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# EFFECT OF 8-WEEK MULTILATERAL TRAINING ON PHYSICAL AND TECHNICAL PERFORMANCE IN YOUNG KARATEKA

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**Abstract:**
Karate training, a Japanese martial art, is considered enough to increase physical-motor and technical performance. Instructors seem to prefer only technical Karate training to other physical-motor training methods. Therefore, the purpose of the present investigation was to assess the effects of 8 weeks of multilateral training on the physical-motor performance and technical gesture quality in young karateka. Participants (8-10 years) were recruited from a karate school and pair-matched based on gender and then randomly assigned to either an experimental group (EG, n = 14) or a control group (CG, n = 14). The EG was trained three times per week on non-consecutive days replacing a part of karate training with a multilateral training (i.e. flexibility, balance, strength and coordination, 45 min.) without increasing the total training time (90 min.). At baseline and after 8-weeks all participants were tested on the sit and reach, stork balance stand, standing long jump, and Harre test, and the technical gesture quality through the prefixed decision-making criteria. After intervention, the EG group showed significantly improvement than CG in the sit and reach test (2.0 vs. 1.1 cm, $p < 0.001$, ES = 0.73) and standing long jump test (8.3 vs. -4.0 cm, $p < 0.01$, ES = 0.88). Furthermore, the subjective evaluation scores of the technical gesture were significantly enhanced ($p < 0.001$, ES = 0.6 - 2.0) for EG in terms of technique, power, expressiveness and rhythm, whereas for CG the scores remained unchanged. Results suggested that incorporating a physical-motor training with a multilateral approach to karate technical sessions was more effective than technical training alone to improve physical-motor and technical performance in children.

**Keywords:** physical education; Shotokan karate; children; motor abilities; martial arts

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## 1. Introduction

Karate translated means 'empty hand', and it is derived from a martial art developed in Okinawa, Japan. It consists of kihon, kata, and kumite training. Kihon involves basic techniques, whereas kata and kumite are two types of competition. Kata best symbolizes the original tradition and principles of karate, with more than 20 types of attack and defence technique used based on personal experience watching performances of kata. Kumite, by contrast, is a match between two opponents in which one symbolically destroys the other with technique and strategy (Funakoshi, 1995). Each form (i.e., kihon, kata or kumite) requires specific training and children that practice karate have shown improvements in their muscle strength (Falk & Mor, 1996), flexibility and balance (Violan, Small, Zetaruk, & Micheli, 1997), anaerobic capacity (Melhim, 2001) and in the general motor abilities of this sport (Chaabene, Hachana, Franchini, Mkaouer, & Chamari 2012). Among 9-year-olds, karate training seems to increase reaction time, explosive leg strength and coordination, as well as better working memory, visual selective attention and executive functions (Lima et al., 2017). For this reason, the instructors seem to prefer only technical Karate training to other physical-motor training methods (Falk & Mor, 1996; Melhim, 2001; Violan et al., 1997; Chaabene et al., 2012).

Generally, participation in sports activities contributes to the development of motor coordination of the children, since their involvement in physical activity offers greater opportunities for learning (Fisher et al., 2005). Fransen et al. (2012) showed that there is a positive relationship between the number of weekly training hours and the increase in performance in flexibility, explosive power of the lower limbs and motor coordination in children. It was demonstrated that fundamental movement skills are elements for the development of basic forms of movement (Barnett et al., 2016); they include functional skills such as running, jumping which are part of the movement skills; control of objects such as manipulation, jumping and gripping; stability such as balance (Gallahue, Goodway & Ozmun, 2006). Failure to learn these skills will make it difficult to learn more complex skills (Clark & Metcalfe, 2002). Unfortunately, if a decade ago children preferred to be outdoors to play, today they prefer to stay in front of the TV or play video games, with the consequent gradual loss, over the years, of the development of fundamental movements and motor skills or reduction of the fitness performance in sports activities (Greco, Tambolini, Ambruosi, & Fischetti, 2017). Some children no longer know how to run, jump or roll. However, participation in sports such as Karate could avoid this severe reduction in motor skills.

