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Anaerobic power, lower-body strength characteristic and some kinetics and kinematics during loaded-squat jump movement in Turkish national boxers and kickboxers

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Abstract

Background & Study Aim: Among martial arts boxing and kickboxing are the most popular combat sports. The purpose of this study was knowledge about anaerobic power, lower-body strength characteristic and some kinetic and kinematics during loaded squat jump movement in Turkish national boxers and kickboxers.

Material & Methods: Seven boxers (age: 25.5±2.57 years; boy: 174.2±4.38 cm; weight: 69.5±5.53 kg) and 6 kickboxers (age: 24.3±4.03 years; height: 176.1±9.45 cm; weight: 70.5±10.25 kg) who had ranks in competitions at Europe and World Championships. Totally 13 athletes (age: 25.0±3.24 years; height: 175.1±6.91 cm; weight: 70.0±7.70 kg), participated voluntarily in this study. Was applied and maximal anaerobic power, maximal anaerobic capacity, minimum anaerobic power and fatigue index values as both absolute and relative was obtained. One repetition maximal (1RM) values in full back squat (SQfull) movement was defined. Loaded-squat jump (SJLoaded) movement was applied by using an external load that corresponds to 40% 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) were obtained.

Results: There are no statistically significant differences between velocity and power values during SJLoaded movement with 1RM and anaerobic power values of Turkish national boxers and kickboxers ($p>0.05$).

Conclusion: As a result, the reason that there are no significant differences between both groups; it can be suggested that both groups consist of high-level athletes who participated in Europe and Word championships and their training systems and methods are similar to each other.

Keywords: 1RM • martial arts • performance • tactics • technique • velocity

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INTRODUCTION

Martial arts are a type of sports that includes such traditions as improving the skills and characteristics of the athlete in general and teaching them to fight as unarmed [1]. Among these types of sports, boxing and kickboxing are the popular combat sports [2, 3]. Boxing is a full-contact martial art that aims to punch a rival without being punched before [4]. Different from boxing, kickboxing is a type of martial art that aims to apply strong contact to the opponent in which fist, kick, elbow and tibia are used [5].

High-intensity and intermittent sports are mostly based on anaerobic sources [6]. Boxing matches require an energy in which anaerobic power is densely used due to the fact that it is a short-time activity in which such high-intensity explosive movements as punches and defence movements are applied [7], the matches are composed of rounds and referees can stop the match [6, 8]. It is known that boxing is heavily an anaerobic sport at a rate of 70-80% [7, 9]. Similarly, anaerobic power is necessary in order to effectively apply the techniques in kickboxing which is a martial art requiring short-term and high performance [2, 3] in which different motor skills are used [10] although a strong blow to the opponent may mean the end of the competition [5].

In martial sports, a single performance feature is usually not enough. There should be a combination of strength, power, speed, technique and condition for success in most martial arts [11]. It is necessary to have a well-developed muscular strength and power in order to meet the physical needs of a boxing match and to apply technical-tactical skills [6, 12, 13]. Punching is the basic movement of boxing and it should be thrown fast and strongly for an effective blow [12]. For kickboxing sports where effective kicking and punching is important, these basic movements need to be applied both quickly and strongly for success [2, 3, 14]. The muscular strength both in upper and lower extremity is one of the most important elements of success in kickboxing [15]. The most significant factor in scoring with an offensive or defensive technique during a boxing match is to surprise the opponent and to act fast for score in the right time [10].

It is observed in literature that many studies have been conducted on physiological and performance characteristics of boxers and kickboxers. However, there is no such study comparing the performance characteristics of elite boxers and kickboxers. In this regard, in this study we compare some kinetics and kinematics during loaded-squat jump movement with lower body strength and anaerobic power values in Turkish national boxers and kickboxers. It is thought that the results to be obtained from this study will make great contributions to determining the differences in two sports branches and the performance characteristics required for a high-level athletic success and the results will yield great importance for coaches, athletes and sports science literature.

