ORIGINAL ARTICLE

The Effect of High Intensity Resistance Training Performed in the Speleotherapy (Salt Cave) Environment in Olympic National Boxers on Body and Some Physical Parameter Abilities

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ABSTRACT

Aim: The purpose of the research is to examine; high intensity resistance training in the speleotherapy (salt cave) environment which has an effect on body composition, punch speed, jump, reaction time, hand grip strength, VO_2 max and balance parameter abilities in elite boxers.

Material: Research in Turkey championship in the National team selected and 12 male boxers Olympic in the National team preparing for the 2021 Olympics in a different weight class categories (X̄age = 22.08±2.10 years, X̄height = 181.61±8.65 cm, X̄bmi of = 31.39±15.81 kg / m^2, X̄weıght = 82.31±18.55 kg) participated in the study voluntarily. In an area created with resistance training equipment in the Salt Cave in Çankiri, the training consisting of 8 functional movements, divided into 2 sections prepared by the researchers conducting the study, for the Boxing National team before the 2021 Tokyo Olympics, for 12 days, 3 days a week between 10:00-12:00 has been applied. SPSS 22.0 package program was used for statistic analysis. T-test was applied for related samples of the difference between parameters obtained from the research group. It was determined at $p<0.05$ level of meaningfulness.

Results: As a result, it has been observed that high-intensity resistance training applied to elite boxers in the Salt cave environment has a positive effect on punch speed, jump, reaction, VO_2 max and balance parameter abilities.

Keywords: Sportive Performance, salt cave, physical-physiological tests

INTRODUCTION

Rock salt is one of the crucial sources of salt in the world and it is vital for us living creatures. Rock salt caves in the world are used for speleotherapy, fine arts applications, tourism, recreation and storage purposes as well as salt extraction [1]. When we examine the caves where rock salt mines are extracted today, it is seen that alternative medicine methods for speleotherapy are used for sports tourism-recreation purposes related to sports activities [2].

Speleotherapy (in Greek "speleon" means cave and "therapy" treatment) is the use of karstic caves or residual galleries from mine (salt, potassium, etc.) enterprises for therapeutic purposes [3]. As mentioned, both carstic and different mining enterprises have been investigated in terms of its curative (therapeutic, therapeutic) effect. Yet, it has been proven that speleotherapy is much more effective in salt mines [4].

Salt therapy (speleotherapy), which has become more and more widespread recently, has progressed and gained importance in many countries today. Today, there are medical clinics in underground salt caves in 15 countries. The best known of these clinics are Nakhchivan in Azerbaijan, Wieliczka in Poland, Soligorsk in Belarus and Çon-Tuz in Kyrgyzstan. In order to meet the accommodation needs of the patients who come to the clinics, there are hotels etc. just above the caves, inside or in their immediate surroundings and structures were built [5].

Most of the countries with salt caves have added sports tourism-recreational activities; rehabilitative alternative medicine methods as well as contributing to health tourism with the treatment of asthma diseases [6].

Body composition and physical-physiological parameters; have been the subject of research in elite athletes so far in sports activities [7,10]. In order to emphasize the importance of evaluating body composition, physical-physiological factors in the training environment during the preparation period for high-level competitions, it is thought that the exercises performed in sodium chloride environment, which is seen as the reason for our research, have effects on the body composition and some physical parameters of elite athletes [8]. In the salt cave environment (speleotherapy) of our athletes who need different gains especially during the Olympics, the gas components in the air, low relative humidity, increasing negative ion content, bacterial flora and the absence of air allergens, slightly increased carbonic acid content, with a certain air flow, It is aimed to increase their performance with the effect of the self-cleaning feature of the environment [9]. In this context, the purpose of the study is the effect of high-intensity resistance training in a speleotherapy (salt cave) environment on body composition, punch speed, jumping, reaction time, hand grip, VO_2 max, and balance abilities in elite boxers.