Previous studies investigated the relations between specific karate technical training (i.e., kihon, kata and kumite) and specific motor abilities. However, karate training is considered enough to increase physical-motor and technical performance and little is known about the effects of specific multilateral training (i.e., conditional and coordinative motor abilities training) on the fitness performance, general motor coordination, and technical quality in the young karateka. Multilateral training program already showed significant effects in improving fitness performance in youth (Fischetti

& Greco, 2017). The multilateral approach, which focused on the development of the conditional and coordinative motor abilities, respects the physiologic age and psychological maturation of youth and is a means to improve fitness and conditioning (Bompa & Buzzichelli, 2018). Motor abilities include perceptual and physical factors (Fleishman, Quaintance, & Broedling, 1984) in which many important abilities such as general motor coordination (i.e. multilimb and gross body coordination), spatial orientation, balance (i.e. gross body equilibrium), strength, and power are involved.

Based on the previous literature, the purpose of the present investigation was to assess the effects of 8 weeks of motor abilities training with a multilateral approach – replacing a part of karate technical training without increasing the total training time – on the physical-motor performance and technical gesture quality in young karateka. We hypothesized that the multilateral training intervention would promote great improvements in the overall performance of Karate.

## 2. Material and Methods

### 2.1 Study design

In this research, a randomized controlled study design that included pre- and post-testing (at weeks one and eight, respectively) was used to evaluate whether an 8-week multilateral intervention, replacing a part of karate specific training (i.e., kihon, kata and kumite), could produce improvements. This outcome was identified by statistically significant improvements in flexibility of the lower body (i.e., sit and reach), static balance (stork balance stand test), explosive leg power (i.e., standing long jump test), general motor coordination (i.e., Harre test), and technical gesture quality (i.e., scores assigned by the raters following predefined decision-making criteria).

### 2.2 Participants

Twenty-eight healthy participants between 8 and 10 years of age (14 boys and 14 girls) volunteered to participate in this study. An a priori power analysis (Faul, Erdfelder, Lang, & Buchner, 2007) with an assumed type I error of 0.05 and a type II error rate of 0.20 (80% statistical power) was calculated for measures of physical capacity and revealed that 8 participants per group would be sufficient to observe medium 'Time x Group' interaction effects. However, to avoid the experimental mortality, that is the loss of participants that could threaten the validity of the research design, more children were recruited. All participants were recruited from a local karate sport association in April 2019. The exclusion criteria were (a) children with a chronic paediatric disease, (b) children with an orthopaedic limitation, and (c) children older than 10 years and younger than 8 years of age. All volunteers were accepted for participation. Upon completion of testing, the participants were pair-matched based on gender and then randomly allocated into 2 groups: an experimental group (EG, n = 14; age, 8.69 ± 0.85 years; body mass, 31.69 ± 7.25 kg; height, 1.32 ± 0.08 m; BMI, 18.04 ± 3.47 kg·m$^{-2}$; 7 males and 7 females) that performed a multilateral training, or a control group (CG, n = 14; age, 8.85 ± 0.86 years; body mass, 32.93 ± 8.88 kg; height, 1.37 ± 0.10 m; BMI, 17.47 ± 3.22 kg·m$^{-2}$; 7 males and 7 females) that performed a karate technical training only. All participants and their parents received a complete explanation in advance about the purpose of the experiment, its contents, and safety issues and the parents provided their informed consent. The procedures followed were in accordance with the ethical standards of the responsible institutional committee on human experimentation and with the Helsinki Declaration. The study was conducted from April to June 2019.

**2.3 Procedures**

All study procedures were performed in the karate gym. Fitness performance, general motor coordination and technical gesture quality assessment were performed at weeks 1 (baseline) and 8 (end of the study). All subjects participated in an introductory training session before the testing procedures. Before pre- and post-testing, all participants underwent a standardized 10-minute warm-up that consisted of low-to-moderate intensity aerobic exercise and stretching. Initial and final test measurements were made at the same time of day and under the same experimental conditions. All measurements for fitness testing were performed by the same blinded experimenter, and the testing and training procedures were supervised by a physical education graduate. Technical gesture assessment was carried out by two independent blinded judges; if the scores given were different, then the average between scores was considered.

All trials were performed using standardized tests. On the first test day, participants performed, in the following order, the sit and reach, stork balance stand, standing long jump, and Harre test, instead anthropometrical assessment and technical gesture qualitative test were undertaken on day 2.

