

THE TIMING OF STOMPING (FUMIKOMI) IN KENDO ATTACKS: COMPARISON OF KYU AND DAN LEVEL KENDOKAS

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According to the doctrine of Kendo, spirit, sword, and body must be synchronized. This principle also applies to the timing of stomping when striking the head target. We instrumented a right Kendo sock and a Kendo helmet (head gear) with piezoresistive sensors, and measured the time interval Δt between two impacts, stomping and striking the head target, in 16 Kendokas (6 Kyu and 10 Dan holders). Δt was significantly ($p < 0.0001$) different in Kyu and Dan holders, with medians of -0.040 s (stomping before striking) and $+0.502$ s (stomping after striking) respectively, indicating that the two impacts were not synchronised. This study proposes to revise the doctrines of Kendo and accept the fact that in Dan holders, the foot impact on the ground occurs on average 0.5 s after striking the head target.

KEYWORDS: head target, synchronization, pressure sensors, smart equipment, judging.

INTRODUCTION: In the martial arts discipline Kendo (Japanese swordsmanship), the Kendoka must score points by striking one of four targets (head, wrist, flank, throat). Referees award points based on the precise timing of movements when striking a target, intensity of impact, simultaneous shouting of the target's name, follow through, and level of fighting spirit. When Kendokas strike the "*Men-bu*" (Japanese for head target), they lunge at the opponent, thrust the sword forward to deliver a strike, move the right leg forward, and then stomp the ground (*Fumikomi*). According to the Regulations (FIK, 2017) of Kendo *Shiai* (match) and *Shinpan* (referee), three elements (*Ki* / spirit, *Ken* / sword, *Tai* / body) must be combined to meet the requirements of a valid strike in accordance with the correct timing in one movement. Therefore, both impacts, the stomp and the strike on the target, must be synchronised. No points would be awarded if the stomp occurs too early or too late, and *Ki-Ken-Tai* is therefore missing. However, it is questionable whether the referees can distinguish two impact sounds if they are too close to each other, since, according to the Haas effect (Blauert, 1996), two consecutive sounds with delay times of less than 50 ms can no longer be distinguished, regardless of which of the two sounds was stronger.

In recent years, technology has helped to better understand the dynamics of Kendo attacks through the integration of sensors into equipment (Jeong et al., 2018, 2020, 2023). For example, using a pressure sensor included in a Kendo glove (Jeong et al., 2018), it was shown that Dan holders (advanced ranks) have a lower risk of missing the target and also striking the target with greater force (scoring criterion) than Kyu holders (junior/intermediate ranks). There is not a single study in the literature that addresses the timing of the *Fumikomi*, another critical scoring criterion.

The aim of this study was to use pressure sensors to determine the timing of stomping and striking the *Men-bu*, by comparing Kendokas at Dan and Kyu levels. The hypothesis of this study was that the two impact sounds of stomping and striking the *Men* target occur simultaneously, so that the referees perceive the two impact sounds as one.

METHODS:

The participants' customised right sock (*Tabi*) and the opponent's helmet were instrumented with piezoresistive sensors, measuring 73 mm x 73 mm and 137 mm x 235 mm, respectively. The drop voltage of each sensor circuit was measured across the reference resistor by connecting them to a Teensy 3.1 microcontroller (LLC, Sherwood, Oregon, USA). Data were recorded at a frequency of 50 Hz. 16 Kendokas participated in this study (Kyu holders: 6 [4th – 1st Kyu, 3-4 years of experience], Dan holders: 10 [2nd – 5th Dan, 5-23 years of experience]; 7 females, 9 males; body height 1.68 ± 0.09 m, body mass 67.2 ± 14.3 kg). The participants

performed the *Fumikomi* action 15 times by striking the *Men-bu* target under simulated competitive conditions. Failed attempts, i.e., failure to strike the target, were excluded. The participants were not informed of the purpose of this study before the experiments and were simply asked to perform a *Men* attack as they would during a competition (Figure 1). This research received Ethics approval from the Human Ethics Committee of Swinburne University (approval no. 2016/296) and ethically followed the Declaration of Helsinki.