MATERIAL & METHODS

Study Group: For the research; actively Boxing engaged and Turkey selected by the national team technical committee according to their weight from their participation in the championship was elected to the Turkish national team depends on the London Quota uptake and participate in an International Champion 12 male adults National team boxers (X̄age = 22.08±2.10 age, X̄height = 181,61±8.65 cm, X̄bmi = 31.39±15.81 kg/m^2, X̄bw = 82.31±18.55 kg) voluntarily participated. Test procedures are fully explained

and demonstrated by the researchers in practice. Participants signed the written informed volunteer form before the research started.

Training Planning and Schedule: The resistance training program for the boxing team participating in the study was carried out in the same time zone between 10:00 and 12:00 in the mornings, in an area created in the Salt Cave environment in Çankırı, 8 different (4 dynamic 4 static) divided into 2 sections prepared by the researchers who conducted the study.) functional resistance training program was applied. It is aerosolized, pollen and galitic (unprocessed salt mixture) air that is not completely contaminated in the salt cave environment, and its nominal values have been determined and approved by the Provincial Health Directorate. During the training, functional resistance training conditions were created in the area determined in the cave environment for the boxers and the course of the training was followed. The two-week (12 days) camping training program in a cave environment is given below within a program that includes static and dynamic training movement exercises in the morning.

Salt Cave Training Program Design: In the first stage, each movement was exercised for 40 seconds in the first 3 days respectively and the first 3 days were made as 5 sets. Six sets were studied on the 4th, 5th and 6th days. The rest between sets was determined as 4 minutes. Movement series and number order, 1st rope jump, 2nd half squat, 3rd push up, 4.plank, 5th burpee, 6.statik leg raise, 7.jumping jack, 8.lunge 15 seconds right ahead 15 seconds left front in the form. In the second stage, 5 sets on the 7th day, 6 sets on the 8th day and 7 sets on the 9th day were studied and the rest between the sets was determined as 4 minutes. Movement and series sequences, depending on the mixed working times and the number of repetitions, 9.Spinning (30 sec) / 10.kettlebell swing (20 repetitions) / 11.front squat (10 repetitions) / 12th rope swing (30 sec) / 13 deadlift (10 reps) / 14. kettlebell (20 reps lunge) / 15th medicine ball (smash 10 right 10 left) / 16.bulgarian bag back jump (10 reps).

Collection of Data: Performance tests were conducted on the participants as a team of 12 people based on a single group. The measurements and tests of the participants were carried out on the same day. Body composition measurements of the participants were made in the morning on an empty stomach, with only shorts on the boxers, without any extra material (jewelry, etc.), without shoes and socks, and bare feet on the device and according to standard techniques [11].

Participants' height (cm) measurements were measured with a portable Holtain Stadiometer (Holtain Ltd. U.K.), which can measure with an accuracy of ± 1 mm [11]. Inbody 270 (Japan) brand body analyzer was used to determine the participants' body weight (kg), body fat percentage (%) and skeletal muscle weight (kg). The measurements were made while the participants were wearing shorts and T-shirts.

The balance measurements of the participants were used in the Balance System meter test device developed by Performan z, and the programs suitable for our study were used in the device and the measurements were evaluated statically, with eyes open on the left, right and bilateral feet [12].

The reaction time measurements of the participants were used by a test device developed by Performan z, and it includes 8 light switches as a device that measures and improves upper extremity motor reaction and visual reaction level with cognitive difficulties with a single device. On the device, 3 randomly lit lights from each reflector start and turn off with a total of 24 stimuli [12,13]

Participants, vertical jump measurements, Opto jump Next® device was used (Microgate, Bolzano, Italy). The Opto Jump device is widely used in vertical jump tests and its validity and reliability study has been done. In the active jumping test, the participants were asked to kneel and jump vertically at the highest speed possible, keeping their knees fully extended and their body in an upright position. Separating the hands from the waist at any stage of the jump and pulling the knees during the flight phase of the jump were considered to be erroneous movements. In the Squat Bounce test, the participants were asked to jump vertically in the 90 degree squat position and hands free without bending the knees, and the bending of the knees in the "90 degree" squat position and pulling the knees during the hovering phase of the jump were considered as faulty movements, and the test was repeated in the wrong movements. Better than 2 trials were evaluated in vertical jump measurements [14].

