REVIEW ARTICLE

Physical and physiological characteristics of kickboxers: a systematic review

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A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
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Abstract

Background and Study Aim: Kickboxing is one of the most popular martial arts in the world. A typical kickboxing fight consists of 3 rounds lasting from 2 to 3 minutes with a minute break between rounds. Kickboxing is combat sport where two types of fights occur: light-contact (tatami sports) and full contact (ring sports). The aim of this study was knowledge about the available information of body composition, body fat percentage, and aerobic and anaerobic performance indicators of kickboxers based on research from the last 10 years (with one exception, that formed the basis for subsequent research, using a systematic review an meta-analysis).

Material and Methods: The systematic review followed the Preferred Reporting Items for Systematic Review and Meta Analysis (PRISMA). Monitored indicators were somatotype and body fat percentage through skin measurement and bioimpedance analysis, aerobic performance by measuring VO_2max, anaerobic performance through Wingate test. A systematic search was conducted using Web of Sciences, Scopus. A total of 109 studies were screened and 15 were included in the meta-analysis. The inclusion criteria were: the study was published in 2010-2021, observational studies, the average age of the athletes involved in the study was 22 ±5 years, written in English. Data extracted from studies included 285 male athletes (age: 22 ±5 years; height: 175 ±6.7 cm; weight: 71 ±8.6 kg). The sample size, average and standard deviation of the selected characteristics of kickboxers were extracted from each selected study.

Results: Successful male kickboxers have been shown to have a low body fat percentage. In terms of somatotype, the mesomorphic component predominates in men kickboxers. Studies have shown high levels of maximal anaerobic performance of kickboxers.

Conclusions: These results could by an essential objective basis for evaluating some of kickboxers' physical characteristics and for trainers who could benefit from them when developing optimal training plans and setting training goal.

Keywords: body fat • physical fitness • somatotype • VO_2max • Wingate test

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INTRODUCTION

Kickboxing – combat sport where the form of combat are strikes, performed by hands and legs [41]; alternative definition: ***noun*** a form of boxing that involves kicking as well as punching [45].

Systematic review – is a scholarly synthesis of the evidence on a clearly presented topic using critical methods to identify, define and assess research on the topic [42].

Preferred reporting items for systematic reviews and meta-analyses (PRISMA) – an evidence-based statement containing the minimum set of elements necessary for proper reporting of systematic reviews and meta-analyses assessing the benefits and harms of healthcare [21].

Neo-gladiator – a person who trains mix martial arts (MMA) and similar forms of hand-to-hand fighting that do not meet the definition of sport according to the Olympic Charter, p. 18 [46].

Kickboxing is one of the most popular martial arts in the world. A typical kickboxing fight consists of 3 rounds lasting from 2 to 3 minutes with a minute break between rounds. Kickboxing is combat sport where two types of fights occur: light-contact (tatami sports) and full contact (ring sports) [1]. International level competitions have the following age categories: juniors (from 16 to 18 years old) seniors (from 19 to 40 years old) and veterans (from 41 to 50 years old). Kickboxing medallists have 5-7 fights in international competitions, during which they have to perform a large number of kicks and punches. For this reason, high physical and physiological demands are placed on them [2].

In order to achieve the desired results in sports, it's necessary for an athlete to have certain characteristics, among which is very important the body structure, which also plays a role in the physical performance of an athlete [3]. In addition, maintaining an optimal body weight is an important element of the training process and allows athletes to choose the weight category in which they perform best [4].

Changing a weight class to heavier one challenges athletes to fight with new opponents with different body built proportions. The competitors try to maintain they optimal body weight so they could in the weight class that fit them best [5]. Kickboxers who compete in lower weight classes are likely to by characterized by higher technical and tactical skills. The level of body fat and muscle tissue can affect the level of technical and tactical performance [6].

It can be stated that kickboxing is a complex sport with requirements including a number of specific features to achieve a high level of competitive performance. It is well known that understanding the characteristics of top athletes can provide insightful information about what is really needed for competitive success [7].

