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The Relationship Between the Upper-Body Strength Characteristics with Velocity and Power Parameters During the Bench Throw Movement: Is Sport Branch An Important Factor ? *

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Abstract

The purpose of this study was to investigate whether the relationship between the upper-body strength characteristic with velocity and power parameters during the bench throw exercise shows a significant difference according to sports branches. In accordance with this purpose; a total of 52 athletes (age: 22,8±3,61 years; height: 183,3±10,8 cm; weight: 80,1±13,4 kg) including 13 volleyball players (age: 20,3±1,25 years; height: 194,7±7,51 cm; weight: 87,8±7,22 kg) and 13 handball players (age: 25,4±3,86 years; height: 187,5±8,33 cm; weight: 90,9±14,8 kg) competed in Turkey 1. League together with 13 national martial players (age: 25,0±3,24 years; height: 175,1±6,91 cm; weight: 70,0±7,70 kg) and 13 arm wrestling players (age: 20,6±1,93 years; height: 175,7±5,39 cm; weight: 71,9±7,92 kg) participated as voluntarily. To determine the velocity and power parameters, a bench throw (BT) movement was performed using an external load of 30 % of the participants' body weight and mean propulsive velocity (MPV), peak velocity (PV), mean propulsive power (MPP) and peak power (PP) by the help of an isoinertial velocity transducer (T-Force dynamic measurement system). Shapiro-Wilk normality test, descriptive statistics and Spearman correlation analysis methods were used to evaluate the data. According to the results of the analysis, it was found that there was a statistically significant relationship between the upper-body strenght characteristics with together velocity and power parameters during the BT movement and this relationship shows a statistically significant difference compared to the sports branches. While both the volleyball players and the handball players have a high and positive relationship between the upper-body strength characteristics with together velocity and power values during the BT movement ($p<0.05$); it was found that martial players have only a significant relationship with PV and MPP values. On the other hand, it was determined that arm wrestling players don't have any statistically significant relationship between both strength and velocity values and characteristic of upper-body strength ($p>0.05$). As a results, it can be asserted that sports branch is an important factor for the relationship between the upper-body strength characteristics with together velocity and power parameters during the bench throw movement.

Keywords: Sports Branches, Strength, Velocity, Power

INTRODUCTION

The ability of the human body to produce maximum power is associated with a number of positive performance outcomes and high level of sports achievement. Maximal anaerobic power (Pmax) and force-velocity (F-v) relationships are defined as the power generation limits of the neuromuscular system, and measurements of these parameters have become a common field of study in recent years. In particular, the force-velocity relationship explains the ability of the skeletal muscle to produce force and maximal movement velocity (12). Since the maximal abilities of the skeletal muscle are intertwined in order to produce both force and velocity, the force-velocity relationship characterizes the ability to produce and maximize power (19).

The force-velocity relationship represents the characteristic feature of the muscle that determine its power production capacities (11) and is therefore considered as the basis of mechanical power output in sports movements (19). It has been stated that the interaction between force and velocity is an important indicator for successful athletic performance in explosive sports disciplines (14). Studies on force-velocity relationship are carried out especially for athletes engaged in combat sports such as boxing, taekwondo and judo (7) and athletes engaged in team sports such as handball and volleyball (21).

The upper body feature and, accordingly, the maximum upper body pushing power is an important feature for combat sports and some team sports in terms of both pushing or hitting the opponents and applying some movements required by the sports branch (5). Since the performance achievement in many sports branches depends on the power feature applied against objects (such as ball, equipment or ground) (20), issues such as the power feature of athletes or how this feature should be enhanced effectively are highly important for athletes, conditioners or coaches (15). In different studies by Baker (2,3,4), muscle force has been shown to be highly correlated with upper body maximal power characteristics of both elite and less experienced athletes. In addition, since the maximal muscle force is a physical factor affecting maximal power, athletes who want to reach a high maximal power are recommended to develop both agonist and antagonist muscle groups (5).