The purpose of this study was knowledge about anaerobic power, lower-body strength characteristic and some kinetic and kinematics during loaded squat jump movement in Turkish national boxers and kickboxers.

MATERIAL AND METHODS

Participants

A total of 13 elite athletes of combat sports (age: 25.0 ±3.24 years; height: 175.1 ±6.91 cm; weight: 70.0 ±7.70 kg) composed of 7 boxers (age: 25.5 ±2.57 years; height: 174.2 ±4.38 cm; weight: 69.5 ±5.53 kg) and 6 kickboxers (age: 24.3 ±4.03 years; height: 176.1 ±9.45 cm; weight: 70.5 ±10.25 kg) who have participated in European and World championships and been within ranking voluntarily participated in the study. The health condition of the participants is good, and they don't take any medicine that may negatively affect their test performances. Before the research, the participants were informed about the purpose of the study, test procedures, the potential risks and benefits of the study in detail and they signed a written consent stating that they participated in the study voluntarily.

Procedures

Maximal Dynamic Strength Test

One-repetition maximal test (1RM) in the squat movement was applied by using a procedure designed by Beachle et al. [16] on a Smith machine (Esjim IT7001, Eskisehir, Turkey) in order to determine the lower body strength characteristics of participants. In this method: (1) following a 20-minute general warm-up, the participants performed a warm-up by using a load with which they could do 5-10 repetitions; (2) one minute of rest was allowed; (3) a warm-up load which allows

Kinematics – *noun* the scientific study of motion [46].

Performance – *noun* the level at which a player or athlete is carrying out their activity, either in relation to others or in relation to personal goals or standards [46].

Technique– *noun* a way of performing an action [46].

Tactics – *plural noun* the art of finding and implementing means to achieve immediate or short-term aims [46].

Motor skills – *plural noun* the ability of a person to make movements to achieve a goal, with stages including processing the information in the brain, transmitting neural signals and coordinating the relevant muscles to achieve the desired effect [46].

Anaerobic power – *noun* same as **anaerobic capacity** [46].

Anaerobic capacity – *noun* the maximum amount of energy that can be produced by anaerobic metabolism [46].

Strength – *noun* the fact of being strong [46].

Strength training – *noun* training that aims to build muscle strength, usually resistance training [46].

Speed training – *noun* training that uses exercises designed to improve reaction times [46].

Power – *noun* **1.** Physical force or strength **2.** The ability, strength, and capacity to do something [46].

Power training – *noun* intense training that emphasises proper form [46].

Endurance – *noun* the ability or power to bear prolonged exertion, pain or hardship endurance athlete [46].

Endurance training – *noun* exercises designed to increase an athlete's level of aerobic fitness [46].

Condition – *noun* 1. the particular state of someone or something 2. a particular illness, injury or disorder; ***verb*** to undertake a fitness plan to improve general health, appearance or physical performance [46].

3-5 repetitions was determined by adding a load of 14-18 kg to the load used by participants in the first step; (4) two minutes of rest was allowed; (5) a load close to the maximum which allows 2-3 repetitions was determined by adding a load of 14-18 kg to the load used by participants in the 3rd step (6) three minutes of rest was allowed (7) one repetition maximum trial was applied by adding a load of 14-18 kg to the load used by participants in the 5th step; (8) three minutes of rest was allowed; (9) when the participants succeeded in lifting the load in the 7th step, the trial was sustained by increasing loads at the same ratios – when they failed in 1RM trial, the weight was lifted by decreasing 7-9 kg of loads; (10) three minutes of rest was allowed; (11) the load was increased and decreased continuously until the participant completed one repetition maximum with an appropriate technique and 1RM power value of the participant was obtained from 5 trials at most.

Full squat movement applied to the participants was performed in accordance with the procedure designed by Beachle and Earle [16]. The participants griped the barbell with an inward gripping by this procedure and they placed it on their shoulders (high bar position). The feet were a bit wider than the shoulder width and the fingertips oriented towards a little outward when the participant started to descend. The participants reached the lowest point of the descent when their thighs were parallel to the ground and lifted the barbell without any support (without help). An assistant was placed on both sides of the weight bar to ensure the safety of participants. During the deep squat movement, they were told to breathe in while dropping the weight bar and breathe out while lifting. Strong verbal encouragement was ensured in order to increase the performance of athletes during all liftings.