The optimal level of physical performance of an athlete is a key element of efficiency in sports competition [5]. The proper functioning of the cardiovascular system is the basis of physical fitness of kickboxers, because it allows the repetition of intense attacks throughout the fight and also ensures regeneration after the fight [8]. Physical effort is based on submaximal and maximum effort. Martial arts such as kickboxing, which are characterized by high intensity attacks, are mostly based on anaerobic energy sources such as anaerobic glycolysis. Aerobic resources are important between attacks and at the end of the fight, so the kickboxers' training process should include the development of both of these energy systems [2]. Particularly, physiological characteristics of athletes are generally measured by testing their fitness and skill components [9]. Athletes need to know their physical characteristics for effective training because high level of physical fitness can affect their exercise performance. Suppose there is a basis for the standard distribution of physical fitness profiles necessary for the characteristics of sports events [10]. Although the physical characteristics of kickboxers have been well describes in the previous studies [7, 11-14], but no studies have examined the standard distribution of physical fitness characteristics.

Zabukovec et al. [7] was first who contributed about physiological and anthropometric profile of elite kickboxers, but the sample size formed only 4 kickboxers. Silva et al. [15] verified also the physical characteristics of 13 elite kickboxers from the Portugal. Meanwhile, Ouergui et al. [16] divided 20 Tunisian kickboxers into winners and losers of kickboxing combat and comparing the physical fitness and performance between them. In addition, Burdukiewicz et al. [17] compared anthropometric profile of kickboxer with different combat athletes via multivariate analysis. Furthermore, Slimani et al. [18] reported anthropometric, psychophysiological and activity profile of kickboxers using a systematic review but did not present any quantitative results.

Previous kickboxing studies conducted over the last three decades have focused on improving performance through physical fitness characteristics, time motion analysis, specific physical assessments, and by describing the psychological factors that could affect the result of the fight [7, 11-14]. However, it is difficult to use them as a specific indicator because there is no standard distribution to evaluate the level of physical fitness characteristics. Standard distribution data are needed to determine the mean values of Kickboxer athletes' physical characteristics such as body composition, body fat percentage, aerobic and anaerobic performance indicators are [19]. However it can be analysed via a systematic review using the measured variables in previous study. Nevertheless, the validity and reliability of the resulting can be

questioned if different studies have different measurement tools. However, the measurement of physical characteristics has become common all of the world. [20].

The aim of this study was knowledge about the available information of body composition, body fat percentage, and aerobic and anaerobic performance indicators of kickboxers based on research from the last 10 years (with one exception [7], that formed the basis for subsequent research, using a systematic review an meta-analysis).

MATERIAL AND METHODS

The systematic review and meta-analysis followed the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) statement [21].

Search strategy

Data acquisition and processing consisted of several steps. The first step was to search the available resources related to our review study, which was performed up to June 2021 and regularly updated manually. To obtain information concerning selected characteristics of kickboxers, we used foreign scientific literature, scientific articles registered in databases: Web of Science and Scopus. To obtain the necessary in-formation in English, we used the term kickboxing together with the following keywords and their combinations: somatotype, body composition, physical fitness, VO_2max, Wingate test, training diagnostics, physiological characteristics, body fat.

New we input the database search results to Microsoft Excel and performed duplicate elimination. These studies focused on describing the body composition of kickboxers and indicators of aerobic and anaerobic performance. The inclusion criteria were: (a)the study was published in 2010-2021 with one exception, Zabukovec et al. [7], (b) observational studies (c) the average age of the athletes involved in the study was 22 ±5 years, (d) written in English. Articles were excluded for the following reasons: (a) data aside from physical characteristics; (b) irrelevant data for analysis; (c) unavailable full text; (d) duplicates.

Data extraction, quality assessment and risk of bias

Two independent reviewers performed the search, screened the titles and abstracts from the search results and reviewed the full text selected before the inclusion in the me-ta-analysis. The sample size, average and standard deviation of the selected characteristics of kickboxers were extracted from each selected study. Quality assessment was performed by two reviewers. A third reviewer was consulted to resolve any disagreements.

Pooled Mean Calculation

The pooled mean was calculated using the mean and sample size from the final selected study using Equation 1.

$$\mathrm{Mean}_{\mathrm{pooled}} = \frac{(m_1 x\, n_1)+(m_2 x\, n_2)+(m_3 x\, n_3)+\cdots+(m_1 x\, n_1)}{n_1+ n_2+\cdots+n_i-i} \quad \text{Eq.1.}$$

Note: **m** mean of each study; **n** sample size of each study; **i** number of studies.

