

Execution Speed and Impact of Various Karate Punching Techniques

Yon Dan Examination Research Study

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Abstract

In this paper the author presents the results of his research regarding execution speed and impact (kime) of various punching (zuki) techniques ranging from standing position (zenkutsu dachi) to stepping (oi zuki) and shifting (yori ashi). The measurements were made on six black belt karateka from Intel Karate Club, with the aid of high speed photography, slow-motion video and StrikeMeter accelerometer.

The Main Goal of the Research

As requested by the Karate-Do Ranking Examination Guide for Yon Dan, the examinee needs to present a research on either Kumite or Self-Defense. The author noticed that most Kumite matches' scoring points are awarded to punches, and was curious to find out which kinds of punches can be executed in the shortest amount of time (from trigger to impact) and also the amount of force the punch can deliver to the target for these techniques.

Aids to the research

We attached a Strike Meter device to the bottom of the makiwara. StrikeMeter is manufactured by Martial Arts Instruments and measures and displays the highest acceleration that the device senses in



Figure 1. Side view of makiwara with StrikeMeter installed



Figure 2. StrikeMeter installed at the bottom of makiwara

one go. It has a scale from 0 to 6000, these are relative units, i.e. higher reading means higher

acceleration, but not tied to any physics system of measurements. The device was mounted to the bottom of the makiwara, we found that if it was installed higher up, then the reading would exceed the maximum range of the device. The device is actually marketed as to be installed on the round bases of the martial arts standing kicking bags.

We found that the StrikeMeter device was correctly measuring the relative changes in the speed at which the makiwara was hit, i.e. a slower punch would register a smaller number than a faster punch. Same punches by the same karateka would register very similar and consistent numbers. Also, karateka with stronger punches (based on personal experience of being hit by them) generated higher numbers on the device. The device may not be perfect, because it doesn't measure the true kime – the lockdown and destructive power of the punch - for that probably a more sophisticated device would be needed. That means that a higher reading punch may not necessarily cause more damage in a victim than a lower reading punch. However, the author believes that the numbers are an accurate measure of the highest acceleration that the makiwara is going through as it's being hit by the fist.

We also used a high quality camera to take burst photos (29 frames/second) as well as High Frame Rate video (480 fps) and the footage was used to measure relative duration of execution of the techniques.

The participants in the study

Six black belt karateka from Intel Karate Club participated in the measurements. They are identified as Karateka1, Karateka2, etc. The amount of karate experience ranges from about 7 to 20 years.

The First Study: The Impact (acceleration) of various punches from standing position (zenkutsu dachi), stepping (oi zuki) and shifting (yori ashi)

In the first study, the participants were asked to perform the following techniques.

1. Gyaku zuki from zenkutsu dachi, proper stance, proper hikite (fully pulled back hand), back heel down, punching fist starting from hikite position
2. Gyaku zuki, from zenkutsu dachi, back heel up option, punching fist starting from hikite position
3. Gyaku zuki, with the pull-back hand dangling on the side, proper zenkutsu dachi, heel down, punching fist starting from hikite position
4. Short gyaku zuki, both fists starting from fighting position (kamae-te), punching fist travel distance about half as much as in #1-3 above.
5. Three-inch punch, the punching fist starting 3 inches from the makiwara, no pre-motion allowed
6. Oi zuki, stepping punch, proper technique, proper stance, hikite, heel down.
7. Yori ashi (shifting), gyaku zuki, back heel had tendency to be up at impact time.

The participants executed each of these techniques three times over, and the highest reading was recorded.

