UDC:796.077.012.11
Original scientific paper

COMPARISON OF VELOCITY AND POWER PARAMETERS DURING BENCH THROW AND LOADED-SQUAT JUMP MOVEMENTS ACCORDING TO SOME SPORT BRANCHES

Ibrahim Can[1], Serdar Bayrakdaroglu[2], Harun Duran[3]

[1] *[*]Iğdır University, School of Physical Education and Sport, Iğdır, Turkey*
[2] *Gümüşhane University, School of Physical Education and Sport, Iğdır, Turkey*
[3] *Marmara University, Faculty of Sport Sciences, İstanbul, Turkey*
[*]*Corresponding author e-mail: ibrahim.can@igdir.edu.t is*

Abstract

The purpose of this study was to compare velocity and power parameters during bench throw and loaded-squat jump movements according to some sports branches. In accordance with this purpose, 12 handball players (age: 25,2 ± 5,72 years; height: 189,7 ± 7,33 cm; weight: 97,9 ± 11,5 kg), 12 volleyball players (age: 20,2 ± 1,28 years; height: 194,3 ± 7,67 cm; weight: 87,4 ± 7,39 kg) who competed in Turkey 1st League and 12 national martial players (age: 25,2 ± 3,25 years; height: 174,3 ± 6,52 cm; weight: 70,2 ± 7,99 kg) and 12 national arm wrestling players (age: 20,5 ± 2,02 years; height: 174,7 ± 4,76 cm; weight: 72,6 ± 8,31 kg), totally 48 players (age: 22,8 ± 4,17 years; height: 183,2 ± 11,07 cm; weight: 82,06 ± 14,3 kg) participated voluntarily in this study. In order to determine velocity and power parameters, loaded-squat jump (SJLoad) movement was applied by using an external load that corresponds to 40% of body weights and bench throw (BT) movement was applied by using an external load that corresponds to 30% of body weights of the participants by utilizing an isoinertial velocity transducer (T-Force dynamic measurement system) and values of mean propulsive velocity (MPV), peak velocity (PV), mean propulsive power (MPP) and peak power (PP) during both movements were obtained. Descriptive analyses, Shapiro-Wilk normality test, one-way analysis of variance (ANOVA) were used for data analysis. According to the results of the analysis; a statistically significant difference was obtained between the groups in terms of velocity and power parameters obtained during both the BT and the SJLoaded movements. As a result, it can be asserted that the velocity and power characteristics during the movements towards the upper and lower body differ according to the sport branches and characteristics.
Keywords: Bench Throw, Squat, Velocity, Power

Introduction

Velocity, which is a parameter used to digitize the intensity of the exercises in resistance training [8,13,16,28]; is a vector quantity and is defined as the temporal rate of changes in positions [35]. The velocity at which a movement is performed can provide important information to coaches or fitness instructors about the reality of physical effort that athletes have spent in performing any movement or their level of exhaustion. Therefore, although the velocity of performing a movement is a parameter that needs to be further emphasized in order to observe the severity of the exercises performed, the importance of movement velocity has been only emphasized by some researchers [7,13,14,27,31]. Indeed, the phenomenon of movement velocity can produce a more reliable level of physical effort or performance, also called velocity-based resistance training, which is a more accurate and realistic training model [13]. Because of these reasons,

movement velocity is considered to be a very important criterion in order to achieve more regular physiological responses of the trainings [13,14,15,19,29, 30,32]
Power defined as one of the important parameters of sporting performance [9,26,34]; is the mechanical amount of a work done (work) or movement expressed as the temporal ratio (power=work/time) [12] and usually depends on the athlete's ability to produce maximal force [33]. Since the success of performance shown in many sports branches generally depends on the properties of power applied to objects (such as balls, equipment or ground) [26], the issues such as the properties of strength of the athlete or how this property should be developed effectively, are very important for athletes, fitness coaches or trainers. In addition, many sporting movements, such as throwing, jumping and hitting, require nerve-muscle actions that maximize power generation. At the same time, sudden power bursts are required for rapid direction changes and acceleration during various sports or sporting events (such as football, basketball, baseball, gymnastics) [20]. The necessary parameters to be used in power evaluation are different and the most commonly used parameters are average power, average propulsive power and peak power [29].
In the literature, it is seen that there are very limited number of studies in which the kinetic and kinematic parameters in the concentric phase of both bench throw movement and loaded-squat jump movement are evaluated or compared according to sports branches considering elite, national or amateur sportsmanship levels [1,2,3,4,5,6,10,11,18,21,22,24,25]. During both lower and upper body exercises, each velocity and strength parameter may have different characteristics according to the movements exercised depending on the natural structure of the sports branch. Obtaining and designating these parameters according to the branches will help to determine the characteristics of branch-specific training in the branches where explosive but different movement examples are applied. Therefore, investigating whether there is a difference between the velocity and strength parameters during specific motion samples towards the lower and upper body in some sports branches where lower and upper body muscle strength is dominant depending on the sports branch forms the purpose of this study.

