Coll. Antropol. 41 (2017) 3: 267–274
Original scientific paper

Effects of Competitive Level and Gender on Anthropometric Profile and Physiological Attributes in Kickboxers

Maamer Slimani[1,2], Bianca Miarka[3], Foued Chéour[4]

[1] Department of Biological Sciences, Faculty of Sciences of Bizerte, Tunisia
[2] Research Laboratory "Sport Performance Optimization", National Center of Medicine and Sciences in Sport (CNMSS), Tunis, Tunisia
[3] Physical Education School, Federal University of Pelotas, Brazil
[4] High Institute of Applied Biology of Médenine, Tunisia

ABSTRACT

The aim of the study was to compare kickboxing competitive levels and genders in anthropometric, physical and physiological attributes. The sample was composed of four groups (subelite: 6 men and 4 women; amateur: 10 men and 8 women). Anthropometric measurements, 20-meter Shuttle Run aerobic test, Countermovement Jump (CMJ), Medicine Ball Throw (MBT), Bench Press and Back Squat Maximal Strength and Wingate-test for upper (UB) and lower-body (LB) before were used. We found that the subelite male and female kickboxers achieved significantly higher UB (male: subelite = 6.1±0.6 and 7.6±0.8 vs. 5.2±0.7 and 6.5±0.9 W.kg^{-1}, respectively; female: subelite = 4.8±0.6 and 5.9±0.8 vs. amateur = 3.7±0.8 and 4.1±1.1 W.kg^{-1}, respectively), LB mean and peak power (male: subelite = 8.5±0.9 and 10.9±0.9 vs. 7.1±1.1 and 9.3±1.2 W.kg^{-1}, respectively; female: subelite = 6.5±0.8 and 8.6±1.1 vs. amateur = 5.3±0.9 and 6.7±1.4 W.kg^{-1}, respectively). MBT (male: subelite = 4.6±0.3 vs. amateur = 4.1±0.4 m; female: subelite = 3.9±0.4 vs. amateur = 3.2±0.5 m) and maximal oxygen uptake (male: subelite = 54.6±4.3 vs. amateur = 49.1±4.6 ml.min^{-1}.kg^{-1}; female: subelite = 47.6±3.2 vs. amateur = 42.2±3.8 ml.min^{-1}.kg^{-1}) than amateur kickboxers. The effects demonstrated significant difference between male and female amateur kickboxers for anthropometric, physical and physiological performance (P<0.05) and a sexual dimorphism when compared the female subelite level with male groups. The performance of male and female kickboxers primarily depends on the anaerobic alactic and aerobic power.

Key words: *sex characteristics, body composition, anaerobic power, muscle strength, physical endurance, kickboxing.*

Introduction

Kickboxing is a high-intensity intermittent striking combat sport, which is characterized by complex skills and tactical key actions with short duration and high-intensity of activity[1,2]. Power for explosive attacks with integration of responses, intramuscular/intermuscular coordination, and correct timing are necessary for the effective application of techniques[1]. In addition, despite the request of anaerobic power and capacity[3], a typical kickboxing competition contains 3 rounds of 2 minutes, each with a rest period of 1 minutes in-between[1], which requires the aerobic capability to promote the recovery and to maintain the combat performance[1,2]. Due to difficulties in conducting physiological measurements during the combat, a strategic and controlled manner to verify relevant factors, that can differentiate the successful ones, is to conduct physiological measurements, based on kickboxing determinant activities[1]. However, in kickboxing, although preceding reports provided important information for the training organization[1,4], evidences able to differentiate physical and fitness kickboxers profile are still generic and non-consensual[2]. These findings are supported by the physical attributes of striking combat sports studies, which reported a marked high aerobic capacity, and above-average anaerobic power and capacity[5,6], in elite striking combat sports such as boxing[5,7], taekwondo[8,9], karate[6,10] and kung-fu[11]. Primarily, twenty years ago, one investigation described anthropometric and physiological characteristics of elite male kickboxers by weight categories[12]. The authors suggested that elite kickboxers demonstrate a high level of aerobic and anaerobic condition with the ability to

Received for publication May 29, 2015

produce a high muscular force[12]. Though the important contribution, authors did not consider possible gender particularities. As Artioli et al.[11] reported that kung-fu fighters seems to be a highly anaerobic-dependent, with a vertical jump of 37.7 ± 8.4 cm in male and 32.3 ± 1.1 cm of female and moderately high arm mean and peak anaerobic power, with the result of Wingate test in men of 4.1 ± 0.4 and 5.8 ± 0.5 W.kg^{-1} and in women, with 2.5 ± 0.3 and 3.4 ± 0.3 W.kg^{-1}, respectively, and a low body fat in men, with 9.5 ± 6.3% and in women, with 18.0 ± 4.8%.

