

## CASE STUDY

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# Changes in foot pressure on the ground during *Gyaku-Zuki* (punch) in a karate athlete: a case study

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### Abstract

**Introduction.** The quality of the lessons conducted is influenced by among others, the test results of biomechanics in the sphere of the teachings of sport and science of physical education. Therefore, the aim of this research was to obtain knowledge about the influence of selected external factors on the loads of the lower limbs during *Gyaku-Zuki* karate punch. **Material and Methods.** The analyses took into account a Karate athlete holding 2nd dan black belt. During the examination, he was performing right and left *Gyaku-Zuki* punch starting from *zenkutsu-dachi* (without a physical target or into a board measuring 30 × 20 cm and one inch thick). Two dynamometric Kistler platforms (Kistler force plate, Type 9286AA, Kistler, Switzerland) were used for examination. The maximum ground pressure (P) for the left and right leg during *Gyaku-Zuki* performance was recorded while the Karate athlete was hitting the wooden board or had no target (into the air). **Results.** The following values were registered: punch without target – front foot 1150.27-1329.72 N, back foot 621.78-748.13 N; punch on the board: front foot 912.28-697.76 N, back foot 721.44-670.63 N. **Conclusions.** The research conducted indicates that during the course of administering a blow with the fist, namely *Gyaku-Zuki*, the leg thrust forward bears more weight (the leg opposed to the hand administering the blow). The occurrence of a motionless object that constitutes the target of the blow, or its lacking, have an impact on the pressure force on both feet of the karate fighter, while blows administered to a wooden board reduces the pressure force of the feet on the floor.

**KEYWORDS:** martial arts, ground pressure, straight punch forward, *Gyaku-Zuki*, karate biomechanics.

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### Introduction

In karate sports fights, players use different techniques. In the total number of techniques used, 9% is scored, while the rest (91%) is not [7]. Based on that, a significant difference in effectiveness was found between winners and losers. It was found that winners differ from defeated competitors, among others, in the higher level of biomechanical complexity of movements and the specific tactical concept of using impacts in the attack phase. *Gyaku-Zuki* (in Japanese 逆突き) (straight punch forward) is an attacking or a counterattacking technique in karate. It is relatively easy to learn, but difficult to master. The punch performed correctly (masterful performance) can be dangerous for the rival, which is confirmed by the fact that a carotid artery stenosis related to a cerebral

infarction was registered, which was a possible consequence of martial arts training in which punches on the neck were performed [1].

Biomechanical indicators allow us to precisely identify factors affecting the player's proper preparation for competition [1, 14, 15]. Therefore, in the available literature concerning marital arts, publications on the biomechanics of hand punches in karate can be found [9, 10, 16].

To date, among others, the kinetic and electromyographic characteristics of *Gyaku-Zuki* karate punch in professional karate athletes have been determined [6]. There were significant positive correlations between the impact force and the right and left knee flexion at the moment of impact and the strength of the right and left leg. In addition, a significant negative correlation was found between the impact force and the maximum angular acceleration of the trunk. It has been found that there is an asymmetry at the time of *Gyaku-Zuki* performance depending on the stimulus [4]. Agonistic and antagonistic relationships between electromechanical activity of muscles in representatives of different sexes were observed [3]. The results proved that there is a different pattern of coordination in neuromuscular movements in men and women, even though it was expected that long-term karate practice would result in a similar kinematic pattern. Coupling between punch efficacy and body stability for elite karate was examined [2]. The results of the research showed a specific strategy used to maintain body stability by karate experts in relation to novices. It has been diagnosed that the distance of a competitor from the impact target affects the kinetics of punches [7, 20]. However, previous research has not focused on the analysis of the feet pressure force exerted on the floor. Therefore, the aim of this research was to obtain knowledge about the influence of selected external factors on the loads of the lower limbs during *Gyaku-Zuki* karate punch. The assessment was made on the basis of the obtained ground pressure values. The following research questions were defined here:

1. How does the performance in *Gyaku-Zuki* affect the loading of lower limbs?
2. How does the occurrence or absence of a stationary object constituting the target of the punch affect the pressure on the ground of both karate practitioner's feet?

**Material and Methods**

*Participants*

The analyses took into account a Karate athlete holding 2nd dan black belt (age: 36; weight: 97 kg; height: 177 cm). The Human Subjects Research Committee of the University scrutinized and approved the test protocol as meeting the criteria of Ethical Conduct for Research Involving Humans. All subjects in the study were informed of the testing procedures and voluntarily participated in the data collection.

*Research design*

During the examination, he was performing right and left *Gyaku-Zuki* punch starting from *zenkutsu-dachi* (without a physical aim or into a board measuring 30 × 20 cm and one inch thick). The Karate athlete represented less known style *Idokan / Zendo karate Tai-te-tao* [5]. Two dynamometric Kistler platforms (Kistler force plate, Type 9286AA, Kistler, Switzerland) were used for examination. The maximum ground pressure (P) for the left and right leg during *Gyaku-Zuki* performance was recorded while the Karate athlete was hitting the wooden board or had no target (into the air). In addition, the time between the highest P values of the left and right leg ( $\Delta T$ ) was calculated.