A single dataset consisted of timestamp, *Tabi* pressure data and *Men* pressure data, with the latter two expressed as ASCII data representing the voltage drop across the sensors. The *Tabi* and *Men* impacts were identified by the sudden voltage jumps as shown in Figure 1. The interval Δt (Figure 1) between the timestamps at the end of the voltage jumps (*Tabi* timestamp minus *Men* timestamp) corresponded to the timing of the two impacts, i.e., negative or positive Δt if the *Tabi* impact occurred before or after the *Men* impact, respectively. The Δt data from Kyu and Dan holders were compared for significant differences using the Mann-Whitney U-test (Kyu Δt not normally distributed).

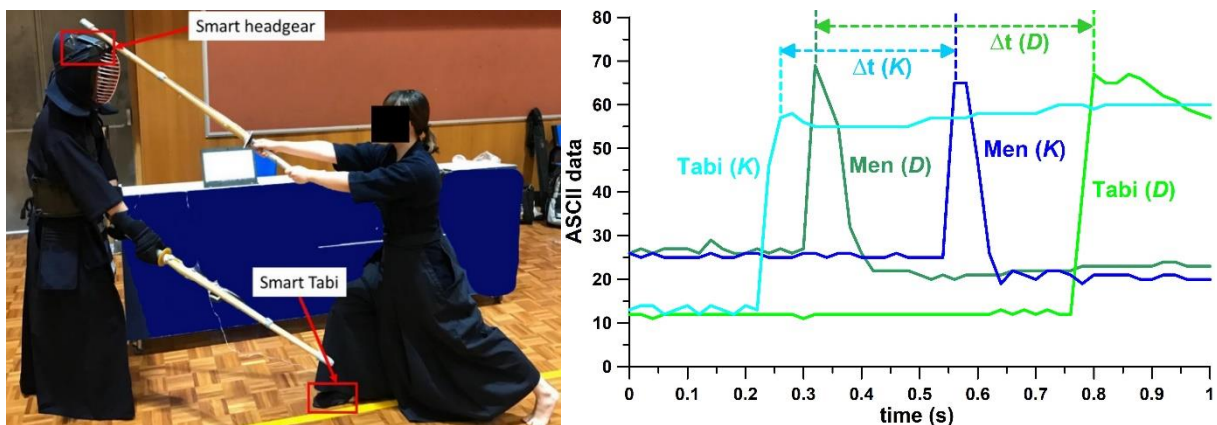


Figure 1: Experimental setup (left) and data of two experiments (right); Kyu (K) level: signals of *Tabi* (K) and *Men* (K) recorded simultaneously, *Tabi* (K) impact precedes *Men* (K) impact; Dan (D) level: signals of *Tabi* (D) and *Men* (D) recorded simultaneously, *Men* (D) impact precedes *Tabi* (D) impact.