Estimation Error Calculation

The estimation error was calculated using the sample size, standard deviation, and Z-score for a confidence level of 95% using Equation 2.

$$\mathrm{Error}_{\mathrm{estimation}} = \pm 1.96\, \mathrm{x}\, \frac{\sigma}{\sqrt{\mathrm{n}}} \quad \text{Eq.2.}$$

Note: **n** sample size; $\boldsymbol{\sigma}$ standard deviation.

RESULTS

Data search and characteristics of the studies

A total of 109 studies were screened, and after applying the criteria, we included 15 scientific studies were finally included in the meta-analysis. The screening and selection processes are shown in Figure 1.

From studies included in the meta-analysis 9 scientific studies [7, 22, 15, 23-26, 18, 27] out of these were focused on the proportion of body fat on the body composition of kickboxers (Table 1), 4 studies [7, 22, 23, 17] were focused on kickboxers somatotypes (Table 2) and 15 studies were focused on aerobic and anaerobic performance indicators of kickboxers, of which 6 studies examined aerobic performance [7, 15, 13, 25, 26, 18] (Table 3) and 9 studies examined anaerobic performance [7, 22, 11, 13, 24, 16, 33, 18, 31] in kickboxing (Table 4). Data extracted from 15 studies included 285 male

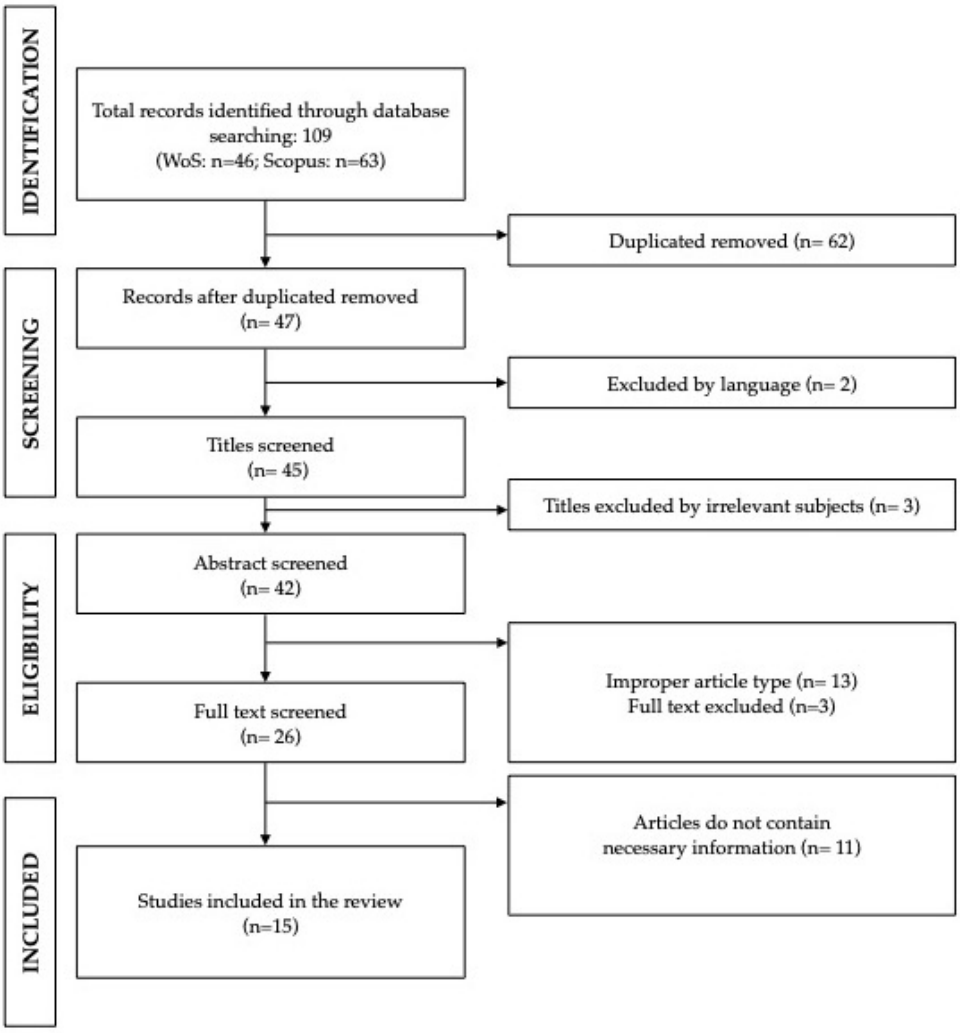

Figure 1. Flow diagram for the search and screened and included articles.

athletes (age: 22 ±5 years; height: 175 ±6.7 cm; weight: 71 ±8.6 kg), therefrom 84 athletes were on elite level, 40 were on subelite level, 73 on national level, 48 on recreational level and 40 athletes were on amateur level. We reviewed whether the final selected literature could allow an analysis selected characteristics of kickboxers by weight class, however, no weight class information was described. We attempted to classify the weight classes by the weight values from previous studies, although errors can occur because of the mean value.