Method

Participants

48 athletes consisting of 12 handball and 12 volleyball players competing in Turkish 1st level, alongside with 12 martial athletes and 12 arm wrestling players who are national athletes in their branches voluntarily participated in this study. The physical characteristics of the subjects are given in table 1. Participants in the study are in good health and do not use any medication that may adversely affect their test performance. Prior to the study, participants were informed in detail about the purpose of the study, the test procedures to be applied, the potential risks that may occur during the study, and the benefits of the results obtained in the study to the sports sciences, and the participant signed a written consent that they participated in the study voluntarily.

Table 1. Physical characteristics of the participants

Branches		Age (years)	Height (cm)	Mass (kg)
Volleyball (n=12)	Mean	20,2	194,3	87,4
	Std. Deviation	1,28	7,67	7,39
	Minimum	18,0	178,0	78,2
	Maximum	22,0	201,0	105,0
Handball (n=12)	Mean	25,2	189,7	97,9
	Std. Deviation	5,72	7,33	11,57
	Minimum	19,0	175,0	77,0
	Maximum	34,0	198,0	115,0
Martial Sports (n=12)	Mean	25,2	174,3	70,2
	Std. Deviation	3,25	6,52	7,99
	Minimum	21,0	164,0	60,0
	Maximum	30,0	185,0	85,0
Arm Wrestling (n=12)	Mean	20,5	174,7	72,6
	Std. Deviation	2,02	4,76	8,31
	Minimum	18,0	168,0	55,2
	Maximum	24,0	184,0	84,1
Total (n=48)	Mean	22,8	183,2	82,0
	Std. Deviation	4,17	11,07	14,32
	Minimum	18,0	164,0	55,2
	Maximum	34,0	201,0	115,0

Procedures

The height and body weight measurements of the participants were determined using a Seca769 brand electronic measuring instrument (SecaCorporation, Hamburg, Germany) with an accuracy of 0.001 m and 0.01 kg, respectively. After determining the physical characteristics of the participants, the external loads corresponding to 30% and 40% of body weights were calculated. A linear speed transducer system (T-Force Dynamic Measurement System; Ergotech Consulting S.L, Murcia, Spain) was attached to the last section of the bar to determine the velocity (PV: peak velocity; MPV: mean propulsive velocity) and power (PP: peak power; MPP: mean propulsive power) parameters during bench throw (BT) and loaded-squat jump (SJLoad) movements. The use of this system is particularly suitable for resistance training exercises where it is necessary to overcome a load (constant mass) moving along a vertical axis against gravity or typical weight-lifting. The system includes electromechanical hardware (velocity sensor and interface), a dedicated computer program (T-Force system software) that manages this hardware, and a hook connected to the barbell [29, 32].

While the SJLoad movement was performed using free weights with an external load corresponding to 40% of the participants' own body weights; bench throw (BT) movement was performed on a Smith machine (Esjim IT7001, Eskisehir, Turkey) using an external load corresponding to 30% of the participants' own body weights. Test procedures were performed on two (2) different days, giving one (1) day rest period. Prior to the application of both movements, the participants were allowed to perform a 10-minute general warm-up exercise to warm the lower and upper body muscles. The participants were instructed to do a SJLoad movement first.

In the implementation of this test, participants were asked to flex their knees from the static position until their thighs were parallel to the floor, and after the start command they were asked to jump as quickly as possible without their shoulders losing contact with the bar and repeat the jump motion 3 times [23]. In SJLoad movement, the exercise was reconstructed when the required necessities from the subjects were not fulfilled or incomplete, as the velocity and power parameters would be determined by moving the body weight in addition to the external load and the participants' attribute of accelerating their total mass (external load and body weight) [7]. In the BT movement, participants were asked to lower the weight bar in a controlled manner until the bar lightly touches their chests, with the start command they were asked to throw the weight bar as fast and as high as possible and repeat this movement three times [21]. In the bench throw movement, the reason why smith machines are used instead of free weights to ensure accurate and reliable measurements; is because this tool limits the exercise in the vertical direction [15]. Strong verbal encouragement was provided to further improve the performance of athletes during both BT and SJLoad.

Analysis of the Data

For the analysis of the data, first of all, by looking at the Shapiro-Wilk coefficient related to the normality of distribution of the data the distribution of the data was found to be normal. One-way analysis of variance (One-way ANOVA) was used to determine whether there was a statistically significant difference between the velocity and power parameters reached during the bench throw and loaded-squat jump movements in accordance with the branches, and Scheffe analysis was used to determine which branches had differences between them. All variables were expressed as mean and standard deviation. SPSS version 16.0 (SPSS Inc, Chicago, IL) was used for all statistical calculations and the significance level was accepted as $p<.05$.

Findings

In this study, descriptive analysis results for velocity and power parameters during SJLoad and BT movements are shown in table 2, the results of the analysis regarding whether or not these parameters show a significant difference according to the sports branches are given in table 3, the results of the analysis showing which branches had significant differences between them are given in table 4 and 5. According to the results of the analysis, there was a statistically significant difference between the sports branches related to velocity and power parameters obtained during both BT and SJLoad movements ($p<.05$, table 3).

