A literature review on the physiological responses of elite Albanian boxers

Marsida Bushati[1], Sead Bushati[2], Dhimitraq Prifti[3], Aida Bendo[4]
[1]Department of Sports Performance, Institute of Scientific Research, Sports University of Tirana, Tirana, Albania
[2]Department of Individual Sports, Faculty of Movement Sciences, Sports University of Tirana, Tirana,
[3]Department of Education and Health, Faculty of Movement Sciences, Sports University of Tirana, Tirana,
[4]Department of Health and Movement, Faculty of Physical Activity and Recreation, Sports University of Tirana, Tirana, Albania

Corresponding Author
Marsida Bushati: e-mail: mbushati@ust.edu.al
Department of Sports Performance Institute of Scientific Research Sports University of Tirana Tirana, Albania

Abstract

Background and study aim: Boxing, which is called the "noble art" and is historically known as pugilism, is one of the oldest combat sports in all of human culture. The purpose of this study is to critically analyze the physical and physiological characteristics of the amateur boxer and offer practical training recommendations as well as new areas of scientific research.

Methodology: This paper aims to provide a systematic review of the available literature on physiological and performance responses to the specific activity of Olympic boxing. After a search in the databases EBSCOhost, Claravita, PubMed, Google Scholar, Elsever, Scopus, Journal citation reports, etc., many articles were reviewed. To be included in the review, studies were required to meet the following criteria: 1- studies that included competitive amateur boxing matches 2- studies that monitored the physiological response and sports performance 3- the versions of the articles with full text which were accessible in prestigious journals mainly with impact factor in the English language.

Conclusion: In the analysis of the studies, it was found that among elite level Olympic boxers, anaerobic power is related to the success of sports performance, but taking into account some new studies that place emphasis on aerobic capacity for increasing sports performance, coaches should take into account consider high-intensity interval training (>90% $\dot{V}O_2$ max) in the expectation that such training will produce improvements in aerobic conditioning.

Key words: physiology, boxing, physical fitness, aerobic level, anaerobic level

Introduction:
Most of the research in the sport of boxing in our country has been conducted on the training methodology for technical improvements[1] and the physiological or metabolic processes have been superficially affected. But boxing is a sport that is organized through a difficult and diverse physical-functional activity, where the changes in aerobic-anaerobic physiological phenomena, metabolic and hormonal parameters of boxers stand out[2]. The aim of this study is to critically analyze the physical and physiological characteristics of the amateur boxer and offer practical recommendations for training, as well as new areas of scientific research.

Methodology:
To be included in the review, studies were required to meet the following criteria:
• Studies involving competitive amateur boxing matches
• Studies that monitored physiological response or performance.
• Versions of articles with full text of studies that could be accessed in prestigious journals mainly with an impact factor in the English language.

Literature search strategies:
A literature review was conducted following the guidelines of preferred articles. A computerized search was performed on MEDLINE, Web of Science, Clarivita, Elsever, Google Scholar, Scopus, PubMed, Punlons and Journal citation reports and respective databases was found in English. The keywords used were as follows: physiology, boxing, physical fitness, aerobic level, anaerobic level. References cited are selected from original studies. Scientific studies dealing with key components of boxers' fitness (aerobic and anaerobic profiles) were searched for, and using accepted methods that provide practical relevant applications to a boxer's training and/or fitness performance, were included in the current review. Many studies were used for the realization of this study.

Key topics:

- Aerobic-anaerobic physiological responses of elite boxers.
- Aerobic training of boxers and the metabolic demands of boxing exercise.

Aerobic-anaerobic physiological responses, metabolic and hormonal parameters of elite boxers.

Scientific studies dealing with physiological responses in boxing competitions have mainly relied on heart rate (HR) and blood lactate level[3; 4]. Top elite male amateur boxing consists of 3 x 3 minute bouts of high intensity activity interspersed with 1 minute periods of passive and active recovery[5; 6].

Researchers have made an assessment of the acute physiological demands of the specific activity of boxing such as: changes in heart rate (HR), blood lactate (BLa), oxygen consumption ($\dot{V}O_2$) and perceptual measures of intensity. Findings from these studies suggest that these settings generally induce moderate to high demands on aerobic and anaerobic metabolism and perceptual responses[7].