Additionally, a recent systematic reviews have presented evidence that athletes with different competitive levels presented different physical and physiological profile which is not extensively studied[5,9]. Also, few studies have examined fitness profiles for combat sport athletes at different competitive levels to identify anthropometric, neuromuscular, or physiological differences that may contribute to the success[13,14]. In fact, to our knowledge, no one study has examined the differences in any physical fitness or anthropometrical marker between subelite vs. amateur male and female kickboxers. Examination of fitness profiles in these subjects can contribute to talent selection and could be of great importance for optimizing specific strength, muscle power, and endurance training programs to improve male and female kickboxing performance. However, each combat striking sport has its own rules, weight divisions, competitive levels, specific techniques and, consequently, different variables contributing to success. As in many open skills sports, technique, tactics and physical conditioning are some of the main aspects investigated to increase the understanding of these different contributors to performance and to improve the training prescription to athletes preparing for competition[5,15]. Therefore, the aim of this study was to investigate which anthropometric, physiological, and neuromuscular factors are different between subelite and amateur male and female kickboxers. It was hypothesized that subelite male and female kickboxers would have a more favorable body composition and higher anaerobic and aerobic power compared with male and female amateur kickboxers.

Materials and Methods

Subjects

Ten subelite kickboxers (male = 6: age = 24.2 ± 4.6 years; weight = 71.2 ± 10.4 kg; height = 1.75 ± 0.08 m; female = 4: age = 23.4 ± 3.2 years; weight = 69.5 ± 7.8 kg; height = 1.70 ± 0.08 cm) and eighteen amateur kickboxers (male = 10: age = 25.4 ± 5.1 years; weight = 72.5 ± 9.6 kg; height = 1.76 ± 0.1 m; female = 8: age = 24.4 ± 4.2 years; weight = 71.4 ± 8.4 kg; height = 1.73 ± 0.9 cm) took part in this study. To be placed in the subelite groups (male and female), the kickboxers had at least six participations representing their country in Arabian and African Championships. Amateur kickboxers (male and female) had been finalists at their respective national Championships Tunisia in the last season, although they had not taken part in any mentioned competition. Training experience of all the participants ranged from 8 to 12 years. They trained 1.3 hours per day 5 times a week. Besides the kickboxing training, all athletes have been engaged in supplemental strength and conditioning training for years during both preparatory and competitive period. The testing was conducted at the beginning of the preparation cycle (that is at the end of the transition period) for the Arabian Championship. Exclusion criteria were: previous injury or current instability in upper or lower limbs, regular participation in other sports activities and presence of reported cardiovascular disease. The subjects and coaches were informed in detail about the experimental procedures and the possible risks and benefits of the project. The experimental procedure was approved by the institutional ethics committee.

Procedures

The tests were performed on three days separated by at least 2 days. On the first day, kickboxers were assessed of anthropometric and body composition measurements in the morning (7–8) and of vertical jump (CMJ), explosive power of arms (MBT) in the evening (5:30–7) and maximum dynamic strength tests (1RM bench press and back squat). In the second test day, each subject was subjected to graded 20-m shuttle run test at the same time of day. In the third testing day, each subject was subjected of upper and lower limbs Wingate anaerobic test..

Considering the lack of a specific kickboxing performance test in the literature, we required athletes to perform a nonspecific battery of physical performance tests. We based our choice on other studies evaluating combat sports athletes[5,6,9]. Validity and feasibility of the tests were also considered.

Anthropometric Measurement

Height and body mass were measured to the nearest 0.1 cm using a stadiometer (Harpenden Portable Stadiometer, UK) and 0.1 kg using a digital scale (Harpenden Balance Scale, UK), respectively. Skinfold measurements were taken in duplicate from four sites (biceps, triceps, subscapular and suprailiac) was measured using Harpenden callipers (Lange, Cambridge, MA, USA) determined by the formula of Brozek et al.[16] based on the body density determination by the formulas of Lohman et al.[17] and Sinning et al.[18]. The average of the 2 measurements was recorded and computed for lean body mass and body fat percentages according to the Anthropometric Standardization Reference Manual[19].

Testing Procedure

Participants were told to stopping from heavy training, alcohol, caffeine, and tobacco usage for the 2 days preceding testing sessions. Only drinking water was allowed 2 hours before the test. To avoid any chronobiological bias on physical performances, all tests have been performed in the same environmental condition (temperature: 15˚C to 22˚C) at the same time of day (between 5:30–7 p.m.). During the week before the beginning of the experiment, athletes were familiarized with the test battery to avoid

the learning effect during the testing period of the study. The testing of physical performance was preceded by a standard 10-min warm-up including jogging, dynamic stretching and sprints.

Countermovement Jump (CMJ)

CMJ was performed using an infrared jump system (Optojump, Microgate, Bolzano, Italy) which was interfaced with a microcomputer. During the CMJ, subjects were asked to be in a standing position, and prior to jumping, counter-moved until the knee was flexed approximately to 90°. After that they extend immediately their knees to jump vertically off the ground as high as possible. For all jumps, kickboxers retained their hands on their hips to eliminate the influence of the arms swing impulse[20]. Three trials were completed with 1-min interval in-between, and the best performance was used for the subsequent statistical analyses. CMJ final results are expressed in centimeters (cm).

