	.603	2.163	**.043***	**.543***			
		Dom.180°/sn Flex.	-.534	1.839	-.081	-.291	.774	**.365***			
	Model 8	Constant	3.666	1.560		2.350	.029		.385	.148	.863
		Ndom.60°/sn Flex.	.331	1.059	.083	.312	.758	.289			
		Ndom.180°/sn Flex.	2.281	1.857	.327	1.229	.233	**.379***			
Vertical Jump (cm)	Model 9	Constant	8.471	7.094		1.194	.246		.543	.295	3.693
		Dom.60°/sn Ext.	-1.633	3.947	-.128	-.414	.683	**.379***			
		Dom.180°/sn Ext.	18.675	9.014	.639	2.072	.051	**.537***			
	Model 10	Constant	15.717	5.233		3.003	.007		.514	.264	3.773
		NDom.60°/sn Ext.	-1.135	3.107	-.103	-.365	.719	.324			
		NDom.180°/sn Ext.	12.720	6.120	.584	2.079	.051	**.509***			
	Model 11	Constant	24.079	7.089		3.397	.003		.331	.109	4.150
		Dom.60°/sn Flex.	8.678	5.879	.463	1.476	.156	.292			
		Dom.180°/sn Flex.	-7.174	9.740	-.231	-.737	.470	.111			
	Model 12	Constant	18.032	7.469		2.414	.025		.341	.116	4.134
		Ndom.60°/sn Flex.	4.637	5.071	.248	.914	.371	.327			
		Ndom.180°/sn Flex.	4.131	8.892	.126	.465	.647	.282			

*$p<0.05$

According to the results of Regression Analysis, it can be seen that strength performance of ndom.180°/sec extension and dom.60°/sec flexion has a significant effect on anaerobic power and anaerobic capacity ($p<0.05$). There is no significant effect on vertical jump, and anaerobic power of other parameters related to lower extremity strength ($p>0.05$).

DISCUSSION AND CONCLUSION

When literature is searched, it is known that angular velocity-power relation is in line. Even if range of joint movement (ROM) remains stable, movement in different angular velocity affects the muscle's fascicle length (Ichinose et al., 2000). It is seen that the strength value of ndom.60˚/sec extension (112.04±29.14 Nm) is higher than the value of dom.60˚/sec extension (111.91±21.03 Nm). In the study done by Östenberg et al (1998), in their work with female football players, dom.60˚/sec extension strength value was determined as 88.1±15 Nm; ndom.60˚/sec extension power value was determined as 87.7±14 Nm; dom.180˚/sec extension value was determined as 60.1±9 Nm; and ndom.180˚/sec extension value was determined as 59.8±10 Nm. All strength values show differences in this study. The strength values obtained in this study were found to be higher. The age average of football players in both studies is similar. Once the years of the studies are considered, it is thought that this difference is caused by the different training methods which are created by ever-growing training learning. Andrade et al. (2002), in the measurement they made with female football players, found that dom.60˚/sec extension strength value was found as 169±27 Nm, and dom.60˚/sec flexion strength value was found as 91±18 Nm. Data obtained from that is higher than the ones we get from this study. The strength difference is thought to happen because of the approach of the teams and the football players to the training, the average body weight (59.8±6.6), and muscle mass and age average (25.3±7.2). Eustace et al. (2019), in the study done with female football players in Premier League, dom.60˚/sec extension value was found as 152.3±25.1 Nm, ndom.60˚/sec extension value was found as 144.2±24.2 Nm, dom.180˚/sec extension value was found as 112.7±19.4 Nm; and dom.180˚/sec extension value was found as 103.8±21.6 Nm. When it is compared to the values of this study, it is obvious that there is a huge difference. When we consider the age average of the football players is similar, it is thought that strength difference may have occurred because of league level, the conception of professionalism of the players, and training methods and application.