Table 2. Descriptive statistics results for velocity and power parameters during loaded-squat jump and bench throw movements

		Loaded-Squat Jump Movement				**Bench Throw Movement**			
Branches		MPV (m/sec^{-1})	PV (m/sec^{-1})	MPP (W)	PP (W)	MPV (m/sec^{-1})	PV (m/sec^{-1})	MPP (W)	PP (W)
Volleyball (n=12)	Mean	1,42	2,51	727,39	1363,72	1,30	2,12	340,92	733,27
	Std. Deviation	,09	,15	117,14	189,49	,19	,18	66,46	126,44
	Minimum	1,27	2,36	598,6	1159,4	1,01	1,75	273,4	589,5
	Maximum	1,58	2,83	987,5	1760,4	1,62	2,42	460,6	942,9
Handball (n=12)	Mean	1,36	2,30	697,21	1259,45	1,2524	2,12	364,71	811,15
	Std. Deviation	,17	,265	75,68	174,76	,17572	,15	57,54	98,6
	Minimum	1,12	1,90	587,9	1013,2	1,05	1,95	273,1	601,0

	Maximum	1,68	2,71	785,2	1487,4	1,62	2,45	448,0	953,9
Martial Sports (n=12)	Mean	1,48	2,38	576,68	974,49	1,3718	2,21	290,43	623,57
	Std. Deviation	,10	,18	113,7	201,44	,18797	,14	58,33	101,0
	Minimum	1,32	2,05	458,6	750,3	1,14	1,98	213,1	475,1
	Maximum	1,68	2,66	847,4	1443,5	1,63	2,41	413,1	825,1
Arm Wrestling (n=12)	Mean	1,22	2,12	443,73	834,87	1,1189	1,88	246,95	519,82
	Std. Deviation	,12	,17	112,2	157,08	,15399	,25	22,67	71,86
	Minimum	,95	1,79	257,1	498,6	,95	1,58	210,4	424,1
	Maximum	1,47	2,40	650,7	1074,9	1,40	2,31	283,7	664,6
Total (n=48)	Mean	1,37	2,33	611,25	1108,13	1,2610	2,08	310,75	671,95
	Std. Deviation	,15	,24	152,72	277,44	,19629	,22	69,61	148,41
	Minimum	,95	1,79	257,1	498,6	,95	1,58	210,4	424,1
	Maximum	1,68	2,83	987,5	1760,4	1,63	2,45	460,6	953,9

MPV: Mean Propulsive Velocity; PV: Peak Velocity; MPP: Mean Propulsive Power; PP: Peak Power

Table 3. One-Way ANOVA results on whether velocity and power parameters differentiated in accordance with sport branches

			Sum of Squares	df	Mean Square	F	Sig.
Loaded-Squat Jump Movement	**MPV**	Between Groups	,447	3	,149		
		Within Groups	,755	44	,017	8,681	**,000***
		Total	1,201	47			
	PV	Between Groups	,964	3	,321		
		Within Groups	1,778	44	,040	7,951	**,000***
		Total	2,742	47			
	MPP	Between Groups	601630,109	3	200543,370		
		Within Groups	494687,389	44	11242,895	17,837	**,000***
		Total	1096317,498	47			
	PP	Between Groups	2169078,809	3	723026,270		
		Within Groups	1448803,103	44	32927,343	21,958	**,000***
		Total	3617881,912	47			
Bench Throw Movement	**MPV**	Between Groups	,409	3	,136		
		Within Groups	1,402	44	,032	4,284	**,010***
		Total	1,811	47			
	PV	Between Groups	,716	3	,239		
		Within Groups	1,579	44	,036	6,652	**,001***
		Total	2,295	47			
	MPP	Between Groups	99660,902	3	33220,301		
		Within Groups	128103,315	44	2911,439	11,410	**,000***
		Total	227764,217	47			
	PP	Between Groups	583462,460	3	194487,487		
		Within Groups	451855,657	44	10269,447	18,938	**,000***
		Total	1035318,117	47			

* p<.05

MPV: Mean Propulsive Velocity; PV: Peak Velocity; MPP: Mean Propulsive Power; PP: Peak Power

According to the results of the analysis performed to determine which branches had a statistically significant difference between each other; for the MPV and PV in the SJLoad movement, the athletes competing in handball and martial sports compared to the arm wrestling players; for MPP the athletes competing in handball, volleyball or martial sports compared to the arm wrestling players; and for PP volleyball and handball players had better values than those who competed in arm wrestling and martial arts (table 4). In terms of the BT movement; for MPV martial arts athletes against arm wrestling players; for PV handball, volleyball and martial arts athletes against arm wrestling players; for MPP volleyball and handball players against arm wrestling players; for PP volleyball players against arm wrestling and handball players against both arm wrestling and martial arts athletes had better values. There was no statistically significant difference between the other branches beyond these.