Body fat percentage on body composition and somatotypes

Before each fight, kickboxers must meet the body weight limit by maximizing fat-free mass and minimizing fat mass [18]. The most utilized methods on body fat measurements was skinfold measurements (Table 1). For the male kickboxers, the total sample size in relation to the body fat percentages was 173. Pooled mean of percentage of body fat was 11.96 with estimated error 1.38%. STD pool was 1.50. One article found statistical differences between sub elite and amateur kickboxers [18]. In accordance with this approach, high-performance kickboxers have shown a tendency to low body fat values, with body fat values being around 12% for these kickboxers and for elite kickboxers body fat values being around 8-9% (Table 1).

Four articles about somatotypes were included in analysis. The most utilized methods to detected somatotypes was skinfold measurements (Table 2). For the male kickboxers, the total sample size in relation to the somatotypes was 67. Pooled mean of somatotypes values was for endomorphic

Table 1. The overview of research focused on body fat measurement in kickboxers.

Authors	Year	Participants (number, level)	Body fat (%) (average SD)	Method
Zabukovec et al. [7]	1995	Canadian (n = 4 elite)	8.1± 2	skinfold measurements
Nikolaidis et al. [22]	2011	Caucasians (n = 18 recreational)	14.5 ±5	not reported
Silva et al. [15]	2011	Portuguese (n = 13 elite)	9.72± 5.7	bioimpedance analysis
Catikas et al. [23]	2013	Turkish (n = 15 national)	12.20 ±3,07	skinfold measurements
Ouergui et al. [24]	2014	Tunisian (n = 30 amateur)	12.6± 3.5	not reported
Ljubisavljevic et al. [25]	2015	Serbian (n = 16 elite, n= 34 subelite)	11.42± 5.81	bioimpedance analysis
Salci [26]	2015	Turkish (n = 10 international)	9.5± 3.5	skinfold measurements
Slimani et al. [18]	2017	Arabian and Tunisian (n = 6 subelite, n=10 amateur)	10.8± 4.4 12.4 ±4.7	skinfold measurements
Mala et al. [27]	2019	European (n = 17 elite)	12.63± 3.92	bioimpedance analysis

component 2.87 with estimated error 1.09%. STD pool was 1.64. For mesomorphic component was 5.17 with estimated error 1.05%. STD pool was 1.52. For ectomorphic component was pooled mean 2.41 with estimated error 1.06%. STD pool was 1.56. Based on these researches, we can say that kickboxers have a profile that emphasizes their mesomorphic properties, in large amount of muscle mass and a low body fat percentages. These values are comparable to those observed of elite taekwondo athletes [28] and elite boxers [29] for whom somatotype values were: endo-morphic component 2.3 ±0.6; mesomorphic component 4.9 ± 0.7; ectomorphic component 2.3 ±0.8.

Aerobic and anaerobic performance indicators

The authors determined the aerobic performance of kickboxers by measuring the maximum oxygen consumption (VO_2max) by a continuous stress exercise test on a cycle ergometer or a treadmill test in the laboratory (Table 3). However, when comparing the results of the above studies, it is necessary to doubt the possibility of comparing aerobic performance, due to the use of different trainers, when due to the high degree of muscle groups involved, the values of VO_2max are about 5-10% higher when they are examined on a treadmill as when they are examined on a cycle ergometer [30]. However, in a study by Salci [26],

Table 2. The overview of research focused on kickboxer somatotypes.