Participants' right and left hand grip strengths were determined using the Takei Kiki Kogya brand hand dynamometer twice while the subjects were standing and the best results were evaluated [15].

The "Tendo Power and Speed Analyzer" device used to detect the punching speed of boxers is fixed to a pre-set platform that can be punched at shoulder level. Boxers were asked to punch 5 times right and left directly in the straight guard position, respectively, and the average speed was calculated for both hands [16].

Participants, Yo-Yo İntermittent Recovery Tests (YIRT2): Yo-Yo test protocols were developed in accordance with the physical and physiological structures of athletes [17,18]. The second level of the YIRT2 tests is applied to elite athletes [19]. The test was applied by creating the running area marked with 20-meter lines and a recovery area 5 meters from the starting line. YIRT2 Test running speed was started at 13 km/h and the running speed was increased depending on the protocol. When the participants could not travel a distance of 40m despite receiving a signal during both tests and repeating this situation twice in a row, the test was terminated and the distance was recorded as test performance [17].

Statistical Analysis: SPSS 22.0 package program was used for statistic analysis. T-test was applied for related samples of the difference between parameters obtained from the research group. At $p<0.05$ level of meaningfulness.

Findings: The tables of statistical analysis results applied for the parameters obtained from the Boxers constituting the research group are given below.

The t-test results for the pre-post test related samples for the parameters of body weight, body fat percentage, body mass index and skeletal muscle weight obtained from the boxers forming the research group are given in Table 1.

RESULTS

Table 1: Pre-post test t-test results of body weight, body fat percentage, body mass index and skeletal muscle weight parameters obtained from boxers

Parameters	Test	X̄ mean	Sd	t	n	p
Body Weight (kg)	Pre test	82.37	18.52	.439	12	.668
	Post test	82.26	18.25			
Body Fat Percentage (%)	Pre test	11.89	5.06	.846	12	.414
	Post test	11.51	4.30			
BMI (kg/m^2)	Pre test	24.59	3.74	.745	12	.524
	Post test	24.59	3.63			
Skeleton Muscle (kg)	Pre test	41.36	7.84	-1.662	12	.122
	Post test	41.74	7.94			

*p<0.05

When Table 1 is examined, there is no statistically significant difference in body weight, body fat percentage, body mass index and skeletal muscle weight parameters (p> 0.05).

Table 2: Pre-post test t-test results of the parameters of straight guard left and right-hit punching velocity obtained from boxers

Parameters	Test	X̄mean	Sd	t	n	p
Straight Guard Left (cm/sec)	Pre test	7.89	0.94	2.402	12	.047*
	Post test	8.20	1.06			
Straight Guard Right (cm/sec)	Pre test	7.83	1.09	1.767	12	.041*
	Post test	8.80	1.71			

*p<0.05

When Table 2 is examined, a statistically significant difference is observed between the punch speed pre-post test values produced by the boxers during the straight guard punch (p <0.05).

Table 3: Pre-post test t-test results of jump parameters obtained from boxers

Parameters	Test	X̄mean	Sd	t	n	p
Squat jump (cm)	Pre test	30.56	4.94	-3.232	12	.012*
	Post test	32.71	5.44			
Active jump (cm)	Pre test	31.96	5.30	-1.275	12	.038*
	Post test	33.00	4.64			
15 sec jump highest (cm)	Pre test	14.35	6.61	2.757	12	.028*
	Post test	8.25	3.41			
15 sec jump average (sn)	Pre test	11.94	5.70	3.168	12	.016*
	Post test	6.44	2.80			
15 sec jump number ®	Pre test	30.25	4.80	-2.907	12	.023*
	Post test	34.25	3.37			

*p<0.05

When Table 3 is examined, a statistically significant difference is seen between the squat, active and 15 seconds jump pre-post test values of the boxers (p <0.05).