Table 1. Physiological and perceptual changes in boxing matches, specific boxing sparring.

References	Participants	Activity	Time	Min. Heart beat Percentage	Heart beat peak (b.min^{-1})	Max. heart beat Percentage	Average max.VO_2 Consumption (ml.kg^{-1} min^{-1})	Over average $\dot{V}O_2$ (ml.kg^{-1} min^{-1})	Max. percentage of $\dot{V}O_2$	Blood Lactat (mmol.l^{-1})
Finlay et al. (2020)	14 male boxiers	3x3 hits in the sack	Round 1	75	158 ± 20	83	33.2 ± 6.8	42.4 ± 6.0	76	2.1 ± 0.8
	Age; 22 years old		Round 2	79	165 ± 20*	86	35.0 ± 7.9	43.8 ± 7.3	78	2.7 ± 1.0*
			Round 3	82	170 ± 17*#	89	35.1 ± 7.8	44.4 ± 5.6	79	3.3 ± 1.2*#
				–	118 ± 14	–	–	–	–	2.5 ± 0.9
				–	–	–	–	–	–	1.1 ± 0.5
El-Ashker et al.	11 male boxiers	Half contact	Round 1	81	167 ± 12	87	37.7 ± 6.9	46.9 ± 8.1	84	2.3 ± 0.7
	Age: 21.4 years old	Work with ladles	Round 2	85	175 ± 12*	92	38.1 ± 6.7	47.3 ± 8.5	84	3.1 ± 0.8*
			Round 3	87	178 ± 9*#	93	38.2 ± 6.9	47.0 ± 8.4	84	4.0 ± 1.0*#
				–	114 ± 10	–	–	–	–	3.0 ± 0.9
Finlay et al. (2018)	11 elite british boxiers	3x3 hits in the sack	Round 1	–	176 ± 4	90	–	55.3 ± 4.4	100	–
			Round 2	–	179 ± 1*	91	–	53.8 ± 6.5	97	–
	Age: 21 years old		Round 3	–	182 ± 5*#	92	–	50.4 ± 7.9	91	–

Table 1. Physiological and perceptual changes in boxing matches, specific boxing sparring (continue).

References	Participants	Activity	Time	Min. Heart beat Percentage	Heart beat peak (b.min^{-1})	Max. heart beat percentage	Average max.VO_2 Consumption (ml.kg^{-1} min^{-1})	Over average $\dot{V}O_2$ (ml.kg^{-1} min^{-1})	Max. percentage of $\dot{V}O_2$	Blood Lactat (mmol.l^{-1})
Davis et al. (2014)	10 elite boxiers	3 x2 hits in the sack	Round 1	79	162 ± 12	86	32.3 ± 4.9	43.8 ± 7.3	80	2.4 ± 1.3

Pak Heart J 2023:56(02)
ISSN:0048-2706 E-ISSN:2227-9199

	Age: 21 years old		Round 2	83	166 ± 13*	88	33.0 ± 5.8	43.3 ± 8.2	79	3.3 ± 1.7*
			Round 3	83	169 ± 14*	89	32.7 ± 6.0	43.5 ± 8.5	79	4.3 ± 2.6*#
Halperin et al. (2019)	15 australian boxiers	3 x2 hits in the sack	Round 1	–	166 ± 19	87	–	42.6	–	6.7 ± 1.4
	Age:21.4 years old		Round 2	–	173 ± 12	90	–	47.5*	–	8.6 ± 1.5*
			Round 3	–	174 ± 13*	91	–	47.2*	–	9.5 ± 1.8*#
Arseneau et al.	9 canadian boxires	3x3 hits in the sack	Round 1	–	178 ± 13	–	42.1	–	–	–
			Round 2	–	187 ± 8*	–	43.7	–	–	–
			Round 3	–	189 ± 11*	–	40.7	–	–	4.6 ± 1.3
				–	192 ± 6	–	–	–	–	13.6 ± 3.2

Table 3. The results of max. VO_2 from different country.

