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## COACHING & KINESIOLOGY

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# Effects of *kiai* on jumping performance and striking reaction time in Karate athletes

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**Key words**: martial arts, mobile applications, karate, reaction time

**Abstract**
Background. *Kiai* is a breathing technique, usually related to a short scream that aims to focus the martial artist's energy in a given attack. However, the influence of *kiai* in the technical and physical aspects related to striking performance needs more evidence. Thus, the purpose of this study was to investigate the effect of *kiai* in the performance of vertical jumps, and reaction time (RT) for punches and kicks in amateur Karate athletes.
Methods. Sixteen male amateur athletes aged 18.5 ± 4.3, body mass of 68.5 ± 10 kg, height of 1.7 ± 0.1 m, and 2.4±1.8 years experience in Karate were recruited. Five attempts at each technical action and three attempts at each vertical jump were performed with and without using *kiai*. The RT was measured by the *TReaction*® app and the vertical jumps by using a contact mat. Paired t-tests and Cohen's d effect sizes were used to test differences between conditions, while ANOVA was applied to test differences between attempts for both RT and jumps.
Results. No significant differences were found between *kiai* and control conditions for the countermovement jump (CMJ; p= 0.496), squat jump (SJ; p= 0.374), and drop jump (DJ; p= 0.147) performance. There was no evidence (p> 0.05) of significant differences between conditions for punch and kick Rts.
Conclusion. The *kiai* technique does not promote or affect RT of punch, kick, and vertical jump performance in Karate athletes.

## Introduction

Karate is a Japanese martial art with relevant popularity worldwide, mainly as a combat sport, which was included in the Tokyo 2020 Olympic program in both *Kata* and *Kumite* competition configurations. While Kata is characterized by choreographed battles against invisible opponents, *Kumite* is the combat itself [Blaszczyszyn *et al*. 2019]. In this context, *Kumite* actions are based on high speed and force punches and kicks aiming for the knockout and/or punctuation [Serina, Lieu 1991].

Indeed, in Karate, determinant motor actions demand high force productions at high speed, which is known as the rate of force development [Cronin, Sleivert 2005]. This nature of physical performance promotes the increase in muscular fibers recruitment, mainly those of rapid contraction [Baker, Davies 2006], which highlights the need for muscle power evaluation in these athletes [Sant'ana *et al*. 2014]. Currently, vertical jump tests have been widely used to infer lower limbs muscular power in athletes of different sports modalities [Cronin, Sleivert 2005], despite it has also been questioned [Morin *et al*. 2019]. Performance in vertical jumps seems to be able to discriminate against Karate athletes by their competitive status since international level athletes showed higher performance than those at the national level [Ravier *et al*. 2004]. Also, there is evidence of strong correlations between the average power in the countermovement jump test (CMJ) and shorter time (r= -0.89) and average time (r = -0.79) of kicks cycles in a specific test to evaluate anaerobic power and capacity in combat sports athletes [Ravier *et al*. 2004]. Thus, the power jump tests may be associated with higher muscular power and energy production capacity, which would contribute to faster motor actions while executing punches and kicks [Sant'ana *et al*. 2014].

In Karate, optimizing the ability of athletes to perceive the opponent's information during the fight, as well as, perform the attack or counterstrike movements with slower reaction time (RT) and greater accuracy, allows for greater effectiveness of scoring in the competitive scope [Mori *et al*. 2002]. Moreover, greater competitive success has been verified in athletes with lower values of RT [Fontani *et al*. 2006; Mori *et al*. 2002]. The concept of RT is defined as the time between a given non-forehanded stimulus and the onset of an individual's motor response [Le Mansec *et al*. 2019]. In combat sports, RT is described as the total time spent between the presentation of the stimulus (visual or sound) until the moment the attack reaches the target [Ana *et al*. 2016]. That said, any intervention that could improve the fighter RT would be of interest, especially regarding visual stimulus [Cojocariu 2011].

