

Pilot Study: 3D Kinematic Analysis of Three Different Gyaku-Zuki Punch Variants in Karate

Amelie Schneider ¹, Beat Göpfert ²

¹Kantonschule Alpenquai Luzern Switzerland

²Departement Biomedical Engineering, University of Basel, Switzerland

Email: beat.goepfert@unibas.ch

Summary

This pilot study examined three variations of the Gyaku-Zuki punch in karate using 3D-optical motion analysis. An experienced athlete performed 10 repetitions of each variation in the Zenkutsudachi stance. The study aimed to analyse hand movement and speed at impact. The variations differed in initial pelvic and torso positioning and in the execution of arm and hand movements. Results showed significant differences in range of motion, particularly in pelvic and thoracic rotation, and shoulder and elbow flexion. Hand path and impact velocity also varied between the 3 variations. Variation 1 showed the greatest range of motion, Variation 2 the longest hand movement path and Variation 3 the highest impact velocity. These findings provide insight into the biomechanics of karate punching techniques and may help to optimize performance.

Introduction

In karate, the speed and precision of movements are crucial factors for successfully hitting the opponent and winning the fight. Small variations in the movement sequence can be decisive for the success of a hit. This pilot study analyzed three variants of the Gyaku-Zuki punch in the Zenkutsudachi stance using optical 3D motion analysis. The aim was to investigate the range of motion and hand velocity upon impact with the target.

Methods

An experienced athlete (6th Dan, 40 y, 86.7kg, 182 cm) was recorded performing the Gyaku-Zuki punch using optical 3D motion analysis (Vicon Nexus 2.9, 12 cameras, framerate: 250Hz, full-body marker model CGM2 [1]). The athlete performed the following three-punch variation of the Gyaku-Zuki in the Zenkutsudachi stance with the right arm:

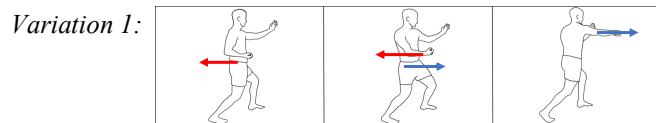


Fig.1: Red arrow: indicates body movement backwards. Blue arrow: indicates body movement forwards or towards the target.

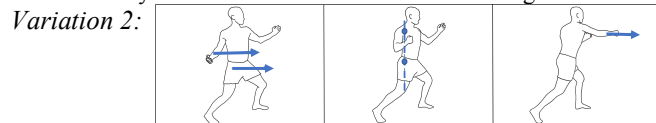


Fig.2: Blue arrow: indicates body movement forwards or towards the target. Blue dotted line: vertical alignment of shoulder and hip.



Fig.3: Red arrow: shows the non-existent backward movement. Blue arrow: indicates body movement forwards or towards the target.

Measurement procedure and Data evaluation

The athlete moves to the starting position. The target pad is held by a second person at chest height at a distance of approx. 70 cm from the left side of the athlete's pelvis. The athlete performs 10 repetitions of each of the three punch variations with self-selected pauses between punches.

From the 3D movements of the markers, the 3D kinematics and angular movement of the pelvis, thorax, upper and lower arm as well as the hand of the striking side during the punch are calculated using the CGM2 model and the average value over the 10 repetitions is calculated.

Results and Discussion

The results of the three punch variations show significant differences in the range of motion during the punching movement, particularly in pelvic and thorax rotation, as well as flexion in the shoulder and elbow joints. The hand's path during the forward movement of the punch and the impact velocity also differ between the three variations.

Table 1: Kinematic results of the 3 punch variations

	Variation 1		Variation 2		Variation 3		Unit
Start position at beginning of the punch	Angle	STD	Angle	STD	Angle	STD	
Flexion elbow	104	4	82	6	98	12	Degree
Flexion between shoulder and upper arm	75	5	-31	2	-20	1	Degree
Abduction between shoulder and upper arm	12	3	19	2	23	2	Degree
Rotation thorax	-20	7	-76	3	-60	4	Degree
Rotation pelvis	-4	2	-57	3	-48	5	Degree
Rotation between pelvis and thorax	-16	7	-19	3	-12	5	Degree
Position at the impact with the target	Angle	STD	Angle	STD	Angle	STD	
Flexion elbow	70	3	69	3	71	3	Degree
Flexion between shoulder and upper arm	35	8	30	4	26	2	Degree
Abduction between shoulder and upper arm	51	11	62	3	68	2	Degree
Rotation thorax	15	10	15	2	18	2	Degree
Rotation pelvis	13	2	14	1	15	2	Degree
Rotation between pelvis and thorax	2	10	1	2	3	2	Degree
Range of motion from start to impact	Angle	STD	Angle	STD	Angle	STD	
Flexion elbow	33	4	13	3	27	3	Degree
Flexion between shoulder and upper arm	41	8	61	4	46	2	Degree
Abduction between shoulder and upper arm	38	10	43	3	45	2	Degree
Rotation thorax	34	10	91	3	78	4	Degree
Rotation pelvis	17	5	71	3	63	4	Degree
Kinematic data of the punch		STD		STD		STD	
Duration of movement from start to impact	0.59	0.04	1.00	0.09	0.59	0.08	sec
Duration of hand forward motion during the punch	0.19	0.01	0.23	0.03	0.18	0.01	sec
Distance moved by the hand during the punch	863.30	19.37	1110.15	49.12	926.55	47.35	mm
Max. velocity of the hand during the punch	9.87	0.43	10.19	0.38	11.28	0.49	m/sec

Conclusions

- Variation 1 has a larger range of motion over the entire movement due to a backward rotation of the trunk at the beginning.
- Variation 2 has the longest hand movement path, achieved through greater trunk rotation and shoulder flexion.
- Variation 3 has the highest impact velocity with smaller trunk rotation and shoulder flexion compared to Variation 2.

References

- [1] Leboeuf et al, J. Biomech. 2019