Medicine Ball Throw (MBT)

The MBT is a common measure of upper-body (arm) power. It is conducted using a standard 5 kg medicine ball. Subjects were seated on the bench with his legs fully extended and his back is against the wall. The medicine ball is held with both hands against the centre of the chest and the forearms are positioned parallel to the ground. Subjects were instructed to throw the medicine ball as far straight forward as he can while keeping his back maintained against the wall. The distance thrown is recorded in meters (m) and the best of the three trials is recorded.

Maximum Dynamic Strength Tests

Maximum dynamic strength (1RM) for squat and bench press exercises was assessed on a Smith machine. For the bench press 1RM was assessed with the subjects lying on a horizontal bench. Body and hand positioning on the bench and on the bar were recorded. Then, subjects performed familiarization trials to get acquainted with the test procedures. In short, subjects ran for five minutes of various exercises (e.g., jogging, hopping), followed by lower and upper limbs stretching exercises. Before each exercise, subjects should perform were performed: (a) warm-up of 50% of approximately 1RM for 8–10 repetitions; (b) 1 minute of rest and light stretching and a second set of 75% of approximately 1RM lifted for 3-5 repetitions; and (c) after 2–3 minutes of rest and more light stretching, 3–4 1RM attempts performed with 2 minutes of rest between each attempt. After each repetition, the weight was increased by 2.5–10 kg for each repetition until failure. Subsequent lifts were single repetitions of progressively heavier loads, until failure. Maximum dynamic strength (1RM load) was determined as the maximum weight that could be lifted once with proper technique. Strong verbal encouragement was provided during all lifts.

For the squat exercise, subject's body and feet positioning were determined and recorded with measuring tapes fixed on the bar and on the ground, respectively. The same procedures were completed for 1RM testing for bench press and squat exercise on each type of equipment.

Lower-Body Wingate Test

Lower-body (LB) anaerobic mean and peak power was determined using the Wingate anaerobic test. It was conducted on a calibrated friction loaded cycle ergometer (Monark Ergomedic 894^{E}, Vansbro and Sweden interfaced with a microcomputer. The cycle was equipped with toe-clips to prevent the subject's feet from slipping. To avoid an intraindividual effect of postural changes, foot position on the pedals, saddle height, and upper body position were adjusted to each subject's satisfaction and maintained identical throughout the study. The Wingate test consisted of a 30-s maximal sprint against a constant braking resistance equivalent to 7.5 N.kg^{-1} [21]. During the test, subjects had to remain seated and were strongly encouraged by the same investigator to avoid pacing and to reach the maximal pedaling rate as quickly as possible. Results are expressed on relative mean and peak power (W.kg^{-1}).

Upper-Body Wingate Test

The Wingate anaerobic test was used to measure the upper-body (UB) mean and peak power[22]. The 30-second Wingate test was performed on a Monark cycle ergometer (Monark 894^{E}, Vansbro, Sweden). Load was set at 4.9 N.kg^{-1} of body mass[23]. In test, computer software recorded the velocity and calculated the power output for each second. The results are expressed in relative mean and peak power output (W.kg^{-1}) of each subject.

Shuttle Run Aerobic Test

A multistage shuttle run test was used to evaluate the endurance level of kickboxers by determining maximal oxygen uptake (VO_2max) from maximal aerobic speed[24]. Subjects started running back and forth a 20-m course and touched the 20-m line at an initial speed of 8.5 km/h. The speed of the shuttle runs got progressively faster (0.5 km/h every minute), in accordance with a pace dictated by a sound signal on an audio tape. Several shuttle runs made up each stage, and subjects were instructed to keep pace with the signal for as long as possible. Maximal aerobic speed (MAS) is the lowest speed enabling you to obtain the VO_2max which the level of maximum aerobic power for a subject. The VO_2max was established according to the equation provided by Léger and Gadoury[25].

Statistical Analysis

Descriptive statistics were obtained using SPSS 20.0 software (SPSS Inc., Chicago, IL, USA, version. 20.0). Results are expressed as the mean ± standard deviation (SD). Student's t-test for independent samples was used to determine the differences in fitness parameters between the subelite and amateur groups and male and female kickboxers. ANOVA two-way was conducted to compare measured variables across gender and level groups. When differences were detected, the Bonferroni test was used as *post hoc* to identify specific differences between groups. Eta squared (η^2) was calculated. For all analysis, the significance level of $P \leq 0.05$ was used.

TABLE 1
MEAN ± STANDARD DEVIATION (SD) OF PHYSICAL AND PHYSIOLOGICAL PROFILE OF SUBELITE (MALE = 6; FEMALE = 4) AND AMATEUR (MALE = 10; FEMALE = 8) KICKBOXERS.