Traditionally, in Karate training and competition, an action usually applied is the *kiai*, which is a breathing technique, usually related to a short shout that aims to focus the martial artist energy in a given attack and, consequently, induce higher levels of strength and speed in the motor action [Martins *et al*. 2014; Welch, Tschampl 2012]. *Kiai* is defined as "KI", which means energy, and "AI" which means harmony, and occurs when the individual focuses his energy in the central region of the body, called "tandem" by practitioners. Theoretically, the KI would be dissipated through respiration and scream along with the core muscle contraction, giving harmony between concentration, scream, and energy release [Kotarska *et al*. 2019]. In this sense, it is suggested that *kiai* would be relevant for technical actions performance in martial arts. Based on that, Welch and Tschampl [2012], tested the effect of *kiai* in the handgrip strength of athletes with different experience levels and found an increase in strength performance when *kiai* was used. Also, Martins *et al*. [2014], observed that the *kiai* generates an increase in the peak acceleration of kicks in taekwondo athletes. Notwithstanding, Morales *et al*. [1999], found no effect of screaming in the rate of force development in weight lifting athletes, which could reinforce that expected effects are not based on the scream only and the specificity context of martial arts concentration and training would play a role in *kiai* effects.

Thus, considering that i) muscular power and RT [Baker, Davies 2006; Loturco *et al*. 2017] may allow athletes to improve physical and technical aspects that are related to the ability to perform traumatic blows, which may contribute to Karate sports performance; and ii) the effects of *kiai* on these variables are not well established even though its traditional premise in martial arts, the purpose of this study is to describe and examine the effects of *kiai* on vertical jumps performance and RT for punches and kicks of amateur Karate athletes.

## Material and Methods

### Participants

Sixteen male amateur athletes with aged of 18.5 ± 4.3 years old, body mass of 68.5 ± 10 kg, height of 1.7 ± 0.1 m, and 2.4±1.8 years of experience in Karate were recruited. As inclusion criteria, athletes should have a minimum experience of 12-month karate training and have not had any recent joint or muscular injuries that prevented them from performing training or tests. Subjets that presented joint and/or muscular discomfort during the tests or did not perform all procedures would be excluded.

### Procedures and Measures

This study was approved by the local Ethics and Research Committee and all participants signed the consent form according to resolution N º 466/12 of the Brazilian National Health Council for research with human beings. Two meetings were needed for this investigation, with a seven-day interval between them. In both experimental situations' participants attended the lab at the same time of day to avoid circadian alterations. First, the participants were randomized to perform the blows with or without *kiai*, and the order was reversed at the next meeting. Subsequently, a specific warm-up of the modality was performed, using jumps and runs around the mat, then the participants were instructed to perform Karate specific technical actions, mainly punches and kicks. RT was measured through the *TReaction*® app (ETS4ME, Sao Jose, SC, Brazil-www.ets4.me/treaction.html). All

participants were verbally encouraged to perform the blows with the highest speed and strength possible and to perform the *kiai* at the same time that the blows came into contact with the target. For vertical jumps performance three attempts were made for each jump (CMJ; squat jump, SJ; and drop jump, DJ) through the contact mat (JUMP SYSTEM PRO®, Cefise, Brazil).

*Performance in Vertical jumps*
All measurements of vertical jumps were performed through the contact mat, which was compatible with the operational system Windows 10 (Jump System Pro 1.0). The system operates through the circuit that fires as soon as the athletes land on the contact platform, shortly after the surface of the feet stops touching the ground. The maximum height performance is calculated from the flight time, the software transmits the information to the notebook, thus demonstrating the graphics of the maximum height in real-time [Farias *et al*. 2013]. All vertical jumps had their technique (jump and landing) standardized. This instrument showed high reproducibility values (ICC= 0.97), according to a previous study [Farias *et al*. 2013].

*Countermovement Jump (CMJ)*
The CMJ started from the standing position with the hands on the hips, then the athlete was asked to perform the eccentric phase (knee flexion at ~90°) and immediate displacement of the body mass in the vertical direction was performed, starting from the ground and thus achieving maximum height [Hassani *et al*. 2014].

