Original Article

# Changes of physical capabilities of muscular strength, power and flexibility in a karate competition

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## ABSTRACT

Karate is an ancient martial art practiced by around 100 million people worldwide. In Brazil, it is estimated that approximately 250,000 people practice this modality. However, limited data are available outlining the physical capabilities of these athletes. The purpose was to analyse changes in physical capabilities of muscular strength, power and flexibility in karate athletes during a state championship. Data were collected during a karate state championship. From a total of approximately 200 participating athletes, data were collected from male (n = 34, 19.0 ± 9.84 years, 67.6 ± 21.8 kg, 165 ± 11.2 cm, 24 .3 ± 5.99 kg/m²) and female athletes (n = 12, 16.0 ± 4.47 years, 59.1 ± 11.8 kg, 156 ± 6.35 cm, 24.1 ± 4.35 kg /m²). Measurements: body mass, height, flexibility, handgrip muscular strength and lower limb power were performed before and after competition fights by a team of trained evaluators. Data were analysed between sexes, pre and post-competition, as well as by age group and number of fights performed. After the fights, there was a significant increase in muscular strength (+5.2%, $p$ = .004), with no difference between different age groups ($p$ = .141), sexes ($p$ = .196), and number of fights performed ($p$ = .072). There were no significant changes in muscle power performance ($p$ = .124) and flexibility ($p$ = .241) across fights or between sexes. A karate tournament in which athletes are involved in one to three fights does not seem to impair their performance in terms of muscular strength, power and flexibility, regardless of age, sex and number of fights performed.

**Keywords**: Performance analysis of sport, Martial arts, Athletic performance, Athlete.

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## INTRODUCTION

Due to the great publicity in the media of events related to combat sports, such as the Ultimate Fighting Championship (UFC), for example, the search for fighting modalities has increased (Bastidas, Levine, & Stile, 2012). Among these sports we have Karate, which debuted at the 2020 Olympics in Tokyo debuted as an Olympic sport. Currently in Brazil, karate has more than 250 thousand registered practitioners in Brazil, and it is believed that there are about 100 million practitioners of this modality around the world (Oliveira, 2022).

Karate is an ancient martial art practiced by around 100 million people worldwide (Martínez et al., 2020). In karate competitions, the modalities used are kata and Shiai kumite, requiring athletes to possess physical and motor skills to perform different movements, such as punches, strikes, and kicks (Ribas et al., 2020; Voltarelli et al., 2009). During a kumite fight, movements need to be performed at maximum speed, ensuring that the attacker's hand or foot reaches the target without the opponent being able to respond (Przybylski, et al., 2021).

Since karate is a combat sport that requires muscular strength, speed and power from the practitioner, it is crucial to provide appropriate training periodization to allow athletes to achieve championship-level performance (Przybylski, et al., 2021; Loturco et al., 2014). Indeed, most combat sports usually require a combination of technique, muscular strength, aerobic fitness, power, and speed. Investigations have shown that the most significant determining factors for successful karate performance appear to be ideally developed muscular strength, power, and flexibility based on the morphology of the limbs (Przybylski, et al., 2021; Loturco et al., 2014; Katić et al., 2009; Koropanovski et al., 2011; Zaborski et al., 2015).

In a recent narrative review performed to determine a needs analysis of karate kumite, several very interesting combat worthy aspects of this sport were mentioned. Caution needs to be taken when analysing studies that focus on simulated fights or official kumite fights since demands during simulated matches might be different from those of official competitions. Because karate is considered to be a high-intensity intermittent activity, when prescribing a training program for karate athletes, coaches are advised to train both the athletes` anaerobic and aerobic metabolisms (Chaabene et al., 2019).

To our knowledge, there is a paucity of studies that have analysed how the athlete's physical capabilities might be impacted during a kumite fight in a competition environment. Such information might provide strategies that could have an influence on the outcome (win or lose) of a match. Some previous studies have analysed the behaviour of power (Loturco et al., 2017), lactate concentration, and heart rate (Petrov; Penov; Kolimechkov, 2018) in simulated kumite fights, which usually provide different results when compared to competitive conditions (Zaborski et al., 2015; Chaabene et al., 2019; Loturco et al., 2017; Petrov et al., 2018).

