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Anthropometric and Physiological Profile of Elite Iranian National Kickboxing Team: A Comparison of Ring-Style and Tatami-Style Kickboxing

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Abstract: Kickboxing is a physically demanding combat sport. Understanding elite national team kickboxers' anthropometric and physiological characteristics are crucial for enhancing performance and designing effective training programs. The aims of the present study are to (a) profile anthropometric and physiological characteristics of the male Iranian National Kickboxing Team and (b) examine differences between Ring (uncontrolled) and Tatami (controlled) Kickboxing styles. ***Materials.*** A total of twelve male athletes, comprising six Tatami and six Ring-style kickboxers, with an average age of 26.9 ± 3.3 years, joined the Iranian national team in 2019 and were recruited for this study. The following parameters were measured at Iran's Olympic Academy Center: body composition, muscle strength, muscle endurance, aerobic power, flexibility, speed, agility, reaction time, anaerobic power, and explosive leg power. ***Research methods.*** The data were analyzed with mean and standard deviation, and the independent t-test was used to compare the data of both styles. ***Results.*** Ring-style kickboxers outperformed Tatami-style kickboxers in fat-free mass, body fat percentage, arm span, relative squat, relative chest press, relative deadlift, relative handgrip, modified pull-ups, push-ups, sit-ups, vertical jump, flexibility, VO2max, arm and leg Wingate ($p<0.05$). Both groups had high levels of physical fitness, except for aerobic capacity, which was lower than expected in both groups. ***Conclusion.*** These findings suggest that Iranian elite kickboxers have ideal physical fitness components. Coaches should design specific training programs to improve the aerobic capacity of these athletes, which is vital to enhancing their performance. The study's results can contribute to the Kickboxing community, including coaches, trainers, and athletes, by optimizing effective physical fitness programs.
Keywords: Martial Arts, skill-related physical fitness, Wingate; Vo2 max.

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Introduction

Kickboxing is a combat sport that has evolved from ancient Asian martial arts, such as Muay Thai, Boxing, and Karate. Kickboxing has gained popularity worldwide and has been adapted to different styles and rules, making it a diverse and ever-evolving sport. It is now widely recognized as a full-contact combat sport requiring physical fitness and technical skills (1). It combines boxing punches with kicking techniques, making it a highly versatile and dynamic sport. Kickboxing has different styles, including Tatami (controlled) and Ring (uncontrolled), for fighting while standing (1). In the Tatami style, all strikes, which may lead to serious injury, are forbidden, while such strikes are not controlled in the Ring style (2). Kickboxing athletes are grouped based on their gender, weight, and age categories (3). According to the rules established by the World Association of Kickboxing Organizations (WAKO), junior and senior level athletes in Ring and Tatami compete in a formal bout consisting of three active two-minute rounds separated by one-minute rest periods (2). However, the duration and number of rounds in professional kickboxing bouts may vary depending on the organization's rules. In international kickboxing competitions, medalists are often required to compete in three to five bouts, and the match results are determined after the third round (4).

Fighters' body mass is evaluated on the registration day for athletes in both styles. Ring-style athletes' weights will be checked every morning throughout the competition. Each kickboxer is assigned to a specific weight category (2). Therefore, weight control and body composition during competition and training days are essential (5). Moreover, as kickboxing is a dynamic, high-intensity intermittent striking combat sport, the athletes need a high level of physical fitness. The athletes must perform a great number of actions during each match (6-8). Despite the increasing popularity of kickboxing as a competitive sport, more research needs to investigate the anthropometric and physiological characteristics of elite kickboxers at the national level. Therefore, understanding elite kickboxers' physical fitness and physiological profiles is crucial for designing appropriate training programs and enhancing performance. This study aims to address this gap in the literature by profiling the anthropometric and physiological characteristics of the Male Iranian National Kickboxing Team members and examining differences between Ring and Tatami-style Kickboxers. To achieve this, health-related and skill-related tests will be used to measure the athletes' aerobic power, muscular endurance and strength, flexibility, body composition, speed, agility, power, balance, coordination, and reaction time. Given the complex demands of Kickboxing, which require the effective integration of these components (9-12), this study will provide valuable insights into the physiological characteristics that distinguish top-level kickboxers from their peers.

While there have been some investigations into the physical fitness characteristics of kickboxers from other countries, such as Turkey (13), more information on Iranian kickboxers needs to be given. Understanding successful athletes' physical fitness and physiological profiles can inform future athletes' training program development (14).