**2.4 Physical and motor abilities testing**

The flexibility of the lower body was evaluated using the *Sit and reach test*. The sit and reach box (Cartwright Fitness, Chester, UK) was braced against a wall and subjects sat with their legs fully extended (medial sides of their feet 20 cm apart, no shoes) and bottoms of the feet against the box. While exhaling, subjects slowly bent forward toward the top of the box with 1 hand over the other. The technician ensured that the knees stayed in full extension and that movement was conducted slowly and smoothly. Participants performed 4 trials, each held for 1–2 seconds and the farthest reach was recorded in centimetres (Adams & Bean, 2008). The test-retest reliability reported good reliability for this test (ICC = 0.82).

Postural static balance was evaluated using the *stork balance stand test* (Hatzitaki, Zlsi, Kollias, & Kioumourtzoglou, 2002). In this test, the subject stood on his dominant leg. The participants were instructed to lift and hold the contralateral leg against the medial side of the knee of the stance leg while keeping his hands on the iliac crests. The trial ended when the heel of the involved leg touched the floor, the hands came off the hips, or the opposite foot was removed from the stance leg. This test was conducted with eyes opened only. The subjects performed three attempts and the best time (sec.) was recorded for analysis. High test-retest reliability has been reported for this test with an intraclass correlation coefficient (ICC) of 0.91.

The *standing long jump test* has been considered a general index of muscular fitness in young and evaluates explosive leg power (Castro-Pinero et al., 2010). Before the test started, subjects were instructed to stand with both feet right behind a starting line and to jump as far as possible. Subjects were allowed to use arm swing during the test. Three trials were performed with a 2 min rest between trials. The best trial in terms of maximal distance from the starting line to the landing point at heel contact was used for statistical analysis. Measurements were taken to the nearest cm using a tape measure. The standing long jump test reported good reliability with an intraclass correlation coefficient (ICC) of 0.85.

The *Harre circuit test* is a popular and widely used test in the scientific literature (Chiodera et al., 2007; Harre, 1982) to assess the ability of a subject to coordinate quickly complex movements and general motor tasks with high dimensionality in terms of number of joints involved and levels of force generated. After an initial somersault, participants were asked to perform three consecutive passages above and below three obstacles, turning around a central cone, at maximum speed as described in Figure 1. Three trials were performed and separated by 5 min of rest. Total time of each trial was recorded by using a photocells system (Microgate, Bolzano, Italia) and the average time was considered in the analysis. The time employed to run the whole circuit is recorded to the nearest 0.1 seconds. In case of mistakes (e.g. touching the obstacle), children were asked to repeat the trial after 2 minutes of rest. All trials were performed in an indoor karate gym, observing the same conditions. The Harre test reported high reliability with an intraclass correlation coefficient (ICC) of 0.96.

