

BIOMECHANICS

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Analysis of time-space parameters of the front kick using the example of an athlete training in *Muay Thai*

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Abstract

Problem. The main aim of this paper was to study the kinetics of the front kick of a Muay Thai athlete (age: 32, body mass: 71 kg; height: 173 cm).

Methods. The study was conducted on an athlete who had long training experience, (about 16 years) and a high level of training. In the study the BTSSMART DX 6000 system of motion complex analysis was used. The system consisted of six cameras that read the position of 22 markers placed on the athlete's body in real time.

Results. The work presents the velocity for the foot and knee during a kick without target (air) and when aiming at a target. Most differences between velocities show statistical significance ($p < 0.05$).

Conclusions. In addition, the analysis showed significant changes in the kinematic parameters of the kick when a kicking target is introduced. The analysis showed that in most cases the kick in the air is characterized by higher velocities for the foot in relation to the kick at a target.

Introduction

Thai Boxing is a national sport of the Kingdom of Thailand. They train with equal rigor in the arts of meditation and self-defense, on the premise of believing that a strong body leads to a strong spirit [Junlakan 2001].

Speed and timing include both muscular speed and reaction time. Aspects of the fundamental parameters of power, speed, and timing have been investigated through a wide variety of indirect and direct methods in the past decades [Buchmann 2004; Wasik 2013].

From a biomechanical perspective, basic Thai Boxing skills and techniques utilize the principles of velocity, force, and torque to produce powerful striking movements. Furthermore, there is a limited number of research studies that have examined the kinematics of Thai Boxing [Sidthilaw 1996].

Biomechanical optimization of the combat sports' techniques can enhance the ability to learn and perform the fastest and most powerful strikes. That is the reason why many researchers attempt to find and identify the factors which influence efficient strike performance [Wasik 2013].

A number of scientists have analyzed the strike. It was proved that the velocity of the knee and the time of the movement influence the speed of the kick. [Wasik *et al.* 2015; Sorensen *et al.* 1996] wrote, that in the case of the high front kick slowdown of thigh is caused by the start move of a lower limb, not by the inhibition activity. [Pozo *et al.* 2011] were measuring a difference in execution of frontal kick in the karate Shotokan athletes.

There is a limited number of research studies that have examined Thai Boxing skills and none of them specifically have examined the kinematics of the dominant and non-dominant legs while in a double collar or double under hook clinching position. The purpose of the study was to investigate the kinematics of the dominant (right) and non-dominant (left) leg [Trial 2013]. Power, speed, and timing are some of the most important factors for martial arts striking performance [Wasik, Shan 2015; Chan *et al.* 2011].

The purpose of the study was to investigate the kinematic parameters of diagonal front kick performed by the dominant (right) and non-dominant (left) leg. The

experiment was performed in terms of aiming at the target and without target.

Material and methods

The study used time-space parameters of the front kick on the example of a Muay Thai athlete who had long training experience (about 16 years) and a high level of training. The athlete surveyed holds the titles of the International Champion of Poland in competitions based on the rules of K1 (2017), the runner-up of Championships of the Polish Uniformed Services (2017) and the title of the bronze medalist of the Polish Championship in Muay Thai (2014). The player's height is 173 cm and the weight is 71 kg.

The sequences of front kicks performed in two variants were analyzed in this work. In the first place, the athlete performed a kick without a given target (into the air), then an attempt was made to reach the target. The target of the kick was a small ball hanging still above the ground at the height of 90 cm. The athlete made three attempts to kick without and at the target. The sequences of kicks were recorded using the BTSSMART DX 6000 system of motion complex analysis. The system consisted of six cameras that read the position of 22 markers placed on the athlete's body in real time. Thanks to this, it was possible to register the motion image of the examined body and evaluate the obtained kinematic parameters in relation to the target. The kinematics of selected parts of the lower limb during the kick was analyzed. The analysis used basic statistical parameters (average and standard deviation) and the non-parametric Wilcoxon test.



