

# Kinematics analysis of the front kick with and without impact on traditional karate

## Authors' Contribution:

- ✉ **A** Study Design
- 📁 **B** Data Collection
- 📊 **C** Statistical Analysis
- 📄 **D** Manuscript Preparation
- 📁 **E** Funds Collection

**Bruno Sergio Portela<sup>ABCDE</sup>, Michelle Regina Barbosa<sup>ABCD</sup>, Timothy Gustavo Cavazzotto<sup>ACD</sup>, Marcus Peikriswili Tartaruga<sup>ACD</sup>**

<sup>1</sup> Department of Physical Education, University of Middle-West, Unicentro, PR, Brazil

**Financial support:** Departmental sources

**Received:** 06 September 2013; **Accepted:** 14 June 2014; **Published online:** 24 July 2014

**ICID:** 1122904

## Abstract

### Background & Study Aim:

The traditional karate is a martial art that includes an application of many forms of kick in situations to combat sports, this way, involving different training methods to improve the technique of kicking. The objective of this study is the kinematics variables of the front kick of karate practitioners of traditional style in conditions with impact in a target and without impact.

### Material & Methods:

Collected the anthropometrical data from 8 graduate male karateists athletes with brown and black belt ( $30.1 \pm 10.2$  years, body weight of  $85.3 \pm 16.2$  kg and height of  $178.9 \pm 4.9$  cm, time of medium training  $13.7 \pm 4.7$  years). The assessment of kinematic of the kick was made by means of computed kinometry, acquiring 3 sequences of front kick in conditions with and without impact with both sides of the individuals, being analysed in the Skillspector 1.3.2 software. The statistical analysis was performed in the SPSS software.

### Results:

In relation to the kinematics variables analysed the velocity of 5th metatarsus in the condition with impact and using the dominant member was significantly larger than the other conditions, as well as at the speed of the lateral malleolus in the condition with impact and utilizing the dominant member. In relation to the angle of the ankle joint the condition without impact presented better results, the knee joint the best results were seen in the condition without impact.

### Conclusions:

Finally, the study concludes that the kicks conducted with impact by the dominant member has higher speed values, however the kicks without impact present better angular conditions to the technique of the kick. Therewith, recommends that it be prioritized in sports training traditional karate the application of kicks with the impact targets.

### Key-words:

biomechanics • traditional karate • front kick

### Author's address:

Bruno Sergio Portela, Department of Physical Education, University of Middle-West, Unicentro, PR, Brazil; e-mail: bruno\_sergio\_por@yahoo.com.br

**Traditional Karate** – means “empty hand” that was created by Gichin Funakoshi. Karate is a Japanese martial art whose physical aspects seek the development of defensive and counterattacking body movements.

**Mae geri** – is the front kick in traditional karate.

**Kinematic analysis** – is the process of measuring the kinematic quantities used to describe linear and angular motion (position, velocity and acceleration).

**Kick with impact** – kick used in *kumite* (Free Sparring) and self-defence.

**Kick without impact** – kick used in *kata* (forms) competition.

## INTRODUCTION

karate is a fighting Japanese sport, consisting of repeating sequences of attacks and defences interrupted by rest periods [1]. While having a relatively short duration, the karate fight are characterized by maximum intensity [2] and its practice requires high levels of motor and functional abilities [3].

The Karate is an activity which practiced regularly, provides benefits not only physical but also psychosocial at their practitioners. Including, we can highlight the improvement in fitness that generates acquisition of power, muscle endurance, joint flexibility, increased cardio respiratory capacity [4, 5] and the environment of psychic qualities involving the discipline, hierarchy, perseverance and patience, and can also be applied to self-defence [5, 6].

The sports of karate is composed of specific blows of defence and attack at the opponent, may be used in both the upper and lower members. All the movements and thrown blows in this martial art require a thin control of motion associated with a good skill techniques performed in the fastest possible way [7, 8].