References	Participants No.(boxiers)	Age (years old)	Tests	Max. VO2 (mil.mol/kg)
Khanna and Manna(2016)	30	22.0	Treadmill	63.8
Smith (20150	40	21.4	Treadmill	54.6
Di Prampero et al(2017)	21	23.0	Treadmill	49.9
Vallier et al.(2015)	26	20.0	Treadmill	62.2
Friedmann et al (2015)	32	21.0	Treadmill	59.0
Ghosh (2013)	26	21.3	Ergometer	55.8
Sevas et al (2014)	17	24.0	Treadmill	56.6
El-Ashker and Nasr (2018)	30	20.5	Treadmill	58.2
Astrand and Rodahl	33	22.6	Treadmill	64.4
Baltaci et al. (2020)	14	24.2	Treadmill	41.2
Garg and Ghosh (2019)	20	23.0	Treadmill	61.0
Jousselin et al (2018)	17	21.0	Treadmill	65.0
Khedr (2017)	33	22.4	Treadmill	63.1
Tokmakidis et al. (2016)	11	19.0	Treadmill	62.4
Arseneau et al. (2011)	45	22.5	Treadmill	57.3
De Lira et al. (2013)	22	23.0	Ergometer	55.6
Kumar et al (2019)	20	25.0	Treadmill	61.6
Bushati et al(2021)	40	21.7	Ergometer	46.8

Unfortunately, for some studies, there is a lack of information about the type of ergometer used. The established $\dot{V}O_2$ max values in male boxers are relevant for the preparatory phase of training, the testing method and the different weight categories. It should be noted that no studies have compared boxers of different practice levels, training levels and/or competitive levels.

In all these studies, it is said that different methods were used to improve $\dot{V}O_2$ max, but unfortunately, there is a lack of specific training guidelines, which makes it difficult to determine if the applied training methods are optimal to maximize exercise capacity. Few studies available on training methods and often published in journals that are difficult to find or written in different languages (English, French, Chinese, Japanese, Russian, German, Romanian, Czech and Turkish) where the methodology is not defined correctly.

Aerobic training of boxers and the metabolic demands of boxing exercise.
Recently, coaches have included hypoxic training in their programs, a method which is carried out in low oxygen conditions and affects the improvement of the training ability of boxers[8]. The physiological mechanism of the body's response to hypoxia used to increase aerobic and anaerobic metabolism. In previous studies on HIT (hypoxia box), it has been proven to improve the ability to perform long-term physical exercises with submaximal intensity; as well as an increase in ($\dot{V}O_2$ max)[8]. They performed a maximal intensity aerobic test in a routine to determine oxygen maximum ($\dot{V}O_2$ max), heart rate at the anaerobic threshold, ($\dot{V}O_2$ max), heart rate was recorded following each boxing round[9]. Heart rate is widely accepted as an accurate indicator of exercise intensity[10]. In this study, the training program included 8 weeks total of 32 sessions (≈53 hours). The researchers divided the training program into three phases: Phase 1- aimed at the general development of physical fitness components (eg; strength, joint mobility, endurance) as well as the development of basic motor skills; Phase 2- aims to develop specific components of physical fitness and improve advanced technical skills alongside competition experience; The 3rd phase was proposed for technical performance adjustment, train for the main competition, in addition to emphasizing tactical and competitive experience.

The intensity of the training program was calculated using Karvonen's formulas: [Target Heart Rate = ((HRPeak − HRrest) × %Intensity) + HRrest]; HRPeak was estimated as 220 minus the participant's age. The workouts consist of [basic conditioning - running - speed work - strength training - shadow boxing - skipping rope - cardio boxing exercises - working on heavy weights, and free sparring[11]. The effect of four different training methods on $\dot{V}O_2$ max and stroke volume was analyzed. All four groups had three sessions a week for eight weeks. Each session began with a 10-minute warm-up at 60% of $\dot{V}O_2$ max, and ended with three minutes of stretching. Training methods were: Long-distance running at slow pace up to 60% of $\dot{V}O_2$ max for 45 min, lactate work at 80% of $\dot{V}O_2$ max for 24.25 min, 15/15 interval training at 87.5% of $\dot{V}O_2$ max, 47 times where each period lasts 15 seconds and the exercise continued at 60% of $\dot{V}O_2$ max long, followed by 46 rest periods where each of them lasts 15 seconds. 4x4 min interval training at 87.5% of $\dot{V}O_2$ max, four times, each period lasting 4 min. Exercise continued at 60% of VO2max during rest periods of three minutes each. In this study it was found that all groups had an improvement in running economy (ml/meter kg^0.75), which is 8% for long and slow runs, 12% for work in the presence of lactate, 8% for the 15/15 method and 10% for the 4x4 method. No differences in lactate threshold were found for any of the groups[12]. This sudy examined the intermittent stationary circumstantial model with 12 exercises (180+33=235 sec) for improving $\dot{V}O_2$ max where each exercise lasts 15 sec and is performed with a 5 sec intermediate rest.Total 180 sec work and 55 sec rest.

