

# Changes in foot pressure on the ground during *mae-geri kekomi* (front kick) in karate athlete - case study

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## Abstract

- Purpose:** Biomechanical analysis of martial art techniques are objective and quantitative method, which may be useful in training practice for the purpose of improving these techniques as well as monitoring and enhancing athletes performance. The aim of this study was to assess selected kinetic parameters and lower limb loading during karate front kick, using force platforms, for both kicking and support leg.
- Material:** Karate athlete, second dan, black belt holder in Idokan style, participated in this case study. The subject performed front kick in the air (without a physical target), both for his right and left leg, while standing on the force platforms. For the purpose of kinetic data recording **two force platforms were used in this study** (Kistler force plate, type 9286AA, Kistler, Switzerland). Selected kinetic parameters for kicking and support leg as well as front kick execution time were analysed.
- Results:** Results of our case study revealed higher values of the kinetic parameters for the right leg, comparing to the left leg. This results confirm athlete's declaration of being right leg dominant.
- Conclusions:** Analysis of selected kinetic parameters may be useful in identifying lower leg laterization (leg dominance), as well as existing asymmetries between the dominant and non-dominant leg in karate and other martial art athletes.
- Keywords:** martial art, karate, kinetics, frontal kick, force platform

## Introduction

Biomechanics of martial arts allows for identifying and better understanding the factors that can influence a successful performance at a competition, show or during a fight. This knowledge can also enhance the ability of proper learning and teaching of the karate strokes and techniques. The frontal kick is relatively easy to learn, but it is difficult to master karate technique. It includes rotational movements performed to produce high-speed movement of the lower leg kinematic chain segments. In the available scientific literature concerning the biomechanics of combat sports and martial arts it is not one of the most commonly analysed kicks, while the most attention is devoted to the roundhouse kick [1-4].

Previous studies concerning biomechanical analysis of this type of strokes have already provided some basic information. The average kicking time is about 0.63 seconds and the average speed is 10.40 m / s for the taekwon-do athletes [5]. It was found that the speed of the front kick technique mostly depended on the movement velocity in the knee joint and kicking time (duration of the kick) [5, 6]. Sorensen et al. [7] reported that in the case of high front kick, the thigh slowing is due to movement which depends on the initial movement in the lower limb rather than the inhibition activity. Differences in kinematics during performance of the frontal kick were observed in Shotokan karate athletes [8]. Depending on the athletes level of experience, more repeatability in the movement kinematics were observed, especially in the

pre-loading phase, which precedes the attack phase. It was found that the duration of the kick and the repeatability of the lower limb movement could be useful when selecting the top karate players and monitoring their preparation status. It is recommended that in karate sports training this type of kicking should be performed using physical targets [9].

We know that distance from the physical target affects kinetics of the kick [10]. Increasing distances reduces the impact force and increases the reaction time.

Speed is an important element of success in combat sports and self defence. Sometimes, the victory or the defeat in the confrontation depends on the athletes speed of reaction. However, it has been suggested that precision and kicking speed are opposite priorities [11,12].

Cynarski et al. [13] described that the karate front kick (*mae-geri kekomi*) should be done very precisely. All of the aforementioned movements should form a single fluent motion without any pauses, so that the first movement of raising the knee adds impact to the violent kick. If the kick is towards the *chudan* zone, i.e. at the height of the solar plexus, the striking surface (*chusoku*) shall move towards the target along a straight line in the final section of motion. The front kick is best performed from a stable stance. It can be done with the front leg or the back leg, as well as when stepping forward.

Therefore, the purpose of this study was to assess selected kinetic parameters and lower limb loading during karate front kick, using force platforms. Changes of the force of pressure applied to the ground for both kicking and support leg were recorded and analysed.

We hypothesised that we can observe some difference between the right and left leg due to the lateralization (lower leg dominance).

### Material and methods

#### Participants

Karate athlete, second dan black belt holder in *Idokan* style [14], participated in this case study (age: 36 years; body mass: 97 kg; height: 177 cm).

The study procedure was approved by the Ethical Committee of the University of Rzeszow as a meeting the criteria of Ethical Conduct for Research Involving Humans. A subject participating in this study was informed about all testing procedures and has signed written informed consent.

#### Procedure

The athlete participating in our study was asked to perform front kick in the air (without a physical target), from *zenkutsu-dachi* standing position, both for his right and left leg, while standing on the force platforms. For the purpose of kinetic data recording two force platforms were used in this study (Kistler force plate, type 9286AA, Kistler, Switzerland), in order to acquire kinetic data for both kicking and support leg. Changes in pressure force applied to the ground for both legs were recorded and

analysed. Following parameters for the support leg were calculated:  $P_N$  - maximum force applied to the ground (pre-loading phase),  $P_K$  - maximum force applied to the ground during leg extension phase of the kicking leg (attack phase for the kicking leg). For the kicking leg following parameters were determined:  $F_T$  - maximum force applied to the ground (pre-loading phase),  $F_E$  - maximum force applied to the ground after the kick execution,  $T$  - front kick execution time (kicking foot with no contact with the ground)

#### Statistical analysis

Due to the fact that our research was a case study, there was no statistical analysis of the results applied [15]. Data in the results section of this article is presented as an average (maximum) value of selected kinetic parameters obtained from the force platform, as well as in the graphs.

