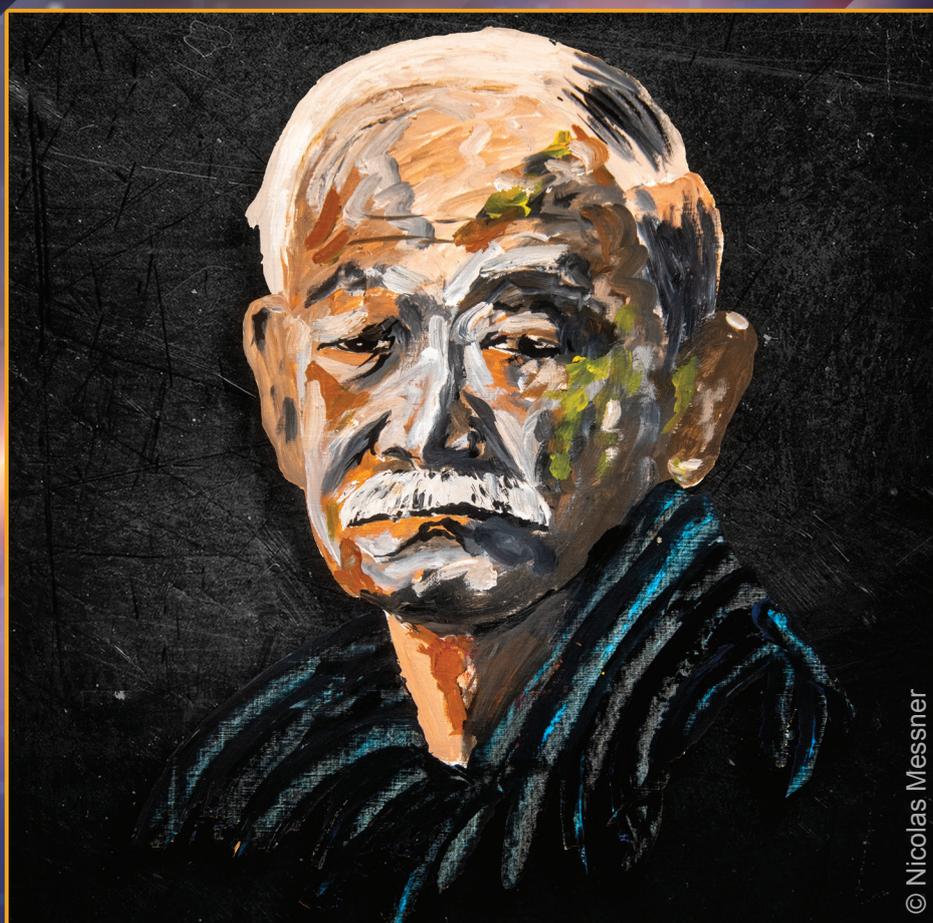




# THE ARTS AND SCIENCES OF JUDO



AN INTERNATIONAL INTERDISCIPLINARY JOURNAL  
Vol. 01., No. 2., 2021

# „The Arts and Sciences of Judo“

## Interdisciplinary journal of International Judo Federation

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Volume 01., No. 2., 2021; ISSN 2788-5208

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**Publisher:** IJF Academy Foundation (Malta, Ta Xbiex)

**Co-publisher:** International Judo Federation (IJF)

**Layout:** Nicolas Messner, IJF Media

**Front page:** Nicolas Messner



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# Judo, One of the Safest Olympic Sports: Injury Statistics from Europe's Top Level Judo Competitions

By Peter Smolders

**Abstract:** *The main goal of the study was to gather statistical data on injuries occurring during Europe's top-level judo competitions. We aim to obtain epidemiological data concerning frequency of injuries, anatomical localisation, type of injury, seriousness of injury and possible differences between weight categories.*

*During the period 2005 to 2019, at Europe's top tournaments (European Open, European Championships), a member of the EJU Medical Commission present, together with the local physician in charge, filled in the EJU Injury Registration form. This form registers sex and weight category of the judoka, anatomical localisation, type of injury, tissue involved, site of the lesion and whether the judoka can continue the fight or must be transported to hospital.*

*During 123 top level competitions, with a total of 25,397 competitors, 664 injuries were registered (2.6% of all competitors needed medical assistance). By anatomical location, the knee (18.5%), shoulder (15.6%) and elbow (15.2%) were sites for the most common injuries. Distention (43.6%) was by far the most frequent injury type, followed by contusion (22.6%). There is no significant statistical difference in injury incidence between men and women, although women have significantly more elbow injuries ( $p < 0.01$ ). When weight categories are compared, heavy weights have a remarkably low number of elbow injuries, with more knee injuries being observed. Lighter weights seem to be more prone to elbow injuries. During the registration period, an injury incidence of only 2.6% was registered. Ongoing statistical monitoring can help with the prevention of judo injuries.*

**Keywords:** *judo; epidemiology; injury; knee; elbow; shoulder*

Although some studies concerning injury statistics in judo have been done, long term data is scarce and varies in outcome. A study of Pierantozzi and Muroli (2009) showed an injury rate of no less than 28.9%. During the London Olympic Games of 2012, an injury rate of 12.3% was reported, in the study of Engebretsen, Soligard et al. (2013). On the other hand, the epidemiological survey of Frey, Lambert et al. (2019) reported an injury incidence during judo competitions in France, for all ages and all levels, of 1.1%. Since the Medical Commission of the European Judo Union collects data on injuries, enough information was gathered for an epidemiological study following the first initiative of Maximilien Jung (2017).

## METHOD

During Europe's top level judo competitions (European Open and European Championships) injury data was collected using the EJU injury registration form. Every time a medical intervention was needed this form was filled in

by the local physician in charge or by the team physician. This was under the supervision of the EJU Medical Commissioner present. The form collected information about the sex of the judoka, weight category, anatomical localisation, type of injury, tissue involved, site of the lesion and whether the *judoka* can continue to compete or should be transported to hospital. Identified 'minor injuries' like small nose bleeds or superficial skin abrasions were not counted. The statistical significance was calculated using the Student t-test and chi-squared test.

## RESULTS

Data was registered during 123 top level competitions with a total of 25,397 competitors, in the period 2005 to 2019. A total number of 664 injuries were registered. This means that 2.6% of all participating *judoka* needed medical assistance.

*Author's affiliation: European Judo Union*



## Anatomical location

The anatomical location of 632 injuries was correctly registered. As shown in Table 1, the most frequently injured area was the knee (18.5%), closely followed by the shoulder (15.6%) and elbow (15.2%). 40% of all injuries were sustained by the upper extremities, as shown in Table 1.

**Table 1. Anatomical location of the injuries**

Location	Number of injuries (N)	Percentage (%)
Knee	117	18.5
Shoulder	99	15.6
Elbow	96	15.2
Hand	43	6.8
Ankle	37	5.9
Skull	33	5.2
Neck	29	4.6
Face	25	4.0
Thorax	21	3.3
Foot	19	3.0
Femur	15	2.4
Wrist	15	2.4
Calf	13	2.1
Back	11	1.7
Eye	9	1.4
Nose	9	1.4
Mouth	8	1.3
Others	33	5.2
Total	632	100.0

## Injury Type

660 injury registration forms were submitted with correctly indicated injury type. Table 2 shows the injury types. 43.6% of the injuries were sprains, which is clearly the most frequent injury type. Contusions were in the second place with 22.6%. Luxation was registered at 8.8% as the third most common injury type.

**Table 2. Injury type**

Injury Type	Number of injuries (N)	Percentage (%)
Sprain	288	43.6
Contusion	149	22.6
Luxation	58	8.8
Bleeding	47	7.1
Strangulation	45	6.8
Fracture	27	4.1
Rupture	21	3.2
Commotio cerebri	19	2.9
Other	6	0.9
Total	660	100.0

## Gender differentiation

14,664 participating *judoka* were men (58%) and 10,733 were women (42%). Out of the 664 injured, 361 (54%) were men and 303 (46%) were women. This difference is not statistically significant ( $p>0.05$ ).

Table 3 shows how the anatomical location differs between men and women.

If we compare the three most frequently occurring anatomical locations, we find that:

- there is no statistically significant difference in the amount of shoulder injuries between men and women ( $p>0.05$ ),
- women have a statistically significant increased frequency of knee injuries when compared men ( $p<0.05$ ),
- women have a statistically significant higher frequency of elbow injuries than men ( $p<0.01$ ).

**Table 3. Gender differentiation in injury anatomical localisation**

Anatomical Localisation	Men (N, %)	Women (N, %)
Knee	57 (16.6)	60 (19.8)
Shoulder	57 (16.6)	42 (13.9)
Elbow	42 (12.2)	54 (17.8)
Hand	22 (6.1)	21 (6.9)
Ankle	17 (4.7)	18 (5.9)
Skull	20 (5.5)	13 (4.3)
Face	21 (5.8)	4 (1.3)
Neck	16 (4.4)	13 (4.3)
Foot	13 (3.6)	4 (1.3)
Thorax	12 (3.3)	8 (2.6)
Femur	10 (2.8)	4 (1.3)
Throat	3 (0.8)	9 (3.0)
Others	71	53
Total	361 (100.0)	303 (100.0)

In both genders the sprain was the most frequent injury type. The only clear difference between the genders is with bleeding; men have more than women. These findings are shown in Table 4.

**Table 4. Gender differentiation in injury type**

Injury Type	Men (N, %)	Women (N, %)
Sprain	148 (41.3)	140 (46.0)
Contusion	81 (22.0)	58 (22.0)
Luxation	32 (8.9)	26 (8.6)
Unconsciousness after strangulation	21 (5.9)	24 (7.9)
Bleeding	34 (9.5)	13 (4.3)
Fracture	16 (4.4)	11 (3.6)
Rupture	13 (3.6)	8 (2.6)
Commotio Cerebri	11 (3.0)	8 (2.6)
Total	356 (100.00)	288 (100.0)



## Serious injuries

A serious injury is defined as an injury which requires transport to hospital. In the period of registration, 2005-2019, a total of 127 *judoka* suffered a serious injury. This means that 0.50% of all competitors needed transport to hospital. Of these 127 *judoka*, 66 were male and 61 were female. In men the incidence of serious injuries was 0.45%. In women this incidence was 0.57%. This difference is not statistically significant ( $p > 0.10$ ).

Concerning the anatomical location of the serious injuries, we noticed that the shoulder is most afflicted (26.0%), followed by elbow (23.6%) and knee (13.4%).

The most common serious injury types are sprain (33.9%), luxation (26.0%) and fracture (18.1%), as shown in Table 5.

There was no *judoka* who had to be transferred to hospital after strangulation; 3 *judoka* had to be transferred after neck injury and 4 after commotio cerebri. This means that these potentially very dangerous injuries have a very low incidence.

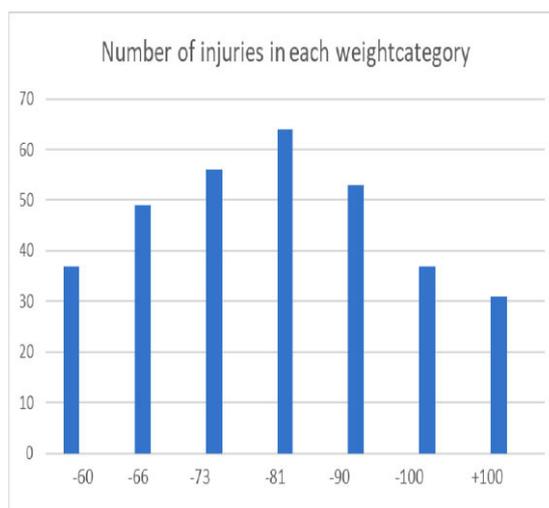
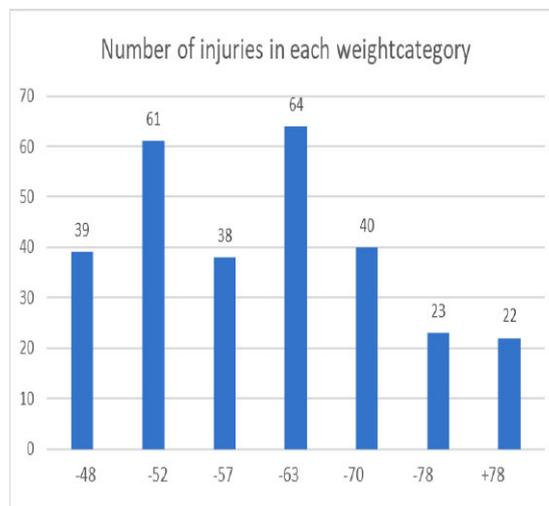
**Table 5. Serious injuries by anatomical location and injury type**

Anatomical Location	Serious Injuries (N)	Serious Injuries (%)	All Injuries (%)
Shoulder	33	26.0	15.6
Elbow	30	23.6	15.2
Knee	17	13.4	18.5
Skull	6	4.7	5.2
Ankle	6	4.7	5.9
Foot	5	3.4	3.0

Injury Type	Serious Injuries (N)	Serious Injuries (%)	All Injuries (%)
Sprain	43	33.9	43.6
Luxation	33	26.0	8.8
Fracture	23	18.1	4.1
Contusion	9	7.1	22.6
Rupture	8	6.3	3.2
Bleeding	5	3.9	7.1
Commotio Cerebri	4	3.1	2.9

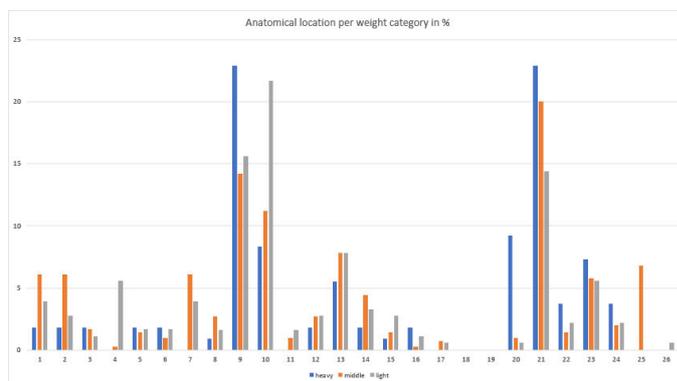
## Injury incidence in different weight categories

As shown in Figure 1 we see that in the men's categories the distribution of the number of injuries are perfectly comparable to the distribution of the number of participants in each category. In the women's categories we see a remarkably high incidence of injuries in the under 52 kg category.



**Figure 1. Distribution of injuries by weight category**

To compare the anatomical location in each weight category we defined 'light weights' as the -48kg, -52kg, -60kg and -66kg categories. The 'middle weights' are -57kg, -63kg, -70kg, -73kg, -81kg and -90kg. The 'heavy weights' are -78kg, +78kg, -100kg and +100kg. The results are shown in Figure 2.



1 = Skull, 2 = Face, 3 = Eye, 4 = Ear, 5 = Nose, 6 = Mouth, 7 = Neck, 8 = Throat, 9 = Shoulder, 10 = Elbow, 12 = Wrist, 13 = Hand, 14 = Thorax, 15 = Back, 16 = Abdomen, 17 = Pelvis, 18 = Genitals, 19 = Inguinal, 20 = Femur, 21 = Knee, 22 = Leg, 23 = Ankle, 24 = Foot, 25 = Other, 26 = None

**Figure 2. Distribution of anatomical location by weight category**

As we analysed these results at the EJU Medical Commission, we noticed that with shoulder injuries the 'heavy weights' are over-represented. With elbow injuries the 'light weights' seem to be over-represented. With knee injuries we again see more 'heavy weights'.

## CONCLUSIONS

The main conclusion is that the overall incidence of injuries during Europe's high-level competitions was 2.6%, with an incidence of serious injuries of 0.5%. This places judo among the sports with the lowest injury rates among Olympic sports. It could be suggested that an active Medical Commission of judo specialists, with a clear view of prevention and suggestions to adaptations of the rules, contributes to this low incidence of injuries.

Knee, shoulder, and elbow are the anatomical locations most prone to injury. Sprains are clearly the most frequent injury type. Within the total number of injuries there is no statistically significant difference between men and women, although women have significantly more shoulder injuries.

Why the -52kg category has a notably higher injury incidence needs further research. Concerning the weight categories, we see that heavy weights have more shoulder and knee injuries, whereas light weights have more elbow injuries.

Further analysis of these results and an ongoing injury registration could contribute to more prevention programmes and reducing the injury incidence further.

## Acknowledgements

Thank you to all the members of the EJU Medical Commission, past and present, for their efforts in collection of the data and Injury Registration Forms, which made writing this article possible. Without their tireless help this statistical analysis could never have been done.

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## Article history

Received: 25 February 2020

Accepted: 11 May 2021

# Acute and Late Phase Consequences of Fainting Due to *shime waza* in Judo

By Daigo Matsunaga<sup>1,2,5</sup>, Yuji Nimura<sup>3,4,5,6\*</sup>, Takeaki Sugimoto<sup>4</sup>, Hiroshi Mizutani<sup>2</sup> & Yukihiro Yokoyama<sup>3</sup>

**Abstract:** *There is no known research on long-term effects of fainting due to shime waza (choking) in judo. This study sought to investigate the actual experience of fainting due to shime waza and its late phase effects in retired judoka.*

*A questionnaire was designed focusing on the length of judo career, time and frequency of fainting, associated symptoms during fainting and possible late phase effects. The survey was conducted by sending emails to 513 graduate members of Nagoya University and Kyoto University Judo Club.*

*A total of 161 (31%) participants responded to the questionnaire. The median (range) age of the 161 respondents was 58 (23 - 85) and the median (range) length of their Judo career was 11 (2 - 60) years. When the term is divided into 3 periods such as high school students, undergraduates and graduates, the experience of fainting was highest for undergraduates (84%) and lowest for graduates (12%), with a significant difference among the three groups ( $p < 0.001$ ). The average number of fainting episodes was highest in undergraduates (high school students 2.6 times, undergraduates 14.5 times, graduates 0.6 times). Associated symptoms such as convulsion, drooling or incontinence were observed during fainting in 65 cases (45%). No fainted respondents developed any persistent symptoms after awakening and none have persistent physical impairment detectable during their lifetime.*

*This study characterized the frequency of fainting experiences in retired judoka. Repetitive fainting due to shime waza did not lead to any residual disability in their lifetime.*

**Keywords:** *judo; choking; shime waza; fainting; physical impairment*

**A**cute trauma or repetitive stress associated with athlete activities sometimes lead to sports injuries. It has been reported that head contusions, sustained by being thrown while doing judo, can lead to an acute subdural hematoma (Kamitani, Nimura, Nagahiro, Miyazaki, & Tomatsu, 2013; Nagahiro & Mizoguchi, 2014; Pocecco et al., 2013). On the other hand, repetitive hits to the head in contact sports lead to chronic traumatic encephalopathy (CTE), which does not appear until years after the head injuries occurred. Therefore, the symptoms of sports injury, especially those related to head and neck injuries, should be evaluated not only in the time immediately after an accident but also in a later phase (Gavett, Stern, & McKee, 2011; Omalu et al., 2005; Omalu et al., 2006).