Authors	Year	Participants (number, level)	Somatotype values (component)	Method
Zabukovec et al. [7]	1995	Canadian kickboxers (n = 4 elite)	endomorphic: 2.7 ±1.2 mesomorphic: 4.3 ±0.2 ectomorphic: 2.7 ±0.7	skinfold measurements
Nikolaidis et al. [22]	2011	Caucasians kickboxers (n = 18 ecreational)	endomorphic: 3.5 mesomorphic: 4.9 ectomorphic: 2.3	not reported
Catikas et al. [23]	2013	Turkish kickboxers (n = 15 national)	endomorphic: 2.9 ±1.3 mesomorphic: 4.25 ±1.30 ectomorphic: 3.10 ±1.30	skinfold measurements
Burdukiewicz et al. [17]	2018	Polish kickboxers (n = 30 recreational)	endomorphic: 2.5 mesomorphic: 5.9 ectomorphic: 2.1	skinfold measurements

VO_2max was determined in field conditions using a maximal multistage 20 m shuttle-run test. For the male kickboxers, the total sample size in relation to the aerobic performance was 123. Pooled mean of aerobic performance was 51.63 with estimated error 4.354%. STD pool was 2.23. Two article found statistical differences between kickboxers on different level [25, 18].

The most utilized methods to evaluate the anaerobic profile of kickboxers was Wingate test (Table 4). Results were expressed by maximal anaerobic power and fatigue index [7, 9, 31]. These variables were expressed for actions performed by both the upper and lower parts of the body [7, 11, 18, 31-33]. These studies showed that for sub elite kickboxers, the average values of anaerobic power were 3.6 $W \cdot kg^{-1}$ for the upper limbs, but for elite kickboxers, the average values of anaerobic power were around 4.7 $W \cdot kg^{-1}$ for the upper limbs and 10.5 $W \cdot kg^{-1}$ for the lower limbs. For the male kickboxers, the total sample size in relation to the anaerobic performance was 150. Pooled mean of peak power for arms was 5.62 with estimated error 0.729% and STD pool was 1.03. Pooled mean of mean power was 4.70 with estimated error 0.683% and STD pool was 1.02. For legs was pooled mean of peak power 1059 with estimated error 1.391% and STD pool was 1.26. Pooled mean of mean power was 10.08 with estimated error 1.006% and STD pool was 1.12.

DISCUSSION

In kickboxing, as well as in other combat sports (martial arts), where athletes are divided according to weight categories, the optimal body composition is important. However, due to the wide range of weight categories, it is not possible to create one optimal body type for a kickboxer or his somatic profile. The values of body fat percentage of kickboxers are very similar to the values of athletes in other combat sports. Body fat percentages of boxers, according to research by Chabene et al. [34] range from 9% to 16%, for MMA neo-gladiators these percentages range from 7% to 17% [35]. However, there are differences between kickboxers and high-level karate athletes, with karate athletes achieving lower body fat percentages ranging from 7.5% to 16.8% [36]. Such a comparison was also made in research by Mala et al. [27], when they compared the values of body fat percentages in six martial arts (karate, kickboxing, judo, fencing, wrestling, taekwondo), while the highest values of body fat percentages were reported by taekwondo athletes together with kickboxers. (12.63% to 12.82%). The lowest values of body fat percentages were found among judokas (9.81%). These observations suggest that, as in other martial arts, low body fat percentages appears to be assumption for high performance of kickboxers. However, to our knowledge, no attempts have been made to describe the percentage of body

Table 3. The overview of research focused on testing aerobic performance in kickboxing.

Authors	Year	Participants kickboxers (number, level)	Monitored Indicators	VO_2max ($ml \cdot kg^{-1} \cdot min^{-1}$)	Selected diagnostic tests
Zabukovec et al. [7]	1995	Canadian (n = 4 elite)	maximum aerobic power (VO_2max)	61.5 ±7.5	Spiroergometri on cycle ergometer
Silva et al. [15]	2011	Portuguese (n = 13 elite)	Maximal oxygen consumption, Maximum aerobic power (VO_2max)	57.99 ±10.3	Maximum treadmill test, with 1 minute stages
Ouergui et al. [13]	2014	Tunisian (n = 30 amateur)	maximum aerobic power (VO_2max)	51.9 ±4.3	The progressive maximal cycle ergometer test
Ljubisavljevic et al. [25]	2015	Serbian (n = 16 elite, n = 34 subelite)	maximal oxygen consumption (VO_2max)	57.99 ±10.3 47.6	Out laboratory Von Dobelin's test
Salci [26]	2015	Turkish (n = 10 international)	HRmax, VO_2peak	48.5 ±3.0	maximal multistage 20 m shuttle-run test
Slimani et al. [18]	2017	Arabian and Tunisians (n = 6 sub elite, n = 10 amateur)	Maximal oxygen consumption (VO_2max)	54.6 ±5.3 49.1 ±4.6	maximal multistage 20 m shuttle-run test

Table 4. Overview of research focused on testing anaerobic performance in kickboxing.