Furthermore, analyzing this data can help inexperienced athletes comprehend the physical fitness and physiological demands needed to compete at the national level (15). The records achieved by contemporary elite athletes are vastly superior to previous generations due to various factors, such as the correct application of training science, proper nutrition, and rigorous management (16). One of the most important and influential factors in determining an athlete's performance at the elite level is their physiological and physical fitness characteristics, underscoring the importance of understanding these characteristics (17). Access to elite athletes' physiological and anthropometric profiles can promote performance by facilitating objective and accurate feedback about their performance abilities (7). Such data helps coaches to identify elite athletes and to get sub-elite athletes to the elite level with proper planning. It also allows coaches to develop training programs to achieve goals and success scientifically (6).

Iran has a rich martial arts and combat sports tradition, such as wrestling, judo, and taekwondo. However, kickboxing is still a relatively new and developing sport in the country. Due to the lack of research and development in the field of kickboxing in Iran, there needs to be more information available on the anthropometric and physiological characteristics of Iranian kickboxers. Therefore, it is essential to establish appropriate criteria for measuring and comparing the physical fitness and physiological profiles of Iranian kickboxers with athletes from other countries.

To the best of our knowledge, no prior research has compared elite kickboxing athletes' anthropometric and physiological characteristics in Tatami and Ring styles. Our study seeks to fill this gap by proposing a standardized set of anthropometric and physiological tests for elite Iranian kickboxing athletes and comparing the Tatami and Ring style kickboxers. Such insights include developing effective training programs and selection criteria not only for Iranian national team coaches but also for coaches in other countries (7).

Materials and Methods

In coordination with the Iranian National Team officials, the study recruited twelve male kickboxers from the Iranian National Kickboxing Team in 2019 in the National Olympic Committee Center: six Tatami-style and six Ring-style athletes with an average age of 26.9 ± 3.3 years. These individuals were selected based on accessibility, willingness to participate, and extensive background in kickboxing and national team experience. All recruited athletes had previously competed in international tournaments and won medals. Before data collection, all subjects were informed of the research objectives and potential risks and provided written consent. The study was conducted in accordance with the ethical standards of the Helsinki Declaration and was approved by the Ethics Committee of the National Olympic Committee of Iran.

All body composition and physical fitness tests were performed at the Iran National Olympic Academy. Valid instruments on the first day measured anthropometric characteristics. Body height was measured using a standard stadiometer (Seca 213, Germany). The seated height was measured by placing the athlete in a seated position on a chair using a meter tape to measure the distance between the seat and the head to the nearest 0.01

m. The arm span was measured by meter tape to the nearest 0.01 m from fingertips on outstretched, opposing arms. Body mass was measured using the Beurer BF800 digital scale to the nearest 0.1 kg. Fat percentage and fat-free mass were measured with the InBody 570 (Korea) (18).

On the same day, strength tests were taken after a warm-up of 5 min of jogging and 5 min dynamic stretching. A handheld dynamometer (Lafayette, US) was used to measure handgrip strength, adjusted to the proportions of each athlete's hand. Grip strength is reported as the average of both hands on the best of two trails (19, 20). Maximum strength for chest press, deadlift, and squat was measured by the one repetition maximum (1RM). After a warm-up, subjects were asked to select the maximum load they could lift once. After a 3-minute rest, they could attempt to lift heavier weights. Since lean body mass influences the results of absolute strength, relative strength was calculated by dividing strength by body weight for comparison between groups (21). Muscle endurance was measured with modified pull-ups, Sweden push-ups, and sit-ups as the number of repetitions that could be done in 60 seconds. On the second day, each athlete was asked to participate in a Visual Reaction Test using the Newtest 1000 electronic reaction time meter (22). The test was conducted in a noise-free environment. Participants were seated before the equipment and asked to push a button when they saw the light. Five repetitions were performed before the test, and the mean of the five repeated measurements was calculated. Measurements for an athlete's physical speed were obtained with the 36-m sprint with a running start, using photocells placed at the start and finish line (23). The better of two sprints were recorded. The 4×9 test measured agility. Subjects ran a 9-meter distance between two cones four times, with timing recorded using photocells. The test was repeated two times, and the best record was ultimately used. On the next (third) day, subjects performed a 30-s Wingate test on a stationary bicycle ergometer (Monark Model 894E, Monark, Vansbro, Sweden) to measure lower body anaerobic power.