Anaerobic Power Test

Wingate anaerobic power test (WanT) was applied by using a stress testing bike (Monark 839E, Sweden) in order to determine anaerobic power and capacities of the participants. Before starting the test, 5-minute warm-up was allowed to the participants for adjustment to the test procedure. After the participants cycled for few seconds with no load during the test, a load corresponding to 7.5% of each participant's body weight was applied as a resistance when they reached the determined cycling speed and they cycled at high speed for 30 seconds against the resistance created by this load. The number of cycles was recorded for each 5 second and all power indicators were calculated with a computer software as absolute and relative values [17-22]. The indicators obtained in anaerobic power test are given below [23]: *The Highest Power (Maximal Anaerobic Power):* It is the highest mechanical power generated during the test within any five (5) seconds time period; *Mean Power (Maximal Anaerobic Capacity):* It is the mean power generated during the test; *The Lowest Power (Minimum Power):* It is the lowest mechanical power generated during the test within any five (5) second time period; *Fatigue Index (FI):* It is the percentage indication of power decrease during the test. It is found by dividing the difference between the highest power value and the lowest power value obtained in any five (5) second time period during the test by the highest power value.

Loaded-Squat Jump Test

Linear velocity converter (T-Force Dynamic Measurement System; Ergotech Consulting S.L., Murcia, Spain) was used to obtain velocity (MPV: mean propulsive velocity and PV: peak velocity) and power (MPP: mean propulsive power and PP: peak power) indicators of the participants during the loaded-squat jump (SJ_{Load}) movement. Loaded-squat jump movement was applied by using free weights and an external load corresponding to 40% of the participants' own body weights. In order to apply this test, subjects were asked to bring their knees to the flexion until their thighs were parallel to ground from the static position, to jump as fast as possible without losing contact between their shoulders and bar following the start command and to repeat it 3 times [24]. These movements were repeated when these requirements were not fulfilled since body weight must be moved in addition to the external load during the loaded-squat jump test and indicators such as velocity and power must be determined thanks to the ability to accelerate the total mass (external load and body weight) of the subject [25].

Statistical Analysis

All variables were evaluated as mean and standard deviation. By looking at the normality of distribution of data, independent t-test was used to determine whether there was a statistically significant difference between groups. SPSS version 16.0 (SPSS Inc., Chicago) has been used for all statistical calculations. $p<0.05$ value has been accepted as the significance level.

Warm-up – *noun* an exercise or a period spent exercising before a contest or event [46].

Match – *noun* **1.** a contest between opponents, especially a sporting contest **2.** somebody or something capable of competing equally with another person or thing [46].

1RM – individual's maximal strength or 1 repetition maximum [47].

Martial arts – *plural noun* any of various systems of combat and self-defence, e.g. judo or karate, developed especially in Japan and Korea and now usually practised as a sport [46].

Combat sport – *noun* a sport in which one person fights another, e.g. wrestling, boxing and the martial arts [46].

Combat sport & martial art – relation according to the theory of combat sport: "every combat sport is martial arts but not vice versa" [48, p. 18]

RESULTS

There is not statistically significant (p>0.05) difference between anaerobic power values and maximal dynamic strength and between velocity and power values during loaded-squat jump movement of boxers and kickboxers (Table 1 and 2).

DISCUSSION

The activity sample of boxing matches are accepted as "intermittent" due to the fact that pauses and low intensity periods occur as boxers clinch or referees intervene or high-intensity activity moves are realized [7, 8, 26, 27]. Boxing is predicted to be anaerobic at a rate of 70-80% and aerobic at a rate of 20-30% [28]. Kickboxing is a martial art in which punches are used just like in boxing, feet are used as in karate branch [29] and knees and elbows are used in line with some rules [30]. The main purpose of kickboxing matches is to be able to use strength, endurance and skills specific to sports in order to physically defeat an opponent [31]. As in other combat sports, the study performed by kickboxers depends on both aerobic and anaerobic power. However, kickboxing is stated to be an anaerobic sport due to the fact that such activities as punches and kicks depend on high muscular strength [5].