Table 4. Results of Scheffe analysis on which sports branches velocity and power parameters during loaded-squat jump movement show differences

Dependent Variable	Branches	Branches	Mean Difference	Std. Error	Sig.
	Voleyball	Handball	,06258	,05346	,714
		Martial Sports	-,06150	,05346	,725
		Arm Wrestling	,19875	,05346	**,007***
	Handball	Volleyball	-,06258	,05346	,714
		Martial Sports	-,12408	,05346	,162
		Arm Wrestling	,13617	,05346	,106
MPV	Martial Sports	Volleyball	,06150	,05346	,725
		Handball	,12408	,05346	,162
		Arm Wrestling	,26025	,05346	**,000***
	Arm Wrestling	Voleyball	-,19875	,05346	**,007***
		Handball	-,13617	,05346	,106
		Martial Sports	-,26025	,05346	**,000***
	Volleyball	Handball	,21408	,08206	,094
		Martial Sports	,13000	,08206	,481
		Arm Wrestling	,39050	,08206	**,000***
	Handball	Volleyball	-,21408	,08206	,094
		Martial Sports	-,08408	,08206	,789
		Arm Wrestling	,17642	,08206	,217
PV	Martial Sports	Volleyball	-,13000	,08206	,481
		Handball	,08408	,08206	,789
		Arm Wrestling	,26050	,08206	**,027***
	Arm Wrestling	Volleyball	-,39050	,08206	**,000***
		Handball	-,17642	,08206	,217
		Martial Sports	-,26050	,08206	**,027**
	Volleyball	Handball	30,17500	43,28759	,921
		Martial Sports	150,70833	43,28759	**,013***
		Arm Wrestling	283,65833	43,28759	**,000***
	Handball	Volleyball	-30,17500	43,28759	,921
		Martial Sports	120,53333	43,28759	,065
MPP		Arm Wrestling	253,48333	43,28759	**,000****
	Martial Sports	Volleyball	-150,70833	43,28759	**,013**
		Handball	-120,53333	43,28759	,065
		Arm Wrestling	132,95000	43,28759	**,034**
	Arm Wrestling	Volleyball	-283,65833	43,28759	**,000***
		Handball	-253,48333	43,28759	**,000**
		Martial Sports	-132,95000	43,28759	**,034***
	Volleyball	Handball	104,26667	74,08030	,581

		Martial Sports	389,23333	74,08030	**,000***
		Arm Wrestling	528,85000	74,08030	**,000****
	Handball	Volleyball	-104,26667	74,08030	,581
		Martial Sports	284,96667	74,08030	**,005***
PP		Arm Wrestling	424,58333	74,08030	**,000***
	Martial Sports	Volleyball	-389,23333	74,08030	**,000***
		Handball	-284,96667	74,08030	**,005***
		Arm Wrestling	139,61667	74,08030	,327
	Arm Wrestling	Volleyball	-528,85000	74,08030	**,000***
		Handball	-424,58333	74,08030	**,000***
		Martial Sports	-139,61667	74,08030	,327

*. The mean difference is significant at the .05 level.
MPV: Mean Propulsive Velocity; PV: Peak Velocity; MPP: Mean Propulsive Power; PP: Peak Power

Table 5. Results of Scheffe analysis on which sports branches velocity and power parameters during bench throw movement show differences

Dependent Variable	Branches	Branches	Mean Difference	Std. Error	Sig.
	Volleyball	Handball	,04825	,07286	,932
		Martial Sports	-,07117	,07286	,812
		Arm Wrestling	,18175	,07286	,117
	Handball	Volleyball	-,04825	,07286	,932
		Martial Sports	-,11942	,07286	,451
MPV		Arm Wrestling	,13350	,07286	,352
	Martial Sports	Volleyball	,07117	,07286	,812
		Handball	,11942	,07286	,451
		Arm Wrestling	,25292	,07286	**,013***
	Arm Wrestling	Volleyball	-,18175	,07286	,117
		Handball	-,13350	,07286	,352
		Martial Sports	-,25292*	,07286	**,013***
	Volleyball	Handball	-,00233	,07733	1,000
		Martial Sports	-,09075	,07733	,712
		Arm Wrestling	,23808	,07733	**,034***
	Handball	Volleyball	,00233	,07733	1,000
		Martial Sports	-,08842	,07733	,729
PV		Arm Wrestling	,24042	,07733	**,032***
	Martial Sports	Volleyball	,09075	,07733	,712
		Handball	,08842	,07733	,729
		Arm Wrestling	,32883	,07733	**,002***
	Arm Wrestling	Volleyball	-,23808	,07733	**,034***
		Handball	-,24042	,07733	**,032***
		Martial Sports	-,32883	,07733	**,002***
	Volleyball	Handball	-23,79167	22,02816	,762
		Martial Sports	50,49167	22,02816	,170
		Arm Wrestling	93,96667	22,02816	**,002***
	Handball	Volleyball	23,79167	22,02816	,762
		Martial Sports	74,28333*	22,02816	**,017***
MPP		Arm Wrestling	117,75833	22,02816	**,000***
	Martial Sports	Volleyball	-50,49167	22,02816	,170
		Handball	-74,28333	22,02816	**,017***
		Arm Wrestling	43,47500	22,02816	,287
	Arm Wrestling	Volleyball	-93,96667	22,02816	**,002***
		Handball	-117,75833	22,02816	**,000***
		Martial Sports	-43,47500	22,02816	,287