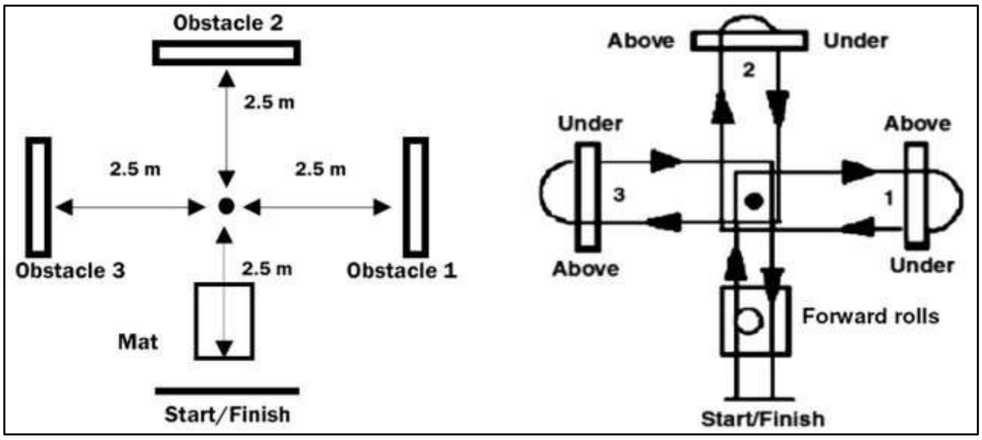


**Figure 1:** Scheme of the Harre circuit

## 2.5 Technical gesture subjective rating

The decision-making criteria for the technical gesture evaluation were *a)* technique (evaluation of styles, dynamic equilibrium, stability), *b)* power (strength, speed and efficiency of the technique), *c)* expressiveness (ability to communicate) and d) rhythm (amplitude and speed of the technical gesture). Two blinded raters, karate experts, independently assigned the scores to the participants for each criterion. The ranges of the assigned scores were as follows: Technique 1 - 6; Power 1 - 4; Expressiveness 1 - 7; Rhythm 1 - 3. Higher scores indicate a higher quality of the technical gesture (scores from scarce to optimum). The penalty of one point has been assigned for a slight loss of balance or synchronization, for hesitation or lack of control during execution. Two points were subtracted for an obvious loss of synchronization, while three penalty points were given in case of exasperated and anti-physiological positions. Five points were subtracted in case of heavy loss of balance or fall. A very good interobserver agreement was reported for power and rhythm, k = 0.91 and 0.88, respectively, whereas a good agreement was reported for technique and expressiveness, k = 0.75 and 0.79, respectively.

### 2.6 Multilateral training procedures

EG was trained three times per week on non-consecutive days (Monday, Wednesday and Friday) for eight weeks replacing a part of their karate technical training with a multilateral training without increasing the total training time under carefully monitored and controlled conditions by a physical education professional. Before each training session, all EG participants participated in a 10-minute dynamic warm-up period followed by dynamic and static stretches exercises (5 min.). The dynamic warm-up included arm swings, trunk twisting, high marching, stride jumping, high knees, side bending, side stretching, skipping leg swings, backward sprinting, and lateral shuffles. Stretching included Achilles' tendon/calf stretches, skier's stretches, quadriceps stretches, hurdler's stretches, straddle stretches, groin stretches, back stretches and archers. Each training session ended with ~5 min. of cool-down activities. The daily training duration for both study groups was 90 minutes.

Immediately after the 15-minute warm-up, the experimental group performed a multilateral training for 45 minutes and then continued the training by doing 30 minutes of specific karate techniques. The specific program was performed gradually from the first to the fourth level and focused on the development of the following motor abilities (both conditional and coordinative): flexibility, balance, explosive leg strength and general motor coordination as indicated in detail in table 1.

**Table 1**: Example of an 8-week multilateral training program performed by young karateka (3 weekly lessons of 45 minutes for a total of 24 lessons in the study period)

| Level | Goals | Training contents |
|---|---|---|
| 1 | Basic motor and postural scheme<br>Reinforcement of the spatial-temporal organization<br>Opto-manual coordination | Exercises with small and big pieces of equipment, somersaults, ball control (balls of different size and weight), circuits and courses. |
| 2 | Reinforcement of the running scheme<br>Reinforcement of the static-dynamic balance | Exercises with small and big pieces of equipment, varied circuits, blindfolded courses. |

| | | |
|---|---|---|
| | Reinforcement of the throwing-grasping scheme<br>Introduction to the sense of direction | |
| 3 | Reinforcement of the balance control in precarious situations<br>Improvement of joint mobility<br>Improvement of strength<br>Integration between motor and postural schemes | Exercises with small pieces of equipment and with balance beams, different types of jumping, somersaults, pulling and pushing, varied circuits, relays. |
| 4 | Reinforcement of the sense of direction<br>Integration between different motor schemes<br>Reinforcement of the respiration control<br>Development of motor planning | Exercises with small pieces of equipment, somersaults, spins, rotations on the body axis, varied circuits, relaxation and respiratory control exercises. |

### 2.7 Data Analysis

All analyses were performed using SAS JMP® Statistics (Version <14.1>, SAS Institute Inc., Cary, NC, USA, 2018) and the data are presented as group mean values and standard deviations. Because we could not detect significant differences between males and females ($p > 0.05$), the data were pooled.