In the competition, with regard to offensive blows, are used only punches and kicks [9]. Among them, there is a wide variety of techniques and movements imposed to each one specifically. The kicks, for example, can be made in order frontal, lateral, slewing and even with jumps, reaching the opponent with different areas of the foot. With it, one of the most used attack both in training, as in combat sporting is the front kick, known as *mae geri*, which is also one of the strongest [10] and with higher linear velocity of karate second meta-analysis based on the literature by Marques Junior [11] (*mae geri* =  $15.8 \pm 5.4 \text{ m}\cdot\text{s}^{-1}$  versus *mawashi geri* =  $8 \pm 3.2 \text{ m}\cdot\text{s}^{-1}$ ), which technique is to reach the opponent with part of the plantar metatarsal-phalange foot, starting from movements of ankle plantar flexion, knee extension and hip flexion.

It was observed that the kicks with impact showed higher speed on all variables analysed, which differs from the results obtained in a study performed with practitioners of kung-fu, which shows that kicks made without impact elevate the level of muscle activation and consequently the level of speed of the kick [14]. It is noteworthy that kung-fu uses similar techniques to those of the front kick karate.

Currently karate training in traditional style is seen that there is a predominance of use of methods that do

not involve the action of kick in surfaces of impact, by following old training precepts. However, in sports competitions or even in situations of self-defence requires that the practitioner makes kicks with targets set (region of the head or abdomen), so there is a movement in the effectiveness (achieve a score or incapacitate an aggressor) [10]. This way, the present study seeks to analyse the kinematics of the front kick of traditional karate with and without impact.

## MATERIAL AND METHODS

The study was approved by the Committee on Ethics in Research of State University Midwest – UNICENTRO, state of Parana - Brazil (number 040/2012). Just after, occurred the process of selection of participants.

The sample was composed by eight practitioners of traditional karate style who train in gyms in the city of Guarapuava – PR, Brazil. As inclusion criterion was considered the graduation of the karateist all the participants should had graduation in brown or black belt and be male. The selection to the sample was made by invitation to the practitioners, this way having a method of sample selection for convenience.

The volunteers were informed about the study procedures and after, signed Informed Consent agreeing to participate in the research. In sequence, the individuals answered a questionnaire containing information about: age (years), training time (years), graduation (belt) and dominance of member (right or left side). Then they passed an anthropometric evaluation where it was measured body weight (kg) and height (cm).

Following are the data that characterize the study participants, compound of 8 individuals practitioner of karate of the traditional style graduated with brown or black belt (Table 1). Among the studied subjects only one had the dominant member the left leg.

**Table1.** Characteristics of the subjects evaluated.

|                       | Mean   | Standard Deviation | Minimum | Maximum |
|-----------------------|--------|--------------------|---------|---------|
| Age (years)           | 30.1   | 10.2               | 21      | 53      |
| Training Time (years) | 13.7   | 4.7                | 6       | 19      |
| Body Weight (kg)      | 85.34  | 16.22              | 6.9     | 111     |
| Height (cm)           | 178.94 | 4.92               | 171     | 185     |
| BMI (kg.m-2)          | 27.0   | 4.5                | 21.9    | 34.3    |

Kinematic analysis consisted of the capture by computed kinematics of sequences of kicks. Initial, the individuals dressed a black shorts adhering to the skin and after, were fixed passive reflective markers in the following accidents osseous: 5th metatarsus, lateral malleolus, lateral epicondyle of the femur, greater trochanter of the femur and acromion, in both sides of the subject. After this proceeding, the karateists were instructed to start a session of warming and stretching self-selected, in order to avoid the risk of lesion.

After the warming, the subjects were instructed to realize the front kick with the member inferior without the use of impact and with the highest speed possible. Then, the individuals should realize the same technique of front kick with the use of impact over a sandbag. Were collected information from right and left lower member, totalizing four conditions of kick: front kick without impact with right lower member (WIRM), front kick without impact with left lower member (WILM), front kick with impact with right lower member (IRM) and front kick with impact with left lower member (ILM). The total of the capture were three kicks to each condition, being obtained the average of these, making an amount of twelve kicks per individual.