Parameters	Gender	Amateur	Subelite	95% CI	p
Body fat (%)	Male	12.4 ± 4.7#	10.8 ± 4.4#	–3.48–6.68	0.5
	Female	20.7 ± 5.2	18.2 ± 4.9	–4.47–9.47	0.4
CMJ (cm)	Male	33.7 ± 3.8#	37.2 ± 3.5#	–7.59–0.59	0.08
	Female	27.4 ± 3.7	31.2 ± 3.1	–8.61–1.01	0.1
MBT (m)	Male	4.1 ± 0.4#	4.6 ± 0.3*#	–0.90–0.09	0.01
	Female	3.2 ± 0.5	3.9 ± 0.4*	–1.34–0.05	0.03
UB mean power ($W.kg^{-1}$)	Male	5.2 ± 0.7#	6.1 ± 0.6*#	–1.63–0.16	0.02
	Female	3.7 ± 0.8	4.8 ± 0.6*	–2.11–0.08	0.03
UB peak power ($W.kg^{-1}$)	Male	6.5 ± 0.9#	7.6 ± 0.8*#	–2.05–0.14	0.02
	Female	4.5 ± 1.1	5.9 ± 0.8*	–2.79–0.009	0.04
LB mean power ($W.kg^{-1}$)	Male	7.1 ± 1.1#	8.5 ± 0.9*#	–2.54–0.25	0.02
	Female	5.3 ± 0.9	6.5 ± 0.8*	–2.38–0.01	0.04
LB peak power ($W.kg^{-1}$)	Male	9.3 ± 1.2#	10.9 ± 0.9*#	–2.82–0.37	0.01
	Female	6.7 ± 1.4	8.6 ± 1.1*	–3.69–0.10	0.04
1RM bench press (kg)	Male	65.7 ± 11.2#	74.2 ± 12.4#	–21.39–4.39	0.17
	Female	51.3 ± 10.5	55.7 ± 9.4	–18.29–9.49	0.4
1RM squat (kg)	Male	102.5 ± 13.6#	115.5 ± 13.5#	–28.02–2.02	0.08
	Female	82.1 ± 14.4	90.5 ± 12.3	–27.23–10.43	0.3
VO_2max ($ml.\ min^{-1}\ .kg^{-1}$)	Male	49.1 ± 4.6#	54.6 ± 4.3*#	–10.47–0.52	0.03
	Female	42.2 ± 3.8	47.6 ± 3.2*	–10.35–0.44	0.03

CI: confidence interval; CMJ: countermovement jump; MBT: medicine ball throw; UB: upper-body; LB: lower-body; *: Significant difference at P<0.05 compared with amateur kickboxers; #: Significant difference at P<0.05 compared with female kickboxers.

Results

The characteristics of the subjects are presented in Table 1.

Anthropometric Characteristics

The statistical analysis showed differences in body fat percentage ($F_{(3,24)}$=7.109, p<0.001, η^2=0.47), amateur female presented higher body fat percentage values than amateur male (p=0.05) and subelite male (p=0.004). In Student's t-test, amateur male and female kickboxers showed higher (p<0.05) average body fat values than subelite kickboxers in both gender. There were no differences in average age, height, body mass and fat-free body mass between the groups.

Muscular Power

The comparison showed differences in CMJ height ($F_{(3,24)}$=7.996, p<0.001, η^2=0.50), amateur female presented a smaller height than Amateur male (p=0.01) and subelite male (p<0.001). No other significant difference in CMJ height was detected. Effects were observed in MBT results ($F_{(3,24)}$=7.996, p<0.001, η^2=0.50), amateur female presented lower values than amateur male (p<0.001) and subelite male (p<0.001) groups. In Student's t-test, the MBT of subelite male and female kickboxers were 12.1% and 21.8% higher (p<0.05) than in amateur male and female kickboxers, respectively. Difference of gender was also found for subelite and amateur kickboxers in both tests (p<0.01), with higher value for male than female kickboxers.

Muscle Power Output

Effects were observed in comparisons of UB peak power ($F_{(3,24)}$=12.706, p<0.001, η^2=0.61), amateur female presented lower values than amateur male (p<0.001) and subelite male (p<0.001). No differences were detected between subelite female and amateur male or subelite male comparisons of UB peak power. Significant differences were observed when compared LB peak power values ($F_{(3,24)}$=12.596, p<0.001, η^2=0.67), amateur female presented lower values than amateur male (p<0.001) and subelite male (p<0.001), and, subelite female showed lower values than subelite male (p=0.028). In Student's t-test, average LB mean power output for Wingate test examined in subelite male and female kickboxers were 19.7% and 22.6% higher (p<0.05) than amateur male and female kickboxers, respectively. Further, UB anaerobic mean power was higher in subelite male and female kickboxers (p<0.05; 17.3 and 29.7%, respectively) than amateur male and female kickboxers. Similarly, differences between male and female were observed for subelite and amateur kickboxers (p<0.05).

Muscular Strength

The statistical analysis showed differences in 1RM bench press comparisons ($F_{(3,24)}$=5.759, p=0.004, η^2=0.42), subelite male presented higher values than subelite (p=0.005) and amateur female kickboxers (p=0.042). Effects were found in the 1RM squat analysis ($F_{(3,24)}$=7.695, p<0.001, η^2=0.49), subelite and amateur male groups presented higher values than amateur female (p<0.001 and p=0.020, respectively). Moreover, Student's t-test showed effect of gender for amateur and subelite kickboxers (p<0.05).