After cycling for five minutes at 60 revolutions per minute (rpm) for warm-up, participants increased the pedaling rate to reach maximum cadence and manually dropped the basket, holding a load of 0.075 kg per kg of body weight. Subjects also conducted a 30-s Wingate test on a modified electromagnetically braked cycle ergometer (EE) (Technogym, Italy) to measure upper body anaerobic power. Subjects sat on a chair while they kept their feet flat on the ground. The seat height and backrest were adjusted so that, while grasping the pedals of the ergometer, the elbow joint was almost in full extension (165-175°) and the shoulders aligned with the center of the ergometer's shaft. On the last (fourth) day, maximal oxygen consumption (VO2 max) was measured using an incremental running test on a motorized treadmill (Pulsar ® 3p, h/p/Cosmos, Nussdorf, Germany). The test started at 10 km/h for 3 minutes, followed by increments of 1 km/h every 1 minute at 1% inclination until voluntary exhaustion. The maximum oxygen uptake and produced carbon dioxide were analyzed breath-by-breath using a calibrated ergo spirometer (MetaLyzer3B, CORTEX, Germany).

Statistical analysis

Data were analyzed with the Statistical Package of Social Sciences (SPSS, IBM, v20) and presented in mean ± standard deviation (SD). Figures were prepared in GraphPad Prism (Version 7.03, GraphPad Software). An independent t-test was performed to compare the differences between the two styles. The level of significance was set at $p \leq 0.05$ for all analyses.

Results and discussion

Anthropometric characteristics of the Tatami and Ring style athletes are presented in Table 1. There were significant differences in arm span (p=0.001), fat percentage (p=0.001), and body fat mass (p=0.001) between the two styles.

Table 1

Anthropometry features of national adult kickboxers

Tested variables	Group variables		
	Ring style	Tatami Style	Average
Age (year)	25.5±3.4	28.4±3.2	26.9±3.3
Height (cm)	175.4±2.5	176.2±1.2	175.8±1.9
Sited height cm)	91.3±2.5	93.4±3.3	92.4±2.9
Arm span (cm)	183.8±2.7	178.6±3.2*	181.2±2.9
Body weight (kg)	75.7±2.5	76.5±1.7	76.1±2.1
BMI (kg/m^2)	24.40±2.50	24.8±2.7	24.6±2.6
Fat-free mass (kg)	68.9±3.6	66.2±2.8*	67.6± 3.7
Body fat percentage	11.3±2.3	14.3±2.5*	12.8±2.4

*Significant differences with Ring style group ($p<0.05$)

Due to the weight categories in this sport, relative strength, calculated by dividing lift weight by body weight, is a helpful indicator for comparing athletes. Table 2 contains data on the relative strength of squats, chest presses, deadlifts, handgrips, and muscle endurance of modified pull-ups, Sweden push-ups, and sit-ups. Independent t-test showed that relative strength and muscle endurance in all variables in Ring style athletes were significantly higher than in Tatami style athletes ($p<0.05$).

Table 2

Relative strength and muscle endurance in Iranian national kickboxers

Tested variables		Group variables		
		Ring style	Tatami Style	Average
Relative strength (Kg lifted / kg body weight)	Squat	1.5±2.4	1.1±1.5*	1.3±1.9
	Chest press	1.6±2.5	1.2±3.6*	1.3±3.0
	Deadlift	1.5±1.3	1.1±1.5*	1.3±1.3
	Both hand grip	0.7±1.2	0.6±0.2*	0.7±0.7
Muscle endurance (number/min)	Pull-ups	65.9±4.6	52.7±3.4*	59.3±4.0
	Sweden Push-ups	43.4±4.7	38.9±3.6*	41.2±4.1
	Sit-ups	65.3±2.9	53.8±3.8*	59.6±3.3

*Significant differences with Ring style group ($p<0.05$)

The data for speed, agility, reaction time, vertical jump (Sargent test), and flexibility in the two styles are presented in Table 3. There were no significant differences between the two styles in speed (t=1.83, p=0.29), agility (t=1.37, p=0.51), and reaction time (t=1.04, p=0.33). However, the two groups had significant differences in flexibility (t=2.65, p=0.001) and vertical jump test (t=3.57, p=0.001)