Authors	Year	Participants kickboxers (number, level)	Monitored indicators	Peak power ($W \cdot kg^{-1}$)	Mean power ($W \cdot kg^{-1}$)	Selected diagnostic tests
Zabukovec et al. [7]	1995	Canadian (n = 4 elite)	Anaerobic capacity, peak anaerobic power	A: 7.4 ±0.7 L: 18.1 ±4.6	A: 5.4 ±0.4 L: 10 ±0.7	30- sec. Wingate Anaerobic power test for arms and legs
Nikolaidis et al. [22]	2011	Caucasians (n = 18 recreational)	Maximal anaerobic power	NR	A: 7.01 ±1.68 L: 15.3 ±3.69	Force- velocity test for upper and lower extremities
Ouergui et al. [11]	2013	Tunisian (n = 18 elite)	Peak power, mean power, fatigue index	A: 5.89 ±0.69 L: NR	A: 4.51 ±0.53 L: NR	30- sec. Wingate Anaerobic power test for upper body
Ouergui et al. [13]	2014	Tunisian (n = 30 amateur)	Peak power, mean power, fatigue index	A: 4.3 ±0.7 L: 9.8 ±2.1	A: 3.2 ±0.7 L: 6.7 ±1	30- sec. Wingate Anaerobic power test for upper and lower body
Ouergui et al. [24]	2014	Tunisian (n = 18 regional)	Peak power, mean power, fatigue index	A: 5.85 0.83 L: NR	A: 5.56 ±0.56 L: NR	30- sec. Wingate Anaerobic power test for upper body
Ouergui et al. [16]	2015	(n = 20 regional and national)	Peak power, mean power, fatigue index	A: 5.8 ±1.3 L: NR	A: 4.56 ±0.56 L: NR	30- sec. Wingate Anaerobic power test for upper body
Ouergui et al. [33]	2016	(n = 20 regional and national)	Peak power, mean power, fatigue index	A: 5.6 ±1.2 L: NR	A: 3.6 ±0.9 L: NR	30- sec. Wingate Anaerobic power test for upper body
Slimani et al. [18]	2017	Arabian and Tunisian (n =6 sub elite, n = 10 amateur)	Peak power, mean power	Sub elite A: 7.6 ±0.8 L: 10.9 ±0.9 Amateur A: 6.5 ±0.9 L: 9.3 ±1.2	Sub elite A: 6.1 ±0.6 L: 8.5 ±0.9 Amateur A: 5.2 ±0.7 L: 7.1 ±1.1	30- sec. Wingate Anaerobic power test for upper and lower body
Bayrakdaroglu, Can [31]	2018	Turkish (n = 6 elite)	maximal anaerobic power, maximal anaerobic capacity, minimum power, fatigue index	A: NR L: 11.4 ±1.45	A: NR L: 7.82 ±0.57	30- sec. Wingate Anaerobic power test

Note: **NR** not reported; **A** arms; **L** legs.

fat of kickboxers in relation to different weight categories. As each weight category may require different body composition requirements, further research is clearly needed in this area.

Kickboxers have a profile that accentuates the mesomorphic properties (very high muscularity, low linearity and low fat). This tends to be accompanied by a smaller, albeit sometimes evenly distributed ectomorphic component, which characterizes the relative linearity and as significantly lower endomorphism, which reflects the relative degree of fatness. Male kickboxers athletes can be predominantly classified as "ectomorphic meso-morphs" in accordance with conventional descriptors [37]. These values are comparable to the values found in other martial arts such taekwondo [28], karate [38] and boxing [29]. Somatotype values for elite boxers [29] were: endomorphic component 2.3 ±0.6; meso-morphic component 4.9 ±0.7; ectomorphic component 2.3 ±0.8. Somatotype analysis of male categories in karate confirmed that karate athletes, just like kickboxers, have a profile that emphasizes their mesomorphic properties [38]. Somatotype values for international taekwondo athlete were: endomorphic component 2.4 ±0.9; mesomorphic component 5.1 ±1.2; ectomorphic component 3.6 ±1.1, which is comparable with values of kickboxers somatotype. The somatotype data presented here may serve as a framework for athletes training and a valuable composite of talent identification. The predominant mesomorphic and ectomorphic character of male kickboxers would suggest that a mixture of mild musculoskeletal tissue and relative body linearity with relative low fatness may be desirable for this sport.