*Squat Jump (SJ)*
With the hands-on hips, the subjects started from a squatting position (~90°) and positioned their feet apart with the distance from the shoulder width and flexed the knees leaving them parallel to the ground, at this moment the participants maintained the squatting position for two seconds. Then, the knee and hip extension movements were performed at the highest possible speed, to perform the vertical propulsion at its furthest point of the ground [Van Hooren, Zolotarjova 2017].

*Drop Jump (DJ)*
Starting from the platform measuring 31 cm high, the subjects initially positioned with the feet parallel in the shoulder line and with the hands at the height of the iliac crest, then the inclination of the body was performed projecting to fall on the ground. After the landing, a fast eccentric to concentric transition was performed by knee and hip extension to achieve maximum jump height to the ground. Additionally, the contact time with the ground was also analyzed [Marshall, Moran 2013].

*Kicks and Punches*
The Gyaku Zuki (GZ) punch begins with the rotation process of the pelvic girdle, following the release of the back arm of the Karateka guard, performing the process of elbow extension and radioulnar rotation in the rotating movement of the wrist [Kim *et al*. 2011]. In the kick movement called Mawashi Geri (MG), characterized by a roundhouse kick, in which the process of rotation of the pelvis occurs in conjunction with the spine. The execution leg of the kick remained flexed followed by the rotation of the supporting leg, the end of the movement occurs with the knee extension of the executing leg and plantar flexion [Martinez de Quel, Bennett 2014; Quinzi *et al*. 2016]. Both techniques are presented in Figure 1.

*Response Time Measurement (RT)*
The RT was measured through the *TReaction*®, which is a smartphone application (app) available in the Play Store and able to measure the RT in milliseconds. The app started to measure time when the visual stimulus was triggered (camera flash) and was interrupted by the sound of the strike in the punching bag (Figure 1). The *TReaction*® app has been used in combat sports and martial arts to measure the RT efficiently and was validated for measuring striking response time in combat sports [Coswig *et al*. 2019]. The RT measurements were obtained with the participants performing a total of five MG kicks (*kiai* or control) with a random interval from 10 to 15s. After two minutes of rest, the athletes performed a total of 5 GZ punches (*kiai* or control) with

**Figure 1.** Athlete and evaluator positioning for the response time test.
Left: Guard position; Middle: Final movement stage for GZ punches; Right: Final movement stage for GZ kicks.

**Table 1.** Mean and standard deviation for performance in vertical jumps and reaction time for punches and kicks with and without *kiai* use.

| | Control | *Kiai* | Difference (ms) | t(p) | ES |
|---|---|---|---|---|---|
| *GZ Punch Response Time (ms)* | | | | | |
| Best | 583.2±128.7 | 576.9±90.5 | 6.3 | 0.251 (0.804) | 0.05 |
| Average | 675.0±136.0. | 664.5±102.8 | 10.6 | 0.369 (0.716) | 0.08 |
| Worse | 794.5±250.6 | 770.8±142.5 | 23.8 | 0.382 (0.707) | 0.09 |
| Total | 17830.6±214.1 | 17517.7±1097.4 | 312.9 | 0.817 (0.424) | 0.26 |
| *MG Kick Response Time (ms)* | | | | | |
| Best | 777.5±154.9 | 806.5±123.7 | -29.0 | -0.715 (0.483) | -0.19 |
| Average | 887.8±114.0 | 879.0±109.8 | 8.7 | 0.558 (0.583) | 0.08 |
| Worse | 987.6±179.3 | 952.7±130.4 | 34.8 | 1.675 (0.110) | 0.19 |
| Total | 17704.1±1037.0 | 17152.5±1239.0 | 551.5 | 1.579 (0.131) | 0.53 |
| *Vertical Jumps performance* | | | | | |
| CMJ (cm) | 31.9±6.1 | 32.5±5.8 | -0.6 | -0.694 (0.496) | -0.09 |
| SJ (cm) | 31.8±6.3 | 32.4±5.9 | -0.6 | -.911 (0.374) | -0.09 |
| DJ (cm) | 31.5±6.1 | 32.6±5.8 | -1.1 | -1.511 (0.147) | -0.18 |
| CT in DJ (ms) | 887.8±340.2 | 1070.4±790.9 | -182.7 | -0.037 (0.970) | -0.54 |