What appears to be missing in previous analyses is the effect of actual competitive fights on physiological aspects of performance. Such information can help coaches to properly prescribe a training routine focusing on improving those physical capabilities that might be crucial for the athlete's success during a karate competition. Therefore, the purpose of the present study was to analyse the changes in physical capabilities of muscular strength, power and flexibility of karate athletes during a state championship. We hypothesized that athletes would show significant decreases in the physical capabilities analysed.

 

## MATERIALS AND METHODS

### *Experimental design*

This study was carried out during a karate state championship in Paranavaí, PR, Brazil. Prior to competition, all investigation procedures, benefits, and possible risks were announced and explained via microphone to all participants regularly registered in the tournament (approximately 200 athletes). Subsequently, they were invited to participate in the present study. The athletes who volunteered to participate were submitted to anthropometric (body mass, and height), upper body muscular strength (dominant handgrip), flexibility (sit-and-reach test), and leg power (standing long jump test) evaluations before the beginning of competition (called kumite) and immediately after the end of their fight(s) (varying from 1 to 3 fights, depending on the athlete).

### *Participants*

Male (n = 34, 19.0 ± 9.84 years, 67.6 ± 21.8 kg, 165 ± 11.2 cm, 24 .3 ± 5.99 kg/m²) and female athletes (n = 12, 16.0 ± 4.47 years, 59.1 ± 11.8 kg, 156 ± 6.35 cm, 24.1 ± 4.35 kg /m²) volunteered to participate in this investigation. All athletes provided a written informed consent prior to measurement. Before the beginning of each kumite fight and immediately after the completion of their fight(s), each participant was submitted to all measures. Figure 1 displays the schematic representation of the measurement logistic.

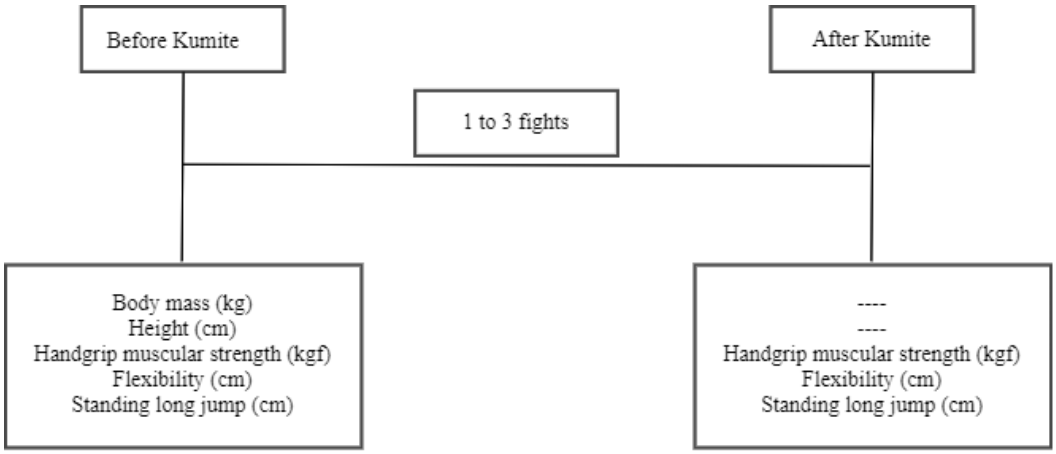


Figure 1. Schematic representation of the data collection.

### *Anthropometry*

Body mass was measured to the nearest 0.1 kg using a calibrated electronic scale (Balmak, Laboratory Equipment Labstore, Curitiba, PR, Brazil), and height was measured to the nearest 0.1 cm with a stadiometer attached on the scale. Participants wore light clothes and no shoes. Body mass index was calculated as body mass in kilograms divided by the square of height in meters.