Aerobic Power

The analysis showed differences in VO_2max comparisons ($F_{(3,24)}$=10.231, p<0.001, η^2=0.56), amateur female presented lower values than amateur male (p=0.009) and subelite male (P<0.001). Student's t-test showed that VO_2max in subelite male and female kickboxers was higher (p<0.05; 11.2 and 12.7%, respectively) than in amateur male and female kickboxers. An effect of gender was also found for subelite and amateur kickboxers (p<0.05).(Table 1)

Discussion

To our knowledge, this is the first study that simultaneously analyzes anthropometric, power of the lower and upper limbs and aerobic fitness of subelite male and female kickboxers compared to amateur male and female kickboxers. The results of this study demonstrate that significant differences exist in performance of MBT and maximal oxygen uptake between subelite and amateur male and female kickboxers. Further, an effect of gender was also found in both successful and less successful kickboxers. In addition, when observed the interaction between gender and level, the present study verified a sexual dimorphism of subelite female kickboxers, when observed body fat percentage, CMJ, maximum dynamic strength on bench press and in the Shuttle Run results. However, performance in kickboxing may be determined by a competitor's technical, tactical, physical and physiological attributes analysed in international and national levels. On the other hand, one of the keys to establish internal validity of the present study was the recognition that championship level was associated with the experimental research and with the criteria's, it refers both to how well the research design, operational definitions used, variables measurements procedures and the results showed that how confidently one can conclude that the change in the dependent variable was produced solely by the gender (in all analysis) and by levels (when compared the peak power of upper and lower body measurements).

Judging the performance of the human body by its body mass and body fat has been a topic of great concern. In addition, body fat plays an important role for the assessment of physical fitness of the athletes. There are a limited number of studies investigating the body composition of male kickboxers[12], and scarce in female kickboxers. It is our belief that this study is the first to present such data for amateur and highly competitive kickboxers in male and female. The subelite group had significantly longer kickboxing experience than the amateur group for both genders, which may indicate that experience and time commitment for development of specific body fat required in kickboxing is important. Our result showed that subelite male and female kickboxers similar mean body fat than the amateur kickboxers for both gender. Moreover, Giampietro et al.[13] revealed that the body composition of two groups of athletes practicing karate at high and medium competitive levels was similar, while much lower body fat was presented by elite compared with medium level karate athletes. While, Olds and Kang[26], for instance, identified a lower proportion of body fat in international competitors male taekwondo athletes (7.3%) than their state-level counterparts (10.7%). Further, Toskovic et al.[27], for instance, reported significantly lower body fat in experienced male and female taekwondo practitioners than in their novice counterparts. Imamura et al.[28] reported that there is no significant difference regarding the mean body fat percentage between highly competitive and novice karate athletes. The variation in body composition between different levels of competition and experience may be a function of divergent training volumes[27], nutritional practices and/or the requirements to 'make weight' for competition[29]. Female kickboxers tend to demonstrate greater body fat than their male counterparts. Our result is compatible with some researches in taekwondo[9], karate athletes[6], and boxing[5] that showed that body fat percent in female practitioners' greater than male counterparts. Compared with athletes in combat sports, kickboxers have similar fat content, but lower fat, than other combat sports. Body fat content observed in subelite athletes was similar to that previously established with elite male endurance athletes[30], elite boxers[5,7], and elite kung-fu athletes[11]. Additionally, these body fat values are lower than those reported with elite karate athletes[31] and elite taekwondo athletes[8]. Body fat percentage in male and female amateur kickboxers is comparable to that previously recorded in boxing[5], taekwondo[9], and karate athletes[6].

The importance of lower and upper-body explosive power (as measured with the CMJ and MBT tests) in kickboxing lies in the ability of the athlete to lift certain offensive actions, punching and kicking, and to resist attacks by his opponent. Although the vertical jump test and MBT is not specific, it is widely used as a good indicator of lower and upper limbs power. Nevertheless, we found no significant difference in lower body muscular power (CMJ), but a significant difference in MBT performance between amateur and subelite kickboxers for both genders. The homogeneous of results of CMJ explained by the limited its sample size, which might have affected the statistical significance. Further, we investigated that male kickboxers had greater muscular power than female kickboxers. Interestingly, though, differences in muscular power were not observed between experienced and novice female practitioners[9]. In contrast, Bridge et al.[9] observed a greater vertical jump values for international level when compared to national level athletes for male and female

taekwondo athletes. This difference explained by the competitive level of athletes. Additional research into the muscular power characteristics of taekwondo athletes in relation to sex, senior and junior male taekwondo athletes demonstrate higher absolute muscular power, as represented by higher CMJ performance, than their respective female counterparts[9].