	Volleyball	Handball	-77,88333	41,37118	,328
		Martial Sports	109,70000	41,37118	,086
		Arm Wrestling	213,45000	41,37118	**,000***
	Handball	Volleyball	77,88333	41,37118	,328
		Martial Sports	187,58333	41,37118	**,001***
PP		Arm Wrestling	291,33333	41,37118	**,000***
	Martial Sports	Volleyball	-109,70000	41,37118	,086
		Handball	-187,58333	41,37118	**,001***
		Arm Wrestling	103,75000	41,37118	,114
	Arm Wrestling	Volleyball	-213,45000	41,37118	**,000***
		Handball	-291,33333	41,37118	**,000***
		Martial Sports	-103,75000	41,37118	,114

*. The mean difference is significant at the .05 level.
MPV: Mean Propulsive Velocity; PV: Peak Velocity; MPP: Mean Propulsive Power; PP: Peak Power

Discussion

In this study, it is aimed to compare the velocity and power parameters during bench throw and loaded-squat jump movements in accordance with sport branches. In literature, it is seen that kinetic and kinematics during both BT and SJLoad movements are compared in accordance with some sports branches. In a study conducted by Can *et al.,* [4], on national athletes competing in different sports branches (wrestling, arm wrestling and kickboxing) with similar age averages, although wrestlers had higher velocity and power values compared to other branches, it was found that there was still no statistically significant difference between sports branches in terms of power and velocity parameters during SJLoad movement (p>.05). In the mentioned study, MV values of wrestlers were found to be 1,23 (±,12 m.sec-1), MPV values were 1,35 (±,14 m.sec-1) and PV values were 2.31 (±,25 m.sec-1); MV values of arm wrestlers were found to be 1.15 (±,10 m.sec-1), MPV values were 1.22 (±,12 m.sec-1) and PV values were 2.12 (±,17 m.sec-1) ; MV values of kickboxers were found to be 1,20 (±,14 m.sec-1), MPV values were 1.31 (±,81 m.sec-1) and PV values were 2.25 (±,24 m.sec-1). In terms of power parameters, MP values of wrestlers were found to be 359.8 (±67.6 W), MPP values were 558.6 (±139.7 W) and PP values were 1007.8 (±239.1 W); MP values of wrist wrestlers were found to be 327.0 (±63.7 W), MPP values were 443.7 (±112.2 W) and PP values were 834.8 (±157.0 W); and for kickboxers the MP values were found to be 324.7 (±51.6 W), the MPP values were 483.1 (±108.7 W) and the PP values were 892.6 (±158.5 W). In the an another study conducted by Can *et al.,* [5], the velocity values of kickboxers during the SJLoad movement were was found to be 1.38 (± 07 m.sec-1) for MV, 1.54 (±,10 m.sec-1) for MPV and 2.58 (±,15 m.sec-1) for PV.

In a study by Can [2] comparing the kinetic and kinematic parameters of the national arm wrestlers and 1st league handball players during the SJLoad movement, it was found that there was a statistically significant difference between the branches in terms of MV and PV values (p<.05); however, there was no statistically significant difference between the branches in terms of MPV, MP, MPP, and PP (p>.05). In the mentioned study, MV values of arm wrestlers in terms of velocity parameters were found to be 1.21 (±,09 m.sec-1), MPV values were 1.29 (±,12 m.sec-1) and PV values were 2.28 (±,15 m.sec-1), while for handball players these values were 1.10 (±,07 m.sec-1) for MV, 1.17 (±,09 m.sec-1) for MPV and 2,12 (±,09 m.sec-1) for PV. In terms of power parameters, MP values of arm wrestlers were found to be 353.2 (±69.4 W), MPP values were 512.2 (±117.6 W) and PP values were 966.9 (±190.9 W), while for handball players these values were obtained as 322.7 (±53.3 W) for MP, 448.7 (± 72.0 W) for MPP and 873.5 (±116.8 W) for PP. According to these results, it can be said that arm wrestling players had higher lifting velocity in SJLoad movement than handball players. High velocity in jumping was

expected from handball players due to the fact that jumping in handball is an important performance indicator and jumping exercises are available in training programs. Although the lower body is not an important performance indicator in the arm wrestling branch and there are no jump exercises in the training programs, it is a surprising result that arm wrestlers still had higher jump velocities. Such a result could probably be due to the physical characteristics of the athletes and their level of effort. In other words, it was claimed that arm wrestling players being national athletes and having less bodyweight lifted lower weights and therefore had higher jump velocities.

In the study conducted by Bayrakdaroğlu and Can [1] on 13 elite-level combat athletes consisting of 7 boxers and 6 kickboxers who participated and ranked in the European and World championships analyzing whether there is a significant difference between the velocity and power values during SJLoad, it was found that there was not a statistically significant difference between sports branches ($p>.05$). In the mentioned study, while velocity and power values of the boxers during the SJLoad movement were found to be 1.50 (±,10 m.sec-1) for MPV, 2.36 (±,18 m.sec-1) for PV, 552.6 (±74.9 W) for MPP and 919.6 (±120.8 W) for PP; for kickboxers, these values were 1.45 (±, 09 m.sec-1) for MPV, 2.44 (±, 20 m.sec-1) for PV, 634.3 (±152.4 W) for MPP and 1097.8 (± 273.1W) for PP. It has been suggested that the lack of a statistically significant difference between the velocity and power values of boxers and kickboxers during the loaded-squat jump movement may be due to the fact that both boxers and kickboxers are athletes who had ranked in the European and World Championships, the combat patterns of both branches, the training systems, and the practice programs are similar to each other.