When the literature is examined, if a classification is made with the norm values determined for female athletes by Zupan et al.(2009), it's seen that anaerobic power (W) values is fair, anaerobic power (W/kg) values is average level, anaerobic capacity (W) values is fair, anaerobic capacity (W/kg) values is below-average. Harmancı et al. (2016), in the study done with female football players (their age average is 19.57±1.28), the average value of anaerobic power (W) is evaluated as 462.35±40.59, the average value of anaerobic power (W/kg) is evaluated as 7.98±0.76, the average value of anaerobic capacity (W) is evaluated as 356.03±34.41, the average value of anaerobic capacity (W/kg) is evaluated as 6.15±0.71. There are differences in values when they are compared with this study. Anaerobic power and capacity values are higher in this study. The differences in power are thought to happen because of the experience years of the athletes, their training levels, and their measurement period (the beginning of the season, in the season etc.). Hasegawa and Kuzahara (2015), did a study with 21 football players, who were in the Women's First League. They found the average value of anaerobic power (W) as 561.1±95.1, and the average value of anaerobic power (W/kg) as 10.2±1.2. When the obtained data is compared to the ones we get from this study, it is seen that the average value of anaerobic power (W) is higher than the values in this study, and the average value of anaerobic power (W/kg) is similar. The working group's age average (19.4±0.9) and average body weight (54.7±5.1) are similar and when this is considered, it is thought that anaerobic power (W) is higher because of the training level and league difference of the athletes. Can et al. (2019), in the study done with female football players in Turkey Women's First League, the average value of anaerobic power (W) is evaluated as 439.7±61.1, the average value of anaerobic power (W/kg) is evaluated as 8.04±1.09, the average value of anaerobic capacity (W) is evaluated as 316.1±34.4, the average value of anaerobic capacity (W/kg) is evaluated as 5.78±0.56. When the average values are checked, values obtained from this study are higher than all variables. The athletes in this study have higher values even though they are playing in a lower league. The differences in power are thought to happen because of the age, training level, muscle fibril type difference, or sample number (n=11) in another study.

When the Counter Movement Jump values are evaluated, the average vertical jump values are evaluated as 28.86±4.19 cm. Sedano et al. (2009), in the study done with elite female football players, it was seen that the average CMJ values (26.1±4.8 cm) were similar. In the study done with first league's female football players by Hasegawa and Kuzuhara (2015), it was seen that the average CMJ height (27.5±3.8 cm) was similar. In the study by Haugen et.al (2012), the average CMJ values of the football players in National Team was 30.7±4.1 cm, and the average CMJ values of the football players in the First League was 28.1±4.1 cm. When both parameters are checked, the average values of the National Team football players are higher than the values in this study; and the average values of the First League football players are similar to the values in this study. The differences in the vertical jump of the National Team players are thought to happen because of their league level and power-strength difference. In the study done with female players (U17) by Castagna and Castellini (2013), the average CMJ values were 29.0±2.1 cm. The values obtained are similar to the values in this study.

When the relationship of lower extremity extension strength values, anaerobic power/capacity, and vertical jump values is evaluated, it is found that the increases angular velocity (180˚/sec) means the closer relationship between anaerobic power/capacity and vertical jump. It is thought that the strength quantity created by the extensor muscle group (quadriceps) in high angular velocity has a positive effect on anaerobic power/capacity and vertical jump performances. When it comes to lower extremity flexion strength values, it was determined that as angular velocity decreased, the relationship with anaerobic power/capacity and vertical jump increased. It is thought that the strength quantity created by the flexor muscle group (hamstring) in low angular velocity has a positive effect on the athletes performances.

It is thought that the performances of female football players will be better if they include explosive power training more in their training routines.

Studies about female football players in literature are rare. To get more information, this study can be done again with another sample group whose training level, years of experience, and league level is higher with the same variables.

In order to determine the differences between the genders and to prepare more accurate training plans, studies can be conducted to compare the different physiological and motoric characteristics of male and female football players in their developmental period.

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