Decisive actions in a kickboxing match, a kick or a punch, are dependent on muscle power. Considering that power is the product of force and velocity, higher power represents a higher velocity at the same relative load. The significant difference found in power between amateur and subelite kickboxers (Table 1) is of great interest, successful awarding depends on the power and the speed of an action. Therefore, greater power would represent a greater punching or kicking velocity[6]. It is known that kickboxers training routine consists of performing unloaded punches and kicks which can induce a greater adaptation in the velocity portion of the force-velocity curve and result in greater segment velocity. Explosive power performance evaluated via CMJ test of subelite male and female kickboxers is similar to that recorded with kung-fu athletes[11], but lower than those recorded with elite taekwondo athletes[9]. Muscular power or explosiveness is a vital key for success in kickboxing, which will need to address this weakness with strength power and plyometric training.

The activity-to rest ratio has been revealed to be approximately 1:1 in international kickboxers and 1.2 in amateur kickoxers[32]. These findings imply that activity pattern of the amateur and elite kickboxing match is intermittent and characterized by short-duration, high-intensity bursts of activity interspersed with periods of lower intensity and/or pauses caused by kickboxers' clinching and/or the referee's interruption. It has been reported that high-intensity intermittent sports rely mostly on anaerobic energy sources, with determinant actions being a function of explosive movement[33]. Thus, kickboxers' decisive actions depend mainly on anaerobic energy pathways. Further, kicking and punching are the keys component of kickboxers. As in boxing, they require a high level of both speed and power[34]. In this context, it has been suggested that the ability to produce high-level muscular power is considered one of the major fundamental prerequisites underlying successful performance among kickboxers[35]. There is no specific test protocol for assessing the anaerobic fitness level of kickboxers. The Wingate anaerobic power test is a widely used and accepted protocol for assessing anaerobic power characteristics and for assessing working capacity using both the adenosine triphosphate and phosphocreatine (ATP-PCr) and glycolytic systems[36]. Compared with previous studies on combat sport athletes[7,10,11], better lower and upper-body anaerobic power were observed, with significant differences between subelite and amateurs male and female kickboxers. Considering that explosive lower and upper limbs power is believed to be a fundamental prerequisite in kickboxing[12], and crucial for the execution of kicking and punching techniques, it seems reasonable to expect statistical differences between athletes who successfully compete at national level. Further, our finding demonstrated that peak power and mean power were higher in male compared with female athletes. The same result has been found by Doria et al.[10] who reported that peak power and mean power were higher in male compared with female karate athletes in both kata and kumite. Therefore, it is possible to acknowledge the coach's capability to discriminate athletes with better jumping and throwing performances.

There were no significant differences between male and female for two groups of amateur and subelite kickboxers of participants in measures of absolute maximal strength of lower and upper limbs. But, we observed a significant difference between male and female kickboxers. However, it is evident that average absolute strength values of lower and upper extremities, especially in subelite kickboxers, are respectable. Our result is compatible with study of Markovic et al.[14] who showed no significant difference between international and national Croatian female taekwondo athletes in the maximum upper and lower body strength performance. In contrast, Markovic et al.[14] also noted a trend for greater absolute 1RM bench press and back squat performances in international female medallists compared with non-medallists taekwondo athletes. However, for relative bench press and back squat performances, the differences between these groups were (statistically) more notable[9]. These data tentatively suggest that while the ability to generate maximum strength may be important in taekwondo, it might not determine success in international competition. Also in karate, maximal absolute bench press and half squat 1RM differed significantly between highly competitive and novice male karate athletes[28]. These findings led the authors to suggest that the bench press and half squat are indicative of top-level competitive athletes. Further research is needed into kickboxers' maximum strength characteristics in relation to age to enhance existing knowledge and to permit effective preparatory strategies for different populations within the sport.

Aerobic fitness has been well recognized as an important physiological contributor to performance[37]. However, rounds in kickboxing last 2 minutes and a match may have up to 3 rounds, which suggest that, during a course of a match, a kickboxer could reasonably derive more than 50% of ATP from aerobic metabolism[1]. For instance, the greatest significant differences occurred in mean values VO_2max between subelite and amateurs for both gender, and, male and female kickboxers. Similar in other combat sports, Sadowski et al.[38], on the other hand, observed a tendency for senior and junior male medallists to perform a greater number of shuttles during multistage shuttle running tests than their non-medallist taekwondo athletes' counterparts. Bridge et al.[9] reported higher VO_2max in international male taekwondo competitors when compared with their state-level counterparts. As well as, senior male international taekwondo competitors demonstrate a higher range of VO_2max scores than their female counterparts. Our kickboxers' VO_2max, which was comparable to those, reported with elite taekwondo athletes from field

test (Shuttle run aerobic test)[8]. These findings highlight that aerobic power and cardiovascular function are one of the most significant physical factors for success in kickboxing. Further, the present study considers that adequate aerobic capacity is indispensable because it enables relatively fast recovery between rounds and fights. High aerobic capacity also facilitates faster recovery during and after a training session. And it is well known that rapid recovery enables an athlete to reduce the rest intervals and to perform at higher intensities, especially in sports that demand many repetitions of a sport specific skill[39].

Conclusion

In summary, the findings of this study suggest that subelite kickboxers have, high leg and arm anaerobic power and high aerobic power than amateur kickboxers for both genders. Choosing athletes for kickboxing as branch of sport requires an emphasis on these factors and within the process of athlete's development these parameters must be truly integrated to training system so that their importance can stand out. For instance, it appears reasonable to infer that selection of kickboxing athletes should rely on sport-specific tailored physical tests, integrating the relative information with that gathered from physiological measurements.