Legend: t= paired t-test, ES= effect size, CMJ= countermovement jump, SJ= squat jump, DJ= drop jump, CT= Contact time, GZ= Gyaku Zuki, MG= Mawashi Geri.

a random interval from 10 to 15s, among them. After seven days the procedures were repeated to test the other condition. The height and distance of the target, as well as the position of the base feet and the execution of the MG kicks, as well as the arms, were adjusted for each athlete and maintained throughout the protocol to guarantee the same individual conditions for each athlete. The best (lower), average, worse (higher) and total (summed) values of RT measured for both actions (GZ punch and MG kick) were included in the analysis.

## Statistical Analysis

First, the Shapiro-Wilk test was performed to test data distribution and means ± standard deviations (SD) were used. To compare vertical jumps and the RT (best, average, worse, and total) means between conditions (*kiai* vs control), paired t-tests were applied. In addition, effect sizes (ES) were calculated accordingly to Cohen's *d* and were considered as trivial (< 0.20), small (0.20 to 0.30), medium (0.40 to 0.70) or large (> 0.80) [Cohen 1992]. The correlation measures between the performance in vertical jumps and the RT for GZ punches and MG kicks were tested by the Pearson correlation coefficient (r) and characterized as follows: <0.50 (trivial), 0.50 to 0.75 (moderate), 0.75 to 0.90 (good) and > 0.90 (excellent) [Lakens 2013]. Additionally, for the analysis of the 5 attempts of both GZ punches and MG kicks with different stimuli a two-way analysis of variance (ANOVA) with repeated measures was applied, when appropriate, the differences were tested by the Bonferroni posthoc. The Wilcoxon test for paired measurements was used for no-parametric data analysis (Contact time with the ground in DJ). All analyses were performed in the SPSS statistical package version 22.0 and the significance level was established when $p \leq 0.05$.

## Results

The results for GZ punches and MG kicks and vertical jumps performance are presented in Table 1. The results of RT showed no difference between control or *kiai* conditions for the best time, average, worse, and total for both traumatic actions ($p > 0.05$). Moreover, vertical jumps performance was not significantly different among conditions for all variables ($p > 0.05$). Finally, the contact time in DJ did not show a significant difference between conditions ($p > 0.05$).

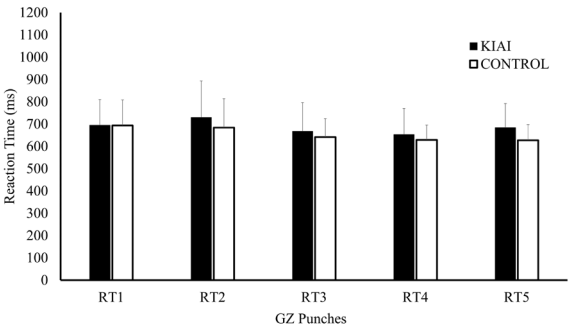


**Figure 2.** Response Time of GZ Punches presented by mean ± SD through the five attempts.

Figure 2 shows the values of the five attempts of GZ punches and MG kicks by situation (*kiai* vs control), the results did not demonstrate differences between situations (F= 0136; p= 0716; $\eta^2$= 0.007). Regarding main effects for GZ punches, a statistically significant difference