For the anaerobic performance defined as a person's ability to do maximal anaerobic exercise in literature, such concepts as mechanical power, anaerobic power, mean power, anaerobic capacity, anaerobic working capacity, local muscular endurance, instant power, maximal power and short-term power are used in literature. Generally, the ability to produce the highest mechanical power in a few seconds (peak power or maximal power) and the ability to maintain high power efficiency over a short period of time (mean power) can be considered as the main indicators of anaerobic performance [21].

Khanna and Mann [9] have determined that the relative mean power values of Indian male national boxers in 30-second Wingate anaerobic power test are 4.9 ±0.7 W/kg for junior athletes below the age of 19 and 6.5 ±0.5 W/kg for senior athletes above the age of 20. It has been suggested in the mentioned study that relative mean anaerobic power values of senior boxers are higher, and this difference may arise from the fact that senior boxers are subject to anaerobic trainings more than young boxers. In a study performed by [32], anaerobic characteristics of elite Serbian male boxers (22.2 ±4.7 years) were analysed absolutely and relatively and maximal anaerobic power values were determined as 715.1 ±90.2 W and 9.27 ±1.1 W/kg while the mean anaerobic power values were found as 517.3 ±56.7 W and 6.72 ±0.8 w/kg.

In the study of Hübner-Wozniak et al. [33] conducted on Polish male national boxers (22.8±2.1 years), relative maximal anaerobic power and mean anaerobic power values of athletes were found 9.8 ± 0.5 W/kg and 8.6 ±0.6 W/kg respectively. In the study of Ozan et al. [34], mean anaerobic power and maximal anaerobic power values of boxers doing sports actively 22.2 ±2.7 years were found as 536.8 ±73.0 W and 735.0 ±93.9 W respectively. In the mentioned study, relative maximal anaerobic power values of boxers were found as 9.96 ±0.91 W/kg. In this study, absolute and relative anaerobic power values of male national boxers were obtained as 825.0 (±

Table 1. The comparison of velocity and power values of the participants during loaded-squat jump movement (p>0.05).

Variable	Combat sport	N	Min ÷ Max	Mean & SD	df	t	p
Load (kg)	boxing kickboxing	7 6	24.0 ÷ 30.0 25.0 ÷ 34.0	28.0 ±2.23 28.0 ±4.28	11	0.000	1.000
Mean Propulsive Velocity (m/sec^{-1})	boxing kickboxing	7 6	1.35 ÷ 1.68 1.32 ÷ 160	1.50 ±0.10 1.45 ± 0.09	11	0.918	0.379
Peak Velocity (m/sec^{-1})	boxing kickboxing	7 6	2.05 ÷ 260 2.10 ÷ 2.66	2.36 ±0.18 2.44 ±0.20	11	–0.731	0.480
Mean Propulsive Power (W)	boxing kickboxing	7 6	463.1 ÷ 661.1 458.6 ÷874.4	552.6 ±74.9 634.3 ±152.4	11	–1.258	0.234
Peak Power (W)	boxing kickboxing	7 6	753.1 ÷1083.1 750.3 - 1443.5	919.6 ±120.8 1097.8 ±273.1	11	–1.565	0.146

Table 2. The comparison maximal dynamic strength and anaerobic power values of the participants (p>0.05).