Normality of all variables was tested using the Shapiro-Wilk test procedure. A multivariate analysis of variance (MANOVA) was used to detect differences between the study groups in all baseline physical characteristics, whereas a Mann–Whitney U nonparametric test was performed to search differences between the groups in the subjective ratings at baseline. A mixed between-within subjects' analysis of variance (ANOVA) was used to determine the interaction between the two independent variables of training (pre/post; within-subjects factor) and group (EG and CG; between-subjects factor) on the dependent variables of physical capacity. When 'Time x Group' interactions reached the level of significance, group-specific post hoc tests (i.e., paired t-tests) were conducted to identify the significant comparisons. A Wilcoxon signed-rank nonparametric test was used to identify the significant changes within the groups in the technical gesture assessment scores after the 8-week intervention.

The reliabilities of the fitness and coordination tests measurements were assessed using intraclass correlation coefficients; scores from 0.8 to 0.9 were considered as good, while values above > 0.9 were considered as high (Vincent & Weir, 2012). Instead, the inter-rater agreement, for the scores given by the two raters on the quality of the technical gesture, was calculated using a weighted Cohen's Kappa; values of 0.8 or above indicated a very good strength of agreement and values between 0.6 and 0.8 represented a good strength of agreement (Altman, 1991).

The effect size was identified to provide the extent to which changes observed were meaningful. Partial eta squared ($\eta^2_P$) was used to estimate the magnitude of the difference within each group and interpreted using the following criteria (Cohen, 1992): small ($\eta^2_P < 0.06$), medium ($0.06 \le \eta^2_P < 0.14$), large ($\eta^2_P \ge 0.14$). Cohen's *d* was calculated as post-training mean minus pre-training mean divided by pooled SD before and after training and interpreted as small, moderate and large effects defined as 0.20, 0.50, and 0.80, respectively (Cohen, 1992). For nonparametric data, the effect size was calculated using this formula $r = Z/\sqrt{N}$ and interpreted as small, moderate and large effects defined as 0.10, 0.30, and 0.50, respectively (Cohen, 1992).

We accepted $p < 0.05$ as our criterion of statistical significance, whether a positive or a negative difference was seen (i.e., a 2-tailed test was adopted).

## 3. Results

All participants attended all training sessions (100% compliance) and no injuries were resulting from either training program. The CG and EG groups did not differ significantly at baseline in any physical characteristics ($p > 0.05$). Likewise, there were no significant differences between groups at baseline with respect to the subjective rating measures ($p > 0.05$).

Significant main effects for 'time' were observed on sit and reach, stork balance stand and Harre test, $F_{(1,26)} = 145.4$, 26.9, and 15.1, respectively, $p < 0.001$, $\eta^2_P = 0.07 - 0.17$. Significant 'Time x Group' interaction was found for the sit and reach, and standing long jump test, $F_{(1,26)} = 85.7$, and 13.9, respectively, $p < 0.01$, $\eta^2_P = 0.08$ and 0.35. Post hoc analysis revealed that EG had greater improvements than CG on sit and reach ($p < 0.001$, d = 0.73) and standing long jump test ($p < 0.01$, d = 0.88). There were no significant interaction effects between groups for the stork balance stand and Harre test, $F_{(1,26)} = 1.6$ and 0.7, respectively, $p > 0.05$.

Significant improvements in scores of all decision-making criteria of the technical gesture subjective rating were detected for the EG after the 8-week intervention ($p < 0.001$, r = 0.6 - 2.0), whereas no differences were found from pre- to post-training for the CG ($p > 0.05$). Pre- and post-intervention results for all dependent variables are presented in Table 2.

**Table 2**: Changes in the control (CG) and experimental (EG) groups.
Data are presented as mean (±SD)

| | **CG (n = 14)** | | | **EG (n = 14)** | | |
|---|---|---|---|---|---|---|
| **Variables** | **Pre** | **Post** | **Δ** | **Pre** | **Post** | **Δ** |
| **Physical and motor abilities test** | | | | | | |
| Sit and reach test (cm) | 2.3 (4.8) | 3.4 (4.5)* | 1.1 (0.9) | 1.8 (8.0) | 3.8 (7.3)*† | 2.0 (1.4) |
| Stork balance stand test (s) | 38.2 (16.1) | 41.6 (14.0) | 3.4 (4.2) | 30.7 (20.8) | 36.2 (17.5) | 5.5 (4.7) |