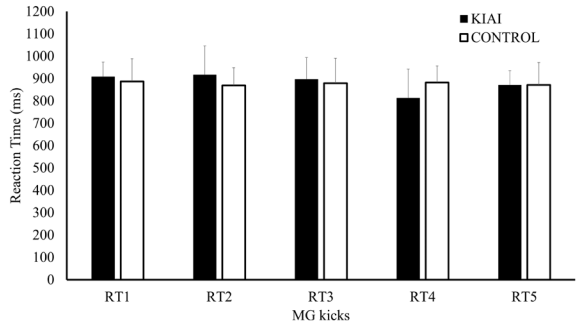


**Figure 3.** Response time of MG Kicks RT presented by mean ± SD through the five attempts.

was evidenced between moments (F= 4.60; p= 0.012; $\eta^2$= 0.0045). However, these was not confirmed in the post-hoc test (F= 2.57; p= 0.07). In addition, there was no moment*situation interaction (F= 0.190; p= 0.940; $\eta^2$= 0.045). The results for successive MG kicks are presented in Figure 3, it is evidenced that no significant difference was found between the situations (F= 0.312; p= 0.582; $\eta^2$= 0.016). Between moments analysis showed that no statistically significant difference was found (F= 0.880; p= 0.498; $\eta^2$= 0.480). Finally, no significant interaction was found (F= 1.382; p= 0.284; $\eta^2$= 0.257).

Correlations between best and average RT and vertical jump performance are expressed in Figure 4. Moderate and negative correlations were found between the CMJ height and average RT values of MG kicks (Panel B) and for SJ height and best and average RT values of GZ punches (Panel D).

## Discussion

The purpose of this study was to describe and examine the effect of *kiai* on vertical jumps performance and RT for punches and kicks of amateur Karate athletes. The results showed that the use of *kiai* did not promote significant effects on jumping outcomes or RT.

Regarding the effects of *kiai*, Martins *et al.* [2014], compared the peak acceleration as an indicator of kick impact. The authors observed that when *kiai* was used,

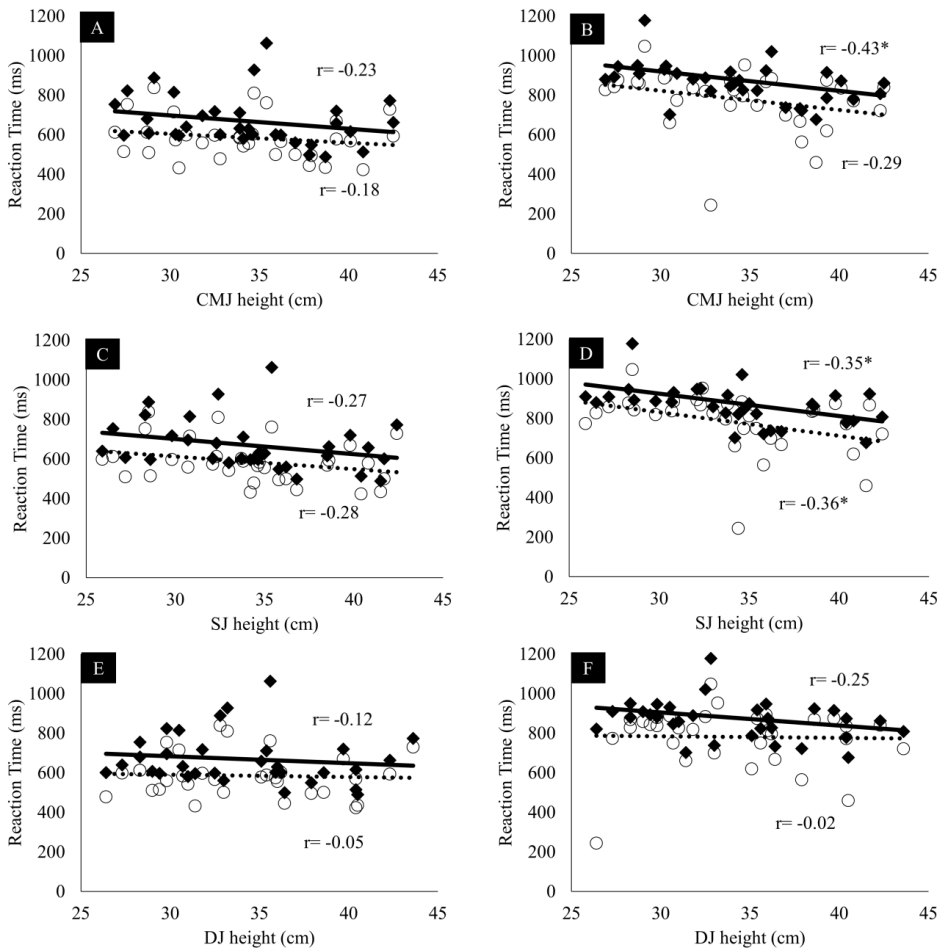


**Figure 4.** Correlations between CMJ, SJ and DJ performance and GZ punches (Panels A, C and E) and MG kicks (B, D and F) best and average RT values.