Table 4: Pre-post test t-test results of reaction parameters obtained from boxers

Parameters	Test	X̄mean	Sd	t	n	p
Reaction test mean (sec)	Pre Test	0.66	0.11	3.046	12	.016*
	Post Test	0.59	0.08			

When Table 4 is examined, a statistically significant difference is seen between the visual reaction pre-post test values of the boxers (p <0.05).

Table 5: Pre-post test t-test results of hand grip strength parameters obtained from boxers

Parameters	Test	X̄mean	Sd	t	n	p
Hand Grip Left (kg)	Pre Test	57.17	8.97	.194	12	.851
	Post Test	59.89	7.51			
Hand Grip Right (kg)	Pre Test	57.14	8.00	.484	12	.181
	Post Test	58.93	5.72			

When Table 5 is examined, there is no statistically significant difference between the hand grip pre-post test values of the boxers (p> 0.05).

Table 6: Pre-post test t-test results for VO_2 max parameters obtained from boxers

Parameters	Test	X̄mean	sd	t	n	p
VO_2 max (ml/kg/min)	Pre Test	69.48	9.84	-12.137	12	.000*
	Post Test	72.13	9.25			

When Table 6 is examined, a statistically significant difference is seen between the VO_2 max pre-post test values that the boxers reached during the Yo-Yo test (p <0.05).

Table 7: Pre-post test t-test results of balance parameters obtained from boxers

Parameters	Test	X̄mean	Sd	t	n	p
Left center (msec)	Pre Test	20.78	7.97	-2.590	12	.032*
	Post Test	37.68	16.60			
Right center (msec)	Pre Test	30.79	18.22	-1.570	12	.015*
	Post Test	40.88	15.17			
Double center (msec)	Pre Test	28.77	18.96	-1.281	12	.026*
	Post Test	33.51	15.05			

When Table 7 is examined, a statistically significant difference is seen between the left, right and Double center balance pre-post test values of the boxers (p <0.05).

DISCUSSION

Boxing is one of the combat sports that require high physical capacity and skill. The perfection of the movements performed during the performance of the performance depends on the previous training. The more the training is suitable for the competition conditions, the more appropriate the performance performed. In order to have a high level of performance, elite athletes are under the influence of many physical, motor and biochemical factors.

The purpose of speleotherapy in this study (in salt caves) of body composition high intensity resistance training on the medium, punch speed, jump, reaction time, hand grip strength, balance and aerobic power ability influence in study on Turkey Men's Olympic Boxing national team athletes this study formed the research group. The variation of the measured parameters within the group according to the pre-test and post-test was examined. Our study has the feature of being the first study conducted in the rock salt cave (speleotherapy) environment. In the literature, there is no study examining the performance parameters of boxers in rock salt environment. Therefore, existing boxing studies in the literature were evaluated.

It was determined that there was no statistically significant decrease in the body weight values of the athletes participating in the study (p <0.05). In our study, the body weight of the athletes before the study was 82.37 kg, while it was seen to be 82.26 kg after the study (Table 1). World and European degrees resulted with 11. The Turkish national team jersey wearing five of them in the top three in Turkey Championship in Category 'E entered a total of 16 fighter 12 week training program after a study that examined the change and development in the physical and respiratory parameters, pre-test 70.93 kg boxer of body weight while the post-test average was reported to be 70.73 kg [20]. While the average body fat ratio of the athletes before the study was 11.89%, it was observed that it was 11.51% after the study (Table 1). Pala and Savucu (2011) stated in their study that there was no statistically significant difference in the average body fat ratio of the boxing group, which was 12.32% before and 12.33% after the camp [21]. It was determined that there was no statistically significant decrease in the BMI values of the athletes participating in the study (p <0.05). In our study, it is seen that the average BMI of the athletes before the study was 24.59 kg\m^2, and 24.59 kg\m^2 after the training (Table 1). Pala and Savucu (2011) found the BMI values of the boxers as 22.11 kg\m^2 before the camp and 22.19 kg\m^2 after the camp [21]. It was determined that there was no statistically significant decrease in Skeletal Muscle Weight values of the athletes participating in the study (p <0.05). In our study, it is seen that the average skeletal muscle weight of the athletes before the study was 41.36 kg and 41.74 kg after the study (Table 1). Mack et al. (2002) found the boxers' BMI values as 22.11 kg \ m^2 before the camp and 22.19 kg\m^2 after the camp [22].