Judo is unique among the Olympic sports because the International Judo Federation only allows *shime waza*

(choking) to subdue an opponent in competition (International Judo Federation, 2019). *Shime waza* was one of the important techniques of *jujutsu* and adopted by Jigoro Kano (Brousse & Matsumoto, 2005; Hancock & Higashi, 1905; Kano, 1994; Maekawa, 1978). Experimental studies on fainting due to *shime waza* in healthy volunteers showed that unconsciousness occurred approximately 6-14 seconds after choking, due to cerebral hypoxia from compression of the carotid arteries. The subjects regained consciousness spontaneously, 10-20 seconds after the release of the choke hold, without any side effects (Haga, et al., 2016; Ikai, et al., 1958; Mitchell, Roach, Tyberg, Belenkie, & Sheldon, 2012; Raschka, Rau, Hubsch, Bunner, & Banzer, 1998; Raschka, Rau, & Koch, 2002; Rau, Raschka, Brunner, & Banzer, 1998; Reay & Holloway, 1982; Rodriguez, et al., 1991; Shibayama & Ebashi, 1978; Tezuka, 1978).

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6. Medical Commission, International Judo Federation



Since 1952, the seven former Imperial Universities in Japan (Hokkaido, Tohoku, Tokyo, Nagoya, Kyoto, Osaka, and Kyushu) have organised an annual judo tournament named 'Shichiteisen,' which adopted different rules from those of Kodokan Judo or the International Judo Federation (IJF) but similar to those of *Kosen* Judo. Competitive *Kosen* Judo was established in 1898 and the first national tournament was organised by Kyoto Imperial University in 1914 (Okano, 1954). As *Kosen* Judo rules put great emphasis on *newaza*, with permission from *hiki-komi* (takedown techniques), those university students used *newaza*, especially *shime waza*, very often, not only in competition but also in daily practice (Study group of *Kosen* Judo techniques, 2003). Although there has been no report of serious accidents due to *shime waza* in the long history of *Shichiteisen* (Niwa, 1988), it can be hypothesized that *shime waza* can induce delayed effects on brain function, which may be similar to CTE. This study sought to investigate the acute and late phase consequences of *shime waza* through questionnaires for retired judoka.

## MATERIALS and METHODS

### Questionnaire

The questionnaire form was designed according to the authors' long-term experiences of fainting due to *shime waza*. It consists of 18 items, as shown in Appendix. The questions focused on the length of judo career, time and frequency of fainting, associated symptoms during fainting and possible late phase effects. The questionnaire was conducted by email, which was distributed to 513 (including 3 women) living members of the *Meijukai*, Graduates' Association of Nagoya University Judo Club (n=264) and *Gakushijudokai*, Graduates' Association of Kyoto University Judo Club (n=249). For 10 respondents with 100 or more fainting episodes due to *shime waza*, following questions were posed:

1. How did you count the number of fainting episodes? (e.g., Number of fainting episodes per day x number of days of practice per week)
2. Where and when did you experience fainting? (e.g., As a high school student, university student, after graduation).
3. Who choked you out?

Finally, the details were confirmed again by direct interview with them and their club mates. Three members with severe mental illness were excluded from this study. Fifty-seven other deceased members at the time of survey were also excluded. A cause of death of 57 deceased members was malignant neoplasm in 29, acute myocardial infarction in 8, infectious disease in 5, suicide in 5, traffic injury in 3, cerebral hemorrhage in 3, renal failure in 2, amyotrophic lateral sclerosis in 1 and thoracic aortic aneurysm in 1, respectively.

This study and questionnaire form were approved by the board of directors of the Graduates' Association of Nagoya and Kyoto University Judo Club and all responders of the as-

sociations have given their informed consent for participation in this study.

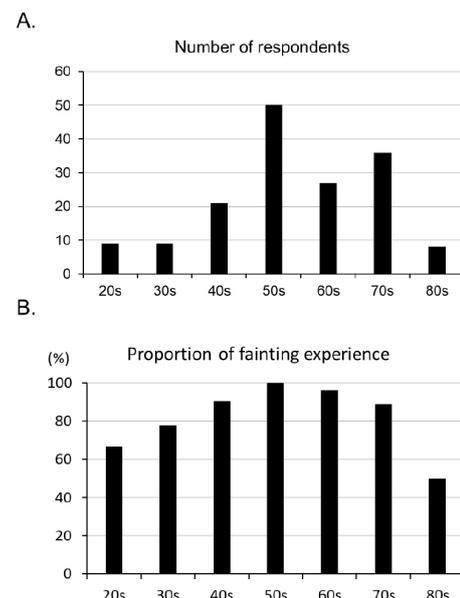
### Statistics

The data was analyzed using the Windows versions of JMP® 13 (SAS Institute Inc., Cary, NC, USA). Continuous data was expressed as mean and standard deviation (SD) or the median and range. Univariate analysis was performed using a parametric or non-parametric test, as appropriate. The  $\chi^2$  test was used for analysis of categorical variables. The results were considered as statistically significant when  $P < 0.05$ .

## RESULTS

### Subjects

From a total of 513 respondents, a completed survey was received from 161 (response rate of 31%), 90 from *Meijukai* and 71 from *Gakushijudokai*. Detailed data was available from 160 out of the 161 respondents (one with incomplete answers). The mean ( $\pm$ SD) and median (range) age of the 160 respondents were 58 ( $\pm$ 15) and 58 (23-85), respectively. The mean and median term of Judo career were 17 ( $\pm$ 14) years and 11 (2-60) years, respectively. When the age of the 160 surveyed respondents was divided by decades of age, 76% (n=121) of the respondents were in the range of their 50s-80s and the greatest proportion was in their 50s (n=50, 31%) (Figure 1A). Some were found to have judo experience prior to their university entrance and continued practice even after their graduation.



**Figure 1. Number of respondents and their fainting experiences according to each decade of age.**

A. Number of respondents (n=160)

B. Proportion of fainting experience due to *shime waza* (n=143)

### Frequency of fainting according to age of respondents

During practice and competition, 144 (90%) of the 160 respondents had an experience of fainting due to *shime waza*. Detailed data was available in 143 of the 144 fainted respondents (one with incomplete answer). The fainting experience was the most common in 50s (100%) and that gradually decreased in younger respondents especially those in 20s (Figure 1B). Among 143 fainted respondents, the maximum number of fainting in a day was once in 91(64%) respondents and twice or more in 49 (34%), while the remaining 3 (2%) did not answer the item of the survey. More than half (52%) of the 50s experienced twice or more fainting in a day (Figure 2).

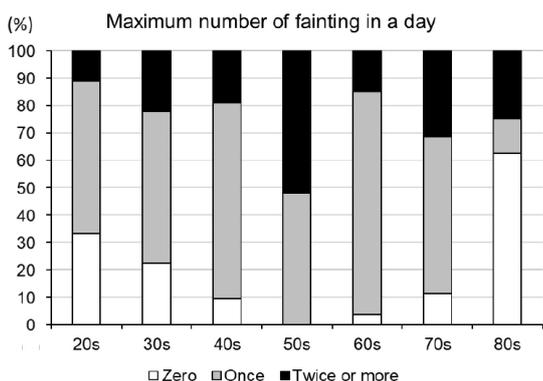


Figure 2. Maximum number of fainting due to *shime waza* in a day according to each decade age. (n= 143)

### Total frequency of fainting in lifetime

The frequency of fainting due to *shime waza* in their lifetime was investigated. One respondent did not answer for this question and the analysis was performed in the remaining 159 respondents. The mean and median number of fainting experiences in their lifetimes were 17.1 ( $\pm 32.3$ ) and 5 (0-200), respectively. In terms of the frequency of fainting, 66 (42%) of the 159 respondents had 1 to 5 times, 30 (19%) had 6 to 10 times, 18 (11%) had 11 to 20 times and 28 (18%) had more than 20 fainting experiences (Figure 3). Ten respondents experienced more than 100 fainting episodes in their lifetime. Among the 28 respondents with more than 20 times of fainting, 3 had 21 to 30 times of fainting, 6 had 31 to 40 times, 4 had 41 to 50 times, 2 had 51 to 60 times, 2 had 71 to 80 times, 1 had 81 to 90 times and 10 respondents experienced 100 or more fainting episodes in their lifetime, respectively. Further questionnaires for the 10 respondents with 100 times or more fainting revealed that 6 had 100 times of fainting, 1 had 112 times, 1 had 120 times and 2 had 200 times of fainting, respectively. A direct interview with 4 of the 10 respondents revealed that frequent fainting was experienced only in a high school for 1 and during their first year at university for 9. All 10 respondents were

choked out during a daily practice with experienced senior members of strict character. Furthermore, all subjects, except one, continued practice immediately after awakening from short fainting.

Among 143 fainted respondents, *kuatsu*, as a traditional resuscitation technique (Matsumoto, 1892; Morinaga, 1894; Nimura, Higaki, Motohashi & Yokoyama, 2021), was immediately applied by an experienced coach or senior student in 109 cases (76%). The subjects were all revived by *kuatsu*. Furthermore, 142 (99%) of them continued practice immediately after awakening from fainting. Only one respondent did not practice after awakening from fainting when he was a junior high school student.

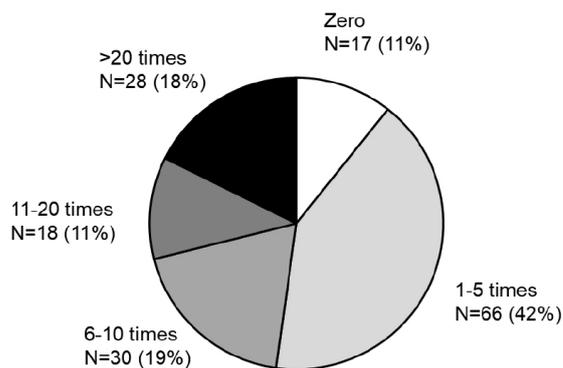


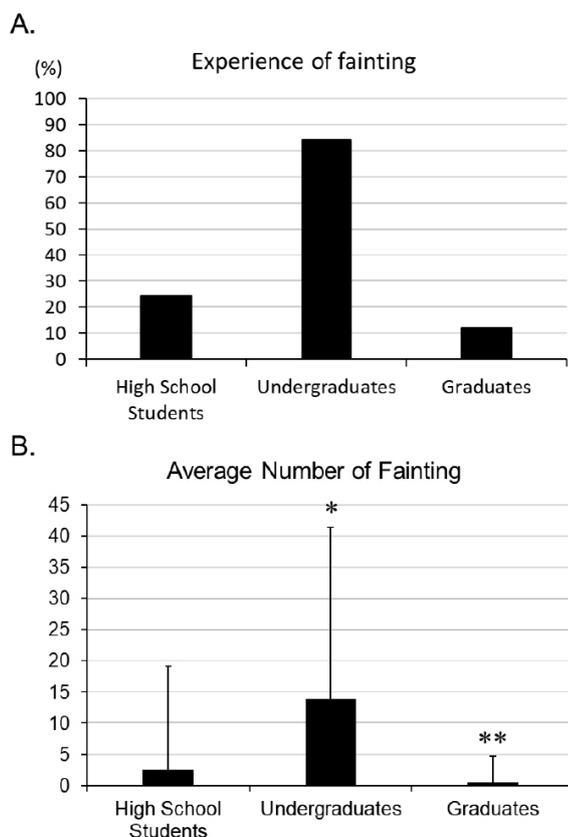
Figure 3. Total number of fainting experienced in lifetime (n=159)

### Frequency of fainting according to the student term

The frequency of fainting due to *shime waza* was further investigated according to the student term. The period was divided into three student terms such as before entering university (high school students,  $\leq 18$  years old), during university (undergraduates, 19~22 years old) and after graduation (graduates,  $\geq 23$  years old). Before entering the university judo club, 39 (25%) of 159 respondents had an experience of fainting due to *shime waza* (Figure 4A). Among them 13 (8%) fainted only one time and others fainted multiple times. The mean and median frequency of fainting were 2.6 ( $\pm 16.6$ ) and 0 (0-200), respectively (Figure 4B). During their active period in University Judo Clubs, 134 (84%) of 159 respondents had an experience of fainting. 72 (45%) fainted 5 times or less, 41 (26%) fainted 6 to 20 times and 22 (14%) fainted more than 20 times, respectively. Nine members (6%) fainted approximately 100 times, especially during the first 2 years after entering the university judo club. The mean and median frequency of fainting was 13.9 ( $\pm 27.5$ ) and 4 (0-200). After graduating from their universities, however, only 19 (12%) had an experience of fainting and the mean frequency of fainting was 0.6 ( $\pm 4.1$ ) times. There was a statistically significant difference in the proportion of fainting experience among the three different school terms ( $p < 0.001$ ) (Figure 4C).



re4A). There were also significant differences in numbers of fainting experiences between all pairs of different school terms (high school students vs. undergraduates,  $p < 0.001$ ; high school students vs. graduates,  $p = 0.003$ ; undergraduates vs. graduates,  $p < 0.001$ ) (Figure 4B).



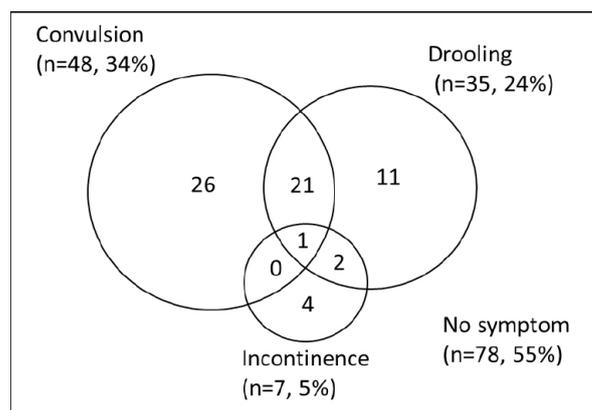
**Figure 4. Experience of fainting according to school term. (n=159)**

A. Proportion of fainting (%). ( $p < 0.001$ )  
 B. Average number of fainting. (\*  $p < 0.001$  vs. high school students and graduates, \*\*  $p = 0.003$  vs. high school students)

### Fainting-associated symptoms

The respondents sometimes developed associated symptoms such as convulsion, drooling or incontinence during fainting. Associated symptoms were found in 72 (50%) out of 143 respondents with fainting experience (Figure 5). Convulsion, which was noticed in 55 cases (38%), was the most common symptom. Drooling was noticed in 32 cases (22%) and incontinence in 7(5%). A total of 21 respondents (15%) had multiple symptoms. These associated symptoms were more frequently observed in 50s. However, the above symptoms disappeared immediately after awakening from fainting. In addition, other symptoms developed after awakening from fainting in 6 (4%) of the 143 fainted respondents. Each member experienced one of the following symptoms: dizziness, nausea, hyperemia, conjunctival hemorrhage, calf cramp or numbness in the

tongue and face. However, these symptoms disappeared soon. Consequently, no respondents developed any persistent symptoms after revival from fainting.



**Figure 5. Associated symptoms during fainting (n=143)**

### Late phase effects of fainting experience

Even after a considerable number of repetitive fainting episodes, with subsequent practice of judo, no respondents suffered from after-effects or incurred any persistent physical impairment. None experienced any trouble in their working life after graduating from the university. One member developed transient cerebral ischemia in his 60s after undergoing medical treatment for hyperlipidemia, hyperuricemia and left carotid artery sclerosis with plaque for more than 10 years since his 50s. Thus, this case was not considered as a late phase effect of *shime waza*, because he had stopped judo practice when he was 30 years old.

### Paths after graduation

To assess the late phase effects of fainting, paths after graduation were assessed in 144 respondents with an experience of fainting. As far as their paths after graduating from the university, 92 (64%) found employment in a company listed on the first section of the Tokyo Stock Exchange and became important employees or executives. Among the remaining respondents, 20 (14%) became university faculty members or researchers, 11 (8%) medical doctors, 9 (6%) government or local officials and 2 (1%) high school teachers. Only one member did not respond to this question. Despite taking important career paths, none of the 144 fainted respondents ever experienced any trouble while working or carrying out daily activity in their lives, even after repetitive fainting from *shime waza*.

## DISCUSSION

### Is *shime waza* really dangerous?

Sprain, strain and contusion are the most frequently reported injuries in judo (Pocecco, et al.,2013). On the other



hand, head and neck injuries have been recognized to lead judoka to potentially fatal events or prolonged severe disabilities (Kamitani et al., 2013; Nagahiro et al., 2014). Over several decades, CTE has emerged in association with a variety of contact sports, including American football, professional wrestling and boxing as well as other activities associated with repetitive mild head trauma (Cajigal, 2007; Gavett et al., 2011; Omalu et al., 2005; Omalu et al., 2006). Furthermore, there have been several discussions about possible brain damage or fatal accidents in judo (Kato, Hayashi, Tanahashi, & Takao, 2017; Koiwai, 1981; Koiwai, 1987; Owens & Ghadiali, 1991). However, there is no scientific evidence of the correlation between repetitive fainting from *shime waza* and its late phase physical impediment, when compared with the results of the above-mentioned contact sports with repetitive head contusion or concussion (Kamitani et al., 2013; Lempert, Bauer, & Schmidt, 1994; Nagahiro et al., 2014; Rodriguez, Vitali, & Nobili, 1998; Stern et al., 2011). Therefore, fainting due to *shime waza* should be differentiated from the brain damage caused by hitting such as CTE. In fact, the results in the present study demonstrated that no brain damage in both acute and late phase was reported by any of the respondents with repetitive fainting due to *shime waza*. In addition, associated symptoms during fainting due to *shime waza* were immediately recovered by an experienced coach or senior student applying *kuatsu*. These results indicated that *shime waza* may not be a dangerous technique if it is used under strict rules (The International Judo Federation, 2019).