Continuous lines: average RT; Dashed lines: Best RT values; White circles: best RT values; Dark diamonds: average RT values; r: Pearson coefficient correlation. *statistically significant at p<0.05.

the average acceleration of the kick was significantly higher ($p< 0.01$). Besides, Welch and Tschampl [2012], examined the effects of *kiai* on the handgrip strength of 50 participants in different situations (*kiai* vs control), to determine whether the experience of athletes could affect *kiai* influences in performance. The results showed that the *kiai* increased the peak of handgrip strength in both the experienced and beginner athletes (Control: 409.1 ± 95.4N to 428.6 ± 98.9N, $p< 0.01$; *kiai*: 406.9 ± 87.6N to 445.6 ± 91.7N, $p< 0.01$). However, our findings showed that *kiai* does not influence the performance of RT to potentiate the traumatic blows tested.

One of the hypotheses to explain the absence of *kiai* effect in RT of GZ punches and MG kicks is due to its combination with the motor actions investigated since the sum of *kiai* and the technique would demand a higher degree of complexity, which seems to be directly related to RT [Henry, Rogers 2013]. Also, to process the unpredictable information, such as the flash issued by the *TReaction*® app plus the use of *kiai*, could induce higher RT [Johari, Behroozmand 2017], another hypothesis may be related to the time and movement relationships between motor actions used and their relationship with the sensory system, which is stimulated by the feed-forward mechanism in the cortical areas within the caudal segment [Vallesi *et al*. 2007]. Although it did not have a positive effect, it should be highlighted that there was no negative influence when using *kiai*, which enables the continuity of traditional aspects without detrimental effects in RT performance.

Concerning the experience level in Karate, Whelan *et al*., [1990], observed that amateur athletes could benefit from psychomotor methods to increase strength and improve RT. However, our results fail to show *kiai*-induced effects on RT. A possible explanation for this is that the athlete´s experience (practice time) influences the intra and intermuscular coordination, RT responses, and velocity [Mori *et al*. 2002]. Besides, the competitive level can improve the adaptations of athletes to new stimuli (eg.: visual or sound) [Faubert 2013]. Therefore, it seems that amateur athletes did not benefit from the stimulus imposed by the *kiai*, at least in the RT performance, which may be different from athletes with higher competitive levels and experience.

Regarding vertical jumps, Cordero and Zamora [2010], did not find significant differences in screaming while jumping in peak strength and flight time in the CMJ, measured in a force platform. Thus, it was hypothesized that the martial arts context and experience (Kung Fu vs non-fighters) could explain those aforementioned contradictions, which was not confirmed by our findings. We hypothesized that intrinsic factors, such as *kiai*, could increase the perception of readiness and would be a contributing factor to improve vertical impulsion. However, this seems not enough to influence muscle activation and, since the pattern of jumping is essentially established by neural pathways [Brody *et al*. 2000], *kiai* may not contribute at this level.

Correlations between vertical jumps and shorter kick time were previously evidenced by Sant'ana *et al*. [2014], with high negative correlations between the meantime of kick cycles and mean power during CMJ performance ($r= -0.79$; $p= 0.04$). Additionally, Estevan *et al*. [2013] found significant negative correlations between the demands of the ground reaction force and RT in different angles (0°, 45°, and 90°) of the positioning of the support base of the feet ($r0°= -0.93$; $r45°= -0.79$; $r90°= -0.90$), which partially agree with our results. According to these findings, it is suggested that performing and repeating punches and kicks with high velocity is associated with the level of strength and muscular power of individuals [Fortier *et al*. 2005]. Therefore, actions with higher power performance and energy production, potentially reduce the time of motor action execution, thus reducing the RT [Sant'ana *et al*. 2014]. Additionally, punches and kicks use shortening and stretching actions similar to jumps, making the correlations significant [Estevan *et al*. 2012; Serina, Lieu 1991]. These factors become relevant to the practice of combat in a competitive environment due it is highly requested in different striking combat modalities (Taekwondo, Muay-Thai, Karate, among others) and may allow a more effective counterattack during a fight [Falco *et al*. 2009; Henry, Rogers 1960; Kim *et al*. 2011], which significantly favors competitive success [Serina, Lieu 1991].