Taking into account magnitude of the observed differences between the two analyzed groups of athletes, we can say, form the practical point of view, that the greatest weight in differentiating the successful from less the successful athletes can be attributed to measures of anaerobic and aerobic power and explosiveness. Hence, the coaches are advised to pay special attention to anaerobic lactic and aerobic power and explosiveness in the process of selecting participants for kickboxing, as well as in designing training programs. Further, coaches should focus on the development of these characteristics in lower-level athletes to attain a better performance. Thus, our study provides baseline values for future investigations where physiological fitness status may be utilized to create general and specific training programs to prepare kickboxers for the physical demands of their sport. It is recommended that further research examines the use of novel technology as a means to differentiate between performance levels of athlete's age and give specific consideration to developing a specific testing protocol for kickboxers, as well as, comparisons between the anaerobic capacities and aerobic power of winners and losers are needed.

Acknowledgments

The authors wish to express their sincere gratitude to all the participants for their effort. We would like to think Dr Emerson Franchini for the relevant comments about this manuscript. This study was supported by the Ministry of Higher Teaching and Scientific Research, Tunisia.

REFERENCES

1. SLIMANI M, CHAABENE H, MIARKA B, FRANCHINI E, CHAMARI K, CHEOUR F, Biol. Sport., 34 (2017) 185-196. — 2. SALCI Y, Int. J. Perform. Anal. Sport., 15 (2015) 39. — 3. OUERGUI I, HAMMOUDA O, CHTOUROU H, ZARROUK N, REBAI H, CHAOUACHI A, J. Sports. Med. Phys. Fitness., 53 (2013) 455. — 4. SLIMANI M, CHAABENE H, MIARKA B, CHAMARI K, Int. J. Sports Physiol. Perform., 12 (2017) 182-189. — 5. CHAABÈNE H, TABBEN M, MKAOUER B, FRANCHINI E, NEGRA Y, HAMMAMI M, AMARA S, CHAABÈNE RB, HACHANA Y, Sports. Med., 45 (2015) 337. — 6. CHAABÈNE H, HACHANA Y, FRANCHINI E, MKAOUER B, CHAMARI K, Sports. Med., 42 (2012) 829. — 7. HUBNER-WOZNIAK E, KOSMOL A, BŁACHNIO, D, Journal of Combat Sports and Martial Arts., 2 (2011) 91. — 8. BOUHLEL E, JOUINI A, GMADA N, NEFZI A, BEN ABDALLAH K, TABKA Z, Sci. Sports., 21(2006) 285. — 9. BRIDGE CA, FERREIRA DA SILVA SANTOS J, CHAABÈNE H, PIETER W, FRANCHINI E, Sports. Med., 44(2014) 713. — 10. DORIA C, VEICSTEINAS A, LIMONTA E, et al, Eur. J. Appl. Physiol., 107(2009) 603. — 11. ARTIOLI GG, GUALANO B, FRANCHINI E, BATISTA RN, POLACOW VO, LANCHA, AHJr, J. Strength. Cond. Res., 23(2009) 20. — 12. ZABUKOVEC R, TIIDUS PM, J. Strength. Cond. Res., 9(1995) 240. — 13. GIAMPIETRO M, PUJIA A, BERTINI I, Acta. Diabetol., 40 (2003) S145. — 14. MARKOVIC G, MISIGOJ-DURAKOVIC M, TRNINIC S. Coll. Antropol., 29(2005) 93. — 15. SMITH DJ. Sports. Med., 33(2003) 1103. — 16. BROZEK J, GRANDE F, ANDERSON JT, KEYS A, Ann. N. Y. Acad. Sci., 110(1963) 113. — 17. LOHMAN TG, Hum. Biol., 53(1981) 181. — 18. SINNING WE, DOLNY DG, LITTLE K, CUNNINGHAM LN, RACANIELLO A, SICONOLFI SF, SHOLES, JL, Med. Sci. Sports. Exerc., 17(1985) 124. — 19. HARRISON GG, BUSKIRK ER, CARTER JEL, JOHNSTON FE, LOHMAN TG, POLLOCK ML, ROCHE AF, WILMORE J, Skinfold thicknesses and measurement technique. In LOHMAN TG, ROCHE AF, MARTORELL R (Eds) Anthropometric standardization reference manual (Champaign Human Kinetics 1988). — 20. KOMI PV, BOSCO C, Med. Sci. Sports., 10(1978) 261. — 21. OUERGUI I, HSSIN N, HADDAD M, PADULO J, FRANCHINI E, GMADA G, BOUHLEL E, Muscles Ligaments Tendons J., 4(2014) 106. — 22. BAR-OR OC, Sports Med. 4(1987) 381. — 23. FRANCHINI E, DE MORAES BERTUZZI RC, TAKITO MY, KISS MA, Eur. J. Appl. Physiol., 107(2009) 377. — 24. LÉGER L, MERCIER D, GADOURY C, LAMBERT J, J. Sports. Sci., 6(1988) 93. — 25. LÉGER L, GADOURY C, Can. J. Sports. Sci., 14(1989) 21. — 26. OLDS T, KANG S, Anthropometric characteristics of adult male Korean taekwondo players. The First Olympic Taekwondo Scientific Congress Proceedings (Seoul, Korea 2000). — 27. TOSKOVIC NN, BLESSING D, J. Sports. Med. Phys. Fitness., 44(2004) 164. — 28. IMAMURA H, YOSHIMURA Y, UCHIDA K, et al, Appl. Human. Science., 17(1998) 215. — 29. TSAI ML, CHOU KM, CHANG CK, FANG SH, Br. J. Sports. Med., 45(2011) 729. — 30. ARAZI H, FARAJI H, MOHAMMADI SM, Middle-East. J. Sci. Res., 9(2011) 162. — 31. AMUSA L, ONYEWADUME I, Acta. Kines. Univ. Tart., 6(2001) 7. — 32. OUERGUI I, HSSIN N, HADDAD M, FRANCHINI E, BEHM DG, WONG DP, GMADA G, BOUHLEL, E, J. Strength. Cond. Res., 28(2014) 3537. — 33. GLAISTER M, Sports. Med., 35(2005) 757. — 34. PIORKOWSKI BA, LEES A, BARTON GJ, Sports. Biomech., 10(2011) 1. — 35. MACHADO SM, OSORIO RAL, SILVA NS, MAGINI M, Med. Biol. Eng. Comput., 48(2010) 573. — 36. ZUPAN MF, ARATA AW, DAWSON LH, WILE AL, PAYN TL, HANNON ME, J. Strength. Cond. Res., 23(2009) 2598. — 37. ZETARUK MN, VIOLAN MA, ZURAKOWSKI D, MICHELI LJ, Br. J. Sports. Med., 39(2005) 29. — 38. SADOWSKI J, GIERCZUK D, MILLER J, et al, Arch. Budo., 8(2012) 141. — 39. BOMPA T, Periodization: theory and methodology of training (Champaign, IL, Human Kinetics 1999).