#### Future perspectives on *shime waza*

Although it was found that repetitive fainting from *shime waza* did not lead to any acute or late phase physical impediments, it must be consistently stressed that upon submission from the opponent, the *shime waza* should be stopped immediately. As shown in this study, fainting due to *shime waza* has decreased over the last decades because recent undergraduates tend to tap when feeling close to fainting due to *shime waza*. In addition, an old and bad tradition of *shime waza* with prohibiting tapping should be reformed for safer management of modern judo. Although the safety limit of the length of choking is uncertain, prolonged choking may be dangerous. However, as the short fainting due to *shime waza* with a help of *kuatsu* does not develop any acute and late phase physical impairments, *shime waza* should not be excluded from the rules of judo, while necessary precautions be taken strictly. It is also important to educate instructors and referees, in order to help them understand the risks from *shime waza*, for the safety management of judo. The precise mechanism of fainting and associated symptoms during fainting caused by *shime waza* should be further investigated in a future study.

#### Limitations

This study includes several limitations. The responding rate to the questionnaire is not high (31%), although the

total number of respondents was sufficient (161 respondents). The questionnaire was distributed to members of the Nagoya University Judo Club and Kyoto University Judo Club only. These members are graduates of Former Imperial Universities in Japan and may not represent the ordinary population. As mentioned above, the frequency of their fainting experience may be higher than that of ordinary judoka. In the future, a nationwide survey, including all generations and all social classes is necessary to understand the real frequency of fainting and actual risk from *shime waza*. The data is mostly dependent on the respondents' memories. However, most of them had clear memories of their fainting experiences, which were also confirmed by hearing accounts from their club mates. It should also be noted that even with such a high frequency of fainting experiences, no respondents experienced acute or late phase impediment in their social activities.

## CONCLUSIONS

This study examined the acute and late phase consequences of *shime waza* in retired judoka. No acute or late phase physical impediments were observed, even after repetitive fainting due to *shime waza*. All respondents worked actively without any residual disabilities in their lifetime. However, it should be encouraged to maintain safer circumstances in daily judo practice and competition. A nationwide survey is required to understand the real frequency and consequences of fainting due to *shime waza*.

#### Acknowledgements:

All authors appreciate the kind advice of Yuishin Izumi, M.D., PhD., Professor and Chairman, Department of Neurology, Tokushima University School of Biomedical Science, on this study plan.

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**Article history**

Received: 02 December 2019

Accepted: 13 May 2021

**Appendix**

Questionnaire form for the fainting experience due to *Shime waza* (choking) and its early and late phase consequences

1. Your name and age : _____,	<input type="text"/>	years old
2. Length of judo experience	<input type="text"/>	years
3. Experience with fainting due to shimewaza (select 1 or 2)	<input type="text"/>	
1) Yes      2) No		
4. Age at fainting and number of times (In case of "Yes" given above)	<input type="text"/>	times
1) under 18 years old	<input type="text"/>	times
2) 19 ~ 22 years old	<input type="text"/>	times
3) over 23 years old	<input type="text"/>	times
5. Maximum times of fainting in a day (select from 1~3)	<input type="text"/>	
1) Once		
2) Twice		
3) ≥ 3 times		
6. Resuscitation with Kuatsu (select from 1~3)	<input type="text"/>	
1) Yes      2) No      3) Unknown		
7. Associated symptoms (select from 1~3)	<input type="text"/>	
A. Convulsion	<input type="text"/>	
1) Yes      2) No      3) Unknown		
B. Drooling	<input type="text"/>	
1) Yes      2) No      3) Unknown		
C. Incontinence	<input type="text"/>	
1) Yes      2) No      3) Unknown		
8. Practice after awakening from fainting (select 1 or 2)	<input type="text"/>	
1) continued to practice immediately after awakening		
2) stopped to practice on the day		
9. Any symptom after awakening (select from 1~3)	<input type="text"/>	
1) Yes      2) No      3) Unknown		
10. Remained symptom (If "Yes", select from 1~4)	<input type="text"/>	
1) Pain around the neck		
2) Headache		
3) Nausea		
4) Others (name of symptom : _____)		
11. Related symptom persisted (select 1 or 2)	<input type="text"/>	
1) Yes      2) No		
12. Name of related symptom (If "Yes", select from 1~4)	<input type="text"/>	
1) Headache		
2) Nausea		
3) Limb paralysis		
4) Others (name of symptom : _____)		
13. Prolonged residual disability (select 1 or 2)	<input type="text"/>	
1) Yes      2) No		
14. Name of residual disability (If "Yes", select from 1~3)	<input type="text"/>	
1) Cerebral infarction		
2) Limb movement disorder		
3) Others (name of disability : _____)		
15. Length of residual disability	<input type="text"/>	years
16. Paths after graduation (select from 1~8)	<input type="text"/>	
1) Employee or executive of companies listed on the First Section		
2) Small business owner		
3) National or local official		
4) State man		
5) Faculty member/researcher of university		
6) Junior/Senior high school teacher		
7) Medical doctor		
8) Others (occupational title : _____)		
17. Have you felt that fainting due to shimewaza might have caused you to trouble carrying out daily activities? (select 1 or 2)	<input type="text"/>	
1) Yes      2) No		
18. Please state your other opinions	<input type="text"/>	



# Mastering *Ukemi* is Essential in Preventing Severe Head Trauma

By Haruo Murayama<sup>1</sup>, Masahito Hitosugi<sup>2</sup>, Yasuki Motozawa<sup>3</sup>, Masahiro Ogino<sup>4</sup> & Katsuhiko Koyama<sup>5,6</sup>

**Abstract:** This study examined the kinematics and biomechanical parameters of the head when a judo expert was thrown backwards with *o-uchi-gari* and the breakfall (*ukemi*) technique prevented the head from hitting the judo-mat (*tatami*) successfully. We also compared the values of head accelerations when thrown with *o-uchi-gari*, with those obtained using an anthropomorphic test device (ATD: the POLAR dummy - a pedestrian dummy used in vehicle crash testing), reported in our previous study. One judo expert (*tori*) threw another judo expert (*uke*) four times. We obtained kinematic data using a digital video camera. Both linear and angular accelerations were measured with a six degree-of-freedom sensor affixed to the centre of *uke*'s forehead. When *o-uchi-gari* was performed, *uke* fell backwards, accompanied by contacting the arm or buttocks with the *tatami*; the linear and angular accelerations began rising and reached peak values. The peak resultant linear and angular accelerations were  $7.0 \pm 0.7$  G and  $564.4 \pm 76.5$  rad/s<sup>2</sup>, respectively (means  $\pm$  standard deviation). Further, when comparing the values obtained in judo experts with those in an ATD and not performing *ukemi*, both the peak resultant linear ( $P = 0.021$ ) and angular ( $P = 0.021$ ) accelerations of *uke* were significantly lower than those with the head-hit ATD. We concluded that the most important measure for avoiding severe head injuries was preventing the head from hitting the *tatami* by effective measures such as *ukemi*.

**Keywords:** acute subdural hematoma; judo techniques; prevention; head acceleration; *ukemi*; head hitting

In Japan, judo-related serious head injuries, especially those resulting in acute subdural hematoma (ASDH), have occasionally occurred by throwing (Kamitani et al., 2013; Nagahiro et al., 2011). *o-soto-gari* is the leading cause of such injuries, followed by *o-uchi-gari* and *seoi-nage* (Kamitani et al., 2013; Nagahiro et al., 2011). In previous studies (Hitosugi et al., 2014; Murayama et al., 2013; Murayama et al., 2014), we made biomechanical analyses of the head of an anthropomorphic test device (ATD, the POLAR dummy - a pedestrian dummy used in vehicle crash testing) when thrown with the above techniques.

Judo's founder Jigoro Kano (Kano, 1994), judo specialists (Inokuma & Sato, 1986) and researchers (Hirakawa, 1971; Kamitani et al., 2017; Koshida et al., 2017; Nagahiro et al., 2011; Nishimura et al., 1988) believe that it is essential to acquire *ukemi* appropriately to prevent head injuries. However, despite advocating the importance of mastering *ukemi* to avoid severe head injuries, the detailed effect of *ukemi* in decreasing the impact on the thrown person's head has hitherto not been clearly quantified.

The present study examined the kinematics and biomechanical parameters of the head when a judo expert was thrown backwards by *o-uchi-gari*, in which hitting

the head was avoided with successful *ukemi*. Additionally, we compared the values of head acceleration with those obtained using the ATD, reported in our previous study (Murayama et al., 2014).

## MATERIALS AND METHODS

One male judo expert (*tori* [thrower]: age 29, height 177 cm, weight 90kg, 5th dan) threw another male judo expert (*uke* [receiver]: age 32, height 172 cm, weight 90kg, 5th dan) repeatedly (Figure 1). We selected the same *tori* we had recruited in our previous study (Murayama et al., 2014) with the ATD measurements.

Written informed consent was obtained from the participants before conducting the experiment. The study protocol was approved by the Research Ethics Committee of Dokkyo Medical University School of Medicine.

In *o-uchi-gari*, *tori* hooks *uke*'s left/right leg from the inside using *tori*'s right/left leg so that *uke* falls onto his/her back (Daigo, 2005) (Figure 1). Because ASDH in judo occurs frequently not only in *o-soto-gari* but also in *o-uchi-gari*, so we studied this throwing technique.

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During the experiment, *tori* threw *uke* four times using *o-uchi-gari*. In all trials, *uke* performed *ukemi* adequately without hitting the head on the *tatami*.

We placed a six-degree-of-freedom sensor array (consisting of three accelerometers and three angular rate sensors [DTS 6DX PRO, Diversified Technology Systems, Seal Beach, CA]) at the centre of *uke*'s forehead and secured it with self-adhesive tape. All data was recorded with a 10kHz sampling rate. We measured linear accelerations of the head with CFC180 filtering. We calculated angular acceleration from the angular rate with CFC60 filtering by differentiating the filtered data. From the accelerations obtained in each direction, we determined the resultant acceleration, as described in our previous report (Murayama et al., 2013). We recorded kinematic data of *uke*'s whole body motions during the trials, using a digital video camera.

Subsequently, the obtained acceleration data was compared with data obtained in our previous study using ATD without performing *ukemi*. We applied a Mann-Whitney test; differences with a P value of <0.05 were considered significant.

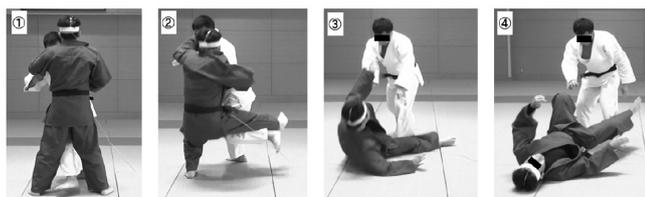


Figure 1. The *o-uchi-gari* technique: both *tori* and *uke* were judo experts

## RESULTS

The kinematic data showed that *uke* fell backward without any head collisions when executing *ukemi* in response to *o-uchi-gari*. Both linear and angular accelerations began rising from the initial body contact (i.e., from the arm or buttocks contacting the *tatami*, until the lowest position of the head against the *tatami*) (Figure 2). For linear acceleration, the peak resultant values were  $7.0 \pm 0.7$  G (mean  $\pm$  standard deviation), ranging from 6.5 to 8.0 G (Figure 3A). For angular acceleration, the peak resultant values were  $564.4 \pm 76.5$  rad/s<sup>2</sup>, ranging from 503.0 to 642.0 rad/s<sup>2</sup> (Figure 3B). When comparing the data of the judo expert with those of the ATD in our previous report, both the peak linear ( $P = 0.021$ ) and angular ( $P = 0.021$ ) accelerations of the judo expert were significantly lower than those of the ATD (Figure 3).

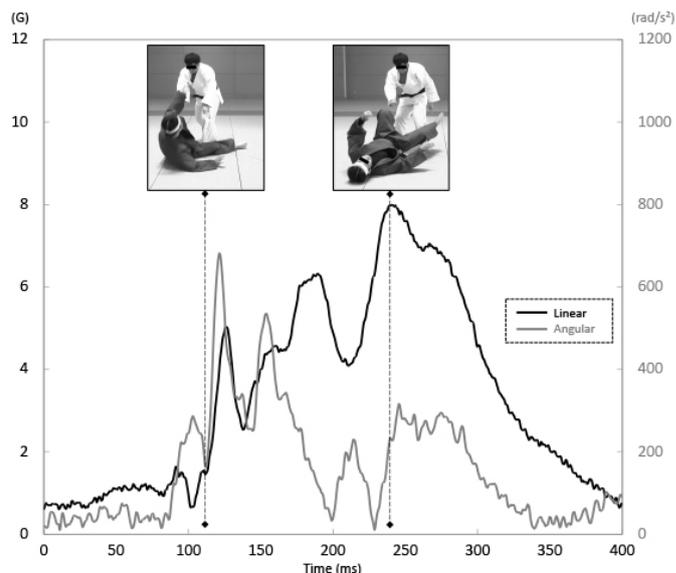


Figure 2. Representative time-courses of the resultant linear and angular accelerations during *o-uchi-gari*

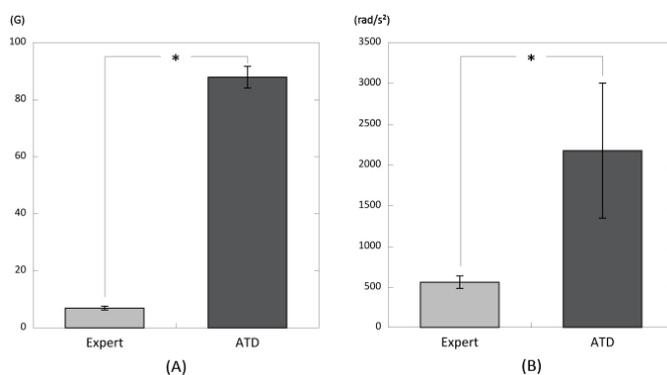


Figure 3. Comparison of the peak resultant linear (A) and angular (B) accelerations between judo experts and when using the ATD during *o-uchi-gari* (\* $P < 0.05$ , Mann-Witney test). The ATD values were obtained from Murayama et al. (2014)

## DISCUSSION

In this study, the kinematics and impact intensity of the head of a judo expert thrown backwards to the *tatami* with *o-uchi-gari*, were objectively clarified.

We found that angular acceleration of *uke* peaked at the time of initial body contact; however, the linear acceleration increased from the first contact of the body part in the sequence. Although the head was swung around the neck by the impact of the first contact against the *tatami*, direct contact with the *tatami* was avoided through proficient *ukemi*. Previously, it was observed that when *ukemi* was not performed, the *o-uchi-gari* resulted in direct contact of the ATD by its occipital head with the *tatami* (Hitosugi et al., 2014; Murayama et al., 2013; Murayama et al., 2014). In contrast to the results of previous investigations, the present study clarified that head acceleration does not

increase when *ukemi* is properly performed without the head-hitting.

Severe head trauma has been reported in judoka with less than 3 years of judo experience (Kamitani et al., 2013). Head trauma was thought to have been due to unskilled performance of *ukemi* with the head hitting the *tatami*. The present results suggest that *ukemi* performed well can prevent severe head injuries.

This study has limitations and advantages. Firstly, the sensor was placed on the forehead. In previous studies using the ATD, the sensor was placed at the center of gravity within the head of a dummy (Akiyama et al., 2001). However, it is impossible to place a sensor inside the head of a living person. Because the distance between the forehead and center of gravity is small, we considered that this limitation did not seriously affect our findings. Secondly, we had little need for experimental repetitions; our participants had high level skills (5th dan), and the obtained values revealed small deviations. Thus, we consider the results as having a high degree of reliability.

In conclusion, the most important measure to prevent severe head injuries is preventing the head hitting the *tatami* by using effective measures such as *ukemi*.

#### Acknowledgements:

The authors gratefully acknowledge Honda R&D (Tochigi, Japan) for supporting the experiment. This study was supported by Grant Aid for Scientific Research (C) from the Ministry of Education, Culture, Sports, Science, and Technology, Japan (16K01730).

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#### Article history

Received: 07 December 2019

Accepted: 20 August 2021



# The Psychoneurobiology Behind Personal and Interpersonal Transformation Through Judo

By Caio Amaral Gabriel

**Abstract:** *This research note seeks to broaden and deepen the discussion on the potential psychoneurobiological aspects underlying mental, socioemotional, moral and behavioural changes resulting from the practice of judo, integrating judo with modern studies in the fields of health and education. When opening this discussion, it is expected that it can contribute to new perspectives of research, teaching and practice of judo. In essence, this research note demonstrates how judo can be understood as a neural exercise characterised by a hybrid physiological state of mobilisation without fear, in which the autonomic nervous system is regulated by focused attention/mindfulness, exercise and social engagement. Then, the consistent experience of judo contributes to an upward spiral characterised by increased vagal tone, resilience, and expansion of the individual's window of tolerance. Also, building on previous studies, this research note also suggests insulin-like growth factor 1, brain-derived neurotrophic factor, neuroplasticity, neurogenesis, epigenetic processes, the regulation of microglia/inflammatory reflex, microbiota and telomerase, mirror neurons and biochemical changes (oxytocin, serotonin, dopamine and endorphin) as the psychoneurobiological factors behind personal and interpersonal transformation through judo. This work ends by suggesting the impact of this transformation through the practice of judo on broader ecological systems and on future generations through epigenetic processes, demonstrating, in practice, Kano's conviction that the education of one generation spans one hundred generations.*

**Keywords:** *judo; mental health; education; character development; interpersonal neurobiology; polyvagal theory*

**T**his research note seeks to broaden and deepen the discussion on the potential psychoneurobiological aspects underlying mental, socioemotional, moral and behavioural changes resulting from the practice of judo, integrating judo with modern studies in the fields of health and education. When opening this discussion, it is expected that it can contribute to new perspectives of research, teaching and practice of judo.