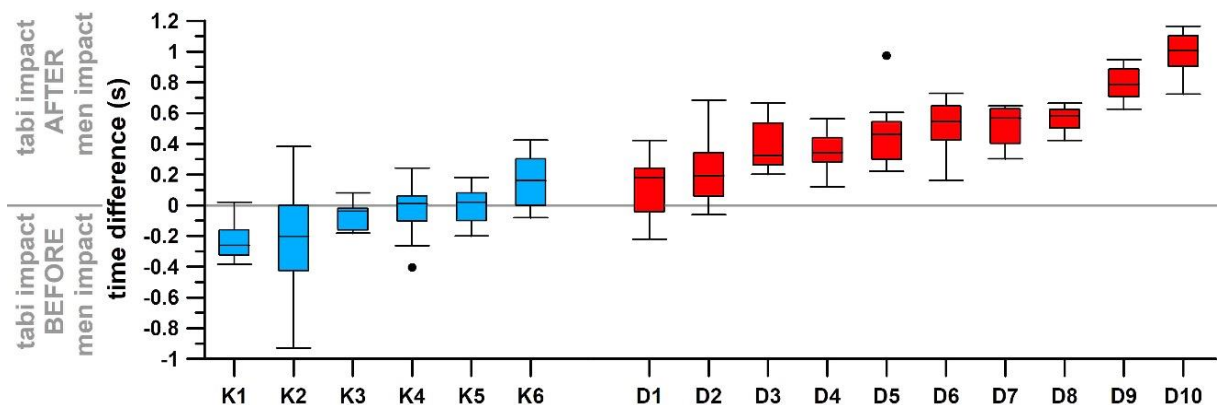


Figure 2: Bow-Whisker plots of *Tabi*-*Men* time differences (*Tabi* impact minus *Men* impact) of Kyu (K) and Dan (D) holders (increasing magnitude of median time difference); •: outlier.

RESULTS: Figure 2 and Table 1 show that the *Tabi* and *Men* impacts are not synchronised. Considering the minimum time period between two consecutive and perceptible sounds (i.e., $\Delta t \leq -0.05$ s and $\Delta t \geq +0.05$ s in Figure 2), the *Tabi* impact occurred, for Kyu holders, before the *Men* impact in 46.1% of Δt data, after the *Men* impact in 28.1%, and synchronous with the *Men* impact in 25.8%. For Dan holders, the *Tabi* impact occurred before the *Men* impact in 2.7%, synchronous with the *Men* impact in 3.4%, and after the *Men* impact in 93.9%.

The medians of the two cohorts, Kyu and Dan holders, differed significantly (Figure 3), with $p < 0.0001$, and a large effect size of $r = 0.886$. The Δt medians and interquartile ranges (IQR)

of Kyu holders were -0.040 s (IQR: 0.242 s), and those of the Dan holders were $+0.502$ s (IQR: 0.344 s).

Table 1: Δt statistic of six Kyu (K) holders and 10 Dan (D) holders; Δt : time difference (*Tabi* impact minus *Men* impact).

Δt (s) statistic	mean	standard deviation	minimum	maximum	range
K1	-0.223	0.127	-0.383	0.020	0.403
K2	-0.208	0.372	-0.930	0.383	1.313
K3	-0.069	0.077	-0.182	0.081	0.263
K4	-0.025	0.168	-0.404	0.242	0.646
K5	0.003	0.107	-0.201	0.181	0.382
K6	0.161	0.162	-0.081	0.423	0.504
D1	0.111	0.180	-0.222	0.422	0.644
D2	0.239	0.213	-0.061	0.684	0.745
D3	0.370	0.145	0.202	0.666	0.464
D4	0.351	0.116	0.121	0.562	0.441
D5	0.466	0.189	0.221	0.973	0.752
D6	0.521	0.152	0.161	0.727	0.566
D7	0.520	0.115	0.303	0.646	0.343
D8	0.568	0.069	0.421	0.664	0.243
D9	0.787	0.099	0.624	0.948	0.324
D10	0.997	0.118	0.723	1.164	0.441