| | | | | | | |
|---|---|---|---|---|---|---|
| Standing long jump test (cm) | 145.5 (13.3) | 141.5 (17.1) | -4.0 (7.6) | 128.4 (13.7) | 136.7 (17.3)*† | 8.3 (9.5) |
| Harre test (s) | 25.9 (7.4) | 23.8 (6.1) | -2.1 (3.1) | 18.9 (3.5) | 17.6 (3.0) | -1.3 (0.6) |
| **Technical gesture subjective rating** | | | | | | |
| Technique | 2.8 (1.3) | 2.8 (1.3) | 0.0 (0.0) | 2.6 (0.6) | 5.1 (0.8)* | 2.6 (0.8) |
| Power | 1.9 (0.9) | 1.9 (0.9) | 0.0 (0.0) | 1.8 (0.7) | 3.2 (0.8)* | 1.5 (0.8) |
| Expressiveness | 3.5 (1.3) | 3.5 (1.3) | 0.0 (0.0) | 3.1 (0.8) | 5.9 (0.9)* | 3.0 (0.6) |
| Rhythm | 2.2 (0.8) | 2.2 (0.8) | 0.0 (0.0) | 1.6 (0.6) | 2.5 (0.6)* | 1.0 (0.8) |

**Notes:** Score range: Technique 1 - 6; Power 1 - 4; Expressiveness 1 - 7; Rhythm 1 - 3. Δ = Pre- and post-intervention differences. *Significantly different from baseline ($p < 0.01$). †Significant interaction effect = effective intervention program ($p < 0.01$).

## 4. Discussion

The present research aimed to examine the effects of 8 weeks of motor abilities training with a multilateral approach – replacing a part of karate technical training without increasing the total training time – on the physical-motor performance and technical gesture quality in young karateka. In the present research, physical-motor performance was examined using fitness tests as sit and reach, stork balance stand, and standing long jump test to check gains in flexibility, static balance and explosive leg power in children after the intervention. Motor coordination was examined by using the Harre test, which evaluates the ability to coordinate quickly complex general motor tasks (e.g. climbing, hopping, running and turning) and cognitive capabilities (reaction time and spatial orientation) using the whole body (Harre, 1982). The quality of the technical gesture execution, on the other hand, was examined by two blinded expert assessors independently assigned the scores to the participants for each criterion, that is technique, power, expressiveness and rhythm. After 8 weeks of the multilateral intervention, children showed a significant improvement in tasks requiring flexibility of the lower body (i.e., sit and reach) and explosive leg power (i.e., standing long jump test). Furthermore, they showed significant improvements in the quality of the technical gesture execution of karate. Conversely, the control group that executed specific karate technical training only have not shown significantly greater improvement in flexibility, leg power and quality of the technical gesture.

Improvements in physical-motor performance found in the experimental group agree with several previous studies (Barnett et al., 2016; Clark & Metcalfe, 2002; Fischetti & Greco, 2017; Fisher et al., 2005; Fransen et al., 2012; Gallahue et al., 2006). A considerable amount of strong evidence-based data exists supporting the concept that training of the motor skills and abilities in school-aged children improves physical-motor performance (Greco, Cataldi, & Fischetti, 2019; Janssen & LeBlanc, 2010) and more. It is known that children engaged in physical education show superior physical and psychological fitness, academic performance and attitude toward school as compared with their counterparts that do not participate in physical education (Cale & Harris, 2006; Dexter, 1999; Fischetti, Latino, Cataldi, & Greco, 2019; Ridgers, Stratton, & Fairclough, 2006; Siegel & Siegel, 2005). In this study, the training of the conditional and coordinative motor abilities with a multilateral approach improved flexibility and strength of the lower limbs more than karate training alone. These results do not agree with Violan et al. (1997) that have studied the effects of 6 months of karate training on flexibility in 8- to 13-year-old boys with no previous martial art experience and compared them with a group of boys involved in recreational sports. These authors showed that the boys participating in karate training had improvements in static flexibility when compared with the control group. However, Probst, Fletcher and Seelig (2007) found that the karate group was not more flexible than the active control group concerning measured variables, particularly for the hamstrings. Consequently, this shows that in the literature the effectiveness of karate in improving the flexibility of the lower limbs is still not well clear. However, in this study, the control group showed a significant increase in performance in the sit and reach test even if less than the experimental group (47% vs. 90%). Surprisingly, the control group has even shown a decrease in standing long jump (-3%), although not statistically significant; this does not confirm previous studies that demonstrated the effectiveness of karate training in improving the power of the lower limbs (Falk & Mor, 1996; Lima et al., 2017; Simonović, Bubanj, Projović, Kozomara, & Bubanj, 2011). However, the standing long jump has a high coefficient of validity and reliability for assessing the rhythmic structure and explosive strength of the young karatekas (Kostovski & Georgiev, 2009), and the comparison between the groups demonstrated the effectiveness of a physical education multilateral training program aimed at the development of motor abilities in general (Fischetti & Greco, 2017; Greco, Cataldi, & Fischetti, 2019).