While the left punch pre-test was 7.89 cm / sec for the punch speed produced by the athletes participating in the study during the Straight Guard strike, it was 8.20 cm / sec in the last test, 7.83 cm / sec in the right strike pre-test, and an improvement with 8.80 cm / sec in the final test, There is a statistically significant difference between the pre-post test values of the punch speed they produced during the stroke (p <0.05). Considering the studies conducted in this field in the literature, the most important determinants of success in boxing are punch strength and speed [23,24]. In the study of Lenetsky et al. (2013), it was shown that fist strength in combat sports is more effective in determining the outcome of the match. However, considering that fist speed is directly related to fist force, it is one of the parameters that should be evaluated [25]. In their study, Chadli et al. (2014) found that the impact strength of the direct fist in elite boxers was similar to the fist speed values we found [26]. Scott (2005) found fist speed in the range of 6.60-12.50 cm / sec in his study [27]. The results of his study conducted by Smith (2006), as well as the results of the research determined in the literature support our study [28].

Jumping values of the athletes attending in the research; the value they produced during the squat jump was 30.6 cm in the pre-test, 32.71 cm in the post-test, 31.96 cm in the active jump pre-test, 33.00 cm in the post-test, 14.35 seconds in the post-test, 8.25 seconds in the post-test, and 11.94 seconds in the average of 15 jump in the pre-test. While the number of leaps of 6.44 seconds and 15 seconds in the post-test was 30.25 repetitions in the pre-test, a statistically significant difference was observed

between the different jump height, duration and number of repetitions of the boxers with 34.5 repetitions in the post-test ($p < 0.05$). When monitoring the studies in this field in the literature; In a study in which the relationships between the vertical jumping abilities of elite boxers were examined, 26 male boxing national team athletes in the adult category participated in a study, it was found that there was a high level of positive and significant correlation between vertical jumping and speed ability [29]. Pala and Savucu (2011), Old Men's Boxing National Team vertical jump (cm) parameter; it is stated that the value of 33.05 cm before and after the camp was 34.55 cm, and the increase was statistically significant. In similar studies performed on national team boxers, similar values such as 39.57 cm, 43.45 cm, 47.82 cm were determined in the vertical jump values of the Turkish Boxing National Team in different periods [21]. There was a statistically significant difference found in the vertical jump values in the study of Savaş et al (2004) about the effects of the eight-week pre-season training program on the physical and physiological characteristics of male boxers [16]. The research results specified in the literature support our study.

The technical parameter values of the athletes participating in the study were 57.17 kg in the left pre-test for hand grip strength, 59.89 kg in the final test, 57.14 kg in the right pre-test, 58.93 kg in the final test, and the pre-test for the force produced by the boxers during the hand grip strength. There is no statistically significant difference between the post-test values ($p < 0.05$). Researchers have stated that the grip strength is directly related to the general strength structure of the body and in a sense it is thought to give general information about physical force. As a sports vehicle, it is observed that the hand grip strength for the branch is also high in the branches that it is directly related to. When looking at the studies in this field in the literature; Aydos et al. (2004) made obvious that the research results on the left hand grip strength values Aydaş with the results of their research found close to one another in all sports Turkey national boxing team of hand grip strength values are supporting our work in terms of the lack of differences by finding 41.90 [30,31]. In terms of studies conducted in different branches, the research results of Savaş and Sevim (1992), who determined that the difference between right-hand and left-hand grip strengths of boxers, karate players and taekwondo players is meaningless, support our study [32].

Reaction test mean values of the athletes participating in the research; While the pretest is 0.66 seconds, there is a statistically significant difference between the reaction test averages of 0.59 seconds in the posttest ($p < 0.05$). Considering the studies done in this field in the literature; O'Donovan et al. (2006) showed a significant difference between the visual hand reaction times of boxing athletes [33]. In a study conducted by Savaş et al. (2004), a significant difference was found between the averages of visual reaction times of boxing athletes [16]. The research results determined in the literature support our study.