### Results

Table 1 presents the value of selected kinetic parameters of the right leg front kick performed by the karate player as well as the right leg front kick execution time, which is 0,95 second. Figure 1 is the graphical presentation of the kinetic parameters, acquired using the force platforms, both for kick leg (right) and support leg (left).

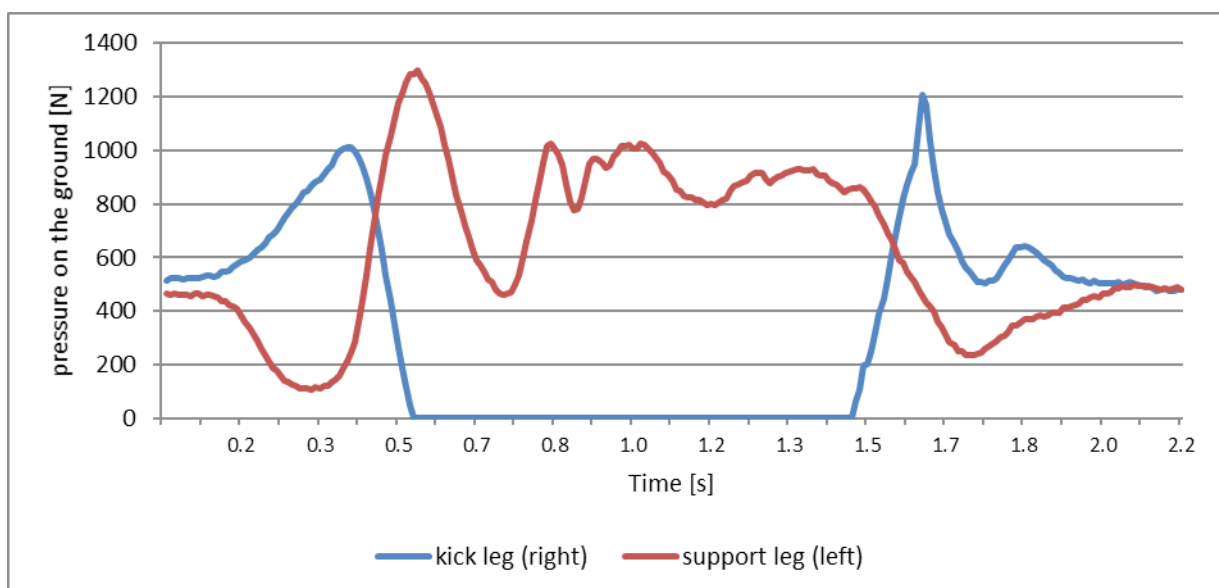
Table 2 presents the value of selected kinetic

**Table 1.** Selected kinetic parameters for right leg front kick

	$P_N$ [N]	$F_T$ [N]	T [s]	$F_E$ [N]	$P_K$ [N]
Kick leg (right)	-	1013,049	0,95	1208,694	-
Support leg (left)	1295,668	-	-	-	1025,557

Parameters for the kick leg (right) -  $F_T$  - maximum force applied to the ground (pre-loading phase),  $F_E$  - maximum force applied to the ground after the kick execution,  $T$  - front kick execution time (kicking foot with no contact with the ground)

Parameters for the support leg (left) -  $P_N$  - maximum force applied to the ground (pre-loading phase),  $P_K$  - maximum force applied to the ground during leg extension phase of the kicking leg (attack phase of the kicking leg)



**Fig. 1.** Changes of foot pressure on the ground while performing the right leg front kick

parameters of the left leg front kick, as well as the left leg front kick execution time, which is 0,89 second. Figure 2 is the graphical presentation of the kinetic parameters, acquired using the force platforms, both for the kick leg (left) and support leg (right).

**Discussion**

Our case study results revealed that the maximum load on the support leg while performing a karate front kick was approximately 1295-1462 N - for the left and right leg respectively (tables 1,2). It has been reported that in taekwon-do players performing the jump front kick, the values of ground reaction forces were about 400 N higher, comparing to our results [16]. During the kicking leg extension phase (in the knee joint), the maximum values of the ground reaction forces for the support leg are around 1024-1025 N - for the left and right leg respectively (tables 1,2). With a constant body weight, the high speed of the kicking leg is associated with a large change in momentum. A large momentum (change in momentum) informs us about a great force impulse [17]. Thus, according to the third principle of dynamics, this should be reflected in the force of pressure on the ground,

recorded using force platforms. In the future, it is worth checking if there is a correlation between the speed of the kicking leg and the ground reaction forces of the support leg.

In our study the front kick execution time (time when the kicking leg has no contact with the ground) was 0,89 seconds for the left leg and 0,95 seconds for the right leg. Within this time, the kicking leg was extended and then returned to the starting position.