Variable	Combat sport	N	Min ÷ Max	Mean &SD	df	t	p
Maximal Anaerobic Power (W)	boxing kickboxing	7 6	783.0 ÷ 875.1 611.4 ÷ 1101.6	825.0 ±35.3 857.2 ±175.4	11	–0.478	0.642
Maximal Anaerobic Power (W/kg)	boxing kickboxing	7 6	10.7 ÷ 13.1 9.51 ÷ 12.9	11.7 ±0.81 11.4 ±1.45	11	0.526	0.609
Maximal Anaerobic Capacity (W)	boxing kickboxing	7 6	497.1 ÷ 576.8 456.0 ÷ 710.4	548.4 ±27.2 586.0 ±101.8	11	–0.945	0.365
Maximal Anaerobic Capacity (W/kg)	boxing kickboxing	7 6	7.34 ÷ 8.29 7.21 ÷ 8.54	7.82 ±0.35 7.82 ±0.57	11	–0.020	0.984
Minimal Anaerobic Power (W)	boxing kickboxing	7 6	285.6 ÷ 392.6 324.7 ÷ 481.9	351.5 ±38.0 387.5 ±56.3	11	–1.367	0.199
Minimal Anaerobic Power (W/kg)	boxing kickboxing	7 6	3.81 ÷ 5.77 3.75 ÷ 6.21	5.02 ±0.65 5.24 ±0.84	11	–0.530	0.607
Power Drop (W)	boxing kickboxing	7 6	436.7 ÷ 521.2 286.7 ÷ 619.7	473.4 ±33.4 469.7 ±128.9	11	0.075	0.942
Power Drop (W/sec)	boxing kickboxing	7 6	14.5 ÷ 17.3 9.56 ÷ 20.6	15.7 ±1.11 15.6 ±4.29	11	0.072	0.944
Power Drop (W/kg/sec)	boxing kickboxing	7 6	0.20 ÷ 0.25 0.15 ÷ 0.24	0.22 ±0.01 0.20 ±0.03	11	1.314	0.216
Fatigue Index (%)	boxing kickboxing	7 6	53.2 ÷ 64.6 46.8 ÷ 60.5	57.4 ±3.85 54.1 ±5.17	11	1.309	0.217
Absolut Full Squat 1RM (kg)	boxing kickboxing	7 6	105.0 ÷ 140.0 105.0 ÷ 155.0	119.2 ±13.3 120.0 ±20.4	11	–0.076	0.941
Relative Full Squat 1RM (kg)	boxing kickboxing	7 6	1.50 ÷ 2.02 1.56 ÷ 1.82	1.71 ±0.20 1.69 ±0.09	11	0.225	0.826

35.3 W) and 11.7 ±0.81 W/kg for maximal anaerobic power, 548.4 ±27.2 W and 7.82 ±0.35 W/kg for mean anaerobic power and minimal anaerobic power respectively while fatigue index values were found as 57.4 ±3.85 %. Analysing the results, it is observed that Turkish national male boxers who have participated in European and World Championships and been within ranking have higher values in terms of both relative and absolute maximal anaerobic power and mean anaerobic power. These results suggest that anaerobic power is an important factor for a successful performance in boxing. Similarly, a significant relation has been ascertained between a successful performance and anaerobic power in boxing in a study by Chaabene et al. [6].

Looking at the studies performed on the anaerobic power characteristics of kickboxers, it is observed that absolute and relative anaerobic power values of the athletes were found as 1360.4 (974.8-1689.7 W) and 18.8 (13.5-22.8 W/kg) respectively while mean anaerobic power was found as 761.1 (625.7-873.8 W) and 10.5 (8.2-11.8 W/kg) in the study of Zabukovec and Tiidus [15] conducted on 4 elite Canadian professional kickboxers with an average age of 27. In the study of Ouergui et al. [35] performed on Tunisian amateur kickboxers, relative maximal anaerobic power values of athletes in Wingate anaerobic power test was determined as 9.8 ±2.1 W/kg while relative mean anaerobic power values were found as 6.7 ±1.1 W/kg. The fatigue index values of the participants were obtained as 54.4 ±7.6 %. Nikolaidis et al. [36] have found the absolute and relative maximal anaerobic power values of kickboxers as 1165.3 ±356.9 W and 15.3 ±3.69 W/kg respectively. In another study of Slimani et al. [3] performed on amateur and sub-elite kickboxers, relative mean anaerobic power and maximal anaerobic power values of the participants in Wingate anaerobic power test which is performed to determine the lower body muscular strength were found as 7.1 ±1.1 W/kg and 9.3 ±1.2 W/kg for kickboxers while these values were determined as 8.5 (±0.9 W/kg) and 10.9 (±0.9 W/kg for sub-elite kickboxers respectively. Maud and Schutz [37] have established that mean anaerobic power values of elite kickboxers are higher than the