In the literature, there are a very limited number of studies in which the velocity and power parameters obtained during the concentric phase of the bench throw (BT) movement are evaluated or compared according to the sports branches by considering elite, national team or amateur athletics levels (8,9,10,17). The velocity and power values during the exercises applied for the upper body may have different features according to the movements applied depending on the natural structure of each sports branch. Determining these features according to sportive branches will help to determine the characteristic features of branch-specific trainings in the branches where explosive but different movement examples are applied. Therefore, the aim of this study is to examine whether there is a difference between the upper body force characteristics of the athletes engaged in different sports branches and the velocity and power parameters during the bench throw movement in the bar throw movement, where muscle force and movement velocity are the main factors.

METHOD

Participants

Total of 52 athletes competing in different sports branches (handball, volleyball, arm wrestling and combat sports) participated in this study voluntarily. While handball and volleyball players compete in the 1st league, the athletes who compete in arm wrestling and combat sports are the national athletes in their branches. Physical characteristics of the participants are given in Table 1. The participants are in good health and do not use any medication that can adversely affect their test performance. Prior to the study, detailed information was provided to all athletes and their coaches about the purpose of the research, the test procedures to be performed within the scope of the study and the potential risks that may be encountered, and the benefits of the results to be achieved at the end of the study for the relevant sports branches and sports sciences, and a written consent was signed to the participants stating that they voluntarily participated in the study.

Test Prosedures and Measurements

Seca769 branded electronic measurement tool (Seca Corporation, Hamburg, Germany) with a precision accuracy of 0.001 m and 0.01 kg was used respectively in the measurement of the body weights and heights of the participants. The bench throw (BT) movement was done on the Smith

machine (Esjim IT7001, Eskisehir, Turkey) using an external load corresponding to 30% of the subjects' body weights. A linear velocity converter system (T-Force Dynamic Measurement System; Ergotech Consulting SL, Murcia, Spain) was connected to the last part of the weight bar to determine the velocity (MPV: mean propulsive velocity; PV: peak velocity) and power (MPP: mean propulsive power; PP: peak power) values during the BT movement. In this system there is an electromechanical hardware consisting of velocity sensor and interface and a hook connected to the weight bar with a special computer program (T-Force system software) that manages this hardware (22,23). The purpose of applying the BT movement to determine the velocity and power values is that this movement is a multi-jointed movement and it is widely used in the development of upper body muscle force (1). In the implementation of the BT movement, it was stated that the participants should lower the weight bar in a controlled manner until they touch it on their breasts, and raise the bar as fast as they can with the command. The participants were asked to perform this movement three (3) times (17). Free weights are not used for the BT movement applied in this study, and the reason for using the Smith machine tool is that the smith machine limits the movement in the vertical direction (16).

Table 1. Physical characteristics of the participants

Sport Branches		Age (years)	Height (cm)	Body Weight (kg)
Volleyball (n=13)	Mean	20.3	194.7	87.8
	Standard Devision	1.25	7.51	7.22
	Minimal	18.0	178.0	78.2
	Maximal	22.0	201.0	105.0
Handball (n=13)	Mean	25.4	187.5	90.9
	Standard Devision	3.86	.83	14.8
	Minimal	20.0	171.0	67.3
	Maximal	32.0	197.0	113.5
Combat Sports (n=13)	Mean	25.0	175.1	70.0
	Standard Devision	3.24	6.91	7.70
	Minimal	21.0	164.0	60.0
	Maximal	30.0	185.0	85.0
Arm Wrestling (n=13)	Mean	20.6	175.7	71.9
	Standard Devision	1.93	5.39	7.92
	Minimal	18.0	168.0	55.2
	Maximal	24.0	184.0	84.1
Total (n=52)	Mean	22.8	183.3	80.1
	Standard Devision	3.61	10.8	13.4
	Minimal	18.0	164.0	55.2
	Maximal	32.0	201.0	113.5

Upper body strength feature was determined by using one repeated maximal (1RMBP) strength test procedure designed by Beachle et al., (6) to determine the maximal strength on bench press (BP) movement on the subjects through Smith machine (Esjim IT7001 Eskisehir, Turkey). The purpose of using this movement in upper body strength measurement is that BP movement is one of the most used exercises during both training and testing of upper body muscles (chest, arm and shoulder) (13).

The tests were applied to the participants within two (2) consecutive days. Before applying both bench press and bench throw movements, all participants were given a comprehensive warm-up of 20 minutes, including 15 minutes of general (5 minutes of lower and upper body stretching after a medium intensity run) and 5 minutes of special (bench press and bench throw trials with submaximal level) exercises. In order to get the highest efficiency during both movements, verbal encouragement was given to the participants during the tests.