Photo 1. Athlete with markers and during the test

Results

The individual sequences were analyzed for selected parts of the lower limb performing the front diagonal kick. Table 1 presents the velocity (average and stand-

ard deviation of absolute values) for the foot and knee during kick without target (air) and with aiming at the target. Most differences between velocities show statistical significance ($p < 0.05$). The analysis showed that there were no significant differences in the speed of the foot (with regard to X and Y axis) when kicking the left lower limb. However, kicking the right lower limb (dominant) significantly differentiates the speed of the foot in each axis. When analyzing knee velocities, there are no significant differences between velocity in the x-axis of the left lower limb and in the x axis of the right lower limb. It is worth noting that in most cases the kick velocities without target were characterized by a greater dispersion towards the kick aiming at the target. The foot velocities, kicking without target were characterized by higher average velocities (Table 1). In the case of the knee, it cannot be clearly stated. The courses of right foot (dominant) velocity changes for the performed kick was presented in Figure 1.

Discussion

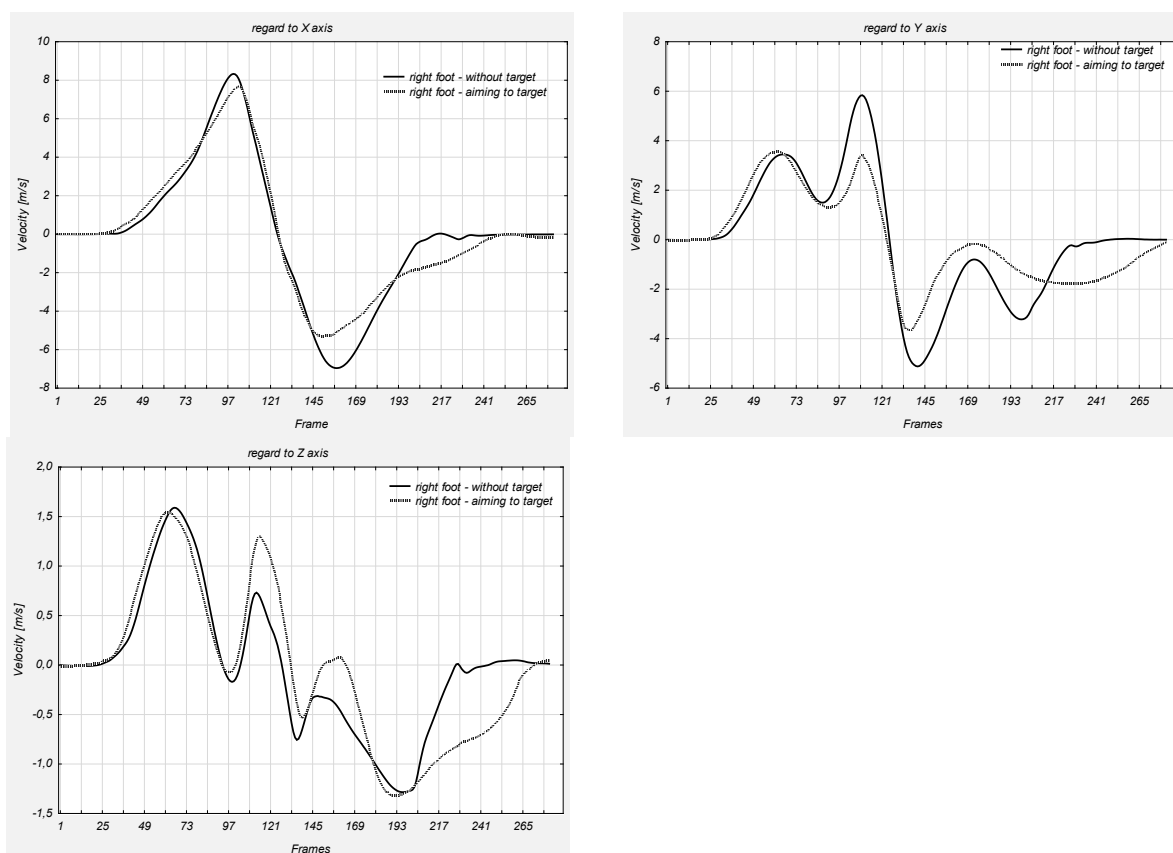
Kinematic parameters of kicks are an element of analysis in various combat sports [Wasik *et al.* 2015; Wasik, Gora 2016; Sidthilaw 1996; Ball 2011]. A very interesting study was carried out in the work by [Wasik *et al.* 2015]. The study was based on six athletes who had practiced taekwon-do for a minimum of 4 years. The data were recorded using six cameras from Smart-D system produced by BTS company. The paper was focused on knowledge about the influence of chosen kinematic factors on the front kick technique. They show that in order to achieve the maximum foot velocity a kicker needs to increase the velocity of the knee traveling towards the target and to decrease the duration of the foot takeoff. Other studies also in taekwon-do have been published in the work by [Wasik, Gora 2016], where similarly to our work, a comparison of the velocity parameters of the kick to the target and into the air was made. The front kick velocity observed by Wasik and Gora was between 10.03 and 13.92 m/s. The lowest foot velocity was recorded during the table tennis ball strike (10.27 ± 0.29 m/s – dominant leg; 10.03 ± 0.15 m/s – non-dominant leg). The study examined Polish *taekwon-do* athletes. Motion analysis and data processing were prepared using Vicon MX-T40 cameras with the acquisition speed of 370 frames per second. The values of velocities recorded in our work differ from the velocities registered by Wasik and Gora, which result from various protocols adopted during the kicking. However, in both cases the kick without target was characterized by a higher velocity of foot compared to the kick aiming at the target.