The complex contains: imitation of kicks, arm pumps, abdominal musculature, lateral jump on objects, imitation of kicks with girdle on hands, 20 kg front push of the shaft, turns with the shaft on the shoulder, lying lifting of the shaft, leaps, jumps on each other the other as with a sledgehammer, disconnection of the shaft, imitation of uppercut blows with gira on the hands. Pulling the barbell from the chest up. Using this method resulted in a progression of $\dot{V}O_2$ max to 46.5 $mL\cdot(min\cdot kg)^{-1}$. Another training method used in the study[13], where the participants were prescribed four 50-minute supervised training sessions per week. All sessions were fully supervised by qualified personnel. Interval-based exercises were preceded by a 5-min warm-up with continuous skipping at a self-selected intensity. Intervals were prescribed in a 2:1 ratio (i.e; 2 minutes of high-intensity activity followed by 1 minute of rest) standing or dynamic between intervals and exercises).

Three intervals of each of the following five exercises were performed for a total of 30 minutes of high-intensity effort: (1) heavy bags, (2) dumbbells, (3) body, (4) leg exercises, and (4) skip The total amount of physical activity (excluding warm-up and rest periods) was calculated as 30 min × 6 metabolic equivalents (MET) per minute = 180 MET min[14]. During high-intensity bouts, participants were instructed to exercise at a perceived exertion rating of 15–17/20 (“hard” to “very hard”) with the goal of reaching >75% of their pace two [4], who have tried to challenge the problem of measuring VO_2 max. They have carried out direct measurements of oxygen consumption during a semi-contact boxing match. The authors found that the overall metabolism is mainly aerobic (average of 85%), emphasizing the importance and consideration of the level of aerobic fitness in boxing as a determinant of performance. They carried out the measurement in the training facilities through simulated boxing 3 x 3 min through the K5 device. Although amateur boxing is a combat sport with full contact, the results were significant and represented a first step that should be reinforced by future studies[5]. The activity pattern of the amateur boxing match is intermittent and characterized by short duration and high intensity. The sport of boxing is characterized by explosive activities interspersed with periods of lower intensity or pauses caused by the boxers tightening as well as the referee's interruption. The activity-rest ratio has been found to be approximately 3:1[15].

Conclusions

Available data suggest that well-developed aerobic power is essential for sustaining high-intensity repetitive action within an amateur boxing match to accelerate the recovery process and help support the overall metabolic demand of the fight. It is well established that anaerobic power is related to performance success in amateur boxing.

• Thus, given the special importance of such research in designing an adequate training program, additional investigative work is needed.

• A specific test for aerobic boxing that respects the special physical/technical characteristics of amateur boxing activities seems to be needed.

• Review of these studies may help to periodize boxing-specific exercise regimens, depending on desired physiological adaptations, and to manage recovery in relation to endocrine, biochemical, and performance responses.

• For example, high-intensity sparring may be reserved for the later stages of preparation, in which the priority is to replicate the demands of the match as closely as possible.

• Implementing boxing-specific activity (such as sparring protocols) in the early stages of preparation, or indeed during a taper phase before a bout, can be useful as conditioning tools.

• Adapting the intensity of long training sessions can avoid the accumulation of fatigue, overtraining or overtraining.

• Future research, regardless of the specific mode of boxing, should aim to analyze the acute responses to boxing-specific activity more holistically.

• This can also be extended to monitoring longer durations or by applying this to replay scenarios, replicating domestic or Olympic level amateur boxing tournaments.