To the capture of the videos were used a video camera Casio FH25, with frequency of 240 Hz positioned two meters from the sagittal plane of the subject. The

biomechanical model for analysis had the segment of the foot, leg, thigh and trunk. The images were analysed in the SkillSpector software ver. 1.3.2, that allowed the acquisition of kinematic data of the movement of kick.

The analysis were made about variables of linear velocity at points of 5<sup>th</sup> metatarsus, linear velocity of the lateral malleolus, joint angle of the ankle and angle of the knee joint, as the study performed by Sorensen [12]. The data were collected in the moment of finalizing of the kick on condition WIRM and WILM and in the moment of the impact against the sandbag in the conditions IRM and ILM.

For data analysis was used descriptive statistics with mean, standard deviation, minimum and maximum. The analysis inferential of the data was performed using the ANOVA of repeated measures. All the analysis made in the SPSS software ver. 15.0, with as level of significance  $p < 0.05$ .

## RESULTS

The evaluation results of the front kicks in the four conditions studied are shown in Table 2. Are presented the data of speed of the 5<sup>th</sup> metatarsus, velocity of the lateral malleolus, ankle angle and knee angle at the time of finalization of the front kick in the four conditions.

**Table 2.** Mean and standard deviation of the kinematic analysis of the front kick in the four conditions.

|                                    | WIRM               | WILM                | IRM                 | ILM                 | p-value* |
|------------------------------------|--------------------|---------------------|---------------------|---------------------|----------|
| 5th Metatarsus Velocity (m.s-1)    | 3.88<br>± 2.23ab   | 3.74<br>± 3.41cd    | 10.70<br>± 1.93ac   | 8.88<br>± 2.42bd    | 0.000    |
| Lateral Malleolus Velocity (m.s-1) | 3,42<br>± 1.42ab   | 3.18<br>± 2.43cd    | 10.32<br>± 1.78ac   | 8.77<br>± 2.12bd    | 0.000    |
| Ankle Angle (°)                    | 132.77<br>± 6.75ab | 135.32<br>± 12.42cd | 105.11<br>± 10.07ac | 101.53<br>± 10.05bd | 0.000    |
| Knee Angle (°)                     | 187.04<br>± 7.23ab | 181.00<br>± 10.58cd | 125.50<br>± 10.21ac | 127.30<br>± 9.61bd  | 0.000    |

- a – Significant difference between kick without impact to the right member and impact with the right member
  - b – Significant difference between kick without impact to the right member and impact with the left member
  - c – Significant difference between kick without impact to the left member and guess that impact with the right member
  - d – Significant difference between kick without impact to the left member and guess that impact with the left member
- \* Significance level  $p < 0.05$

## DISCUSSION

According to Table 2, the kicks in the condition with impact showed up faster than the condition without impact, presenting significant difference. In respect to the member who made the kick, the right lower limb had higher speed results in the 5<sup>th</sup> metatarsal compared with the left lower limb, having significant difference ( $p < 0.05$ ). The default of behaviour of the velocity of the lateral malleolus resembled with the speed shown in the 5<sup>th</sup> metatarsus, being the condition with impact was faster than the condition without impact and the right lower limb was faster than the left lower limb.

Also according with Table 2, the results of the angulations of the ankle joint show that the condition without impact had greater results than the condition with impact, having significant difference ( $p < 0.05$ ). In comparison between right and left members do not had significant difference. The results of the knee angle in the condition without impact were higher than in the condition with impact, having significant difference, but the comparison between the members had not significant difference.