Judo is a powerful tool for personal and interpersonal transformation (Kano, 2008; Watson, 2011), which involves dynamic and organised interaction between mind, brain, body, social relationships, and culture to interdependently optimise health and education, the two main components of the journey of development of human beings throughout their lives (Midford et al., 2020), equitably enabling people to survive and collectively thrive in the world.

Kano stated that a fundamental aspect of judo is the cultivation of virtues (Watson, 2011, p. 76) and highlighted the importance of the idea that training should be carried out with the intention of cultivating virtues for the optimisation of results (Kano, 2005, p. 107).

Intention is the awareness of and motivation to act in a particular way based on a vision and is achieved through the definition of objectives (Code, 2020). In this sense, previous studies have shown positive effects of intention on exercise (Crum & Langer, 2007; Desharnais et al., 1993). In turn, Amaral & Gabriel (2021) pointed to judo as a way to support positive neuroplastic changes in terms of executive functions, when practised with the intention of developing character. Moreover, studies suggest that character development involves epigenetic processes which influence neural development and neuroplasticity (Cloninger, 2020, p. 1235). From this perspective, judo can be understood as a tool to optimise neural integration, the basis of health (Siegel, 2018, p. 76).

Also, neuroscientific evidence related to mirror neuron activity demonstrates the importance of students recognising that the instructor's actions are guided by an objective for students to simulate and internalise the instructor's thoughts and actions, making learning meaningful and memorable (Immordino-Yang, 2008). Then, Immordino-Yang & Damasio (2007) pointed out the importance of emotions in learning, instead of a strictly mechanical approach, in which intrinsic motivation and a sense of relevance to daily life enable students to use the knowledge acquired efficiently when the circumstance requires it.

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Using the working definition of mind as “an embodied and relational, self-organising, emergent process that regulates the flow of energy and information both within and between” (Siegel, 2018, p. 40) contributes to elucidating how judo can regulate the flow of energy and information toward neural integration. In this sense, each aspect of judo, inside and outside the dojo, including engaging with digital tools (Immordino-Yang & Singh, 2011), represents opportunities for interventions: intentional activities that can be performed in different ways and that aim at the cultivation of virtues (Proctor, 2013; Hackney, 2013). In turn, Niemiec (2013, p. 50) proposes the integration between mindfulness and character strengths, in this line, supporting the idea that judo can support neural integration (Siegel, 2018, p. 198) and influence telomerase (Epel et al., 2009).

In practice, Peterson & Seligman (2004) developed a system for classifying and measuring virtues and character strengths that can be used to guide the formulation of the objectives, planning, delivery, and evaluation of judo classes.

Cultivation of character strengths is maximised in a context of emotionally significant relationships, both with others and the environment around them. Cozolino (2013) demonstrated how the human brain evolved as a social organ connected with other brains and minds; how our ability to learn depends on the quality of relationships and pointed out that instructors are important attachment figures, demonstrating the alloparental (Numan, 2020) role of the judo instructor. Then the dojo can optimise learning by stimulating a culture of growth mindset (Dweck, 2017). In this sense, Rassovsky et al. (2019) demonstrated that the practice of martial arts contributes to the production of oxytocin.

In turn, intention can be elicited through playful approaches. Panksepp & Biven (2012) describe play as a motivational system inherent in the human brain at birth and which has a particular neural circuit. When children feel securely connected to other people, the neural circuit of play is naturally activated, supporting what Porges (2011) calls the social engagement system (SES).

In terms of polyvagal theory (Porges, 2011), a safety neuroception allows the activation of SES, characterised by the activity of cranial nerves V, VII, IX, XI and by the influence of the ventral branch of the vagus nerve (X) in the heart. In turn, exercise requires an increase in cardiac output by inhibiting the vagal brake and increasing the spinal sympathetic chain. In this sense, the interaction between the exercises and social engagement behaviours promotes the opportunity to exercise the neural regulation of the autonomic nervous system (ANS), which functions as a neural platform for thoughts, feelings, decision-making and behaviour.

Thus, I propose that judo is a neural exercise, characterised by a hybrid physiological state of mobilisation without fear, in which the ANS is regulated by focused attention/mindfulness, exercise and social engagement. Then, this consistent experience of judo contributes to an upward spiral (Kok et al., 2013) characterised by increased vagal tone, resilience and expansion of the individual's window of tolerance (Siegel, 2018, p. 154). Indeed, a study demonstrated an increase in vagal tone in children and adolescents after 9 months of judo practice (Suetake et al., 2018, p. 5).

Studies demonstrate that individuals with greater basal vagal tone express wiser and less biased moral judgements from a self-distanced perspective (Grossmann et al., 2016) and that they are less likely to base their moral judgements strictly on outcomes (Park et al., 2016). Going further, judo can contribute to the regulation of the inflammatory reflex (Nakazawa, 2020) and support a healthier microbiota (Mayer, 2016), both factors mediated by the vagus nerve and exercise (Mee-Inta et al., 2019). Also, exercise induces the insulin-like growth factor 1 (IGF-1) (Carro et al., 2003), brain-derived neurotrophic factor (BDNF), hippocampal neurogenesis (Mee-Inta et al., 2019), serotonin, dopamine, endorphins (Korb, 2019) and epigenetic processes (Rezapour et al., 2018).

In summary, IGF-1, BDNF, neuroplasticity, neurogenesis, epigenetic processes, vagal tone, microglia/inflammatory reflex, microbiota, telomerase, mirror neurons and biochemicals can constitute the psychoneurobiological factors behind judo.

Finally, human beings are deeply interconnected and able to influence people who are at least three degrees apart from them (Siegel, 2018, p. 260). More specifically, studies have pointed out the influence that children have on parents (Ambert, 2001; Knafo & Galansky, 2008), suggesting that learning within a judo context can impact other ecological systems. Surprisingly, studies also demonstrate that experiences can shape epigenetic controls and with those changes, the brain's activity and structure modify to adapt to prior experience. These epigenetic variations can be directly passed through the gametes to future generations (Siegel, 2018, p. 170), demonstrating, in practice, Kano's conviction that “the education of one generation spans one hundred generations” (Kano, 2008, p. 121).

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**Article history:**

Received: 09 June 2021

Accepted: 14 July 2021

# Body Mass Index and Lower Limb Muscle Power in Judo Athletes

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**Abstract:** *Body mass and muscle power are components of physical fitness that can directly influence the performance of athletes. In this sense, knowledge about the interaction between these variables in the training period provides subsidies for the work of technicians and physical trainers. This study aims to verify if there is a correlation between the body mass index (BMI) and the power of the lower limbs in judo athletes. Forty-one (41) judo athletes participated in this study. All performed vertical jumps, squat jumps (SJ), and countermovement vertical jumps (CVJ) on a contact platform, which allowed measurement of the variables: jump height, absolute power and relative power of the lower limbs. For the calculation of BMI, weight and height were collected.*

*The data was analysed using the Spearman correlation and a significance level of  $p \leq 0.05$  was adopted. The sample's BMI was  $26.4 \pm 5.1$  kg/m<sup>2</sup>. A strong correlation was found between BMI and absolute power in SJ ( $r_s = 0.756$ ) and VJCM ( $r_s = 0.735$ ). On the other hand, there was a negative correlation between BMI and the relative potency in SJ ( $r_s = -0.375$ ) and CVJ ( $r_s = -0.417$ ). Finally, the height of the jump correlated in a moderately negative way with the BMI in the SJ ( $r_s = -0.461$ ) and CVJ ( $r_s = -0.442$ ). We observed that body mass impacts the manifestation of muscle power in judo athletes, indicating that physical trainers and coaches must accompany the associated changes between the variables.*

**Keywords:** *body composition; muscle power; judo; lower limbs*

Originating in Japan, judo is practised by millions of people around the world. More than a sport, it is a way to prepare citizens according to civic values. Such values are legitimised by a moral code composed of eight items, used in any place and nation (Brousse, 2021; Nunes & Rubio, 2012).

The nature of the sport is acyclic and intense. It has short rest intervals (Emerson Franchini et al., 2011). Nevertheless, morphological variables and the anaerobic metabolism can, determinately, contribute to fight outcomes (Degoutte et al., 2003; Emerson Franchini et al., 2014).

Because it is a sport that matches the athletes in weight divisions, the following up of the changes in the components of the physical aptitude is of great relevance for the control of training loads, as well as the analysis of the evolution of sports performance (Preux & Guerra, 2006). It is known that body mass can be a determinant variable for good physical performance, especially for the expression of muscle strength and power (Triani et al., 2018).

As well as in other sports, lower limb muscle power is also fundamental for judo athletes, because it enables athletes to perform movements that match strength and speed in short periods (Preux & Guerra, 2006) and is a factor

that can contribute to the success of judo holds during the fight (E. Franchini, 2001, 2005). The power production is related to the efficiency of the musculotendinous unit during the stretch-shortening cycle (Chmielewski et al., 2006) and specifically for judo, the countermovement vertical jump has been broadly used for the measuring of physical performance (D. Detanico et al., 2012; Markovic & Jaric, 2007).

It is noticed that there is a negative relationship between anthropometric indicators and the production of muscle power, especially when the evaluated population shows indexes of body fat that are higher than the recommended ones (Emerson Franchini et al., 2013). In a study held with judoka, it was noticed that the higher the weight division, the higher the levels of body fat in athletes (Emerson Franchini et al., 2014).

Given the above, physical trainers must analyse morphological and bio-motor aspects of judoka, taking into consideration the existing differences in the body mass and lower limb muscle power, because the modulation of these variables may impact the holding of sports tasks. Thus, this study aimed to check the correlation between body mass index and lower limb muscle power in judo athletes.

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## MATERIALS AND METHODS

This is an observational cross-sectional study. Data was collected in the period between November 2016 and August 2018, in the Laboratory of the Study of Movement at the Bahian School of Medicine and Public Health. Included in the study were male judo athletes, aged 18 to 40 years old, who had not shown any osteoarticular injuries in the 12 months that preceded the examinations. Individuals who expressed pain in any part of the body that could stop the holding of the examination, were excluded.

This study has been approved by the Ethics Committee in Research at the Bahian School of Medicine and Public Health (CPEA: 60162916.1.0000.5544-2). The participants who conformed to the inclusion criteria were guided to a private room to receive information about the research. The ones who were interested in participating signed a term of free and informed consent (law 466/12) and the study protocol was started.

It was a convenience sampling and the athletes were recruited through visits to judo clubs and dissemination on social networks, following 'snowball sampling' (Vinuto, 2014). First a sociodemographic questionnaire was distributed and anthropometric measurements were collected. The variables of weight and height were assessed through a mechanical scale (division in 100g), with a WELMY attached stadiometer. BMI was calculated through the equation: at an angle of about 90° (m)<sup>2</sup>.

After the phases mentioned above the athletes were guided on the jumping performance, which was used for the evaluation of lower limb power. For the countermovement vertical jumps, the athletes were standing with upright trunk and hands on the waist and at the command of the evaluator, they would do an upward thrust with a fast bending and knee extension (Bosco et al., 1983). For squat jumps, athletes would start in the static position, with bended knees at an angle of about 90° and at the command of the evaluator, they would perform the jump with the lower limbs, with the trunk being extended in the aerial phase (Bosco et al., 1983).

Six consecutive jumps were conducted (3 countermovement vertical jumps / 3 squat jumps), with an interval of one minute between them. All the jumps were done on a contact platform (Jump System Pro® - CEFISE) and the best jump was used for the evaluation. The calculation of the height of the centre of gravity, in centimetres and millimetres, was done with the software Jump Test Pro 1.0 that was connected to the platform, by using the formula proposed by Bosco et al (Bosco et al., 1995).

For the elaboration of the database, the Software Statistical Package for the Social Sciences (SPSS) version 14.0 for Windows was used. The continuous variables were presented on mean and standard deviation or median and interquartile range, after checking the normality of data, by using the Shapiro Wilk test. The correlation between body mass and lower limb power was calculated through

the Spearman correlation coefficient. The adopted significance level was  $p \leq 0,05$ .

## RESULTS

The sample comprised 41 male judo athletes, with a mean age of 28.8±9.2 and a BMI of 26.4±5.1 kg/m<sup>2</sup> (Table 1). It was observed that the average for the variable jump height and relative potency are the same, not only in the squat jump but in the countermovement vertical jump as well (Table 2).

**Table 1. Characteristics of judo athletes by age, weight, height and BMI: Salvador – Bahia. N=41**

Variable	Mean	SD
Age (years)	28.8	9.2
Weight (kg)	81.0	17.9
Height (meters)	1.74	0.1
BMI (kg/m <sup>2</sup> )	26.4	5.1

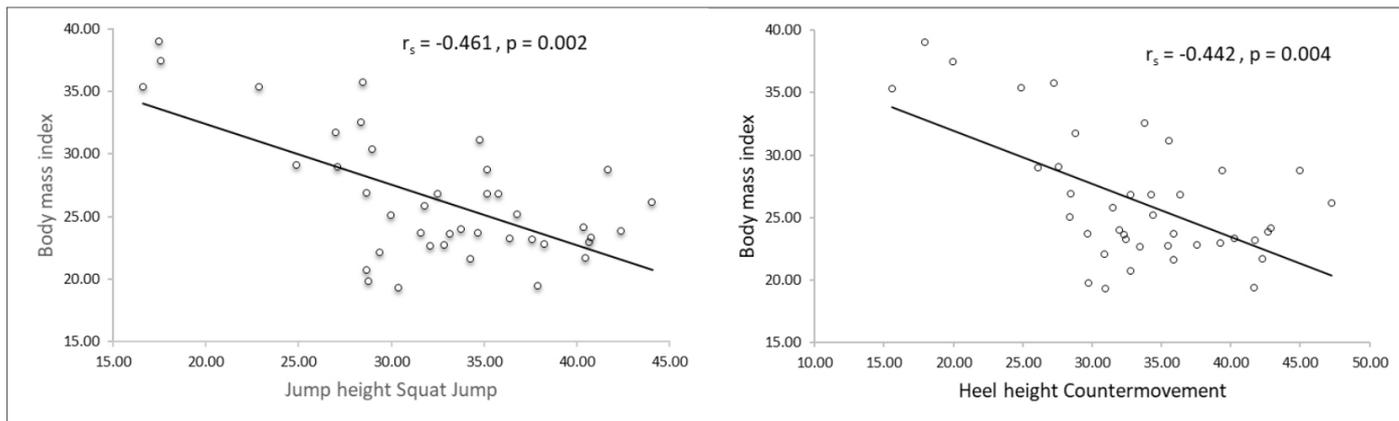
BMI = body mass index; SD = standard deviation.

**Table 2. Performance of absolute and relative power, height in countermovement vertical jump and squat jump: Salvador (BA). N = 41**

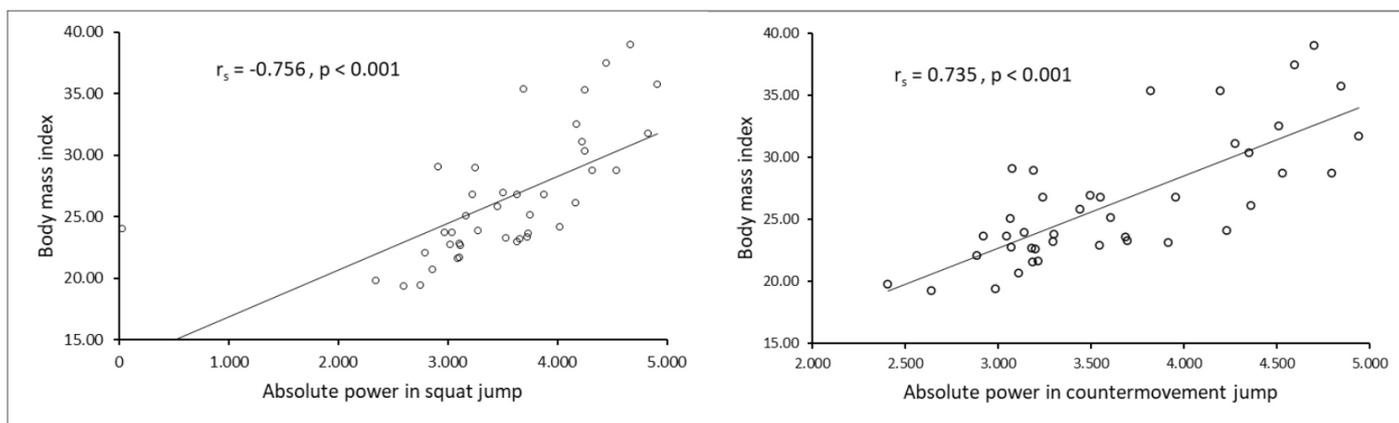
Variable	Mean	SD
<u>Squat Jump</u>		
Absolute power (w)	3505	846.7
<u>Countermovement vertical jump</u>		
Absolute power (w)	3638	666.1
	Median	Quartile
<u>Squat Jump</u>		
Jump height (cm)	32.9	29 – 37
Relative power (w/kg)	44.5	42 – 48
<u>Countermovement vertical jump</u>		
Jump height (cm)	32.8	30 – 38
Relative power (w/kg)	44.4	42 – 49

SD = standard deviation, w= watts.