### *Upper body muscular strength*

Upper body muscular strength was assessed using the isometric handgrip test performed with a dynamometer (TKK 5401 GRIP-D; Smedley, Takei, Tokyo, Japan). From a standing position, participants positioned the dominant arm extended alongside the body, holding the dynamometer with the right hand. At a signal from the examiner, the participant applied maximal handgrip force until the dynamometer registered the final value. The evaluation was repeated three times, with a one-minute interval between measurements, with the highest score considered as the final result of the test.

### *Explosive leg power*

Standing long jump test was used to estimate explosive leg power. The participant stood behind a line marked on the ground with feet slightly apart. A two-foot take-off and landing was utilized by each participant, with swinging of the arms and bending of the knees allowed to provide maximal forward projective drive. The participant attempted to jump as far as possible, landing on both feet without falling backwards. Three attempts were allowed, and the highest score was registered (ACMS, 2012).

### *Flexibility*

A sit and reach flexibility box (WCS, Brazil) was used to assess low back and hip joint flexibility (ACMS, 2012). Each participant sat with legs fully extended and soles of the feet placed flat against the flexibility box. With arms evenly stretched, palms down, the participant reached forward without jerking to push the sliding marker as far as possible along the scale with the fingertips. The position of maximum trunk flexion was held for approximately two seconds. The test was repeated three times. The best value in cm was documented and used for data analysis.

### *Kumite fight*

Before the beginning of the kumite fight, the athletes were submitted to the first battery of measurements (before kumite), and then were allowed to warm up, which consisted of stretching exercises for the whole body, stationary running, and ballistic exercises. This warmup was not controlled or supervised by the examiners. By the announcement of the karate referee, the athletes went up to the met and the kumite started.

### *Statistical analysis*

Normality was checked by the Shapiro-Wilk's test. Data were expressed as means and standard deviations. Levene's test was used to analyse homogeneity of variances. Separate one-way analyses of variance (ANOVA) for independent groups (age group, number of fight(s), and sex) were used for within-group comparisons. In variables where sphericity was violated as indicated by Mauchly´s test, analyses were adjusted using a Greenhouse-Geisser correction. When an F-ratio was significant, Bonferroni's *post hoc* test was employed to identify mean differences. The data were analysed using Statistica software version 13.2 (Statsoft Inc., Tulsa, OK, USA).

## RESULTS

Table 1 displays the general characteristics of the athletes. Men were 6% taller, 41% stronger, presented 34% more explosive leg power, and had almost twice as many fights when compared to women ($p < .05$). Body mass, body mass index (BMI), and flexibility were not significantly different between sexes.

Table 1. General characteristics of the athletes involved in this study.

| Variable | Male (n = 34) | Female (n = 12) | *p* |
|---|---|---|---|
| Body mass (kg) | 67.60 ± 21.80 | 59.10 ± 11.80 | .207 |
| Height (cm) | 165 ± 11.20 | 156 ± 6.35 | .016 |
| BMI (kg/m²) | 24.30 ± 5.99 | 24.10 ± 4.35 | .923 |
| Upper body muscular strength (kg) | 37.30 ± 10.30 | 26.40 ± 5.63 | < .001 |
| Flexibility (cm) | 29.70 ± 8.08 | 31.10 ± 8.71 | .618 |
| Explosive leg power (cm) | 172 ± 25.20 | 128 ± 20.10 | < .001 |
| Number of fights | 1.71 ± 0.91 | 1.08 ± 0.29 | .025 |

*Note. BMI = body mass index. Data are expressed as mean and standard deviation. *Estimated by statistical test: ANOVA.*

 

There was no difference in upper body muscular strength, explosive leg power, and flexibility of the athletes before and after kumite fights, when considering sex, number of fights, and age groups (Table 2). When the data was analysed as a pooled sample (Table 3), there was a significant increase in upper body muscular strength after the kumite fights (+5%), but not for explosive leg power and flexibility.