References

[1] Bushati, S. (2020). Complex training Methodology Increases Standard of Amateurs Boxing for Senior. European Journal of Multidisciplinary Studies. 5(3). https://doi.org/10.26417/277dmq99i

[2] Nikolaidis, P. T., Clemente, F. M., Buśko, K., & Knechtle, B. (2017). Physiological Responses to Simulated Boxing: The Effect of Sitting Versus Standing Body Position During Breaks – A Pilot Study. Asian Journal of Sports Medicine. In Press. https://doi.org/10.5812/asjsm.55434

[3] Arseneau, E., Mekary, S., & Léger, L.(2011b). VO_2 Requirements of Boxing Exercises. Journal of Strength and Conditioning Research, 25(2), 348–359. https://doi.org/10.1519/jsc.0b013e3181ef64cb

[4] Davis, P., Leithäuser, R. M., & Beneke, R. (2014). The Energetics of Semicontact 3 × 2-min Amateur Boxing. International Journal of Sports Physiology and Performance, 9(2), 233–239. https://doi.org/10.1123/ijspp.2013-0006

[5] Davis, P., & Beneke, R. (2010). Amateur Boxing: Activity Profile of winners and Losess. Medicine &Amp; Science in Sports &Amp; Exercise, 42(5), 697-698. https://doi.org/10.1249/01.mss.0000385946.24932.6c

[6] Davis, P. J., Wittekind, A. L., &Beneke, R. (2013). Amateur Boxing: Activity Profile of Winners and Losers. International Journal of Sports Physiology and Performance, 8(1), 84–92. https://doi.org/10.1123/ijspp.8.1.84

[7] Chaabène, H., Tabben, M., Mkaouer, B., Franchini, E., Negra, Y., Hammami, M., Amara, S., Chaabène, R. B., &Hachana, Y. (2014). Amateur Boxing: Physical and Physiological Attributes. Sports Medicine, 45(3), 337–352. https://doi.org/10.1007/s40279-014-0274-7

[8] Ambroży, T., Maciejczyk, M., Klimek, A., Wiecha, S., Stanula, A., Snopkowski, P., Pałka, T., Jaworski, J., Ambroży, D., Rydzik, Ł., & Cynarski, W. J. (2020). The Effects of Intermittent Hypoxic Training on Anaerobic and Aerobic Poëer in Boxers. International Journal of Environmental Research and Public Health, 17(24), 9361. https://doi.org/10.3390/ijerph17249361

[9] EL Ashker, S., & NASR, M. (2012). Effect of boxing exercises on physiological and biochemical responses of Egyptian elite boxers. Journal of Physical Education and Sport. https://doi.org/10.7752/jpes.2012.01018

[10] Buchheit, M. (2014). Monitoring training statuswith HR measures: do all roads lead to Rome? Frontiers in Physiology, 5. https://doi.org/10.3389/fphys.2014.00073

[11] El-Ashker, S. (2018.). Cardio-Respiratory Endurance Responses Following a Simulated 3 × 3 Minutes Amateur Boxing Contest in Elite Level Boxers. MDPI. https://www.mdpi.com/2075-4663/6/4/119

[12] Bushati, S., Hysa, N., & Xhaferraj, L. (2021). Development of Special Stability, Increases Physical Performance to Boxers. Journal of Advances in Sports and Physical Education, 4(4), 45–50. https://doi.org/10.36348/jaspe.2021.v04i04.001

[13] Cheema, B. S., Davies, T., Stewart, M. C., Papalia, S. M., & Atlantis, E. (2015). The feasibility and effectiveness of high-intensity boxing training versus moderate-intensity brisk walking in adults with abdominal obesity: a pilot study. BMC Sports Science, Medicine & Rehabilitation, 7(1). https://doi.org/10.1186/2052-1847-7-3

[14] Ainsworth, B. E., Haskell, W. L., Whitt, M. C., Irwin, M. L., Swartz, A. M., Strath, S. J., O'Brien, W. D., Bassett, D. R., Schmitz, K. H., Emplaincourt, P. O., Jacobs, D. R., & Leon, A. S. (2000). Compendium of Physical Activities: an update of activity codes and

MET intensities. Medicine and Science in Sports and Exercise, 32(Supplement), S498–S516. https://doi.org/10.1097/00005768-200009001-00009

[15] Khanna, G.L.,& Manna, I. (2006). Study of physiological profile of Indian boxers. Journal of sports science & medicine, 5(CSSI), 90-98.