Table 3

Speed features and explosive power and core flexibility of Iranian national kickboxers in Ring and Tatami styles

Tested variables	Group variables		
	Ring style	Tatami Style	Average
Speed (36m) (s)	5.3±0.2	5.2±1.1	5.2±0.6
Agility (4×9) (s)	8.4±1.4	8.5±1.3	8.5±1.3
Speed reaction (millisecond)	399.0±95.0	401.0±72.0	400.0±84.7
Flexibility (cm)	41.1±3.9	45.9±2.7*	43.5±3.8
Vertical jump (cm)	57.6±1.3	54.3±1.2*	55.9±1.25

*Significant differences with Ring style group ($p<0.05$)

The independent t-test showed that Ring athletes had significantly higher aerobic power than Tatami-style ones (Figure 1). The mean VO2 max of both styles was 49.9 ± 3.7 ml.kg-1.min-1. In addition, Ring style athletes had significantly higher anaerobic power in their upper (t=1.23, p=0.001) and lower (t=2.18, p=0.001) bodies compared to their Tatami-style counterparts (Fig. 2).

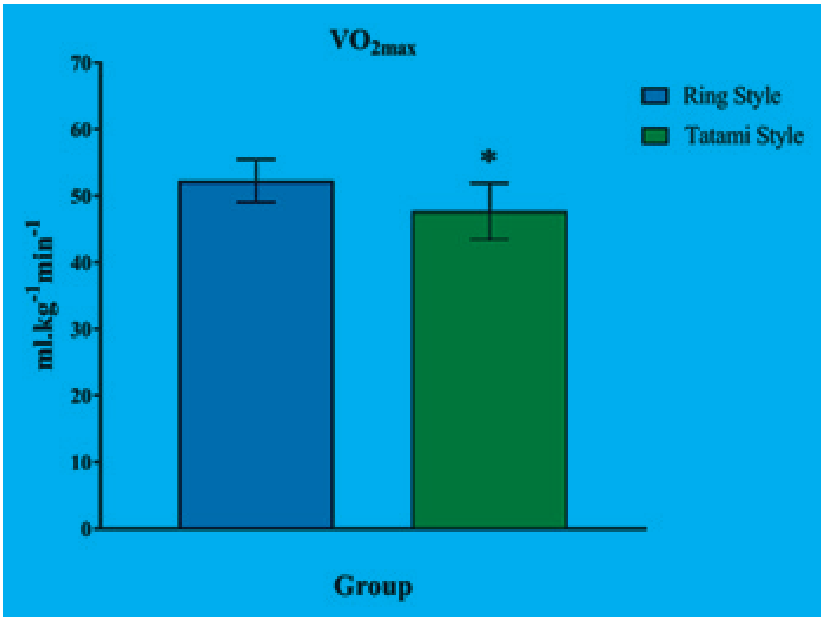

Fig. 1. Aerobic power of Iranian national kick boxers in ring and tatami styles.
*Significant differences with Ring style group (p<0.05)