Dal Pupo *et al.,* [11] reported that sprinters had a higher value than the volleyball players in terms of the PV parameter in both squat jump and counter-movement jump exercises, and it was suggested that the difference could be due to the training protocol practiced by sprinters. Kollias *et al.,* [18] reported that the velocity values of sprint runners in vertical jump exercise were higher than those of volleyball, football, and basketball players. In the study conducted by Loturco *et al.,* [21], they obtained the jump velocities of Brazilian national karate players as 1.23 (±,15 m.s-1) in the SJLoad exercise practiced with an external load corresponding to 40% of their body weight.

In an study conducted by Loturco *et al.,* [25], comparing the power values of elite level male athletes competing in different sports branches in SJLoad movement they practiced with an external load corresponding to 40% of their body weights, the mean absolute MP, MPP, and PP values were found to be 504.4 (±131.7 W), 489.6 (±125.3 W) and 1064.7 (±243.7 W) for martial athletes; 411.4 (±117.9 W), 399.2 (±112.9 W) and 828.2 (±226.7 W) for endurance runners; 535.8 (±88.7 W), 517.2 (±84.0 W) and 1077.3 (±147.9 W) for futsal players; 644.2 (±123.7 W), 622.8 (±116.4 W) and 1258.7 (±175.9 W) for judoists; 541.9 (± 105.0 W), 526.6 (±98.8 W) and 1142.1 (±199.5 W) for tennis players; 671.5 (±118.5 W), 648.8 (±115.0 W) and 1337.8 (±251.5 W) for rugby sevens players; 638.9 (±77.2 W), 621.7 (±74.9 W) and 1366.3 (±184.7 W) for volleyball players; and 690.0 (±98.1W), 669.5 (±93.2 W) and 1420.6 (±183.1W) for track and field athletes, respectively. In the mentioned study, the mean relative MP, MPP and PP values of the subjects were found to be 7.41 (±1.19 W.kg-1), 7.19 (±1.13 W.kg-1) and 15.6 (±2.27 W.kg-1) for martial arts athletes; 6.92 (±1.33 W.kg-1), 6.72 (±1.26 W.kg-1) and 13.94 (±2.51 W.kg-1) for endurance runners; 7.55 (±0.88 W.kg-1), 7.24 (±0.81 W.kg-1) ve 15.2 (±1.50 W.kg-1) for futsal players; 7.61 (±0.99 W.kg-1),7.36 (±0.91 W.kg-1) and 14.93 (±1.35 W.kg-1) for judoists; 7.03 (±0.92 W.kg-1), 6.83 (±0.84 W.kg-1) and 14.82 (±1.65 W.kg-1) for tennis players; 8.28 (±1.06 W.kg-1), 8.00 (±1.03 W.kg-1) and 16.47 (±2.31 W.kg-1) for rugby sevens players; 6.87

(±0.96 W.kg-1), 6.69 (±0.92 W.kg-1) and 14.72 (±2.41 W.kg-1) volleyball players; and 9.02 (±1.07 W.kg-1), 8.75 (±0.99 W.kg-1) and 18.59 (±2.02 W.kg-1) for track and field athletes, respectively. When compared with athletes in other groups, it is seen that track and field athletes have the highest relative and absolute power values, on the other hand, endurance runners have the lowest power values. Loturco *et al.,* [22] obtained that MPP values of the U20 players who practiced SJLoad movement with an external load corresponding to 40% of their body weights were found to be 698.0 (± 113.1 W). In addition, in the mentioned study, the MPP values of the U20 players during the SJLoad movement were slightly lower than those of older players (23.8 ± 3.8 years). In another study conducted by Loturco *et al.,* [24], it was found that Brazilian national Olympic athletes had higher relative MPP values in SJLoad movement compared to paralympic athletes. Cronin and Hansen [10] reported that faster athletes were able to produce higher relative muscle strength efficiency in SJLoad movement.

In a study by Can [3] into handball players playing in Turkish 1st handball league, the velocity values of participants during BT movement using an external load corresponding to 30% of their body weight was found to be 1,12 (±,22 m.sec-1) for MPV and 1,91 (±,29 m.sec-1) for PV; and power values were found to be 307.5 (± 62.6 W) for MPP and 654.3 (± 122.1 W) for PP. In a study conducted by Can and Bayrakdaroğlu [6] into boxers and kickboxers, it was found that there was no statistically significant difference between the velocity and power values of the athletes competing in both sports branches during the BT movement ($p>.05$). In this study, the velocity and power parameters of boxers and kickboxers were 1.41(±,16 m.sec-1) and 1.28 (±,19 m.sec-1) for MPV; 2,26 (±,12 m.sec-1) and 2,14 (±,14 m.sec-1) for PV, 295,8 (±40,8 W) and 282,8 (±73,3 W) for MPP, 634,8 (± 64,6 W) and 626,8 (±138,4 W) for PP, respectively.