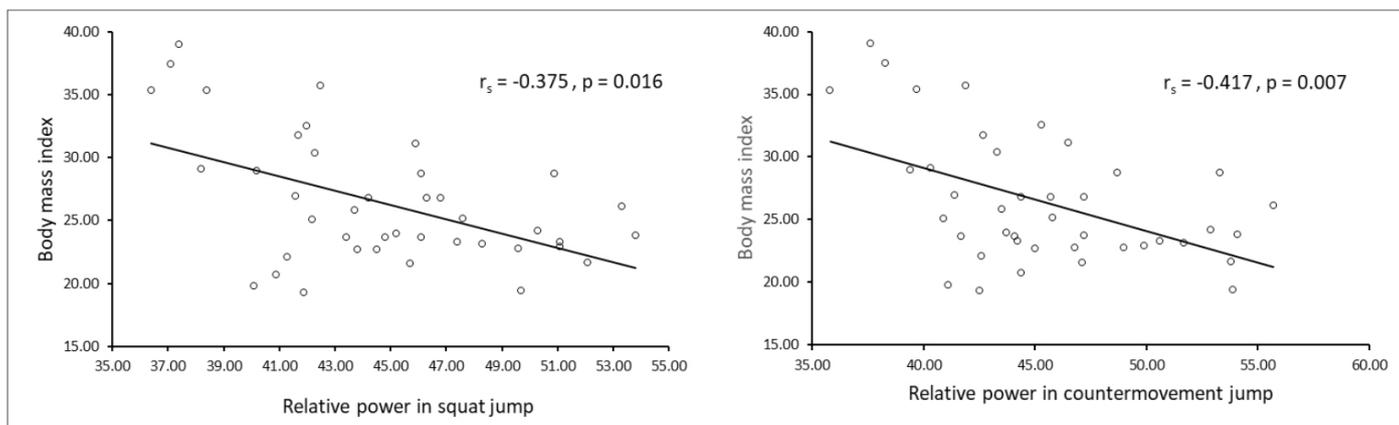
It was observed that there is a moderate correlation between jump height and BMI, not only in the countermovement vertical jump ( $r_s = -0.442$ ) but also in the squat jump ( $r_s = -0.461$ ) (Figure 1). The values of absolute power, found in the jumps, demonstrate a strong correlation with BMI (squat jump ( $r_s = 0,756$ ) and countermovement vertical jump ( $r_s = 0.735$ ), as represented in Figure 2. Differently from absolute power, the relative potency, although it shows statistical significance, it showed a weak and negative correlation with BMI squat jump ( $r_s = -0,375$ ) and countermovement vertical jump ( $r_s = -0,417$ ) (Figure3).



**Figure 1. Correlation between height of squat jump and BMI, height of countermovement vertical jump and BMI in judo athletes, Salvador (BA). N = 41**



**Figure 2. Correlation between absolute power in squat jump, BMI, and absolute power in the countermovement vertical jump and BMI in judo athletes, Salvador (BA). N = 41**



**Figure 3. Correlation between relative power in squat jump, BMI and relative power in countermovement vertical jump and BMI in judo athletes in Salvador (BA). N = 41**

## DISCUSSION

Our results showed a positive and strong correlation between BMI and absolute power of lower limbs in judo athletes. Nevertheless, the relative power of lower limbs and BMI showed a weak and negative correlation.

In a study held with judo athletes, it was noticed that the greater the weight of the category, the higher the absolute power (Athayde et al., 2018), which corroborates with our findings that showed a strong correlation between BMI and absolute power in both tests that were performed. In another study, the absolute power and body composition were compared, which found a moderate correlation for judo and jiu-jitsu athletes and a strong correlation for athletes of sports modalities such as soccer, futsal and volleyball (Kons et al., 2017). These results can be explained by the fact that individuals with greater body mass tend to generate higher strength and power during jumps. Such performance is because there is greater strength to the ground, when compared to athletes of lower body mass, even if it has been observed, in the later ones, a higher speed of takeoffs (Daniele Detanico et al., 2012).

In our study, when we measured the relative power of lower limbs, we found a weak and negative correlation between BMI and countermovement vertical jumps. This outcome can be explained by the use of total body weight in the calculation of this measure (Miller, 2015). When compared, the athletes with greater weight showed lower values of relative power than athletes of lighter divisions (Athayde et al., 2018). In another study with beginners in judo, it was observed that the values of relative power were similar to the ones in our findings (Kons et al., 2017). These results can be explained by a lower efficacy in the use of elastic energy that is accumulated in the musculotendinous structures during the transition between the eccentric and concentric phases of the jumps, in a short period. Thus, body mass overload is presented as a barrier to mechanical efficiency and as a consequence, it can contribute to a decrease in the performance of athletes in vertical jumps (Komi & Gollhofer, 1997).

By observing BMI and the height of a jump, we notice a moderate negative correlation, independently of the jump that was performed (countermovement vertical jump, and squat jump). As a counterpoint to this outcome, when volleyball athletes performed the countermovement vertical jump, they showed a strong correlation between body weight and jump height (Crivelin et al., 2018). The comparison between these results requires attention due to the differences in the studied population, jump protocol and anthropometric measures used. Regarding the judo athletes who were categorised according to weight, those with lower weight presented a higher countermovement vertical jump (Athayde et al., 2018). For all these reasons, in situations where there is no equipment, such as strength and contact platforms, trainers will be able to make use of the information of height and jump for the athletes' performance, correlating to body mass.

The absence of other measures of body composition may have been a constraint because BMI does not reflect the athletes' body composition, which can be an important predictor, given the implication of the skeletal musculature in the production of muscle strength and power. On the other hand, BMI is a broadly used anthropometric indicator for the classification of body mass, because of its easy use and incorporation into various routines (Okorodudu et al., 2010; WHO, 2000). So, it is necessary to follow the morphological alterations in this population to get a better response in the athletic performance (Preux & Guerra, 2006).

We advise physical fitness trainers to monitor changes in the body composition of their athletes as this can affect the production of muscle power and lead to obtaining better physical performance both in training and competitions.

## CONCLUSIONS

It was possible to notice the existence of a strong and positive correlation between BMI and absolute power of the lower limbs in judo athletes. However, a moderate and negative correlation between BMI and relative power in both jumps was noticed. Therefore, when we observe that the body mass affects the manifestation of lower limb muscle power in judoka, we suggest that physical fitness trainers follow the changes of BMI in their athletes, in each category, aiming to guarantee more adequate intervention for the improvement of sports performance.

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#### Article history

Received: 29 June 2021

Accepted: 27 October 2021



# Biomechanical Study of *Seoi-nage*: from the Viewpoint of Elbow Pain in Judo

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**Abstract:** *Judo is a contact sport, in which some injuries occur during training and competition. Therefore, injury prevention is essential and may have a great influence on judo athletes' performance. Judo athletes may injure their elbow joints while applying seoi-nage. In addition, we believe that overuse syndrome due to seoi-nage can be prevented by improving the motion. However, the relationship between the technique of seoi-nage and elbow joint injuries remains unclear.*

*This study aimed to: 1) investigate the characteristics of the force applied by upper limb joints, using instrumented judo clothing that measures the acting force exerted by tsurite on the collar and 2) compare the movements and force of judo athletes with and without pain in the elbow.*

*Nine male varsity judo athletes (four experiencing elbow pain and five with no pain) and one elite judo athlete (without pain) participated in this study as tori. They were instructed to conduct nage-komi and uchi-komi of seoi-nage. Judo clothes were equipped with strain gauge sensors and were used to measure the force applied by tsurite. The results: a) Varsity judo athletes without pain used a large force in the throwing direction and downward force in tsurite to break the balance of the opponent in the throwing direction and b) Varsity judo athletes with pain did not exert force in the throwing direction during the turning phase; tension was observed in the rotation direction.*

**Key words:** *seoi-nage; instrumented judo clothes; tsurite tension; elbow injury; injury prevention; closed loop problem*

Judo is a contact sport in which injuries can occur. However, among Olympic events it has been reported that it is not a sport where injuries occur most (Junge et al. 2009, Engebretsen et al. 2013, Pocecco et al. 2013, Soligard et al. 2017). Some injuries are occurring during training and competition. Pocecco et al. (2013) reported that an average injury risk of about 11–12% was observed during the Olympic Games in 2008 and 2012. Sprains, strains and contusions, usually of the knee, shoulder and fingers, were the most frequently reported injuries, whereas being thrown was the most common injury mechanism. The most common types of injuries in young judo athletes were contusions/abrasions, fractures and sprains/strains. Also, Fujisawa et al. (2016) reported that the top three types of injuries recorded among high school judo players were sprains (28%), bruises (28%) and fractures (24%). Thus, modern judo potentially has risk factors that may cause serious injuries for many children. In addition, it is possible that an injured judo athlete may have changed their special technique or continued to participate even in pain. Therefore, injury prevention is indispensable and could have a great, useful influence on judo athletes.

The representative injuries in judo occurred on the lower limb joints (e.g., knee and ankle joints), on the upper limb joints (e.g., shoulder and elbow joints) and in the lumbar

region. With respect to the lower limb joints, it is more difficult to prevent lower limb injury for judo athletes due to accidents where large loading force, caused by gravity, acts on the joints during training and competition. With a well-planned strength, agility, proprioception, stretching and conditioning programme, the lower limbs become much stronger and this can prevent lower limb injury (von Gerhard et al. 2020). The injuries on the elbow joint and in the lumbar region are heavily affected by overuse syndrome. Considering these facts, it is difficult to prevent acute trauma on the lower limb joints due to a sudden accident, but it is possible to reduce the occurrence of elbow joint injury from overuse syndrome.

The number of injury cases of judo athletes could be reduced with an improvement in their movement. Although the body mass of opponents and judo athletes' own bodies act as inevitably large loads on the lower limbs and on the lumbar region, due to the gravitational acceleration, the load on the elbow joint would be affected highly by technical factors, such as the way to grip the opponent or the way to apply techniques.

It could be possible to prevent the occurrence of injury of the elbow joint by elucidating these factors (e.g., technical factor and risk factor) and by providing judo athletes with appropriate teaching methods. Kamitani et al., (2011) re-

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ported that the incidence of injury to the elbow joint was, for the most part, due to *seoi-nage*, among technical factors. Many studies focused on the performance enhancement of *seoi-nage* (Koshida et al., 2010; Ishii et al., 2016, 2017). Onidani et al., (2017) reported that the elbow joint is fragile and this causes injury when judo athletes try *tsurite* (hand grasping the collar). However, the relationships between the movement for the *seoi-nage* technique and elbow joint injuries are still unclear.

Miyake et al., (2015) analysed the types of victory (penalties and scoring skills) in the last three international judo competitions. *Seoi-nage* is a commonly used technique that significantly influences scoring results. From the scoring results, it was considered that there are many judo athletes competent in the performance of *seoi-nage* and they are applying it frequently in competition. Many studies on elbow joint injury in judo, such as questionnaire surveys and simulations of skeletal models, as well as studies on injuries in judo were investigated. However, there were only a few studies that have analysed elbow joint injury biomechanically, with a medical emphasis. It is necessary to analyse the motion of *seoi-nage* of the player, with or without elbow joint injury, in order to obtain the basic knowledge needed for proper guidance to reduce elbow joint injury.

The purposes of this study were:

\* Firstly, to investigate the characteristics of the force applied by upper limb joints using instrumented judo clothes which can measure the acting force on the collar exerted by *tsurite*.

\* Secondly, to compare the movements and force of judo athletes with and without elbow pain.

## METHODS

### Data collection

Nine male varsity judo athletes (height:  $169.6 \pm 5.1$  cm, body mass:  $74.7 \pm 7.4$  kg, age:  $20.7 \pm 1.2$  y, dan: above second degree). Four of the judo athletes had pain in their elbows (pain group height:  $171.2 \pm 4.1$  cm, body mass:  $77.2 \pm 6.5$ ) and the other five *judoka* did not have any pain (pain-free group height:  $167.8 \pm 5.6$  cm, body mass:  $71.5 \pm 7.0$ ) and one top judo athlete (height: 170 cm, 78 kg, age 32 y; without pain; third place in a world championships) participated in this study as *tori* (thrower). All were instructed to conduct *nage-komi* drills (a judo throwing exercise) and *uchi-komi* drills (a judo technique repetition) three times, where these movements are the basic practice of *seoi-nage*. One judo athlete (height: 178 cm, 77 kg, age 21 y) took the role of *uke* (receiver). Forty-seven reflective markers were

attached to the body of each the participant (*tori* and *uke*). During the experiment, the pain group had elbow joint pain on the *tsurite* when applying *seoi-nage*. However, the pain with which they were still be able to participate the competition where they applied the *seoi-nage* as usual. Written informed consent was given prior to their participation and approval for the experiment was obtained from the institution's Ethics Committee.

Three-dimensional coordinate data of the reflective markers was collected with an optical three-dimensional automatic motion capture system (14 cameras, VICON Motion Systems, Ltd., Oxford, UK), at a sampling frequency of 250 Hz. Three-dimensional coordinate data was smoothed by a Butterworth digital filter at cut-off frequencies ranging from 12.5 to 22.5 Hz, which were decided by a residual method (Wells & Winter 1980). The subjective ratings were evaluated in steps of five (1 is the lowest, 5 is the highest) for the trials. The trials in which *tori* could lift *uke* and *tori* showed the highest subjective ratings, were analysed. Since the markers were attached to judo athletes' bodies directly, judo athletes did not use their normal *judogi*.

*Tori* wore the specially prepared suit for collecting the measurements with the motion capture system. Where the suit is body fitting and covered with Velcro for free attachments of reflective markers constructing with the x-shaped base made from Velcro. Some markers were hidden by body contact during the motion, so markers attached to the normal judo clothes could not be used properly in this study. Therefore, the subjects (*uke*) wore a pair of Spandex long pants, a long-sleeved shirt and specially designed lapels and sleeves that imitated judo clothes. The direction of throwing was shown on the Y axis. The upward vertical direction was shown on the Z axis. The cross product of the Y and Z axes became the X axis and a static global coordinate system consisting of the X, Y and Z axes was defined.

### Instrumented Judo Clothes

One judo athlete grasped the collar and sleeve of the opponent with both hands; thus, it was impossible to determine the exerting force of each hand acting on the collar and sleeve respectively, based on information from the motion of the judo athletes. Instrumented judo clothes were therefore proposed for this study, to obtain kinetic information about each hand.

Figures 1a, b and c show schematic representations of the structures of the tensile force measurement unit (Fig. 1a) inserted in the collar (Figure 1b) of the instrumented judo clothes (Fig. 1c), which measures the pulling force exerted by *tsurite* on the collar. The pulling force was calculated from the tensile force of the ropes inserted into the hole of the collars of judo clothes (Figure 1b). Two sets of orthogonally orientated strain gauges, comprised

of two active gauge measurement units, were used to obtain tensile force exerted along the ropes (Figure 1a). Fig. 1a constitutes a small tension meter utilising strain gauges attached on an aluminium alloy square prism. A set of strain gauges orthogonally orientated was placed in the middle of an aluminium alloy bar (square prism; 24 mm length, 8 mm width, and 8 mm depth). The holes in both ends of the aluminium alloy square prism were used to insert nylon ropes. The sensors were placed in two locations (upper and lower sides) of *tsurite* in the judo clothes, and reflective markers were attached at two sites (Figure 1c).

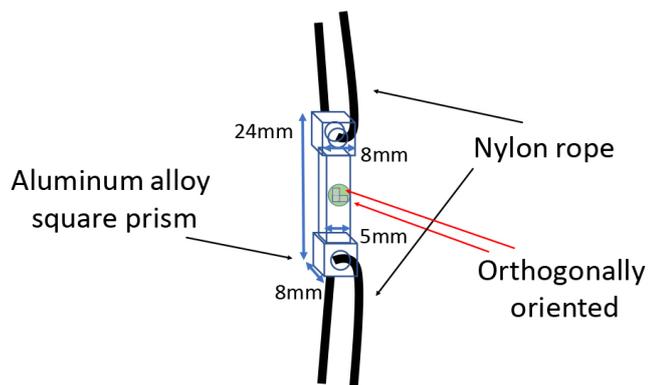


Figure 1 (a). Schematic representation of a tensile force measurement unit with ropes

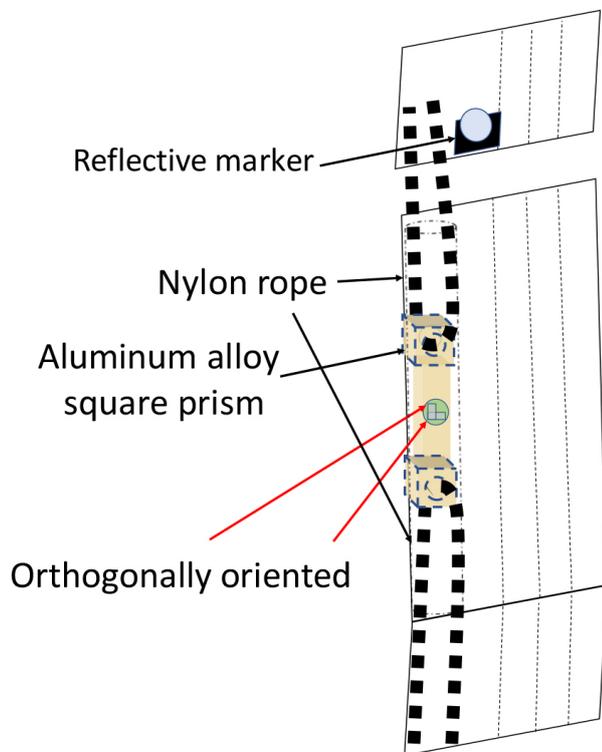


Figure 1 (b). Schematic representation of the inserted tension gauge into a collar

These units utilised a two-active-gauge method by attaching two strain gauges, which were attached to the aluminium alloy rectangle prism orthogonally with each other, for measurement tensile force exerted along the rope, were connected to the amplifier via a bridge box (Figure 1c).