95% of the general male population at similar ages. In this study, absolute and relative anaerobic power values of the kickboxers were found as 857.2 ±175.4 W and 11.4 ±1.45 W/kg for maximal anaerobic power, 586.0 ±101.8 W and 7.82 ±0.57 W/kg for mean anaerobic power, 387.5 (±56.3 W) and 5.24 (±0.84 W/kg) for minimal anaerobic power while the fatigue index values were found as 54.1 ±5.17 %.

Lower-body muscular strength for a kickboxer is an important attribute in order to increase the effect of kicks and to be able to move more effectively around the opponent [38]. However, boxers should have a well-developed muscular strength and power in order to effectively manage the physical and/or technical-tactical requirements of a boxing match [2, 13, 39]. In a study conducted by Aydos et al. [40], mean 1RM values of boxers doing sports actively in squat movement were found as 137.0 ± 38.5 kg. It is observed in the relevant study that 1RM values of the amateur athletes engaged in boxing in the squat movement are considerably higher than the values obtained in our study. The reason for this difference is thought to be application of half squat movement to the participants and the test procedures used. 1RM strength value of amateur kickboxers in squat movement was found as 102.5 (±13.6 kg) while this value was determined as 115.5 ±13.5 kg in sub-elite kickboxers in a study of Slimani et al. [3] performed on amateur and sub-elite kickboxers. The level of combat is seen to affect the maximal strength level of the participants in the relevant study. Due to the fact that both boxers and kickboxers in our study are the medallists of European and World championships and the level of combat is an important factor for athletic performance, it is thought that higher 1RM values have been obtained than the results of the studies conducted by both Aydos et al. [40] and Slimani et al. [2, 3]. While 1RM value of boxers in the full back squat was found as 119.2 ±13.3 kg in our study, this value was determined as 120.0 ±20.4 kg in kickboxers and not a statistically significant difference was established between groups.

Power being one of the important factors of athletic performance has a time component and it is the mechanical amount expressed as the temporal ratio of the study performed (power = work / time). Power generally depends on the individual's ability to create possible maximal force [41, 42]. Velocity is a vectoral quantity and defined as the temporal ratio of changes in positions [43]. In this study, velocity and power values of boxers during the loaded- squat jump movement were obtained as 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 while velocity and power values of kickboxers during the loaded squat jump movement were obtained as 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 ±273.1 W for PP. In addition, no statistically significant difference was found between groups as a result of the analysis. It is observed in literature that there are some studies investigating the velocity and power indicators of athletes in different sports branches during the loaded-squat jump movement; however, the studies directed to martial athletes are limited. Only in the study of Can et al. [44] on kickboxers (20.7±1.81 years), mean propulsive velocity values of athletes during loaded squat jump movement were found as 1.31 m/sec^{-1} and peak velocity values as 2.25 m/sec^{-1} while mean propulsive power and peak power values were determined as 483.1 W and 892.6 W respectively. The results of the above-mentioned study are observed to be considerably lower than the results obtained from our study. This difference can be suggested to arise from the combat levels of athletes. In the study of Loturco et al. [45] performed on Brazilian national karate athletes, jump velocity values during the loaded squat jump movement applied by using an external load corresponding to 40% of athletes' own body weights were reported as 1.23 ±0.15 $m.sec^{-1}$.

CONCLUSIONS

It has been established that there is not a statistically significant difference between the one-repetition maximum strength and anaerobic power values with power and velocity values during the loaded-squat jump movement of boxers and kickboxers. The absence of a significant difference between two groups can be explained with the fact that both boxers and kickboxers are composed of elite athletes being the medallists of European and World championships, they are similar sports branches in terms of combat and the training systems and programs of both groups resemble each other.

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