Kinematic analysis of the kick was also presented in the paper by [Sidthilaw 1996]. The aim of study was

Table 1. Kinematic parameters of diagonal front kicks performed by left and right leg and in terms of aiming at the target and without target.

| Speed | | without target | | aiming at the target | | d | p |
|------------|--------|----------------|------|----------------------|------|-------|-----------|
| | | average | sd | average | sd | | |
| Left foot | X axis | 1.35 | 2.06 | 1.30 | 1.81 | 0.05 | 0.7025 |
| | Y axis | 1.62 | 1.74 | 1.51 | 1.22 | 0.11 | 0.6683 |
| | Z axis | 0.53 | 0.58 | 0.65 | 0.64 | -0.12 | 0.0001*** |
| Right foot | X axis | 2.41 | 2.20 | 2.32 | 2.65 | 0.08 | 0.0001*** |
| | Y axis | 1.79 | 1.68 | 1.47 | 1.06 | 0.32 | 0.0002*** |
| | Z axis | 0.49 | 0.48 | 0.61 | 0.49 | -0.12 | 0.0001*** |
| Left knee | X axis | 0.50 | 0.65 | 0.47 | 0.44 | 0.04 | 0.6396 |
| | Y axis | 1.05 | 1.10 | 1.13 | 0.92 | -0.09 | 0.0001*** |
| | Z axis | 0.39 | 0.33 | 0.46 | 0.35 | -0.07 | 0.0001*** |
| Right knee | X axis | 1.18 | 1.07 | 1.26 | 0.87 | -0.08 | 0.0001*** |
| | Y axis | 1.23 | 1.20 | 1.15 | 0.84 | 0.07 | 0.0143* |
| | Z axis | 0.51 | 0.40 | 0.54 | 0.48 | -0.03 | 0.0877 |

*- statistical significance at the level of 0.05; ***- statistical significance at the level of 0.001;

**Figure 1.** Right foot velocity changes for the kick in terms of aiming at the target and without target.

to determine kinetic and kinematic parameters of three height levels of the roundhouse kick. The study material consisted of ten males (aged between 17 and 24) practicing Thai Boxing. The analysis included the final linear velocity of the ankle, the linear velocity of the kicking ankle and the knee, the angular velocity of the knee, and the angular velocity of the shank and of the thigh projected onto the horizontal plane. Video analysis method

was used to determine kinematic parameters of the kicking. One of the major conclusions was that the use of a kicking bag as a target provided a much more realistic study of the Thai Boxing roundhouse kick.

Other studies about kick kinematics are presented in the paper by [Ball 2011], where examination of the differences between the preferred and non-preferred leg kicking in the drop punt kick of 17 professional male

rugby players was presented. Ball *et al.* show that foot speed, knee, and shank angular velocity at ball contact and hip range of motion were significantly larger for the preferred leg while, hip and thigh angular velocity at ball contact and hip range of motion were significantly larger for the non-preferred leg.

Conclusions

The results obtained can be useful and valuable tips while improving the diagonal front kick technique. In addition, the analysis showed significant changes in the kinematic parameters of the kick when the kicking at the target is introduced. The analysis showed that in most cases the kick in the air is characterized by higher velocities for the foot in relation to the kick at the target.

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