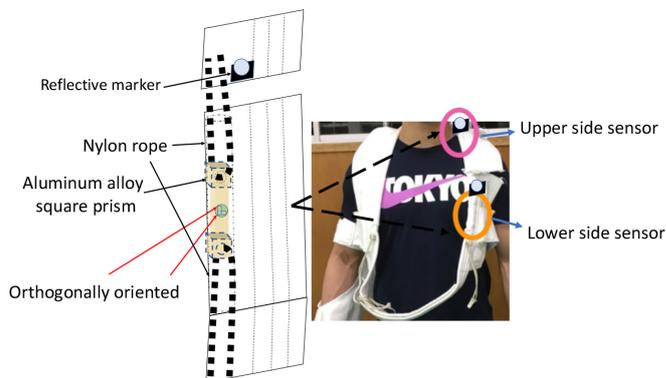


Figure 1 (c). The placement of tensile force measurement units in the judo clothes

The force measurement unit sensor used two active gauge methods by attaching two strain gauges, for compressive and tensile force measurements, to aluminium materials as the base and those were connected to the amplifier via a bridge box. Figure 2 shows the setup for the calibration of the tensile force measurement unit, in which various weights (2, 5, 7, 10, 12, 15, and 18 kg) were loaded via the rope on the measurement unit to obtain information about the sensor, translating coefficients regarding the output voltages amplified through dynamic strain amplifiers.

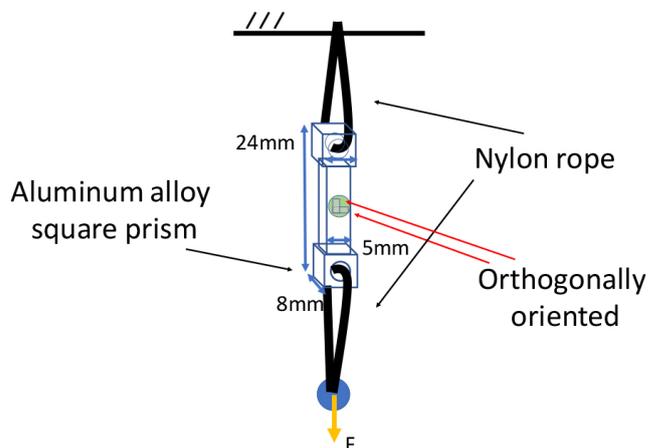


Figure 2. Sensor calibration set-up for the tensile measurement units.

The collar and sleeve parts were reduced to the minimum required parts, so that the reflective marker could be attached independently, not to covering the markers in this experiment. In addition, the upper and lower sides of the gripping area of the collar, for hand's gripping on the *tsurite* side, were separated. The collar was integrated again by passing a single nylon rope through the holes of the adjacent collars.

Two tensile force measurement units were used to calculate the pulling force of *tsurite* from a force equilibrium equation, with respect to the tensile forces of the ropes and the pulling force, using geometric information about the joint centre point for the wrist joint of the *tsurite* and the collar's representative points, obtained with the motion capture system.

Three-dimensional coordinate data of the reflective markers was collected with an optical three-dimensional automatic motion capture system (14 cameras, VICON Motion Systems, Ltd., Oxford, UK) at a sampling frequency of 250 Hz. The *uke* wore instrumented judo clothes with a lead line from the strain gauge connected to a dynamic strain amplifier via a bridge box. The motion capture system and instrumented judo clothes were electronically synchronised (Figure 3).

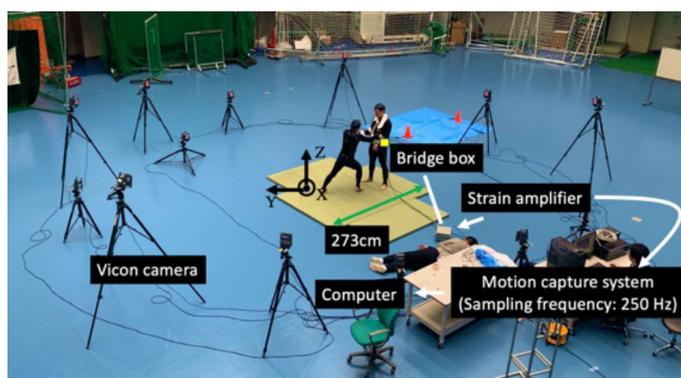
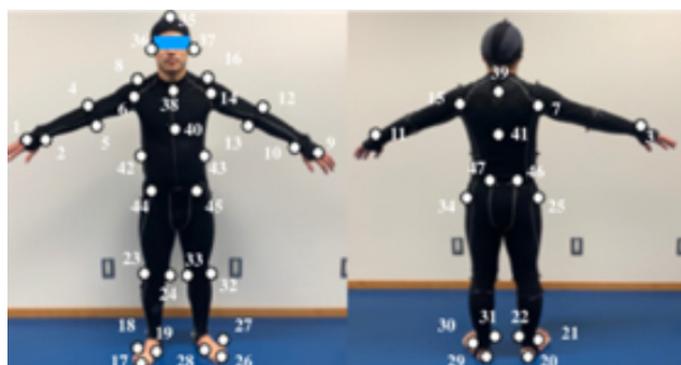


Figure 3. Experimental set-ups

Figure 4 shows the retroreflective marker positions on the body, placed according to the method of Suzuki, Ae, Takemura, and Fujii (2014).



- |         |                           |         |                          |
|---------|---------------------------|---------|--------------------------|
| 1 RHND  | Right hand                | 26 LTOE | Left toe                 |
| 2 RWRL  | Right wrist later side    | 27 LBAL | Left ball lateral side   |
| 3 RWRM  | Right wrist medial side   | 28 LBAM | Left ball medial side    |
| 4 REEL  | Right elbow lateral side  | 29 LHBL | Left heel                |
| 5 REEM  | Right elbow medial side   | 30 LANL | Left ankle lateral side  |
| 6 RSHF  | Right shoulder front side | 31 LANM | Left ankle medial side   |
| 7 RSHB  | Right shoulder back side  | 32 LKNL | Left knee lateral side   |
| 8 RSHA  | Right shoulder anterior   | 33 LKMN | Left knee medial side    |
| 9 LHND  | Left hand                 | 34 LTRO | Left trochanterion       |
| 10 LWRL | Left wrist lateral side   | 35 HEAD | Head                     |
| 11 LWRM | Left wrist medial side    | 36 REAR | Right ear                |
| 12 LEEL | Left elbow lateral side   | 37 LEAR | Left ear                 |
| 13 LEEM | Left elbow medial side    | 38 STEF | Suprasternale front side |
| 14 LSHF | Left shoulder front side  | 39 STEB | Suprasternale back side  |
| 15 LSHB | Left shoulder back side   |         |                          |

Figure 4. Locations of reflective markers on the body of tori

*Nagekomi* motion was divided into four phases as follows: distancing phase (0-40%), turning phase (41-70%) and lifting phase (71-100%). Data was normalised with respect to the duration of the motion, where the distancing phase was considered from the instant *tori* stepped a foot to begin the body's rotation. The turning phase was from the start of body rotation to the instant *tori*'s feet contacted the floor. The lifting phase was from the foot contact to the instant when *uke* was lifted from the floor. The duration of *nagekomi* motion was normalised from 0% to 100%. From the start of movement of *nagekomi* motion ended at the instant of *uke*'s lift was normalised with respect to the duration of to 100% (Figure 5a).

Similarly, *uchikomi* motion was divided into three phases as: first *uchikomi* (0-40%), second *uchikomi* (41%-70%) and third and lifting (71-100%) phases. In *uchikomi*, the *tori* repeated *uchikomi* twice (two times) and then lifted *uke* in the last phase (Figure 5b).

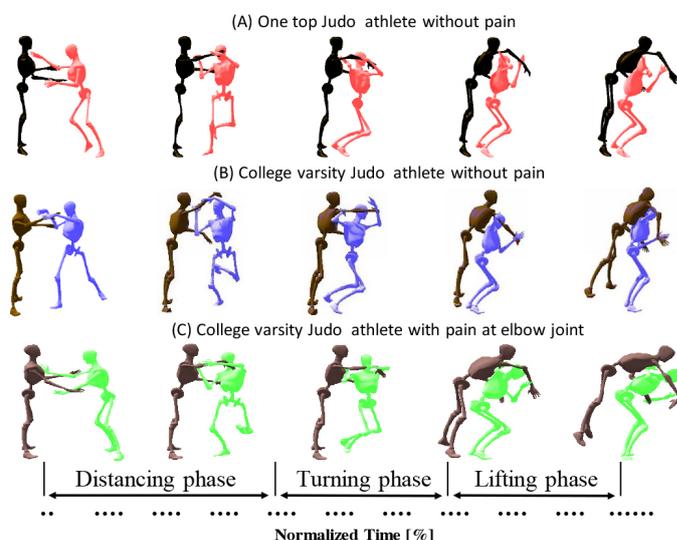


Figure 5(a). Phase definition of *nagekomi* and pictures of the phases in *nagekomi* for the participants

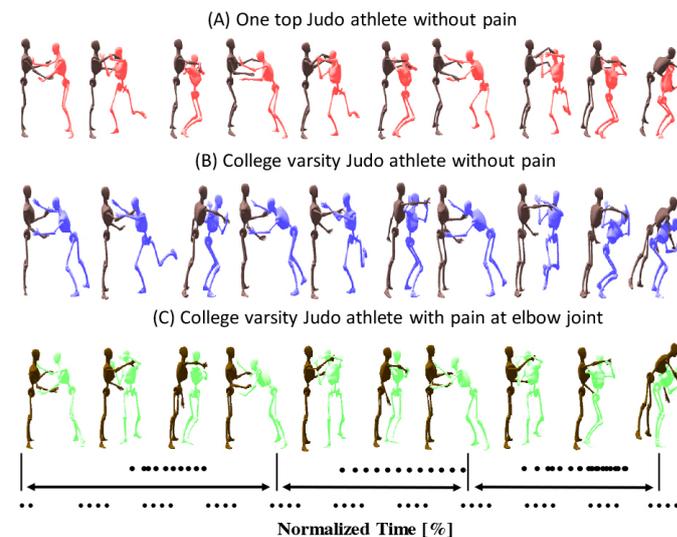


Figure 5(b). Phase definition of *uchikomi* and pictures of the phases in *uchikomi* for the participants

## RESULTS

Strain gauge amplifier's output signals versus weighting loads.

Because the relationship between the signal outputs of the strain amplifier and loading weights showed good linearity (Figure 6), the sensor output signals can be translated into the tensile force of the rope by multiplying a coefficient that was obtained as the gradient of the linear line fitted with the plots.

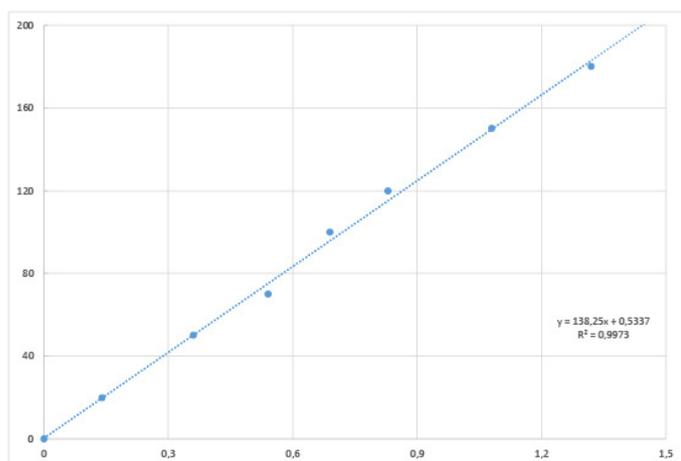


Figure 6. Plots of strain gauge amplifier's output signals versus weighting loads

### Tsurite force of tori (nagekomi and uchikomi)

The time curves of the averaged pulling force of tori's *tsurite* during the *nagekomi* motion, measured with the instrumented judo clothes, showed a different pattern for the participants (Fig. 7).

Time curves of the averaged pulling force of tori's *tsurite* during *uchikomi* motion, measured with the instrumented judo clothes during the *uchikomi* motion, showed a different pattern for the participants. Figure 7a shows the forces exerted by a top athlete without pain. During the late distancing phase and early turning phase, large forces were exerted along the Y and Z axes. After the turning phase, the forces became small. Figure 7b shows the forces exerted by the judo athletes without pain in the elbow. The forces were smaller than those of the top athlete without pain and similar after the distancing phase. The mean values of the standard deviation of 100% normalisation time were 6.8[N] for the X axis, 15.5[N] for the Y axis and 7.9[N] for the Z axis. Figure 7c shows the forces exerted by the athletes with elbow pain. At the beginning of the distancing phase, the small forces were exerted along the Y and Z axes. After the turning phase, a large force was exerted along the X axis. The mean values of

the standard deviation of 100% normalisation time were 14.7[N] for the X axis, 15.4[N] for the Y axis and 13.9[N] for the Z axis.

Figure 8 show the *tsurite* force of tori in *uchikomi*. Figure 8-A and 8-B show the forces exerted by a top athlete without pain and the judo athletes without pain, respectively. Prior to lifting *uke*, the force patterns had similar timing to the *nagekomi* of the top athlete and the judo athletes without pain, while the magnitudes of force were different. Also, the mean values of the standard deviation of 100% normalisation time for the without pain group were 7.3[N] for the X axis, 6.2[N] for the Y axis and 7.1[N] for Z-axis. Figure 8-C shows the forces exerted by the judo athletes with elbow pain. The timing of forces was different between *uchikomi* and *nagekomi*, and large forces were exerted along the X axis. The mean values of the standard deviation of 100% normalisation time were 8.1[N] for the X axis, 5.7[N] for the Y axis and 5.3[N] for the Z axis.

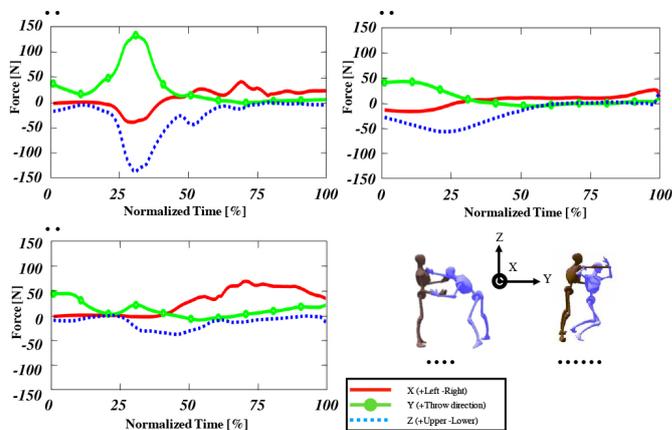


Figure 7. The *tsurite* force of tori (*nagekomi*)

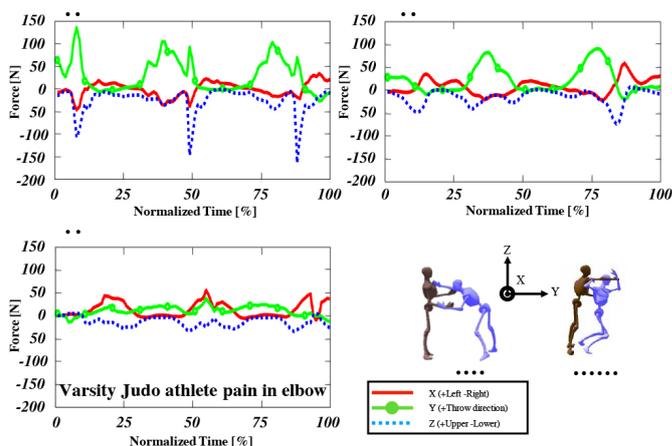
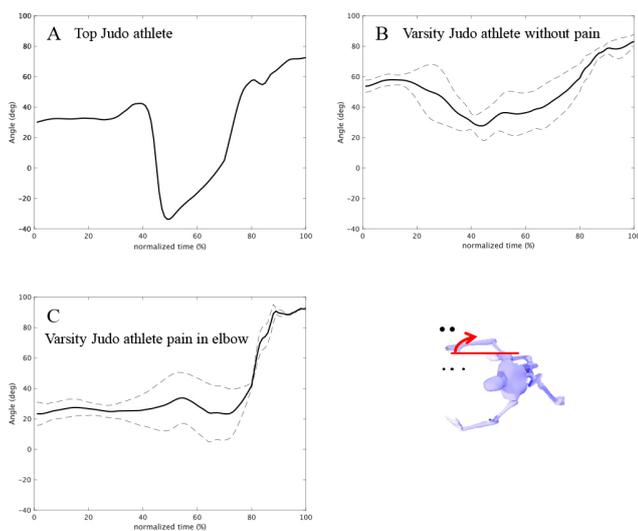


Figure 8. The *tsurite* force of tori (*uchikomi*)

### Internal and external rotation angle of shoulder joint of *tori* in *nagekomi*

Figure 9 shows the internal-external rotational angle of the shoulder joint of *tori* (group) in *nagekomi*. Figure 9a shows the internal-external rotational angle of the shoulder joint of a top athlete without pain. In the distancing phase, the external rotation angle of the shoulder joint is small and there is no displacement. During the turning phase, the shoulder joint rotated internally. After that, it externally rotated when shifting to the lifting phase.

Figure 9b shows the external rotational angle of the shoulder joint of the athletes without pain in elbow. No angular displacement was observed during the distancing phase. The external rotation angle decreased in the turning phase and increased to nearly 80° during the lifting phase. Figure 9c shows the external rotational angle of the shoulder joint of the athletes with elbow pain. No angular displacement was observed during the distancing phase. Similarly, during the turning phase, almost no angular displacement was observed. During the lifting phase, the external rotation angle increased to over 90° during lifting.