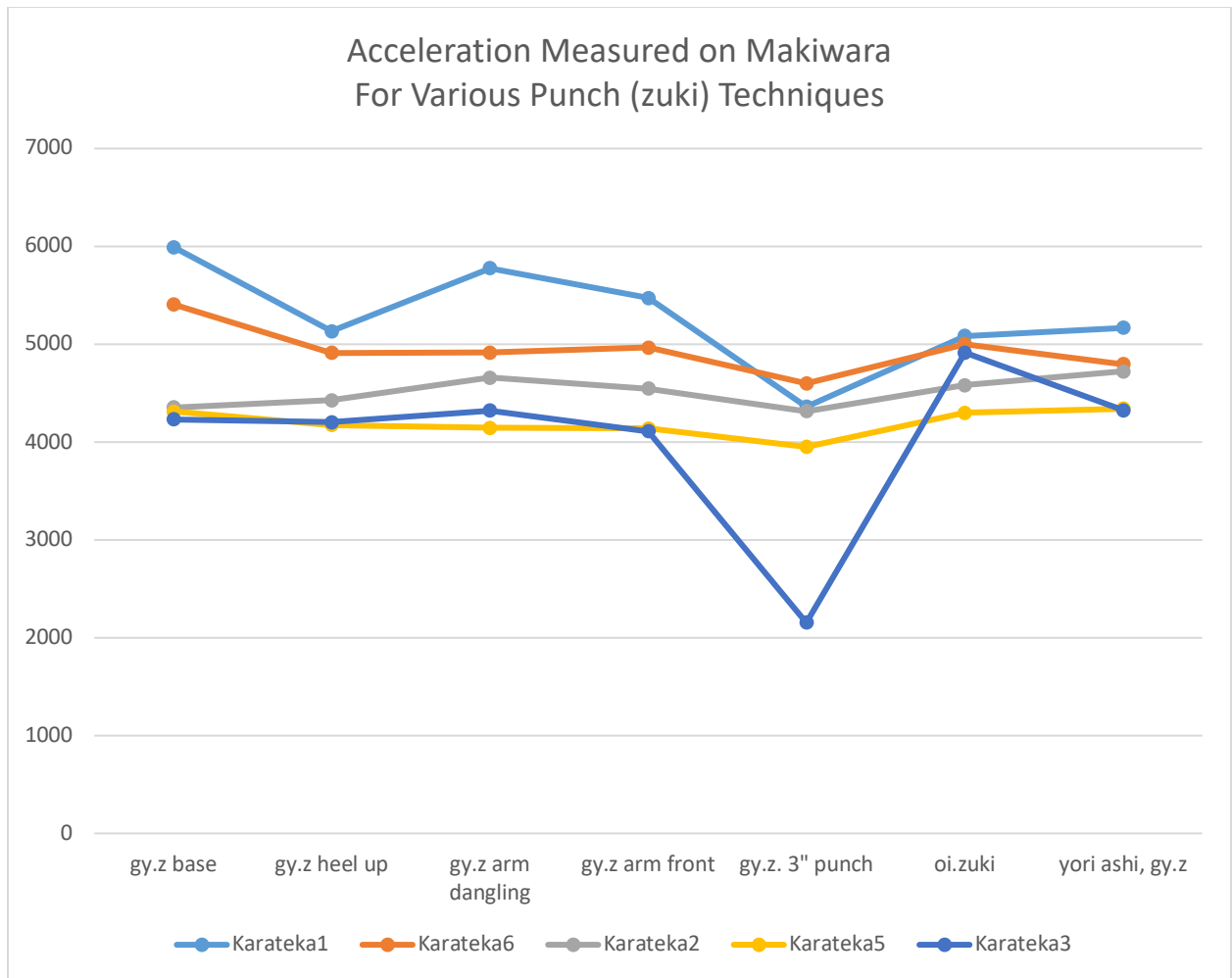


Figure 3. Acceleration measured on makiwara for various punching (zuki) techniques. The different color lines correspond to different karateka. The points on each line represent acceleration readings for that karateka, executing the seven techniques described earlier.

In the chart above, each colored line represents a different karateka who participated in this experiment. The points represent the acceleration readings for each of the seven techniques executed.

The lessons learned from this experiment:

1. There is a relatively stable ordering of karateka, no matter what techniques they executed. A more skilled karateka did relatively better on all punches than a less skilled one
2. For each individual, the distribution is relatively narrow, approximately within 1000 units – with one exception, Karateka3 doing the 3" punch is an outlier
3. The only technique that's clearly and consistently weaker/slower than the others is the 3" punch.
4. For some karateka (Karateka 1 and 6), the static punches are stronger (first 4 data points)
5. For the other three Karateka, the moving punches tended to be stronger (last 2 data points)

6. The dangling hikite or heel up apparently had inconsistent impact, it was better for some, worse for others.
7. Oi zuki (stepping) vs. Yori ashi (shifting) was also inconsistent, some punched faster while stepping, some while shifting.