Table 2. Upper body muscular strength, explosive leg power, and flexibility of the participants before and after the kumite fights, according to sex, age groups, and number of fights.

| | **Upper body muscular strength (kg)** | | **Explosive leg power (cm)** | | **Flexibility (cm)** | |
|---|---|---|---|---|---|---|
| | X ± SD | *p** | X ± SD | *p** | X ± SD | *p** |
| Sex | | | | | | |
| Male (n = 34) | 2.30 ± 4.47 | .196 | 4.21 ± 11.5 | .202 | 0.44 ± 3.41 | .711 |
| Female (n = 12) | 0.50 ± 2.67 | | -1.08 ± 14.0 | | 0.83 ± 2.11 | |
| Age group | | | | | | |
| 10-13 years (n = 12) | -0.13 ± 2.40 | .141 | 1.50 ± 9.80 | .219 | 2.63 ± 3.52 | .079 |
| 14-17 years (n = 13) | 2.32 ± 3.67 | | -0.23 ± 12.8 | | -0.50 ± 2.58 | |
| 18-21 years (n = 9) | 2.69 ± 4.28 | | 0.00 ± 13.30 | | 0.22 ± 2.68 | |
| ≥ 22 years (n = 9) | 2.92 ± 6.08 | | 10.4 ± 11.70 | | 0.78 ± 2.18 | |
| Number of fights | | | | | | |
| 1 (n = 31) | 2.33 ± 4.41 | .072 | 5.29 ± 11.7 | .189 | 0.29 ± 2.93 | .360 |
| 2 (n = 5) | -0.72 ± 2.01 | | -2.00 ± 9.30 | | -0.20 ± 0.84 | |
| 3 (n = 10) | 1.53 ± 3.76 | | -2.40 ± 13.7 | | 1.70 ± 4.14 | |

*Note. SD = standard deviation, X = mean scores. *Estimated by statistical test: ANOVA One Way.*

Table 3. Upper body muscular strength, explosive leg power, and flexibility of the participants before and after the kumite fights.

| **Variable** | **Pre-Kumite** | **Post-Kumite** | ***p**** |
|---|---|---|---|
| Upper body muscular strength (kgf) | 34.5 ± 10.5 | 36.3 ± 11.7 | .004 |
| Flexibility (cm) | 30.1 ± 8.17 | 30.6 ± 7.86 | .241 |
| Explosive leg power (cm) | 161 ± 30.9 | 164 ± 33.3 | .124 |

*Note. *Estimated by statistical test: ANOVA.*

## DISCUSSION

Our study aimed to analyse changes in physical capabilities of muscular strength, power and flexibility in karate athletes during a state championship. Results showed that a karate tournament in which athletes are involved in one to three fights does not seem to impair their performance, regardless of age, sex, and number of fights performed during the competition, which does not confirm our initial hypothesis.

The significant increase in upper body muscular strength (+5%) after the kumite (Table 3) might be explained by a possible post activation potentiation effect, which is in line with a previous investigation that reported an increase in lower limb muscular power production (+7.4%) in a male double world karate champion (Loturco et al., 2017). It is important to highlight that in study by Loturco et al. (2017), the post activation potentiation effect occurred in the lower limbs, but for the upper limbs, there was a significant 8.3% decrease in strength after the fight. When compared to our study, their difference was probably due to the differences between the high-level of their athletes compared with our sample (state-level athletes). In high-level karate athletes, the use of punches is more commonly observed, thus, resulting in a greater potential for fatigue (Loturco et

al., 2017; Petrov et al., 2018; ACMS, 2012, Tabben et al., 2015). On the other hand, other researchers found that the most frequent attack used by Brazilian National karate athletes was the semi-circular kick with the leg positioned behind (lower limb) (Ribas et al., 2020). Unfortunately, we did not determine the number of kicks and punches during each kumite fight to establish a comparison with these investigations.