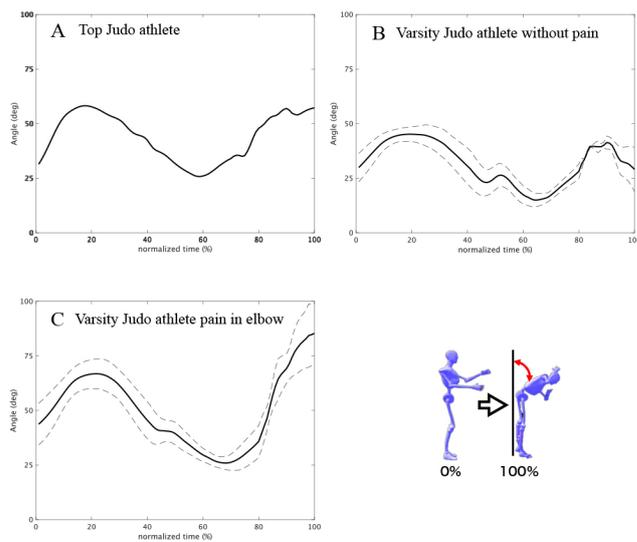


**Figure 9. Internal and external rotation angle of the shoulder joint of *tori* (*nage-komi*)**

### Trunk angle of *tori* in *nagekomi*

Figure 10 shows the trunk angles of *tori* in *nagekomi*. Figure 10a shows the trunk angle of *tori* in *nagekomi*. From the beginning of the movement to the distancing phase, the trunk was bent and during the turning phase the trunk was extended slightly. During the lifting phase the trunk flexion angle was 35° at 80% when the trunk was flexed and the opponent was lifted. Figure 10-B shows the trunk

angles of *tori* in *nagekomi*. The non-pain group also had a wave form similar to that of the top athletes, up to the turning phase. During the lifting phase the trunk was flexed and extended. At 80% of the normalised time when the opponent was being lifted, the trunk flexion angle was approximately 30°. Figure 10-C shows the trunk angles of the *tori* in *nagekomi*. The athletes with pain flexed their trunk during the distancing phase and again during the lifting phase, after extending the trunk during the turning phase. At 80% of the normalised time, when the opponent was lifted, the trunk flexion angle was approximately 45°.

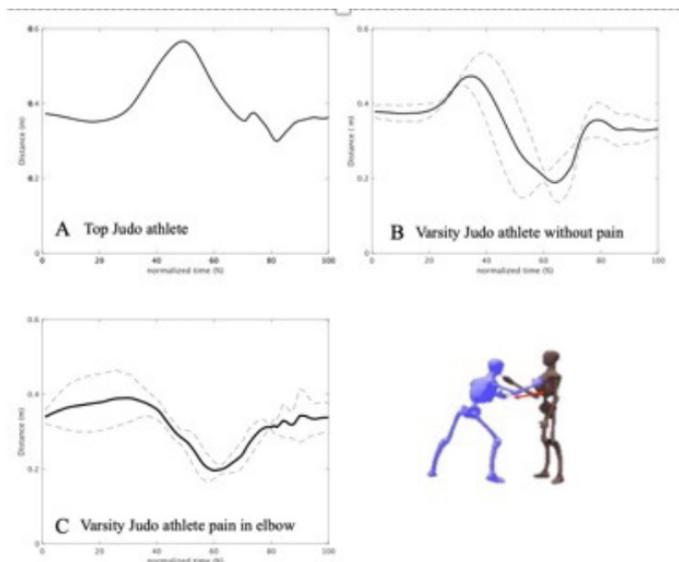


**Figure 10. The trunk angle of *tori* (*nagekomi*)**

### Distance between elbow of *tori* and xiphoid process of *uke* in *nagekomi*

Figure 11 shows the distance between the elbow of *tori* and the xiphoid process of *uke*. Figure 11a shows the top athlete whose distance increased during the turning phase from the latter half of the distancing phase. The distance during the turning phase was approximately 0.4 m and there was no change in the lifting phase.

Figure 11b shows that the distance of non-pain group athlete. slightly during the latter half of the distancing phase and decreased to 0.19m during the turning phase. Subsequently, there was no change in the lifting phase. Figure 11c shows that the distance of pain group athlete. During the distancing phase, there was no displacement of the distance. During the turning phase the distance reduced to 0.22m, on average. Subsequently, there was no change during the lifting phase.



**Figure 11. Distance between elbow of *tori* and xiphoid process of *uke* (*nagekomi*)**

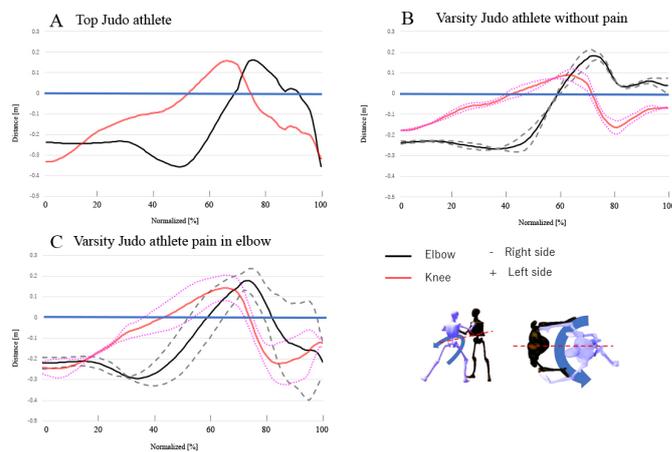
### Rotation timing of *tori* in *nagekomi*

Figure 12 shows the distances between the central axis that were aligned from the centre of gravity of *tori* and *uke* and the right elbow and knee, respectively.

Figure 12a shows that in the top athlete did not pass through the central axis from the start of movement to the distancing phase, passed rotated in the turning phase. It also shows that the elbow of the top athlete rotated once away from the central axis and crossed the central axis during the turning phase.

Figure 12b shows that in the pain group, the distance between the elbow and central axis changed slightly during the distancing phase. During the turning phase, the knee passed the central axis and was followed by the elbow. The average timing of elbow rotation was approximately 60% of the normalised time.

Figure 12c shows the pain group. The knee began to rotate during the distancing phase and the elbow rotated later during the turning phase. The timing of rotation was earlier than that in the pain group. In addition, the difference in rotation timing between elbow and knee was the smallest among the three groups.



**Figure 12. Rotation timing of *tori* (*nagekomi*)**

## DISCUSSION

The top athlete exerted a large force in the throwing and downward directions in *tsurite* (Fig. 7) in order to break the balance of *uke* in the throwing direction. This implied that *uke* received a downward force and *tori* rotated the trunk of the body by this reaction force as an external force. *Tori* pulled *uke* in the throwing direction to create a space between them (Fig. 11) which was related to the loss of balance of *uke* during the late phase. Deguchi et al. (2003) stated that athletes who are good at *seoi-nage* are efficient in breaking down, which is one of the factors that reasonably throw their opponents. From this study, it could be suggested that the top athlete performed rational techniques because they fell in the direction of throwing the opponent in the distancing phase. *Tsurite* moved in the opposite rotational direction before the start of trunk rotation during the turning phase. In competitions, the opponent grasps the sleeves of *tori* to prevent the *tsurite* of *tori* from moving. Simultaneously, *tori* moves the *tsurite* to the opposite of the rotational direction to decrease the load on the sleeves from the opponent. Sasamura et al. (2019) reported that in baseball pitching movements, starting movement from the lower limbs stabilises the hip joint and leads to movement of the upper limbs. This leads to the rotation of the elbows and knees at different times, which reduces the burden on the upper limbs and may enable smooth *seoi-nage* of judo. Therefore, it can be said that a 'kinetic chain' is seen from the lower limbs to the upper limbs (Fig. 12).

In the lifting phase, in addition to the stability of the lower limbs, the forward tilt angle of the trunk did not increase and the external rotation angle of the shoulder joint was 90° or less. Therefore, the burden on the upper limbs was reduced and it was thought that the opponent's body can be lifted. In the non-pain group, *tsurite* exerted force in vertical and throwing directions. However, the non-pain group did not exert as much tension as top athletes. (Fig. 7). The distance between the elbow of *tori* and *uke* was

maintained at 25cm in order to keep a space for rotating the trunk to pull the *tsurite* in the throwing direction. It is probable that, like the top athlete, *tori* created a distance from the *uke* to upset his balance and secure a space in which to rotate their body. During the transition from the distancing phase to the turning phase, with *uke*'s trunk leaned forward, the elbow rotated later than the knee (Fig. 12). This implied not only that *tori* used the upper limbs but also that they moved the whole body to achieve rotation to apply the technique and then it was possible that *tori* pulled *uke* using the grip on the sleeve. During the late turning phase, *uke* started losing balance and *tsurite* did not exert force in the throwing direction. These results implied that *tori* rotated the trunk of the body to bring *uke* to the throwing direction rather than pull him by using *tsurite* when *tori* was turning the body. It was considered that *tori* maintained the distance from *uke* to create a space when breaking the balance of *uke*. During the lifting phase, *tori* did not increase the flexion angle of the trunk (Fig. 10) and it was considered that *tori* used the force from the lower limbs of the whole body to lift *uke* instead of using only the upper limbs. Thus, *tori* could apply the technique without putting an overload on the elbow and would not feel pain. These results are similar to those of the top athlete. Although *tori* exerted force in the throwing direction, unbalancing *uke* and created a space for *tori* to rotate. Therefore, it is possible that the *seoi-nage* can be performed without putting much load on the upper limbs.

In the pain group, the results showed that the rotation timing was significantly different between the pain and no pain groups. During the distancing phase, *tori* did not exert force in the throwing direction and during the turning phase, tension was observed in the rotation direction (Fig. 7). In terms of rotation timing, the timing of each elbow and knee was earlier in the pain group than in the non-pain group and the interval between the elbow and knee rotation timings was shorter. Furthermore, since the rotation timing of the upper and lower limbs in the pain group was short and the tension was exerted significantly in the rotation direction, it was considered that the movement of the upper limb may precede that of the lower limb. *Tori* did not break the balance of *uke*, and the distance between the elbow of *tori* and *uke* was approximately 15cm, which was too close to apply the technique properly as the space was too narrow to rotate the body. Thus, *tori* had to rely more on the upper limbs to throw the opponent. Therefore, when lifting *uke*, there were unique or strange movements that were not seen in athletes in the non-pain group. In the pain group, when *tori* tried to lift *uke*, the external rotation angle of the right shoulder joint and the trunk anteversion angle were larger than those in the non-pain group. According to a report by Ishii et al. (2011), athletes who are good at *seoi-nage* have a forward trunk tilt angle of approximately 30°. Therefore, it was suggested that the large forward tilt angle of the pain group may not be a good player for *seoi-nage*.

From the above, it can be inferred that the throwing method used by the pain group induced more load on the

right elbow joint. For this reason, it may cause injury due to overuse syndrome when repeating basic practice with unnecessary movements.

In the non-pain group, *tori* exerted force in the throwing direction and moved the lower limbs early in order to acquire the distance and space required to enter the armpit of *uke* during the distancing phase, after which *tori* could maintain the space when rotating the body and lifting *uke*. Moreover, when lifting *uke*, *tori* used the upper limbs (*tsurite*) and used the whole body to lift *uke*, reducing the load on the elbow during the throw. However, in the pain group, *tori* did not exert force with their *tsurite* during the distancing phase. Therefore, it is possible that sufficient space was not secured for rotation. Also, since the tension of *tsurite* exerted in the direction of rotation while trying to put their elbows in *uke*'s armpit, *uke*'s centre of gravity did not move. Because the trunk flexion angle was increased while the right shoulder joint was largely rotated externally, it was necessary to rely on the force and movement of the upper limbs (*tsurite*) when lifting. It was considered that a greater load of stress was placed on the *tsurite* in the pain group when compared with the non-pain group.

## CONCLUSION

In this study, athletes without pain used force in the throwing direction and did not increase the external rotation angle of the shoulder joint. This finding suggests that it is important to break the opponent's balance in the throwing direction in the distancing phase, stabilising the lower limbs and maintaining the correct external rotation angle of the shoulder joint when lifting. However, it was suggested that the athletes with pain exerted tension in the direction of rotation, lifted while increasing the shoulder joint angle and tilted the trunk forward, thus putting a burden on the upper limbs. It is necessary to reduce the occurrence of injuries when coaching the basic methods of using the technique and the sequence of coaching. The way in which athletes use the technique is dependent on the characters of the *tori*'s body, which should be considered individually to reduce injuries.

In this study, the tension of *tsurite* was detected and the factors that contributed to the occurrence of *tsurite*'s elbow joint injury were studied. Therefore, it is necessary for *hikite* (hand grasping the sleeve) to develop a sensor using the same method and detect the tension of both the *tsurite* and *hikite*. Here, the participants were divided into those with and without pain. However, by collecting data by age group (i.e., by proficiency level), it is possible to assist the teaching site by clarifying the pre-injury group from these results. In addition, it is desirable that coaching is performed based on the results of these studies so that athletes with pain in the elbow can improve their movements and apply *seoi-nage* without pain.

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#### Article history

Received: 05 December 2019

Accepted: 17 May 2021

# Video Biomechanical Analysis of the Shoulder Kinematics of Impact from *Uchi-mata* and *Ippon-seoi-nage* Judo Throws: a Cross-Sectional Study

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Wieslaw Blach<sup>4</sup> & Manuela Angoi<sup>1</sup>

**Abstract:** *Shoulder injuries are extremely common in judo but there is currently no research looking at the shoulder kinematics during judo throws. To gain insight into injury prevention, video analysis may be used to assess two judo throws that have been found to have a high injury incidence: uchi-mata (UM) and ippon-seoi-nage (ISN).*

*This study aims to compare the peak speed and peak acceleration at the shoulder due to two judo throws and to evaluate shoulder kinematics during the throws, to increase understanding of the mechanism of injury to the shoulder.*

*10 male and 2 female, black belt judo practitioners were recruited. They were recorded on an iPhone 7 camera while taking turns performing the UM and ISN judo throws. Tracking of the shoulder was then done using the Kinovea software, to calculate speed and acceleration of the shoulder. Paired t-tests assessed the differences in peak positive acceleration, peak negative acceleration and peak speed.*

*Peak speed was significantly higher in ISN than UM (4.80 vs 4.49 ms<sup>-1</sup>, p=0.021). No significant difference between the two throws was found for peak negative acceleration. Peak negative acceleration was found to be significantly higher than peak positive acceleration for both throws (p≤0.002 for all variables). ISN has a higher peak speed than UM but they have a similar peak negative acceleration, suggesting overall force is a more important factor than peak force for determining injury risk in judo throws.*

**Keywords:** *judo; shoulder; kinematics; video analysis*

Judo is a martial art, a combat sport practised in over 200 countries around the world (Pocecco et al., 2013). Various studies over the years have shown that injury risk in judo could range from 11% to 29% in high level competitions (Pocecco et al., 2013). This extremely high injury risk paired with the vast popularity of the sport means it is crucial to research mechanisms to reduce these injury risks. Studies have shown that approximately 70% of injuries in judo occur while being thrown (Pocecco et al., 2013). Injuries to judoka (judo practitioners), due to being thrown, have most commonly been found to be in the knees of *tori* (the person performing the throw) and in the shoulders of *uke* (the person being thrown) (Pocecco et al., 2013; Bromley, Drew, Talpey, McIntosh, & Finch, 2018; Minghelli & Isidoro, 2016). The most commonly reported injuries of the shoulder are shoulder dislocation and acromioclavicular lesions, due to high-speed impact with the mat when

falling (Voinea, 2015; Elliott, 1972). Therefore, analysis of the forces experienced by *uke*'s shoulder during judo throws could provide insight into the mechanism of injury and injury prevention.

Unfortunately, no papers investigating the forces of impact or kinematics of the shoulder from judo throws exist currently, despite the high incidence of shoulder injuries in the sport. Among all judo throws, the ISN and UM throws have been shown to be two of the most frequent causes of injury in judo, with a 23% and 9% incidence, respectively (Barsottini, Guimarães, & de Moraes, 2006). However, it must be noted that ISN has an injury incidence that is larger by a factor of 2.5 in comparison to the injury incidence for UM, which raises the question of why the injury incidence of ISN is so significantly larger. Both throws result in *uke* landing on their shoulder. Additionally, these throws were deemed to be two of the most commonly used techniques in tournament settings, according to a

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literature review looking at 13 studies, which analysed 34 judo competitions between 1981 and 2014 (Gardasevic, & Stankovic, 2019). Therefore, these two specific throws can be analysed and compared to investigate whether this drastic difference in injury incidence is linked to differences in G force or impact forces experienced by the shoulder. Peak positive acceleration will be calculated in this study to gain an understanding of the G force experienced by the shoulder during the throwing phase. Since impact forces cannot be measured directly by video analysis, peak negative acceleration following impact with the mat and peak speed during the throwing phase will be calculated to provide an indication of the peak force and overall force during impact with the floor, respectively.

Two-dimensional video analysis has become increasingly accessible and is used by coaches, players and sports medicine physicians in order to analyse biomechanics during high-speed movements (Colyer et al., 2018; DeFroda, Thigpen, & Kriz, 2016). Two-dimensional video analysis allows a video recording to be played back in slow-motion and analysed frame-by-frame, which is more reliable than using the naked eye to assess high-speed movements. This allows more accurate measurements of distance and time to be taken, increasing the validity of results (Weber, & McClinton, 2020). This method only requires a mobile device and a free application named Kinovea and is therefore a much cheaper alternative to other methods of analysing impact forces, such as three-dimensional video analysis, force plates or accelerometers. This also means the study is easy to set up and can be done anywhere, so volunteers will not need to travel to a laboratory to take part in the study, which will increase participation.

There is currently only one paper that has used two-dimensional video analysis to assess judo throws (Imamura, & Johnson, 2007), so the reliability of this method is still relatively unknown. Nevertheless, Kinovea has been shown to be a reliable research tool in multiple studies on other sports (Balsalobre-Fernández, Tejero-González, del Campo-Vecino, & Bavaresco, 2014; Padulo et al., 2014).

**Objectives**

- 1) Compare the differences in peak positive acceleration, peak negative acceleration and peak speed between two judo throws: UM and ISN.
- 2) Develop an understanding of the maximum G force, peak force during impact and overall force of impact experienced by the shoulder during UM and ISN judo throws.
- 3) Produce results of the kinematics of the shoulder during UM and ISN judo throws to increase understanding of the mechanism of injury to the shoulder.