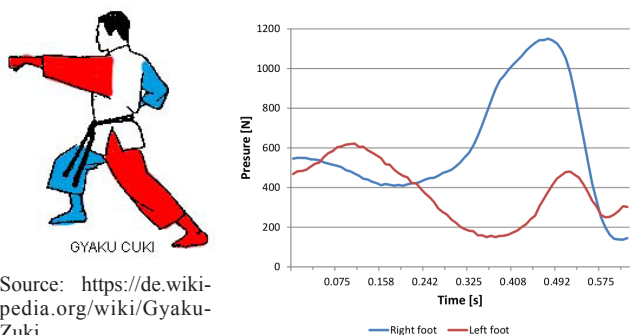
**Results**

Figure 1 shows an example graph presenting the change in the pressure force on the floor exerted by the left and right foot during the *Gyaku-Zuki* punch by a selected Karate athlete. Table 1 shows the maximum values of the pressure on the floor exerted by player's feet and the

**Table 1.** Selected kinetic indicators for straight punch forward

Target	Without target				On the board			
	Left		Right		Left		Right	
Punch	Right	Left	Right	Left	Right	Left	Right	Left
Foot	Right	Left	Right	Left	Right	Left	Right	Left
P [N]	1150.27	621.78	748.13	1329.72	912.28	721.44	670.63	697.76
$\Delta T$ [s]	0.367		0.292		0.233		0.284	

Note: P – maximum pressure on the ground,  $\Delta T$  – time between the maximum pressure on the floor exerted by one foot and the other



Source: <https://de.wikipedia.org/wiki/Gyaku-Zuki>

**Figure 1.** An exemplary illustration of the change in foot pressure on the ground during a straight punch with the left fist

time between reaching the maximum pressure values of the left and right leg.

### Discussion

The recorded material shows that the maximum ground pressure exerted by the Karate athlete while performing a straight punch forward is 1150-1329 N (Table 1). For comparison, it was registered that a Karate athlete during a frontal kick obtained values between 1295-1462 N [4]. While executing the technique of *Gyaku-Zuki* (regardless of the fact of whether it is administered with the right hand or left hand), it always registers greater pressure force on the floor by the foot thrust forward (the leg opposite the hand administering the blow – Figure 1). Hence, it is possible to assume that the limb is more aggravated. In the case of blows without a physical target, the difference between the pressure force of the lead leg and the trail leg amounts to over 580 N.

We can assume that the change of the *Gyaku-Zuki* physical target influences the lower limb's pressure on the ground. The player put the greatest pressure during punches without a physical target, regardless of which hand he used to perform the movement (Table 1).

It can be assumed that a player, seeing an object (which must be destroyed) is forced to properly manage the energy accumulated in his entire body. He cannot allow himself to dissipate it in other directions than the direction of the impact. Therefore, we observe clearly less pressure on the ground, because the energy is directed not downwards but horizontally. Thus, it appears that the object constituting the target, or the lack of such target, forces different implementation of the same movement. This phenomenon is confirmed by other studies [8].

An impact in the board shortened the time between the maximum pressure values of left and right leg. This is probably due to the attempt to produce a higher power of impact by the competitor which, in accordance with

the rules of physics, is inversely proportional to time. Therefore, the shorter the time of the punch, the more power is used.

Time may be affected by the upper limb preference. This specific player preferred to punch with his right fist. This can be explained by the similar time ( $\Delta T$ ) and the greatest pressure on the ground during the punch “into the air” without the object and the smallest pressure when punching the “object” – wooden board. It may be possible to check or figure out the lateralization or preferential limbs of karate fighters based on the ground pressure record.

Interestingly, throwing a punch with the preferred right hand, makes the left leg press on the ground twice as hard during the strike “into the air” (1329 N) than during the impact into the board (670 N) (Table 1).

The results of this study suggest that there is an asymmetry in the pressure force exerted on the floor by the feet depending on the external stimulus. This can affect sport training (and other activities) that requires effective punches into a selected object. Such a method of analysis of karate techniques (and other Far Eastern combat sports) allows to obtain precise information on the course of movement [6, 17].

Although our research has limitations related to the study of one case, the results are promising and may suggest the need to continue research in a larger group of people. The results and considerations presented here may be useful for players and instructors in the preparation of training programs or provide comparative material for other researchers and may set the path for further interdisciplinary research [5].

### Conclusions

The research conducted indicates that during the process of administering a blow with the fist in the style of *Gyaku-Zuki*:

1. The leg thrust forward is more aggravated (the leg opposite the hand administering the blow).
2. The occurrence of a motionless object constituting the target of the blow, or its absence and the impact on the pressure force on both feet of the karate fighter.
3. While administering a blow to a wooden board, the pressure force of the feet on the floor is reduced.

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