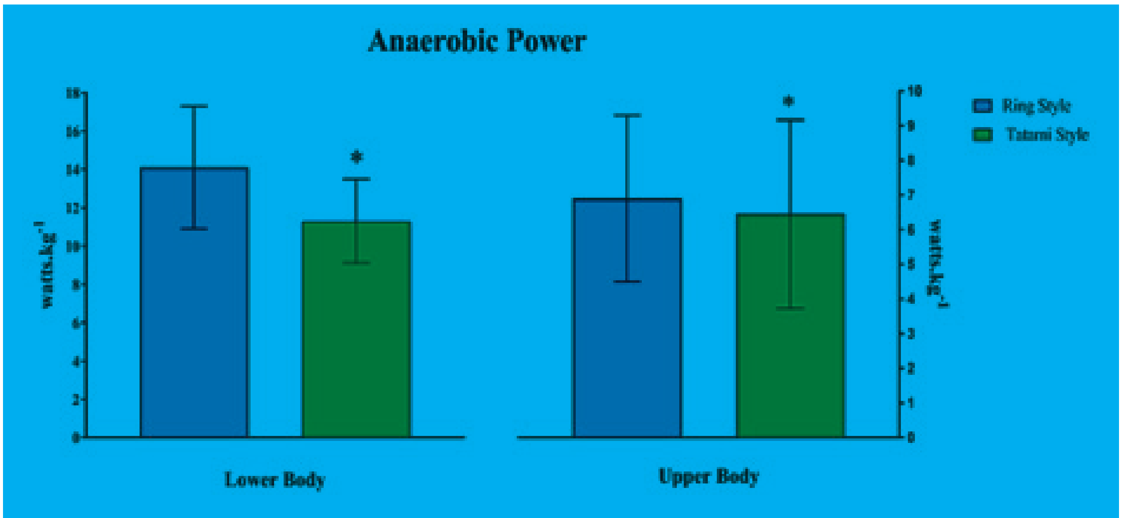

Fig. 2. Anaerobic power of Iranian national kickboxers in ring and tatami styles.
*Significant differences with Ring style group (p<0.05)

The first aim of this study was to provide comprehensive information about the anthropometric and performance levels of Iranian elite kickboxers. By comparing our findings to similar studies in other countries, we can conclude that the performance of Iranian kickboxers is internationally competitive. However, they must improve on some factors, such as aerobic power. The study's second aim was to compare Ring and Tatami-style kickboxers. Because of the demands of competitions, Ring-style athletes perform better than Tatami-style athletes in most physical fitness indicators (2).

In Kickboxing, all competitors are classified by body mass. Despite the extensive range of weight groups, it is impossible to consider a single body type or anthropometry profile for all competitive Kickboxers. So, body composition (low body fat) is an essential advantage, especially in Ring style matches. Kickboxers must be matched with a body mass limit and make the highest fat-free mass and the lowest amount of body fat. Therefore, male and female elite and amateur kickboxers should have low body fat percentages (24, 25). Lean body mass and body fat percentage of Iranian elite kickboxers were the same as elite athletes in other sports. According to the findings, the Iranian elite kickboxers had a mean body fat percentage of 12.8% (2.4), falling within the range of 9-16% for male amateur boxers (24) and 7-17% for Mixed Marital Arts (MMA) athletes (25). The mean body fat percentage of Iranian kickboxers was better than that of Caucasian kickboxers, approximately 14% (26). However, these values were out of the range of male national, and elite kickboxers were 6.1-11.4% (1). For example, the mean body fat percentage of elite Canadian kickboxers was 8.1% (7), and Portuguese kickboxers were 9.7% (27) . The lean mass values were also similar to those of United States karate athletes 12.9% (28) and Indian elite amateur boxers 12.2% (29). It appears that performing generic and specific kickboxing training for many years can lead to such changes in body composition. For instance, a sixteen-week kickboxing training period decreased young male subjects' body fat percentages (30). In addition, our results showed that Tatami-style kickboxers have a relatively higher body fat percentage and lower fat-free body mass than Ring-style kickboxers. The body fat percentage of Iranian Ring-style kickboxers was 11.3%. The observed decrease in body fat percentage could potentially be attributed to the strict competition requirements imposed on Ring-style kickboxers, which mandate them to maintain a stable weight range throughout the tournament (2).

Success for a kickboxer is deeply dependent on muscle strength and muscle endurance in the whole body, especially in the legs and arms. Thus, improving muscle strength and endurance is essential for fighters (31). Marković et al. (2005) provided a profile of performance indices of elite Croatian female taekwondo athletes (32). Elite Croatian taekwondo athletes' mean relative back squats (1.3) were similar to our measurement (1.3). However, their relative bench press (0.9) was below that of Iranian kickboxers (1.3). Notably, this difference in bench press could be attributed to taekwondo mainly utilizing leg techniques. While, Kickboxing requires both arms and legs, potentially leading to greater upper-body strength in kickboxers. In addition, Iranian kickboxers demonstrated greater muscle endurance than elite Croatian taekwondo athletes. In another study, Slimani et al. (2017) assessed Tunisian kickboxers' physiological and performance indices (3). Their data on Tunisian kickboxers' strength show lower performance than Iranian kickboxers. Therefore, based on the findings and comparison with other athletes, Iranian kickboxers' muscle strength is reasonable.

In comparing the two styles, Ring-style kickboxers presented superiority in all relative strength and muscle endurance. The relative strength of the squat and chest press of the Ring-style is more than 1.5 fold of their weights, which is close to top athletes who compete in elite events (3, 33). Higher relative strength in the Ring style is probably due to higher fat-free mass (34). Each style needs different demands that athletes train hard to achieve them.