Inconsistent effects found in the control group may be likely attributed to limited coordinative stimuli that are provided by the technical training of karate only (Falk & Mor, 1996). However, participants trained with specific karate training only showed significant enhancement in static balance (Violan et al., 1997) even if less than the increase obtained by the experimental group (14 % vs. 18%). This improvement could be attributed especially to the sport-specific characteristics of karate since the statistical analyses showed no significant interaction effect. In fact, in karate, besides explosive power and the correct execution of techniques, athletes are evaluated in terms of balance control, which represents the main performance factor (Filingeri, Bianco, Zangla, Paoli, & Palma, 2012). Although not statistically significant, in the Harre circuit test, the control group showed a greater performance increase than the experimental group with a decrease in the run time of the circuit (-8% vs. -7%). This result also shows that karate training may have partly contributed to the increase in the performance of the experimental group (Chaabene et al., 2012; Lima et al., 2017). However, in children, the physical exercise, like the one performed in this study, has been linked to general development that culminates in the improvement of motor and cognitive abilities (Verburgh, Königs, Scherder, & Oosterlaan, 2014). Besides, trained children with specific motor abilities training develop their perceptual-motor skills and consequently can better process information regarding their place in space and time (Notarnicola et al., 2012; Skordilis, Douka Spartali, & Koutsouki, 2004). This could explain the significant increase in performance in the quality of the execution of the technical gesture by the young karateka that performed a multilateral. Nevertheless, an assumption is generally made that with time children automatically become coordinated and attain spatial and directional awareness. Our study randomized controlled data shows that this is not the case; according to Mati-Zissi and Zafiropoulou (2003), maturation and programmed training are two key elements for children to develop greater coordination and spatial awareness.

A major limitation of the present study is related to the subjective evaluation of the technical gesture quality of the young karateka. Although a high level of agreement was demonstrated between the two assessors and the coding was deemed reliable, the results should be treated with extreme caution. A further limitation of the present study is the lacking of a maturation status assessment of all participants before the start of the experimental research. Although no differences were observed among height, weight and body mass between both groups, somatometrics characteristics and neuromuscular maturation may also influence general motor coordination and leg power levels among 8 to 10-years-old children (Freitas et al., 2015). Further studies should be encouraged to introduce a measure of biological maturation status (e.g. through non-invasive procedures) to corroborate or not our results. We are aware that future developments are needed to reinforce the validity of the current results, but they could already be used as indications for training, practising and research. Anyway, the present study provided novel findings in the fields of sports science and physical education. The strengths of this study include the use of multilateral training to examine the effect on the physical-motor performance and technical gesture quality in young karateka. Before now, one has never investigated the effects of a training program, additional to the traditional one of karate and based on the development of coordinative and conditional motor skills, on the quality of the technical gesture.

## 5. Conclusion

In summary, our findings suggested that adding a physical-motor training with a multilateral approach to the karate technical sessions, was effective to improve flexibility of the lower back and hamstring, and explosive leg power in 8 to 10-years-old children over 8 weeks. Furthermore, an improvement of the execution quality of the technical gesture occurred for all the decision-making criteria (i.e., technique, power, expressiveness and rhythm). Thus, the inclusion of multilateral training may be more beneficial rather than practising karate specific motor tasks alone. The instructors of karate and professionals working in the field of martial arts should be encouraged in developing their training program with a multilateral approach.

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**Conflicts of interest**

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