According to our results, muscular strength, power and even flexibility are not impaired during kumite fights (Table 2) but could be a determining factor differentiating between winners and defeated competitors. This may differ from a karate athlete who usually needs to possess an appropriate amount of strength and power in order to ensure that rapid movements are deployed with high precision against the opponent (Chaabene et al., 2012; Przybylski et al., 2021). In fact, a recent investigation that aimed to determine the morphological and motor determinants of successful in Shotokan karate performance among male and female practitioners showed that two variables had the greatest impact on performance outcome of male and female competitors. For women, thigh circumference and speed of the mawashi-geri-kick roundhouse technique were significant contributors to success, while for men the major factors for success were the extent of the sideway swing to the highest possible height (yoko-geri) and overall endurance assessed with the bent arm hang test (Przybylski et al., 2021).

Muscle power seems to play an important role for karate fighters so that they can develop better results. As indicated by the World Karate Federation (WKF) (2019) the performance of athletes depends on their strength, power and speed. In fights, demonstrations of strength can occur in different ways, such as escape actions and immobilizations (Coswig & Andreato, 2020). Chaabene et al. (2012) in their review of the physiological and physical factors of athletes in the modality, indicates that decisive actions during fights (kicks or punches) result, above all, from power. In addition, the power and speed of the upper and lower limbs are essential factors for a good performance during fights.

Another essential factor of the modality not affected during fights is flexibility (Table 3). Flexibility in fighting sports is a fundamental physical capacity due to the necessary joint amplitude, both in attack techniques and in defence techniques (Chaabene et al., 2012; Soares et al., 2005). In a competition, factors such as speed and flexibility play an important role in the execution of effective movements (Srianto & Siswantoyo, (2022). In a recent study, it was found that karate athletes had high levels of flexibility, with 80% of athletes reaching the "*perfect*" index in the sit and reach test (Srianto & Siswantoyo, (2022).

In contrast, the study by Shaw et al. (2020) found that there are no differences between the flexibility levels of lower limbs in athletes of karate, regardless of training levels. Flexibility is an important factor for athletes, as it is necessary for the blows to be delivered, such as high kicks, defences, guard passes and entry into takedowns (Coswig & Andreato, 2020). Thus, is evident the need for the athlete have developed flexibility, speed, power and muscle strength to achieve high performances during competitions.

As for the characteristics of the athletes, the study indicated that men are taller, stronger and have greater explosive strength in the legs and participated in more competitions when compared to women (Table 1). These data are important as the competitions are categorized according to the athletes' weight. In this sense, knowing the anthropometric and physical fitness profile of athletes in the fighting modalities are important information for selecting the most suitable athletes for competitions, since sports efficiency is related to an optimal anthropometric profile (Ribas et al., 2018).

For future research, it is suggested that comparisons be made of the analysed skills of these athletes as a function of the ranking. In addition, it is suggested that additional assessments be carried out, such as

 

monitoring stress levels during the competitive period. As the combat modalities are essentially aerobic (Julio et al., 2017) this system is responsible for keeping the intensity high until the end of the fights (Franchini, 2016), it is also suggested that in future studies the aerobic conditioning be evaluated of the fighters. Above all, due to the intermittent nature of the fight modalities, since in some moments of the fights there is a high intensity followed by moments of partial recovery (Gastin, 2001).

## CONCLUSION

We conclude that a karate tournament in which athletes are involved in one to three fights does not seem to impair their performance in terms of muscular strength, power and flexibility, regardless of age, sex and number of fights performed during the competition. This may be related to the high level of fitness of the athletes preceding the matches. Future research should explore the effects of seasonal training on fundamental fitness parameters of these athletes to differentiate among winners and losers of matches.

## AUTHOR CONTRIBUTIONS

Nascimento, M. A., Graça, A., Nascimento J. R. P., and Fonseca, H. S., participated in the design of the manuscript, analysis and interpretation of data. Belem, I. C., and Guilherme, F. R., wrote the manuscript and critically reviewed the content.

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## DISCLOSURE STATEMENT

No potential conflict of interest were reported by the authors.

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