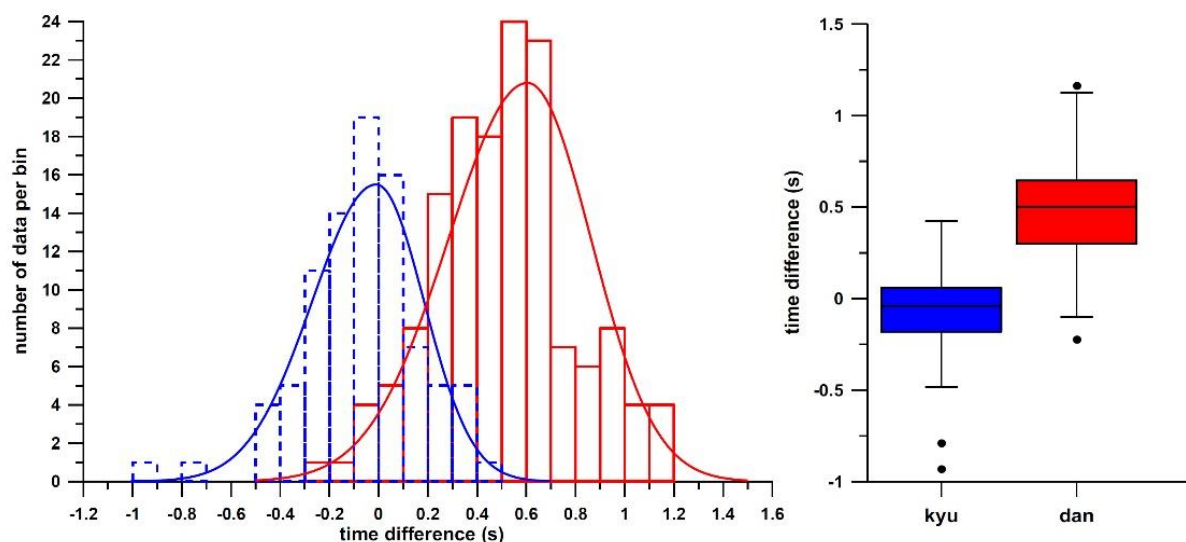


Figure 3: Histograms (left side) and Box-Whisker plots of *Tabi-Men* time differences (*Tabi* impact minus *Men* impact) of Kyu (blue) and Dan (red) holders; •: outlier.

DISCUSSION: Based on the results obtained, the hypothesis that *Tabi* and *Men* impacts are synchronised, must be rejected. Overall (Kyu and Dan data combined), only 12% of the data were in sync. For the Kyu holders, approximately one quarter of the data were synchronised. For the Dan holders, the *Tabi* impact was on average 0.5 s late (Figure 3). The primary question that arises from these results is whether referees actually pay attention to the timing of *Tabi* and *Men* impacts. Based on the refereeing experience of the first author (6th Dan holder) of this study, Kendo referees must assess a variety of parameters such as the strength of the shinai impact sound, the correct placement of the strike, impact timing, timing and strength of shouting, execution of the follow through of the *Shinai* (readiness to repel a counterattack), and the level of fighting spirit. “*Judging the outcome of shiai* [Kendo match] ... is one of the most difficult of tasks” (Hisashi, 1939/2014). And all of this happened within a very short time frame: when attacking the *Men* target, three core attack phases (without basic stance and follow through) are carried out in less than 0.5 s (Jeong et al., 2023). The combination of these

parameters cannot be judged actively and consciously, but rather implicitly based on experience.

Considering that the *Tabi* impact occurs about 0.5 seconds late in *Men* attacks, this type of timing should actually be the standard condition for an experienced referee. Therefore, the question of whether referees pay attention to timing is pointless. Instead, the Kendo doctrine of synchronised *Tabi* and *Men* impacts should be revised accordingly, in the sense that the *Tabi* impact follows the *Men* impact, comparable to the requirement of shouting the targets' names before striking them (equally not synchronised).

CONCLUSION: This study found for the first time that the timing of footwork and *Shinai* (bamboo sword) movements are not synchronised in most cases. This result contradicts established Kendo teaching and judging doctrines. Furthermore, this study addresses the ability of referees to judge unsynchronised foot and shinai impacts, not only because of the multitude of parameters to be considered but also because of the short attack dynamics (< 0.5 s). Consequently, this study proposes to revise the teaching and judging doctrines of Kendo and accept the fact that for Dan holders, the *Tabi* impact on the ground (stomp) occurs on average 0.5 s after striking the *Men* target. *Ki-ken-tai-no-ichi* (synchronisation of spirit, sword, and body) should therefore not be considered as perfectly synchronised but rather seen as the correct sequence of shouting, striking, and stomping.

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