In conclusion, this study investigates the differences between velocity and power parameters during specific movement patterns intended for the lower and upper body in some sports branches where lower and upper body muscle strength is dominantly used. In this study, it was found that there was a statistically significant difference between sport branches related to velocity and power parameters obtained during both bench throw and loaded-squat jump movement. In general, athletes competing in volleyball, handball and martial arts had higher values in terms of velocity and power values during both bench throw and loaded-squat jump movements than those who competed in arm wrestlers. As the reason for this difference, it can be suggested that for the upper body, pushing is an important feature for volleyball, handball and martial arts, whereas pulling movement is more dominant than pushing in arm wrestling. Similarly, the cause can be that lower body muscle strength is an important feature for all three branches, and jump training is an important method for performance development in these sports branches, whereas in the arm wrestling branch, the lower body is not important and usually exercises are not performed for lower body muscle strength in training programs. As a result, it can be asserted that the velocity and power characteristics reached during the movements intended for both the lower body and upper body may vary in accordance with the sport branches or the characteristics of the sport branches.

References

[1]. Bayrakdaroglu, S., Can, I. "Anaerobic power, lower-body strength characteristic and some kinetics and kinematics during loaded-squat jump movement in Turkish national boxers and kickboxers'', *Archieve of Budo Science of Martial Arts and Extreme Sports*, 2018; 14(1).

[2]. Can, I. (2017). "Comparison of power, velocity and force parameters during loaded jump squat exercise in the handball and arm wrestling players'', *Journal of Education and Training Sciences*, 2017; 5(12): 92-98.

[3]. Can, I. "Analysis on relation between velocity and power values during propulsive phase of bench throw exercise and upper body strength characteristics in handball players'', *European Journal of Phyical Education and Sport Science*, 2018; 4(1): 10-27.

[4]. Can, I., Cihan, H., Arı, E., Bayrakdaroglu, S. "Comparison of thevelocity and power parameters during loaded-squat jump exercise of national athletes indifferent branches'', *Journal of Education and Training Studies*, 2018; 6(5): 16-20.

[5]. Can, I., Sadik, S., Bayrakdaroglu, S."The Relationship between repeated sprint performance and velocity values during loaded-squat jump exercise'', *Journal of Education and Learning,* (2018); 7(2): 280-286.

[6]. Can, I., Bayrakdaroglu, S. "Comparison of some parameters during bench throw movement and upper-body strength characteristics in Turkish national boxers and kickboxers'',*CBU Journal of Physical Education and Sport Sciences,* 2019; 14(1): 121-128.

[7]. Cormie, P., McCaulley, G.O., Triplett, N.T., McBride, J.M. "Optimal loadig for maximal power output during lower body resistance exercises'', *Medicine and Science in Sports and Exercise*, 2007; 39(2): 340-349.

[8]. Cormie, P., McGuigan, M.R., Newton, R.U. Developing maximal neuromuscular power: Part 2 - Training considerations for improving maximal power production, *Sports Medicine*, 2011; 41(2): 125-146.

[9]. Cronin, J.B., Sleivert. G. "Challenges in understanding the influence of maximal power training on improving athletic performance'' *Sports Medicine*, 2005; 35(3), 213-234.

[10]. Cronin, J.B., Hansen, K.T. "Strength and power predictors of sports speed'', *Journal ofStrength and Conditioning Research*, 2005; 19(2): 349-57.

[11]. Dal-Pupo, J., Detanico, D., Dos-Santos, S.G. "Kinetic parameters as determinants of vertical vump performance'', *Brazilian Journal of Kinanthropometry and Human Performance*, 2012; 14(1): 41-51.

[12]. Enoka, R.M. "Neuromechanical Basis of Kinesiology'' (2nd edition), United States: Human Kinetics, 1994.

[13]. Gonzales-Badillo, J.J., Sanchez-Medina, L. "Movement velocity as a measure of loading intensity in resistance training'', *International Journal of Sports Medicine*, 2010; 31(5): 347-352.

[14]. Gonzales-Badillo, J.J., Marques, M.C., Sanchez –Medina, L. "The importance of movement velocity as a measure to control resistance training intensity'', *Journal of Human Kinetics (Special Issue)*, 2011; (29A): 15-19.

[15]. Izquierdo, M., Gonzales-Badillo, J.J., Hakkinen, H., Ibanez, J., Kraemer, W.J., Altadill, A., Eslava, J., Gorostiaga, EM. "Effect of loading on unintentional lifting velocity declines during single sets of repetition to failure during upper and lower extremity muscle actions'', *International Journal of Sports Medicine,* 2006; 27(9): 718-724.

[16]. Kawamori, N., Newton, R.U. "Velocity specificity of resistance training: Actual movement velocity versus intention to move explosively'', Strength and Conditioning Journal, 2006; 28(2): 86-91.