Kickboxing is characterized by high intensity movements and short breaks, which are not sufficient for a full recovery during the rounds. The anaerobic metabolic pathway provides energy during short and intense attacks, while the aerobic system contributes to the ability of kickboxers to perform repeated attacks with the same strength and speed throughout the fight, further helping to optimize the energy recovery process during short breaks between series and has an effect on the effective recovery between subsequent fights [15]. Kickboxer´s performance is affected by both aerobic and anaerobic metabolism, so the kickboxer should focus on optimizing each of them [13]. The average values of VO_2max in the mentioned scientific literature fluctuated in male elite kickboxers between 54 and 69 ml · kg^{-1} · min^{-1}. These values are comparable with values in research in other martial arts as boxing, values of amateur boxers ranged from 49 to 65 ml · kg^{-1} · min^{-1}) [34], karate (values of karate athletes ranged from 47 to 61 ml · kg^{-1} · min^{-1}) [36] and taekwondo athletes (values of elite male taekwondo athletes ranged from 44 to 63 ml · kg^{-1} · min^{-1}) [28]. These findings prove that kickboxing, as well as other combat sports and martial arts, require high demands on the cardiovascular and respiratory systems. Available data on the VO_2max of different kickboxers level provide insight into their cardiorespiratory fitness, which can be useful in developing preparatory strategies in sports. However trainers and researchers could recognize the limitations associated with existing knowledge, because some studies obtained direct VO_2max measurements, while others relied on indirect estimates using a multistage shuttle run.

Intermittent high-intensity sports, including kickboxing, mostly depend on anaerobic energy source [39]. For kickboxers, the ATP-PCr energy system is especially important because combinations with a large amount of power can mean premature end of the fight [2]. Results of anaerobic power included in analysis are similar to those of Chabene et al. [36], where elite karate athletes achieved values of anaerobic power of the lower limbs on average 9.1 ±1.1 W · kg^{-1}. Higher values of anaerobic power were achieved by kickboxers in comparison with kung fu athletes, when the elite kung fu athletes showed values of anaerobic power of the upper limbs on average around 4.1 ±0.4 W · kg^{-1} [40]. Compared to boxers, there were no statistically significant differences in maximum anaerobic power in Can's et al. [31] research, which the authors explain by the same level of performance, similarity of martial arts and training systems in both groups. These findings confirm the importance of anaerobic training in kickboxer´s performance as well as in other martial arts. and suggest that the ability of the lower limbs to generate high peak power may be important in competition. The available data generated by the Wingate test provide insight into the anaerobic performance and capacity characteristics of kickboxers on different competitions level, which can be useful for developing preparatory strategies within sport. However, trainers and scientists should be aware of the basic limitations associated with the existing knowledge, in particular the lack of standardization of Wingate protocols and the mechanical specificity demonstrated by the test.

Differences in Wingate load, warmups, start-up procedures, test protocols and ergometer models may confuse the effectiveness of comparing data between existing examinations.

Throughout the analysis, some limitations in current literature were observed. Our review study focused only on male kickboxers, not female kickboxers, of varying performance levels reported in the included studies. Another limitation of the review study is the lack of information on weight categories that were not reported in the studies we selected. The very important issue of motor tests (with the use of sophisticated technology, but also non-apparatus and quasi apparatus tests [43]) and the usefulness of biochemical research in kickboxer training [44]. These issues go beyond the thematic framework of this work, although they are an indispensable element of the discussion of optimizing training not only for kickboxers from the health perspective.

CONCLUSIONS

This study estimated the standard distribution of each characteristics by aggregating previous studies measuring the selected physical characteristics of kickboxers through a systematic literature review. This study found that all selected characteristics of kickboxers and the estimated distribution of the physical fitness variables were generally applicable (estimated error of less than 5%). Successful male kickboxers have been shown to have a low body fat percentage. In terms of somatotype, the mesomorphic component predominates in men kickboxers. This study also prove that kickboxing require high demands on the cardiovascular and respiratory systems and kickboxers should focus on optimizing each of them. Studies have shown high levels of maximal anaerobic performance of kickboxers. These results could by an essential objective basis for evaluating some of kickboxers' physical characteristics and for trainer trainers who could benefit from them when developing optimal training plans and setting training goal.

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