The athlete participated in this study declared that his dominant leg was the right leg. Results of our study confirmed this and revealed higher values of selected kinetic parameters for the right leg, comparing to the left leg. The maximum value of the force applied to the ground in the pre-loading phase -  $F_T$  (before the attack-phase) was almost 63 N higher for the right leg comparing to the left leg (tables 1,2). Interestingly, similar results were observed concerning maximum force applied to the ground with kicking leg after the kick execution ( $F_E$ ) - 1082 N for the left leg and 1208 N for the right leg, with a difference of 126 N between the right and left leg (tables 1,2).

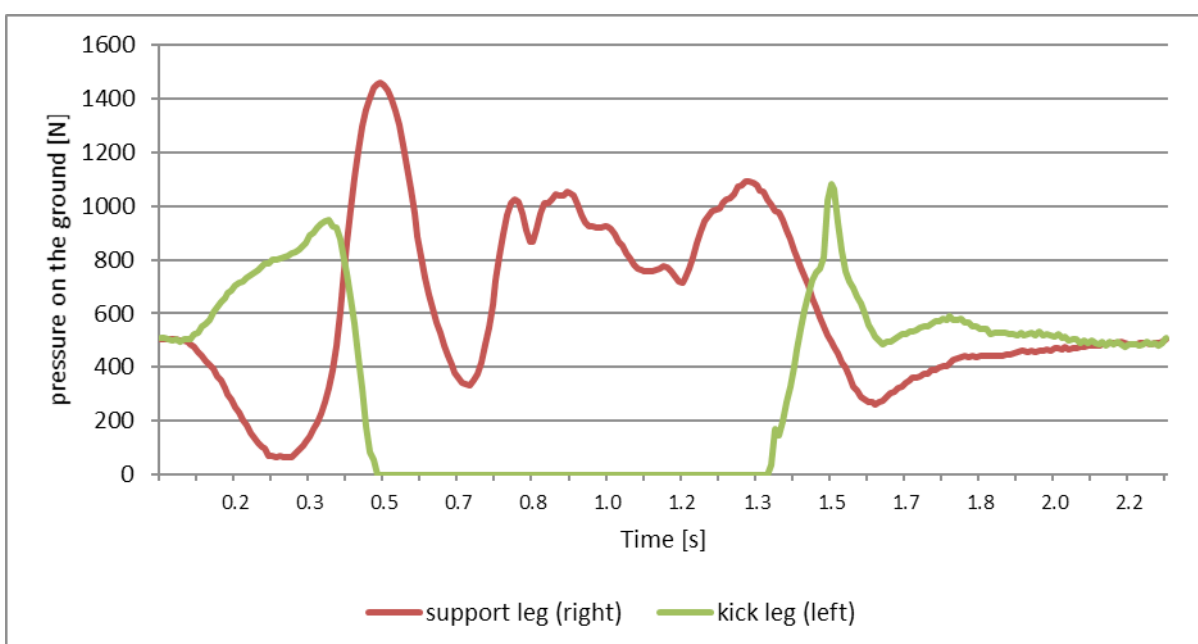
Such a methods of biomechanical analysis of karate

**Table 2.** Selected kinetic parameters for left leg front kick

	$P_N$ [N]	$F_T$ [N]	T [s]	$F_E$ [N]	$P_K$ [N]
Kick leg (left)	-	950,516	0,892	1082,424	-
Support leg (right)	1462,067	-	-	-	1024,301

Parameters for the kick leg (left) -  $F_T$  – maximum force applied to the ground (pre-loading phase),  $F_E$  – maximum force applied to the ground after the kick execution, T – front kick execution time (kicking foot with no contact with the ground)

Parameters for the support leg (right) -  $P_N$  - maximum force applied to the ground (pre-loading phase),  $P_K$  – maximum force applied to the ground during leg extension phase of the kicking leg (attack phase of the kicking leg)



**Fig. 2.** Changes of foot pressure on the ground while performing the left leg front kick

techniques (as well as other martial arts and combat sports) provides precise and quantitative information about the movement, which may enable to improve these techniques in training practice and enhance athletes' performance [13, 18].

Our study has some limitation, due to its single-subject case study character. Although the results are promising and they can indicate the need for its continuation on a bigger group of subjects, which enables for its appropriate statistical analysis. The results presented here may also provide some initial, basic data for further comparisons in a similar research. They can also indicate the need for interdisciplinary exploration and research, which includes the area of therapeutic and rehabilitation activities inspired by martial arts [19-23].

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### Conclusions

Due to the study limitations, it is impossible to present any direct conclusion or statement. We can assume that analysis of selected kinetic parameters may be useful in identifying lower leg laterization (leg preference), as well as existing asymmetries between the dominant and non-dominant leg in karate and other martial art athletes. Besides the results of our study can highlight the importance of quantitative, biomechanical analysis of martial art techniques for the purpose of their improving in training and enhancing athletes performance.

### Conflict of interests

The authors declare that there is no conflict of interests.

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