Statistical Analysis

Spearman correlation was used to determine whether there was a significant relationship between the upper body strength feature and the velocity and power parameters achieved during bench throw movement. All variables were expressed as mean and standard deviation.

RESULTS

Descriptive statistical results of the participants for upper body strength features and velocity and power values in bench throw movement according to sports branches are given in table 2, the relationship between the upper body strength feature of the participants and the velocity and power parameters in the bench throw movement are given in table 3 and the statistical results of this relationship according to the sports branches are given in table 4.

Table 2. Descriptive statistical results for velocity and power values in bench throw movement and upper body strength features according to sports branches

Sport Branches		MPV (m/sec^{-1})	PV (m/sec^{-1})	MPP (W)	PP (W)	$BP_{Absolute\ (kg)}$	$BP_{Relative}$ (kg)
Volleyball (n=13)	Mean (±SD)	1.32 (± .20)	2.13 (± .18)	350.1 (± 71.7)	748.7 (± 133.3)	96.1 (± 13.8)	1.08 (± .12)
	Minimal	1.01	1.75	273.4	589.5	75.0	.86
	Maximal	1.62	2.42	460.6	942.9	120.0	1.31
Handball (n=13)	Mean (±SD)	1.12 (± .22)	1.91 (± .29)	307.5 (± 62.6)	654.3 (± 122.1)	97.8 (± 15.0)	1.08 (± .15)
	Minimal	.74	1.22	194.2	447.5	70.0	.71
	Maximal	1.61	2.40	454.3	918.6	125.0	1.28
Combat Sports (n=13)	Mean (±SD)	1.35 (± .18)	2.20 (± .13)	289.8 (± 55.8)	631.1 (± 100.4)	96.5 (± 13.5)	1.38 (± .18)
	Minimal	1.14	1.98	213.1	475.1	75.0	1.11
	Maximal	1.63	2.41	413.1	825.1	115.0	1.66
Arm Wrestling (n=13)	Mean (±SD)	1.11 (± .15)	1.87 (± .24)	242.9 (± 25.6)	515.1 (± 72.3)	75.0 (± 12.6)	1.04 (± .20)
	Minimal	.95	1.58	197.9	424.1	60.0	.85
	Maximal	1.43	2.31	283.7	664.6	105.0	1.52

MPV: Mean Propulsive Velocity; PV: Peak Velocity; MPP: Mean Propulsive Power; PP: Peak Power; $BP_{Absolute}$: Bench Press Absolute Strength; $BP_{Relative}$: Bench Press Relative Strenght

Table 3. Relationship between the velocity and power parameters in the bench throw movement and upper body strength feature of the participants

Variables		PV	MPP	PP	$BP_{Absolute}$	$BP_{Relative}$
MPV	Correlation Coefficient	.959 **	.695 **	.658 **	.529 **	.527 **
	Sig. (2-tailed)	.000	.000	.000	.000	.000
	N	52	52	52	52	52
PV	Correlation Coefficient		.636 **	.675 **	.536 **	.561 **
	Sig. (2-tailed)		.000	.000	.000	.000
	N		52	52	52	52
MPP	Correlation Coefficient			.922 **	.725 **	.256
	Sig. (2-tailed)			.000	.000	.067
	N			52	52	52
PP	Correlation Coefficient				.685 **	.292 *
	Sig. (2-tailed)				.000	.036
	N				52	52
$BP_{Absolute}$	Correlation Coefficient					.622 **
	Sig. (2-tailed)					.000
	N					52

* 0.05 level a significant relationship; ** 0.01 level a significant relationship

MPV: Mean Propulsive Velocity; PV: Peak Velocity; MPP: Mean Propulsive Power; PP: Peak Power; $BP_{Absolute}$: Bench Press Absolute Strength; $BP_{Relative}$: Bench Press Relative Strenght

Regardless of the difference in sports branches, when the table 3 showing the relationship between the upper body strength feature and the velocity and power values in the bench throw movement was examined, it was seen that there was a statistically positive and high level relationship between bench press absolute values and MPV ($r = .529$; $p<0.01$), PV ($r = .536$; $p<0.01$), MPP ($r = .725$; $p<0.01$) and PP ($r = .685$; $p<0.01$) values. There was a statistically positive and high level relationship between relative bench press values and MPV ($r = .527$; $p<0.01$) and PV ($r = .561$; $p<0.01$), and a positive and moderate relationship with PP values ($r = .292$; $p<0.05$).