In a study by Oliveira et al. [15], were not found significant differences when comparing right and left side, being that the left side was faster, with an average velocity of  $9 \text{ m.s}^{-1}$  for the left side and  $8 \text{ m.s}^{-1}$  for the right side. These results are going encounter the present study were, analysing singly, in both conditions (with impact and without impact) wasn't significant difference between members, but the right side remained faster. Being that for kicks with impact the average of speed was in  $10.5 \text{ m.s}^{-1}$  to the right side and  $8.9 \text{ m.s}^{-1}$  to the left side and to the kicks without impact the average speed was  $3.6 \text{ m.s}^{-1}$  to the right side and  $3.5 \text{ m.s}^{-1}$  to the left side. In a study realized by Falco et al., [16], where by kinetic and kinematic analysis, analysed the roundhouse kick from taekwondo, also don't had significant difference between members. As in a study realized by Elbaum [17] where it was found similarity inter-members in biomechanical analysis of the front kick Shito-Ryu karate.

Nien [18], analysing the kicks with and without the impact of Taekwondo by the method of kinematics, it was observed that the speed of joints of the 5<sup>th</sup> metatarsus and ankle, were significantly higher in impact condition than on without impact condition ( $p < 0.05$ ). This results confirm with the present study, where was observed greater speed in kicks when released into a target to be achieved.

Comparing the data found with the Piemontez et al. [19], observe that the results found in relation to the speed of the ankle just before the foot contact with the punching bag were very close, bearing in mind that the mean velocity was  $7.4 \text{ m.s}^{-1}$ . This way was observed resemblance between the speeds, where the mean of the velocity of the frontal kick with impact with right and left member of the present study was  $9.79 \text{ m.s}^{-1}$ , but the technique used kick by Piemontez et al. [19] was circular kick and of the present study, was the techniques of the front kick. The higher the speed of the kick, greater the energy produced by it. Thus, rapid kicks are not only important to surprise the opponent, but also because of its efficiency in energy production [20]

In relation to the angle of the ankle, it is known that reached the proper angulation, more effective will be the kick, because the foot will be obeying the technique and penetrating the target, considering that the front kick is given to the plantar part of the metatarsus phalangeal and not with the whole foot [21]. Thus, it is believed that the correct angle, so that the kick is really efficient, should be around  $130^\circ$ . Regarding kicks without impact, the result was satisfactory, with an average angle of  $134^\circ$ . Already in kicks with impact, the result was an average of  $103.3^\circ$ .

With regard to knee angle in the technique of the front kick, the leg must perform an extension that reaches an angle which is believed to be close to  $180^\circ$ . This makes the kick get the speed and strength necessary to effectively fulfil its role, been reaching a target imposed or effectively knocking the opponent [21]. In data found by Camomilla et al. [22], comparing kicking techniques with circular and non-impact through electromyography method observed that kicks unleashed with greater and faster knee extension during movement showed up faster in all conditions. In kicks without impact, we observed that the average angle was  $184^\circ$  and in kicks with impact, the average was  $126.4^\circ$ . As in the data angle of the ankle, we found better result of angle in kicks without impact.

Currently training in traditional karate, the blows with impact are used infrequently, unlike other modalities, like the muay thai and taekwondo. Under these modalities, it is clear that athletes has more refined notion of distance. Due many trainings in sequence as *kihon* (exercises roundtrip running scams) and *kata* (choreographed repetitions of strokes mimicking fighting moves), the choice of the coaches is to

train without impact. But this reflects at the moment of itself fighting (*kumite*), where the athlete will not have the notion of important elements, such as the optimal distance from the target and may do not apply strength and speed really efficient for a score. In the results of angulations of the ankle and knee, where we can see that there is a degree of flexion and extension inadequate when the member reaches the target.

## CONCLUSIONS

It is concluded that, comparing the kicks in the conditions with and without impact, higher speeds reached, through the points of the 5<sup>th</sup> metatarsus and ankle, were on condition with impact and the right lower member. Regarding angular motion of the ankle joint

and the knee the condition without impact was significantly greater the condition with impact, do not finding significant difference between sides. Thereby, stands out that should be prioritized in training of traditional karate kicks with impact in order to increase the speed of the blow and adjust the angle to the correct technique of the movement. Also recommends that they be trained both sides of the individual with the same intensity, in order that both members have the same efficiency of motion.

## CONFLICT OF INTEREST

Authors declare that there are no conflict of interests.