M. Slimani

Faculty of Sciences of Bizerte, Assalama 9159, Bir El Hfey, Sidi Bouzid, Tunisia

E-mail: maamer2011@hotmail.fr

UČINCI KONKURENTNE RAZINE KICKBOXINGA U ANTROPOMETRIJSKOM PROFILU I FIZIOLOŠKIM ATRIBUTIMA S USPOREDBAMA PO SPOLU

S A Ž E T A K

Cilj istraživanja bio je usporediti konkurentsku razinu konkurentnosti i spolove u antropometrijskim, anaerobnim atributima i aerobnim kapacitetima. Uzorak se sastojao od četiri skupine (subeliti: 6 muškaraca i 4 žene, amater: 10 muškaraca i 8 žena). Koristili su se antropometrijska mjerenja, aerobni test od 20 metara Shuttle Run, CMJ, lopta s medicinskim kuglicama (MBT), pritisak na stolu i maksimalna čvrstoća stražnjeg čučnjeva i Wingate-test za gornji (UB) i donji dio tijela (LB) , Ustanovili smo da su subelitični mužjaci i ženske kickboxeri postigli značajno veći MBT (muški: subeliti = 4.6 ± 0.3 vs. amateri = 4.1 ± 0.4 m; ženski: subeliti = 3.9 ± 0.4 vs. amateri = 3.2 ± 0.5 m) i UB (muški : subeliti = 6,1 ± 0,6 i 7,6 ± 0,8, odnosno 5,2 ± 0,7 i 6,5 ± 0,9 W.kg^{-1}, ženke: subeliti = 4,8 ± 0,6 i 5,9 ± 0,8 u odnosu na amatere = 3,7 ± 0,8 i 4,1 ± 1,1 W), LB srednja i vršna snaga (muški: subeliti = 8,5 ± 0,9 i 10,9 ± 0,9, odnosno 7,1 ± 1,1 i 9,3 ± 1,2 W.kg^{-1}, ženke: subeliti = 6,5 ± 0,8 i 8,6 ± 1,1 vs. amateri = 5,3 ± 0,9 i 6,7 ± 1,4 W.kg^{-1}) i maksimalni unos kisika (muški: subeliti = 54,6 ± 4,3 vs. amateri = 49,1 ± 4,6 ml.min^{-1}.kg^{-1} ženski: subeliti = 47.6 ± 3.2 vs. amaterski = 42.2 ± 3.8 ml.min^{-1}.kg^{-1}) od amaterskih kickboxera. Učinci su pokazali značajnu razliku između muških i ženskih amaterskih kickboxera za antropometrijsku, fizičku i fiziološku učinkovitost (P <0,05) i seksualni dimorfizam u usporedbi razine ženskih subelita s muškim skupinama. Učinak muških i ženskih kickboxera prvenstveno ovisi o anaerobnoj alakskoj snazi, eksplozivnoj snazi i aerobnoj snazi.