Kickboxing is a sport that requires high levels of muscle endurance to perform the techniques repetitively during the fight. Studies have shown that kickboxers have superior levels of muscle endurance compared to non-athletic individuals (35). Kickboxing training is designed to enhance muscular endurance by utilizing high-intensity interval training and repetitive techniques, which lead to an increase in the oxidative capacity of muscles and improve endurance performance (30). Furthermore, the striking and kicking techniques employed in kickboxing require the use of large muscle groups, which leads to the development of high levels of muscle endurance in these areas (1). The high levels of muscle endurance observed in kickboxers can be attributed to the demands of the sport and the training methods used to prepare for competition.

The ability to produce high amounts of force in short relative periods is represented by muscle power. Kickboxing involves forceful kicking and punching, classified as power movements that demand significant speed and power. This underscores the significance of power training (25). Our measurements of explosive leg power, as evaluated by vertical jump, are consistent with those of top athletes (36). Notably, the Ring-style kickboxers in our study demonstrated a higher vertical jump performance than the Tatami-style kickboxers. This could be related to Ring-style kickboxers' higher strength in the lower body, which may contribute to their greater power output (37).

In the literature, Iranian elite kickboxers demonstrated the same speed and reaction time as other elite counterparts (13). In the defensive and offensive phases, kickboxers have to work quickly (38) so all kickboxers at the professional levels are swift athletes. The two styles had no significant differences in speed and reaction time. High speed and reaction time are prerequisites for being elite (39), suggesting that speed and reaction time are key components of successful performance in Kickboxing.

Aerobic power is one of the most critical parameters of success during kickboxing matches, in which athletes show repeated high-intensity actions (40). They need well-developed aerobic fitness to recover faster and perform the action with high quality during and until the last match in tournaments (7). The average aerobic power of Iranian elite kickboxers in the Ring and Tatami style kickboxers were 52.3 and 47.7 ml.kg-1.min-1 respectively. The aerobic power of Canadian and Portuguese kickboxers were 61.5 and 57.99, respectively, much higher than Iranian athletes (7, 27) However, the aerobic power of Iranian Ring-style kickboxers was higher than Serbian and Turkish kickboxers, which were 49.81 and 48.5 ml.kg-1.min-1, respectively (8, 41). Although no previous study directly compared Tatami and Ring-style kickboxers, we can still compare our measurements for each style with the results reported in other studies. Our findings indicate that Ring-style kickboxers have a higher VO2 max than Tatami-style kickboxers. Moreover, only the Ring-style kickboxers were within the range of top athletes in other countries. Therefore, over many years of hard training, different aerobic levels were formed in the athletes in two styles.

Anaerobic power plays a critical role in kickboxing matches. Athletes typically perform at maximal intensity for most of the match, resulting in near-maximal heart rates (3). In comparison with other relevant research, we find further evidence that our measurements are comparable to elite athletics in other countries. Our research's arm and leg Wingate test mean were 6.2 and 9.3 w/kg, respectively. Slimani et al. (2017) assessed the anaerobic power of Tunisian kickboxers with leg and arm Wingate tests. The mean values of leg and arm Wingate tests of male Tunisian kickboxers were 9.3 and 5.2 w/kg, below Iranian kickboxers (Figure 2). In another study, Ouergui et al. (2013) measured upper and lower body anaerobic power using a Wingate test for amateur and locally competitive kickboxers (38). In the measurements from this study, Wingate test values were significantly lower (5.2 w/kg) than we recorded for Iranian athletes. This difference could be since the athletes who attended Ouergui's investigation were amateurs from a local gym (38), However, Iranian kickboxers were at the international level.

Moreover, as measured in this study, the upper anaerobic power of Iranian kickboxers is close to the top other athletes, like the Brazilian national Judo team, which showed a mean of 5.8 w/kg (42). However, the anaerobic power of elite Canadian kickboxers measured by the Wingate test was higher than Iranian kickboxers for upper (6.4 w/kg) and lower body (14.1 w/kg) (7). Overall, the investigated Iranian athletes show similar characteristics to their counterparts in top National Kickboxing Teams globally. Nevertheless, since anaerobic power is crucial for kickboxers (1), Iranian athletes should enhance this fitness component during their training. The ring-style kickboxers' mean leg and arm Wingate tests were significantly higher than the Tatami style. This difference may be due to Ring-style athletes' greater lean body mass and leg strength, essential factors contributing to an athlete's power (3, 37).

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