[17]. Kobayashi, Y., Narazaki, K., Akagi, R., Nakagaki, K., Kawamori, N., Ohta, K. "Calculation of force and power during bench throws using a smith machine: The importance of considering the effect of counterweights'', *International Journal of Sports Medicine,* 2013; 34(9): 820-824.

[18]. Kollias, I., Hatzitaki, V., Papaiakovou, G., Giatsis, G. "Using principal componenets analysis to identify individual differences in vertical jump performance'', *Research Qearterly for Exercise and Sports*, 2001; 72(1), 63-67.

[19]. Kraemer, W.J., Fleck, S.J., Deschenes, M. "A review: Factors in exercise prescription of resistance training'', *Strength and Conditioning Journal*, 1988; 10(5): 36-42.

[20]. Kraemer, W.J., Newton, R.U. "Training for muscular power'', *Scientific Principles of Sports Rehabilitation*, 2000; 11(2): 341-368.

[21]. Loturco, L., Artioli, G.G., Kobal, R., Gil, S., Franchini, E. "Predicting punching acceleration from selected strength and power variables in elite karate athletes: A multiple regression analysis'', *Journal of Strength and Conditioning Research*, 2014; 28(7): 1826-32.

[22]. Loturco, I., Kobal, R., Maldonado, T., Piazzi, A.F., Bottino, A., Kitamura, K., Abad, C.C.C., Pereira, L.A., Nakamura, F.Y. "Jump squat is more related to sprinting and jumping abilities than olympic push press'', *International Journal of Sports Medicine*, 2015; 28(8): 604-612.
[23]. Loturco, I., D'Angelo, R.A., Fernandes, V., Gil, S., Kobal, R., Cal Abad, C.C., Kitamura, K., Nakamura, F.Y. "Relationship between sprint ability and loaded / unloaded jump tests in elite sprinters'', *Journal of Strength and Conditioning Research*, 2015; 29(3): 758-764.
[24]. Loturco, I., Nakamura, F.Y., Winckler, C., Braganca, J.R., Fonseca, R.A., Moreas-Filho, J., Zaccani, W.A., Kobal, R., Abad, C.C.C., Kitamura, K., Pereira, L.A. "Strength-power performance of visually impaired paralympic and olympic judo athletes from the Brazilian national team: A comparative study'', *Journal of Strength and Conditioning Research*, 2017; 31(3): 743-749.
[25]. Loturco, I., Pereira, L.A., Kobal, R., Kitamura, K., Cal Abad, C.C.C., Nakamura, F.Y., Pai, C.N. "Peak versus mean propulsive power outputs: Whichvariable is more related to jump squat performance'',*The Journal of Sports Medicine and Physical Fitness,* 2017; 57(11):1432-1444.
[26]. Newton, R.U., Kraemer, J.W. "Developing explosive muscular power: Implications for a mixed methods training strategy'', *Strength and Conditioning Association Journal*, 1994; 16(5): 20-31.
[27]. Pareja-Blanco, F., Rodriguez-Rosell, D., Sanchez-Medina, L., Gorostiaga, E.M., Gonzales-Badillo, J.J. "Effect of movement velocity during resistance training on neuromuscular performance'', *International Journal of Sports Medicine*, 2014; 35(11): 1-9.
[28]. Pereira, M.I.R., Gomes, P.S.C. "Movement velocity in resistance training'', *Sports Medicine*, 2003; 33(6): 427-438.
[29]. Sanchez-Medina, L., Perez, C.E., Gonzales-Badillo, J.J. "Importance of the propulsive phase in strength assessment'', *International Journal of Sports Medicine*, 2010; 31(2): 123-129.
[30]. Sanchez-Medina, L., Gonzales-Badillo, J.J. "Velocity loss as an indicator of neuromuscular fatigue during resistance training'', *Medicine and Science in Sports and Exercise*, 2011; 43(9): 1725-1734.
[31]. Sanchez-Medina, L., Garcia-Pallares, J., Perez, C.E., Fernandes, J., Gonzales-Badillo, J.J. "Estimation of relative load from mean velocity in the full squat exercise'', *16th Annual Congress of the ECSS*, 6-9 July, Liverpool, UK, 2011.
[32]. Sanchez-Medina, L., Gonzales-Badillo, J.J., Perez, C.E., Garcia-Pallares, J. "Velocity and power - load relationship of the bench pull vs. bench press exercises'', *International Journal of Sports Medicine*, 2014; 35(3): 209-216.
[33]. Stone, M.H., Sanborn, K., O'Bryant, H.S. "Maximum strength-power performance relationships in college throwers'', *Journal of Strength and Conditioning Research*, 2003; 17(4): 739-745.
[34]. Young, W.B., Newton, R.U., Doyle, T.L., Chapman, D., Cormack, S., Stewart, G., Dawson, B. "Physiological and anthropometric characteristics of starters and non-starters and playing positions in elite Australian rules football: A case study'', *Journal of Science and Medicine in Sport,* 2005; 8(3): 333-345.
[35]. Zatsiorsky, V.M. "Kinematics of human motion'', United States: Human Kinetics, 1998.