VO_2 max values of the athletes participating in the research; While the pre-test was 69.48 ml / kg / min, a statistically significant difference was observed between 72.3 ml / kg / min in the post-test and aerobic power (endurance) values ($p < 0.05$). Considering the studies conducted in this field for the literature, in the studies of Alan et al., They applied aerobic training at sub-maximal intensity for 12 weeks to adult subjects. At the end of the training program, it was observed that there was a 9% improvement in the VO2 max values of the participants [34]. Hopkins et al. Applied 60-80% Cross-fit for 8 weeks, 3 days a week to 17 men aged between 30 and 45 years, and at the end of the study, a significant increase of 6% was observed in VO_2 max values [35]. In terms of cardiovascular endurance, the results obtained in our study are similar to the studies in the literature.

In the aspects of balance parameter values of the athletes participating in the study, the left center pre-test was 20.78, 37.68 in the post-test, 30.79 in the right center pre-test, 40.88 in the post-test, 28.77 in the double-center pre-test, 33.51 in the post-test, a statistically significant difference between the boxers' pre-post test values for balance and there is a difference at ($p < 0.05$) level. Boxers need a lot of balance during industry-specific techniques and movements. The golden rule in boxing is to keep body weight in the back standing continuously [36]. Soykurt, (2017), in his study on boxers, found that among the balance measurements, the athlete single-leg balance test has the best balance according to the general and double-leg balance, while the middleweight group has the worst balance [37], Chen et al. (2012) found a statistically significant difference in the static and dynamic balance values of patient and non-patient boxers [38]. Chaabene et al. (2015) resulted that when comparing the dynamic balance of boxers and wrestlers, the contribution of visual information (anterior-posterior for dynamic postural state) in boxers in challenging conditions is greater than that of wrestlers [39]. The research results determined in the literature support our study.

It has been found that training in rock salt environment increases the performance of boxers. It is predicted that this situation should be studied in different sports branches.

CONCLUSION

In the salt cave environment (speleotherapy) of the National team boxers who need different gains in the preparation process for the 2021 Tokyo Olympic Games, the gas components in the air, low relative humidity, increasing negative ion content, bacterial flora and the absence of air allergens, slightly increased carbonic acid content, With the effect of continuous self-cleaning feature of the underground environment with air flow, resistance training in the salt cave increased the performance-oriented punch speed, jump, reaction, VO2 max and balance abilities.

According to this; High intensity resistance training in the salt cave is caused by resistance and functional strength exercises performed in the salt cave in increasing the punch speed, it is effective in the jumping ability time, and the leg strength and power abilities in training play a role in the formation of this effect after the trainings, it is effective in decreasing the reaction time and training. It can be interpreted as the exercises for arm strength and power abilities in training play a role in the formation of this effect. In addition, it has been observed that the sports activities in

the cave have an important effect on the physiological development of the motoric properties and reaction time found in the human body, and the activity type also affects the specified characteristics at various levels.

This short-term enhancement in VO2 max ability, which is considered as one of the most important expected effects of the applied training, can be interpreted as a result of the effect in the salt cave. Besides, it can be said that it is effective in increasing the balance values, but this effect can be thought to be due to the content of high-intensity training, especially for strength and active balance.

On the other hand, there was no difference in body composition and hand grip strength abilities. The low frequency of training in the cave for body composition can be interpreted as shortness and no difference due to variations in nutrition programs for athletes' weight during the Olympic preparation process. Its ineffectiveness on the hand grip strength can be interpreted as this effect is due to the fact that the exercises for maximal force take fewer places in the work of boxers whose hand grip strength is at the upper limits. In the preparation process of the Olympic Games related to the study area, the national team boxers who need different gains were evaluated together with the indoor facilities of the salt cave (speleotherapy) and according to the results of the study; it is thought that the rock salt cave is efficient in raising the sports performance.

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