The Second Study: Measuring the execution duration as well as impact of various punching techniques

In this second experiment, we had one helper holding an object (a punching pad pinched with two fingers). The helper, on his own timing dropped the punching pad, and that was the signal for starting. The study participant was facing the makiwara, and when the pad started falling, they were instructed to hit the makiwara as fast as they could.



Figure 2. Moment when pad is dropped, signals start of motion



Figure 5. Duration measured from drop of pad to moment of impact on makiwara

The participants were asked to perform the following techniques

1. Oi zuki with front leg's hamstring pre-engaged and ready
2. Oi zuki with front leg's hamstring disengaged
3. Yori ashi gyaku zuki

For each of these, the participants were supposed to hit the makiwara as fast as they could. The duration was measured from the moment the pad was released by the helper to the moment when the

fist hit the makiwara. Techniques 1 and 3 were executed twice, and the reading with the shortest delay (fastest) was picked, regardless of impact. Technique 2 was only measured once.

We marked the floor with a tape for each karateka (based on their height) and they had to start each of these techniques with the front toes on the mark, to assure that they're covering the same distance for each of the three experiments.

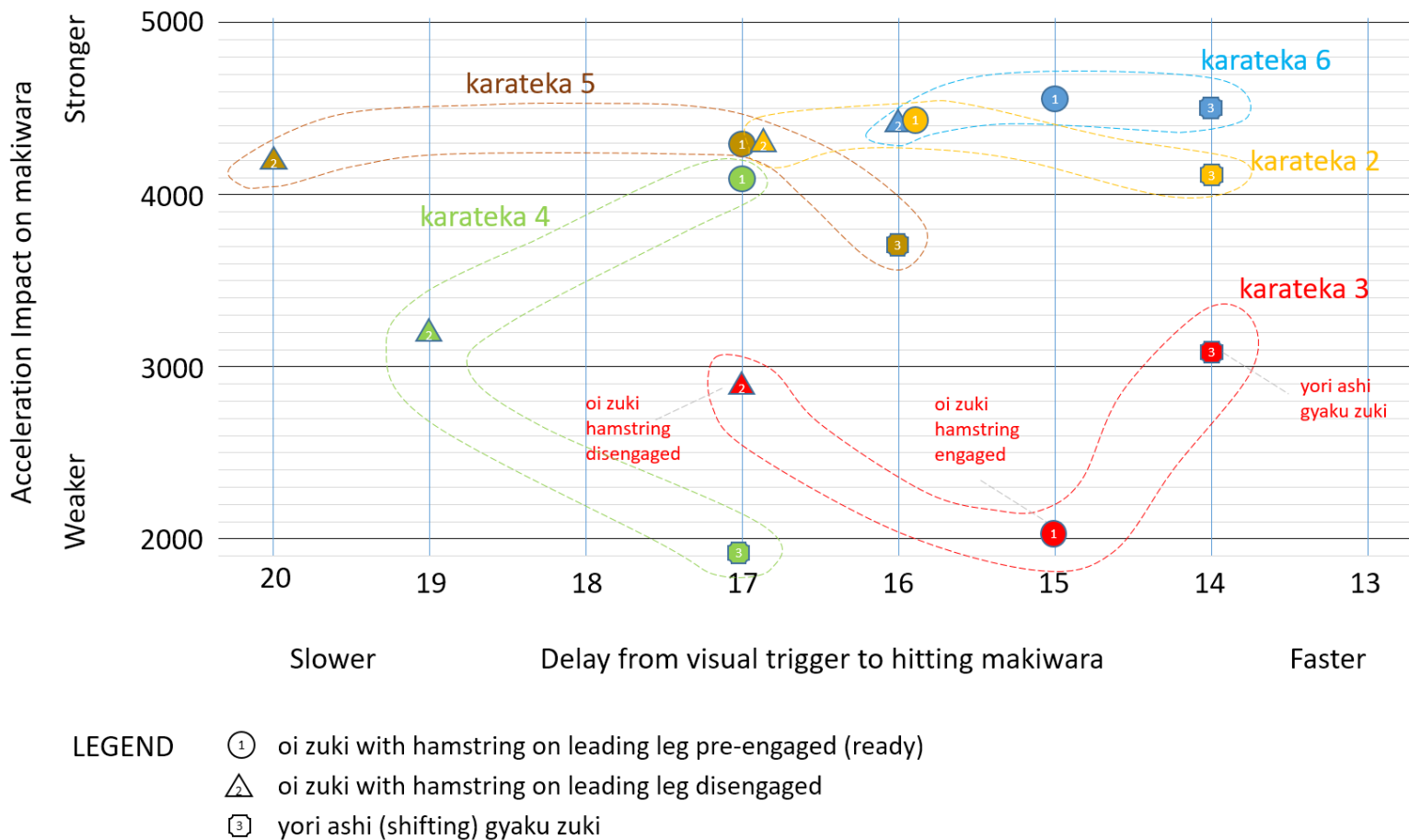


Figure 6. Showing the duration of three types of punching techniques from visual trigger to hitting makiwara (X axis) as well as the impact (Y axis)

For the diagram in Figure 6, the three data points for each karateka are shown, each color corresponding to a separate karateka. The circle labeled 1 represents the data point for oi zuki with the hamstring pre-engaged. The triangle labeled 2 represents oi zuki without engaged hamstring, the square labeled 3 represents the data from yori ashi gyaku zuki.

On the X axis, the delay is shown, shorter delay (faster) on the right, longer delay (slower) on the left. On the Y axis the impact is shown as measured by the StrikeMeter attached to the makiwara. Data points on the upper right are the fastest and strongest.

Observations from the data:

1. For all karateka, the yori ashi gyaku zuki had the fastest execution
2. Pre-engaging the hamstring gave the karateka a clear edge in speed, all were faster with a pre-engaged hamstring as opposed to starting with a disengaged hamstring.
3. Punching power (acceleration) varied, there's no clear winner, for some gyaku zuki had a higher reading, for some the gyaku zuki did.
4. Some karateka were very consistent, across all three experiments (karateka2 and 6), some had a big variation (karateka 3)

Visual and subjective observations during the experiments

In addition to the objective measurements from the previous paragraphs, the author made subjective observations during these experiments, as follows:

1. Some karateka, when starting an oi zuki, moved the front foot back, to speed up the foot exchange, but that ended being detrimental to the duration of the execution
2. Better hikite helped with the duration of the execution
3. Some karateka prematurely rotate the punching arm, and that tended to decrease the amount of power delivered into the makiwara. That is something we will try to fix in the coming months.
4. When starting with a disengaged hamstring, the reaction time was obviously slower, it took the body a some time to tense up to start the forward motion.
5. Yori ashi tended to have a faster reaction time, probably due to the fact that the body is more ready to jump forward because of the naturally compressed back leg and ankle.
6. When punching a right gyaku zuki from a left zenkutsu dachi, if the hip pivots around the front (left) hip, then the tanden (just below the navel) has a forward motion, and this tends to generate stronger and faster punches. On the contrary, if the hip pivot happens at the tanden, or at the back hip, then the tanden either stays in place, or moves slightly back, diminishing the effectiveness of the punch.

Summary of Findings

1. The karateka who participated in this study showed that they can consistently deliver effective punches from various starting positions. There was not much variation in the strength of the punch, regardless of the starting position, except the 3 inch punch, which was clearly weaker than the others.
2. More skilled karateka were able to deliver stronger punches across all tests than other, less skilled karateka. Note that we did multiple measurements of the same techniques and we recorded the highest readings. The readings showed variations for the participants, but the recorded maximums tended to be consistent.
3. For kumite, where execution time is very important, the body needs to be prepared to move forward, it needs to be in a ready state. Either for oi zuki the front hamstring needs to be pre-engaged and the front foot firmly planted with a good grip, or for yori ashi, the back leg needs to be in a ready state. Starting from an unprepared state adds delay to execution time.
4. Yori ashi gyaku zuki tends to be the best surprise attack. It has the fastest execution, covers as much distance as oi zuki (that's how the experiment was conducted) and is equally powerful. We have not measured yori ashi kizami zuki (front fist punch) though.
5. Hikite didn't seem to have effect on the strength of the punch, but it did help in execution time, better hikite made the fist arrive faster at the target. Just note that the StrikeMeter does not measure kime (and lockdown) only the acceleration of the makiwara. It would be very interesting to do another study with a more sophisticated device and measure the effect of hikite on kime and the amount of damage a punch can create in the opponent.



Figure 7. The author breaking a suspended plastic board with oi zuki.



Figure 8. Photo taken a fraction of second after the author broke a suspended, plastic board with oi zuki