For the proper interpretation of our findings, some limitations need to be considered. Firstly, the app used during data collection is not considered gold standard measurement, however, it presented high reproducibility between measurements, and presented high validity and external applicability. Another limitation is the sample size. However, the sample is highly specific and representative of the number of practitioners in the region, when considering the strictness of the inclusion criteria. Moreover, the experimental design in cross over ultimately minimizes the effect of the sample size by the increase in the number of observations. Finally, our findings may apply only for Karate athletes, since relevant differences were expected in the kicking pattern of Muay-Thai, Taekwondo, and Karate athletes [Diniz *et al*. 2018], which would be of interest in future research.

Thus, it is concluded that *kiai* does not produce meaningful improvement in Karate specific GZ punches and MG kicks or in movements that demand neuromuscular performance, like vertical jumps. However, it is noteworthy that the negative effects of *kiai* on these same variables were not demonstrated either.

## Conclusion

Our results become relevant in the sporting setting mainly due to the fact that the *kiai* tradition factor is extremely frequent in competition and training but until the present moment, its effects were unknown in actions that are usually applied by athletes and could determine sports performance. Based on our findings, the use of *kiai* does not seem to promote significant improvements in RT or lower limb power in amateur athletes. Nevertheless, it should be noted that it also does not seem to impair these variables, which enables the use of *kiai* in traditional training and competition, at least for RT and lower limb power. Additionally, our results suggest that higher vertical jumps performance showed a moderate and negative correlation with the best RT responses.

## Declaration of conflicting interests

The author(s) declare(s) that there is no conflict of interest.

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## Wpływ *kiai* na wydajność skokową i czas reakcji na uderzenie u zawodników karate

**Słowa kluczowe:** sztuki walki, aplikacje mobilne, karate, czas reakcji

**Streszczenie**

**Tło**. *Kiai* jest techniką oddechową, zwykle związaną z krótkim krzykiem, która ma na celu skupienie energii zawodnika sztuk walki w danym ataku. Jednakże wpływ *kiai* na techniczne i fizyczne aspekty związane z efektywnością uderzeń wymaga więcej dowodów. Celem niniejszej pracy było zbadanie wpływu *kiai* na wydajność skoków pionowych i czas reakcji (RT) dla ciosów i kopnięć u zawodników karate w kategorii amatorów. **Metody**. W badaniu brało udział 16 mężczyzn amatorów w wieku 18,5 ± 4,3 lat, o masie ciała 68,5 ± 10 kg, wzroście 1,7 ±

0,1 m i 2,4±1,8-letnim doświadczeniu w karate. Wykonano 5 prób każdej akcji technicznej i 3 próby każdego skoku pionowego, z użyciem i bez użycia *kiai*. RT była mierzona przez aplikację TReaction®, a skoki pionowe przez matę kontaktową. Do badania różnic między warunkami wykorzystano testy par t oraz wielkości efektu Cohena d, natomiast do badania różnic między próbami zarówno dla RT jak i skoków zastosowano ANOVA.

**Wyniki.** Nie stwierdzono istotnych różnic pomiędzy *kiai* a warunkami kontrolnymi dla skoków z kontrruchu (CMJ; p= 0,496), przysiadu (SJ; p= 0,374) i podrzutu (DJ; p= 0,147). Nie wykazano również istotnych różnic między warunkami dla RT uderzeń i kopnięć (p> 0,05).

**Wnioski.** Technika *kiai* nie ma wpływu na RT uderzeń, kopnięć i skoków pionowych u karateków.