## REFERENCES

- Ravier G, Dugue B, Grappe F et al. Impressive anaerobic adaptations in elite karate athletes due to few intensive intermittent sessions added to regular karate training. *Scand J Med Sci Spor* 2009; 19: 687-694
- Flinger D, Bianco A, Zangla D et al. Is karate effective in improving postural control? *Arch Budo* 2012; 8: 203-206
- Blazevic S, Katic R, Popovic D. The effect of motor abilities on karate performance. *Coll Antropol* 2006; 30: 327-333
- Shaw DK, Deutsch DT. Heart rate and oxygen uptake responses to performance of karate kata. *J Sports Med Phys Fitness* 1982; 22: 461-468
- Woodward TW. A review of the effects of martial arts practice on health. *Wisc Med J* 2009; 108: 40-43
- Cynarski WJ, Litwiniuk A. Hierarchy of values in case of practitioners of far eastern martial arts in Poland. *Int J East Sport Phys Educ* 2008; 6: 263-291
- Zehr, EP, Sale DG, Dowling JJ. Ballistic movement performance in karate athletes. *Med Sci Spor Exer* 1997; 29: 1366-1373
- Mori S, Ohtani Y, Imanaka K. Reaction times and anticipatory skills of karate athletes. *Hum Mov Sci* 2002; 21: 213-230
- Doria C, Veicsteinas A, Limonta E et al. Energetics of karate (kata and kumite techniques) in top-level athletes. *Eur J Appl Physiol* 2009; 107: 603-610
- Sforza C, Michela T, Grassi GP et al. Repeatability of mae-geri-keage in traditional karate: a three-dimensional analysis with black-belt karateka. *Percept Mot Ski* 2002; 95: 433-444
- Marques Junior NK. Velocidade do soco e do chute do karatê: uma meta-análise. *Lect educ fis deportes* 2012; 17: 1-10 [in Portuguese]
- Gianino C. Physics of Karate: Kinematics analysis of karate techniques by a digital movie camera. *Lat Am J Phys Educ* 2010; 4:32-34
- Sorensen H, Zacho M, Smønsen EB et al. Dynamics of the martial arts high front kick. *J Spor Sci* 1996; 14: 483-495
- Xavier KCR, Shimidt EMN, Kelencz CA. Análise biomecânica dos movimentos de chute frontal e lateral praticados no kung-fu. XII Congresso Brasileiro de Biomecânica 2007 [in Portuguese]
- Oliveira LM, Barbieri FA, Gobbi LTB et al. Simetria intermembros no desempenho do chute mae-geri do karatê. *R Bras Ci e Mov* 2008; 16:1-13. [in Portuguese]
- Falco C, Alvarez O, Estevan I et al. Kinetic and kinematic analysis on the dominant and non-dominant kicking leg in the taekwondo roundhouse kick. *J Biomec* 2009; 3: 242-248
- Elbaum L, Andrzejewski X. Biomechanical analysis of the front kick with the dominant and non-dominant limb in the shito-ryu style of karate. XXIII International Symposium on Biomechanics in Sports. Beijing, China, 2005.
- Nien YH, Chang JS, Tang WT. The kinematics of target effect during roundhouse kick in elite taekwondo athletes. *J Biomec* 2007; 40: 1-2
- Piemontez GR, Martins ACV, Reis NF et al. Características cinemáticas do chute semicircular no karatê. *Lect educ fis deportes* 2011; 16: 1-5. [in Portuguese]
- Diacu F. On the dynamics of karate. *Martial Arts and Math* 2003; 6: 9-11
- Nakayama M. *Dynamic Karate*. New York (NY): Kodansha USA; 1996
- Camomilla V, Sbriccoli P, Quinzi F et al. Roundhouse kick with and without impact in karate of different technical level. 27 International Conference on Biomechanics in Sports. 2009

**Cite this article as:** Portela BS, Barbosa MR, Cavazzotto TG et al. Kinematics analysis of the front kick with and without impact on traditional karate. *Arch Budo Sci Martial Art Extreme Sport* 2014; 10: 47-51