Table 4. Relationship between the velocity and power parameters in the bench throw movement and upper body strength feature according to sports branches

Değişkenler			MPV	PV	MPP	PP
Volleyball	$BP_{Absolute}$	Correlation Coefficient	.556 *	.589 *	.716 **	.739 **
		Sig. (2-tailed)	.048	.034	.006	.004
		N	13	13	13	13
	$BP_{Relative}$	Correlation Coefficient	.670 *	.632 *	.684 **	.634 *
		Sig. (2-tailed)	.012	.021	.010	.020
		N	13	13	13	13
Combat Sports	$BP_{Absolute}$	Correlation Coefficient	.475	.595 *	.609 *	.456
		Sig. (2-tailed)	.101	.032	.027	.117
		N	13	13	13	13
	$BP_{Relative}$	Correlation Coefficient	.250	.397	.059	.179
		Sig. (2-tailed)	.411	.180	.847	.558
		N	13	13	13	13
Arm Wrestling	$BP_{Absolute}$	Correlation Coefficient	.017	.047	.261	.147
		Sig. (2-tailed)	.957	.878	.389	.631
		N	13	13	13	13
	$BP_{Relative}$	Correlation Coefficient	.404	.484	.017	.191
		Sig. (2-tailed)	.170	.094	.957	.532
		N	13	13	13	13
Handball	$BP_{Absolute}$	Correlation Coefficient	.728 **	.775 **	.703 **	.759 **
		Sig. (2-tailed)	.005	.002	.007	.003
		N	13	13	13	13
	$BP_{Relative}$	Correlation Coefficient	.429	.465	.275	.558 *
		Sig. (2-tailed)	.143	.109	.363	.047
		N	13	13	13	13

* 0.05 level a significant relationship; ** 0.01 level a significant relationship

MPV: Mean Propulsive Velocity; PV: Peak Velocity; MPP: Mean Propulsive Power; PP: Peak Power; $BP_{Absolute}$: Bench Press Absolute Strength; $BP_{Relative}$: Bench Press Relative Strenght

When table 4 was examined, it was seen that there was statistically positive and high level relationship between absolute bench press values and handball players' MPV (r = .728; p<0.01), PV (r=.775; p<0.01), MPP (r=.703; p<0.01) and PP (r=.759; p<0.01) values, volleyball players' MPP (r=.716; p<0.01) and PP (r=.739; p<0.01) values, and a positive and moderate relationship between volleyball players' MPV (r=.556; p<0.05) and PV (r=.589; p<0.05) and combat sports athletes' PV (r=.595; p<0.05) and MPP (r=.609; p<0.05) values. In arm wrestlers, there was statistically no significant relationship between absolute bench press values and velocity and power parameters during bench throw movement. It was observed that there was a positive and high level relationship between relative bench press values and volleyball players' MPP (r=.684; p<0.01) values, and a positive and moderate level relationship between handball players' PP (r=.558; p<0.05) and volleyball players' MPV (r=.670; p<0.05), PV (r=.632; p<0.05), PP (r=.632; p<0.05) values. It was found that there was statistically no significant relationship between the relative bench press values and the velocity and power parameters during bench throw movement in both arm wrestlers and combat sports athletes.

DISCUSSION

In this research, it was examined whether there was any relationship between the velocity and power values reached in the concentric phase of the bench throw movement and the upper body muscle strength, if any, whether the sports branch was an important factor for this relationship and it was concluded that the relationship between velocity and power parameters obtained during bench throw movement and upper body muscle strength differed according to branches. In the literature, some studies have examined the velocity and power parameters during certain movements, which include specific

movement samples applied to the upper body of athletes who are engaged in sports branches where upper body muscle strength is an important factor for successful performance and is used dominantly.

In the study conducted by Can (9), bench throw movement was applied on the handball players competing in Turkish 1st handball league by using external load (30% of their body weights) and velocity and power values of the subjects in bench throw movement was acquired as 1.12 (±.22 m.sec.) for MPV, 1.91 (±.29 m.sec.) for PV, 307.5 (±62.6 W) for MPP and 654.3 (±122.1W) for PP, respectively. In addition, the average 1RM strength values of the participants in the bench press movement were determined as 97.8 (± 15.0 kg). In the mentioned study, it was suggested that there was a positive and high level significant relationship between 1RMBP values of the participants and MPV (r=.728), PV (r=.775), MPP (r=.703) ve PP (r=.759) values of BT exercise in propulsive phase ($p < 0.01$); in the handball branch, due to the importance of arm throwing movement in the situations such as passing and shooting and the upper extremity muscle power and strength have a great importance in the throwing motion, handball players have a statistically significant relationship between velocity and power parameters and 1RMBP strength values during the propulsive phase of the BT movement. In a study conducted by Can et al., (8) regarding the arm wrestling branch, where upper body muscle strength is an important factor and examining whether there is a significant relationship between the upper body strength features of the national arm wrestlers and the velocity values achieved in the BT movement (with an external load corresponding to 30% of the body weight), while the average values of 1RMBP of the participants were 75.2 (± 13.4 kg), the velocity values in BT movement were acquired as 1.02 (± .84 m.sec.) for MPV and 1.78 (± .14 m.sec.) for PV. Furthermore, statistically no significant correlation was found between 1RMBP values and MPV (r= .621) and PV (r= 445) ($p> 0.05$), and it was stated that the absence of any relationship between these parameters could result from the arm wrestlers having low 1RMBP values.

In a study conducted by Can and Bayrakdaroğlu (10) on national boxers and kickboxers, the average values of 1RMBP of the participants were 100.0 (± 12.9 kg) for boxers, while this value was found to be 92.5 (± 14.4 kg) in kickboxers. In addition, the velocity and power parameters of boxers and kickboxers during the BT movement were acquired as 1.41 (± .16 m.sec) and 1.28 (± .19 m.sec) for MPV, 2.26 (± .12 m.sec) and 2.14 (± .14 m.sec) 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 the mentioned study, it was found that there was statistically no significant difference between the upper body muscle force and the velocity and power parameters of the national athletes competing in both sports branches. However, a statistically significant relationship was found between 1RMBP values and MPV (r=.613), PV (r=.641) and MPP (r=.611) values. In a study by Loturco et al., (18) on athletes in the Brazilian boxing national team, they argued that there was a high level of relationship between the punching velocity applied by using different techniques and the mean propulsive power in the bench throw movement, and this relationship also gained importance as the necessity for the athletes to develop their existing abilities to apply a high velocity strength using their upper limbs. Similarly, in another study by Loturco et al., (17) on athletes in the Brazilian karate national team, they suggested that there was a relationship between the muscle strength and power ability of the national karate players and the velocity skills for punching and kicking, and this relationship might also be due to the dynamic features of hitting movement.

In this study, it was concluded that the relationship between the velocity and power parameters reached during the BT movement and the upper body strength feature differed according to the sports branches. It was concluded that there was a relationship between absolute 1RM values in the bench press movement and MPV, PV, MPP and PP values of handball players, MPV and PV values of volleyball players, and PV and MPP values of combat sports athletes, but there was no such relation in arm wrestlers. In terms of relative 1RM values, such a relationship was found between the volleyball players' MPP and the handball players' MPV, PV and PP values. However, there was statistically no significant relationship in both arm wrestling and combat sports athletes. In general, it is seen that handball, volleyball and combat sports athletes in terms of absolute values and handball and volleyball players in terms of relative values differ from the athletes competing in other sports branches in relation to the upper body strength feature and the velocity and power parameters

during the puropulsive phase. It can be suggested that the reason for this difference is that the pushing movement for the upper body is an important feature for volleyball, handball and combat sports; on the other hand, in arm wrestling, it can be caused by the pull movement being more dominant rather than pushing, and the velocity and power features obtained during the movements applied to the upper body may differ according to the sports branches or the characteristics of the sports branches. In conclusion, this is a study examining the differences between velocity and power parameters and muscle strength during specific movement examples applied for upper body in some sports branches where upper body muscle force is used dominantly and it is thought to be an important source for sports science field.

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