The null hypothesis is that there will be no difference in peak positive acceleration, peak negative acceleration or peak speed between the two throws: UM and ISN. The research hypothesis is that at least one of these variables will have a higher value in ISN than UM.

**METHOD**

**Study Design**

This study was carried out using a cross-sectional design. There were two separate sessions of recording, due to time constraints and the availability of judoka. This recording portion of the study took place at the Budokwai Judo Club in Chelsea, at the end of their training session. Participants were asked to take turns acting as both *tori* and *uke* and perform two judo throws: UM and ISN.

**Population**

The population of this study was black belt judo practitioners, because this ensured that proper technique was used for each throw. Therefore, the throws in the study would more accurately reflect the forces experienced by the shoulder in judo classes and competitions. Furthermore, use of correct technique would lower the risk of injury to the participants. The population of the study was adult because the study aimed to investigate the kinematics of a fully developed adult.

Healthy participants with no current injuries, or injuries within the past 6 months, were used in this study because such injuries could have affected the way the throw was performed and affect the results. The risk of further injury occurring during the study was also reduced by using only healthy participants.

**Table 1. Inclusion and exclusion criteria**

Inclusion criteria	Exclusion criteria
Age > 18 Black belt judoka Healthy (no current injuries)	Age <18 Non-judoka Judoka below club level or black belt Current injury or injury within the past 6 months Shoulder pain

**Recruitment**

Ethical approval for this study was obtained through the Queen Mary Ethics of Research Committee.

The first step in the recruitment process was to send a letter to the Budokwai Judo Club, informing them about the project and asking for permission to carry out research there. The judo club was asked to inform its members about the study. Potential participants were then provided with information sheets explaining the study, who is eligible to take part and how any personal data is managed. Participants were given a consent form when they agreed to take part in the study. Written consent was obtained from every participant before data collection, ensuring that every participant was able to adequately understand



written and verbal English. All signed consent forms were handed into the Centre for Sports and Exercise Medicine office, at Queen Mary University of London, as paper copies.

### Sample Size

A minimum sample size of 5 was calculated using a similar video-analysis study about judo throws by Koshida et al. (2017). As there were no other studies looking at calculating peak acceleration or peak speed, peak extension momentum values of the neck were used in the sample size calculation. This calculation was performed using G\*Power, with an  $\alpha$  value of 0.05 and a statistical power of 80% (Faul, Erdfelder, Lang, & Buchner, 2007).

### Method of Data Collection

Prior to recording, every participant had their height and weight measured and their age noted. The participants were then assigned a partner of similar height and weight, because tournaments have weight divisions and therefore judoka are generally more likely to throw another judoka of similar height and weight to themselves. The recording session happened at the end of the judokas' training sessions to ensure that they were sufficiently warmed up and avoid disrupting their training.

The floor was covered by standard judo mats, provided by the judo club, to ensure that the participants could perform their throws safely. An iPhone 7 with a 12 Megapixel camera, recording at a frame rate of 30 frames per second and a quality of 1080p, was set up on a 130cm tripod, to remain stationary. A distance of 4.5m from the camera was measured beforehand using a tape measure to mark out the mat with a small piece of masking tape. The participants were then instructed to stand equidistant from the camera, facing each other, approximately one metre apart and with the piece of masking tape directly between them. The positioning of *uke* and *tori* was decided based on which hand was dominant for *tori*, where a right-handed *tori* stood to the left side in respect of the view from the camera, while a left-handed *tori* stood to the right. *Tori* was instructed to lead every throw with their dominant side, which allowed for the best view of *uke*'s shoulder throughout the throw, especially at the beginning of the throw and at the point of impact of the *uke*'s shoulder on the mat. The participants were instructed to return to this position after each throw. The camera was checked to ensure both participants were clearly within frame. The participants were then allowed to do a few throws as practice, to warm up and get used to the movements of the throws.

Once the recording had begun, one person in the pair was asked to perform the UM throw (Figure 1a) three times on their partner. *Tori* and *uke* then swapped roles and the new *tori* performed the UM throw three times. After this, *tori*

and *uke* swapped roles again and each performed the ISN throw (Figure 1b) three times. Between throws a yardstick was placed vertically at the point of shoulder contact with the floor as a reference during video analysis and participants were allowed as much rest as they required. No restrictions were placed on the throws utilised, in order to record as wide a range of techniques as possible and *tori* was instructed to perform the throw as they would in a tournament setting. This is because throws performed in a tournament setting often vary widely in technique, with huge differences possible in areas such as rotation and depth of the throw. All participants were instructed to perform *ukemi*, which is a breakfall technique, to ensure that participants land safely when making impact with the mat, while also ensuring this variable is controlled. *Tori* was instructed to remain standing after every throw, as long as they felt this was able to be done safely. However, any throw that *tori* themselves deemed to be unsatisfactory, such as those with incorrect technique, was repeated. After both participants in the pair had successfully performed each throw three times, the recording was stopped.

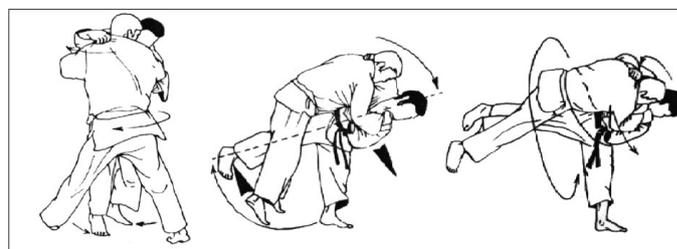
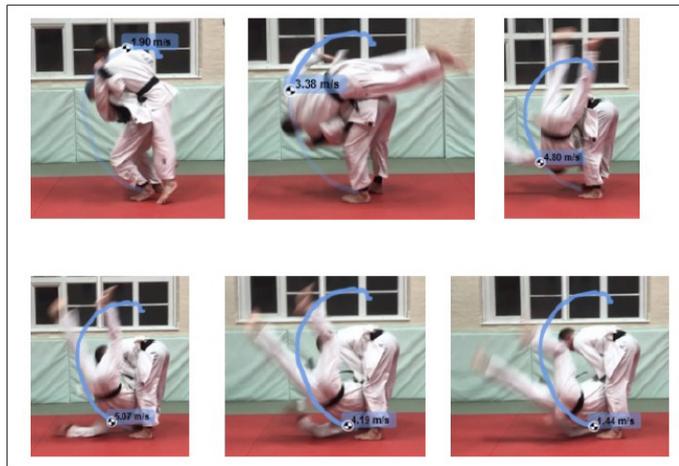


Figure 1a. A demonstration of the *uchi-mata* throw (Hernando, 2012)

### Data Analysis

The video for each throw performed was trimmed for analysis before being uploaded into the Kinovea software (version 0.8.15). The movement of *uke*'s shoulder was tracked frame-by-frame. The yardstick in the recording was then used to calibrate the video, by measuring its length as a number of pixels, using the Kinovea software. This yardstick had a known length of 90cm, so the length of the yardstick in the video was used to calculate the real-life distance that each pixel in the video was equivalent to. This allowed for displacement (distance moved) of *uke*'s shoulder to be calculated objectively. Figure 2 shows a series of screen captures of the Kinovea software being used to track the position of the shoulder frame-by-frame and calculate the speed of *uke*'s shoulder. For each throw, these values for displacement and time were then exported into an Excel spreadsheet. Excel was used to calculate the speed (in ms<sup>-1</sup>) and acceleration (in terms of gravitational acceleration, where *g* is equivalent to 9.81ms<sup>-2</sup>) based on these values of displacement and time. Because of the presence of large and erratic short-term fluctuations, the data for acceleration was smoothed by calculating sliding averages, using 0.1s (3-point average) and 0.167s (5-point average) windows. Smoothing

reduces the presence of these large fluctuations, but also means that some true peaks are removed, so all three levels of smoothing are displayed in the results in order to minimise the loss of data due to over-smoothing. The data for speed was generally smooth and did not, therefore, require further smoothing. Values for peak positive acceleration, peak negative acceleration and peak speed for each throw was then extracted from the raw data in the Excel spreadsheet. This gave a total of 14 variables (raw, 0.1s window and 0.167s window values for peak positive and peak negative acceleration for each throw, along with peak speed for each throw).



**Figure 2. A series of screen captures showing how Kinovea software was used to track uke's shoulder frame-by-frame**

### Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics version 25. Means for the peak positive acceleration, peak negative acceleration and peak speed of each throw were compared using a paired t-test, with a p value of less than 0.05 being statistically significant.

Two-way mixed Intraclass Correlation Coefficient (ICC) with absolute agreement was used to measure the test-retest reliability for all 14 variables extracted from Excel of the three attempts for each throw.  $P < 0.05$  was set as the alpha level of significance and the average mean value was reported. Suggestions for interpretation by Koo et al, in 2016, were used to evaluate the ICC values, with a value above 0.9 being excellent reliability, 0.75-0.9 being good, 0.5-0.75 being moderate and below 0.5, including negative numbers, being poor reliability (Koo & Li, 2016).

## RESULTS

### Participants

10 male and 2 female participants were recruited for the study across the two sessions. Table 2 shows the participants' demographics.

**Table 2. Participants' demographics**

Factor	Mean (range)	Standard Deviation
Age (years)	26.9 (21-42)	6.14
Height (m)	1.75 (1.59-1.90)	0.101
Weight (kg)	80.7 (60-104)	13.2
BMI (kg/m <sup>2</sup> )	26.1 (23.7-28.8)	1.50

### Reliability

The results for ICC for each variable of peak acceleration and peak speed is shown in Table 3. Overall, the reliability for peak positive acceleration was poor to moderate. The reliability for peak negative acceleration was generally good, with three variables being good, one poor, one moderate and one excellent. The reliability for peak speed was excellent for ISN and good for UM.

**Table 3. Intraclass correlation coefficients for all variables of peak positive acceleration, peak negative acceleration and peak speed**

Variable (Peak Acceleration)	Throw	Intraclass Correlation Coefficient
+ve Raw	UM	-0.678
	ISN	0.618
+ve 0.1s	UM	-0.213
	ISN	0.513
+ve 0.167s	UM	0.443
	ISN	0.514
-ve Raw	UM	0.835
	ISN	-0.122
-ve 0.1s	UM	0.921
	ISN	0.685
-ve 0.167s	UM	0.860
	ISN	0.755
Variable (Peak Speed)	Throw	Intraclass Correlation Coefficient
+ve Raw	UM	0.782
	ISN	0.930

Dark green boxes = excellent reliability; light green = good reliability; yellow indicates = moderate reliability; red = poor reliability.

### Peak Acceleration and Peak Speed

36 UM and 36 ISN throws were included in the data analysis, with Table 4a summarising the data for peak positive acceleration, peak negative acceleration and peak speed. As expected, the raw values for peak acceleration were higher than smoothed values.

The results for paired t-tests are summarised in Table 4b and 4c. These revealed there was no significant difference between UM and ISN throws for any of the peak acceleration variables, except for the 0.167s smoothed peak positive acceleration. However, a significant difference

( $p=0.021$ ) was shown between the peak speeds of UM and ISN throws, with ISN having a higher peak speed than UM. The values for peak negative acceleration were significantly higher than corresponding values for peak positive acceleration.

**Table 4a. Descriptive statistics for peak positive acceleration, peak negative acceleration and peak speed for UM and ISN throws**

Variable	Throw	Maximum Peak Acceleration (g)	Minimum Peak Acceleration (g)	Mean Peak Acceleration (g)	± Standard Deviation
+ve Raw	UM	8.75	2.99	5.80	1.60
	ISN	12.06	3.49	5.31	1.64
+ve 0.1s	UM	3.72	1.51	2.42	0.68
	ISN	3.73	1.23	2.24	0.66
+ve 0.167s	UM	2.43	1.05	1.63	0.34
	ISN	2.31	0.95	1.47	0.33
-ve Raw	UM	-12.42	-2.67	-7.08	2.26
	ISN	-10.68	-3.97	-6.88	1.94
-ve 0.1s	UM	-5.49	-1.89	-3.26	0.97
	ISN	-4.87	-1.99	-3.36	0.93
-ve 0.167s	UM	-3.29	-1.38	-2.20	0.46
	ISN	-3.25	-1.41	-2.28	0.54
Variable	Throw	Maximum Peak Speed (ms-1)	Minimum Peak Speed (ms-1)	Mean Peak Speed (ms-1)	± Standard Deviation
+ve Raw	UM	5.70	3.21	4.49	0.66
	ISN	6.50	3.46	4.80	0.73

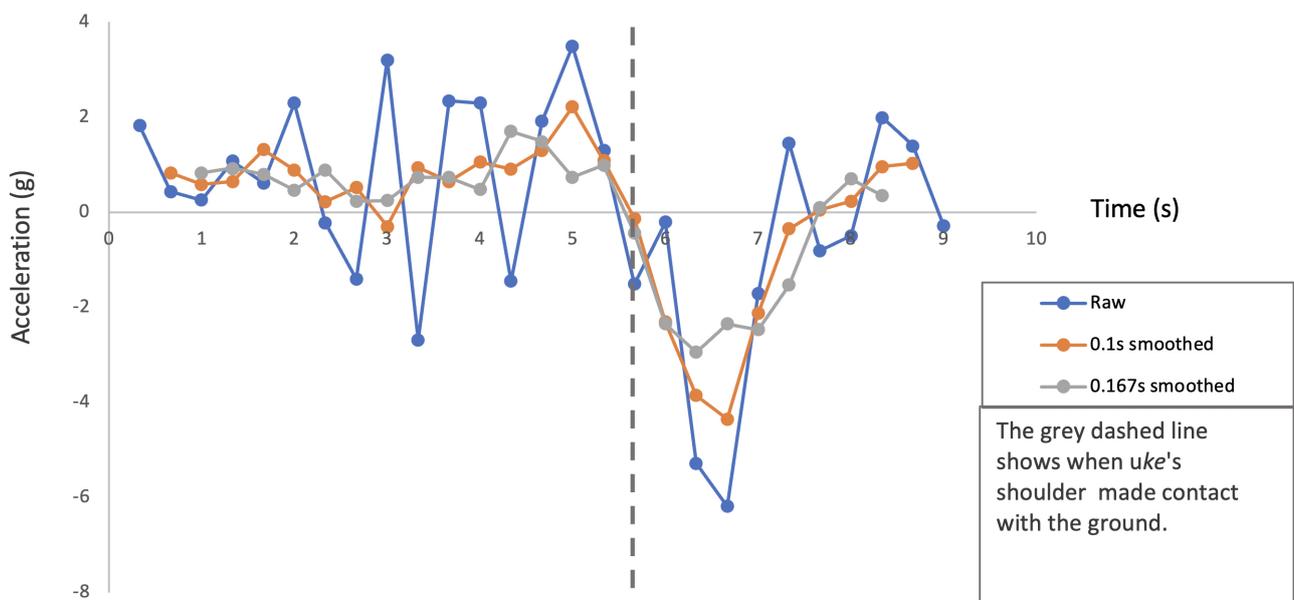
**Table 4b. Paired t-test results comparing peak positive acceleration, peak negative acceleration and peak speed values between UM and ISN throws**

Variable	Throw: Mean Peak Acceleration (g)	Average Difference Between Throws ± SD	t	df	P
+ve Raw	UM: 5.80 ISN: 5.31	-0.49 ± 2.00	1.477	35	0.149
+ve 0.1s	UM: 2.42 ISN: 2.24	0.18 ± 0.95	1.129	35	0.267
+ve 0.167s	UM: 1.63 ISN: 1.47	0.15 ± 0.39	2.420	35	0.021
-ve Raw	UM: -7.08 ISN: -6.88	-0.20 ± 2.23	-0.543	35	0.590
-ve 0.1s	UM: -3.26 ISN: -3.36	0.10 ± 1.06	0.545	35	0.589
-ve 0.167s	UM: -2.20 ISN: -2.28	0.08 ± 0.61	0.741	35	0.463
Variable	Throw: Mean Peak Speed (ms-1)	Average Difference Between Throws ± SD	t	df	P
+ve Raw	UM: 4.49 ISN: 4.80	-0.31 ± 0.76	-2.425	35	0.021



**Table 4c. Paired t-test results comparing the peak positive acceleration with peak negative acceleration for both throws at all levels of smoothing**

Throw: Variable	Positive and Negative Mean Peak Acceleration (g)	Average Difference Between Throws $\pm$ SD	t	df	P
UM: Raw	+ve: 5.80 -ve: 7.08	-1.28 $\pm$ 2.27	-3.379	35	0.002
UM: 0.1s	+ve: 2.42 -ve: 3.26	-0.85 $\pm$ 0.87	-5.871	35	<0.001
UM: 0.167s	+ve: 1.63 -ve: 2.20	-0.57 $\pm$ 0.47	-7.338	35	<0.001
ISN: Raw	+ve: 5.31 -ve: 6.88	-1.57 $\pm$ 2.66	-3.538	35	0.001
ISN: 0.1s	+ve: 2.24 -ve: 3.36	-1.13 $\pm$ 1.08	-6.223	35	<0.001
ISN: 0.167s	+ve: 1.47 -ve: 2.28	-0.80 $\pm$ 0.50	-9.673	35	<0.001



**Figure 3a. Kinematics of ISN throw shown as a graph of acceleration vs. time**

**Kinematics**

Figures 3a and 3b show the kinematics of the same ISN throw as graphs of acceleration vs time and speed vs time, while Figures 3c and 3d show the kinematics of the same UM throw as graphs of acceleration vs. time and speed vs. time. All ISN and UM throws recorded in this study showed similar graphs for acceleration, with generally positive acceleration before impact with the floor, followed by a large negative acceleration peak which then

returned to close to zero as *uke* came to rest. The speed vs time graphs for all recorded throws were also all very similar, with a slowly increasing speed, which peaked within 1 second of impact with the floor, followed by a rapidly reducing speed that returned to close to zero.

The effects of smoothing are also shown in Figure 3a, where large fluctuations are present in the raw results but are reduced as the level of smoothing increased. However, as the level of smoothing increased, the peaks in the graphs also reduced in amplitude.



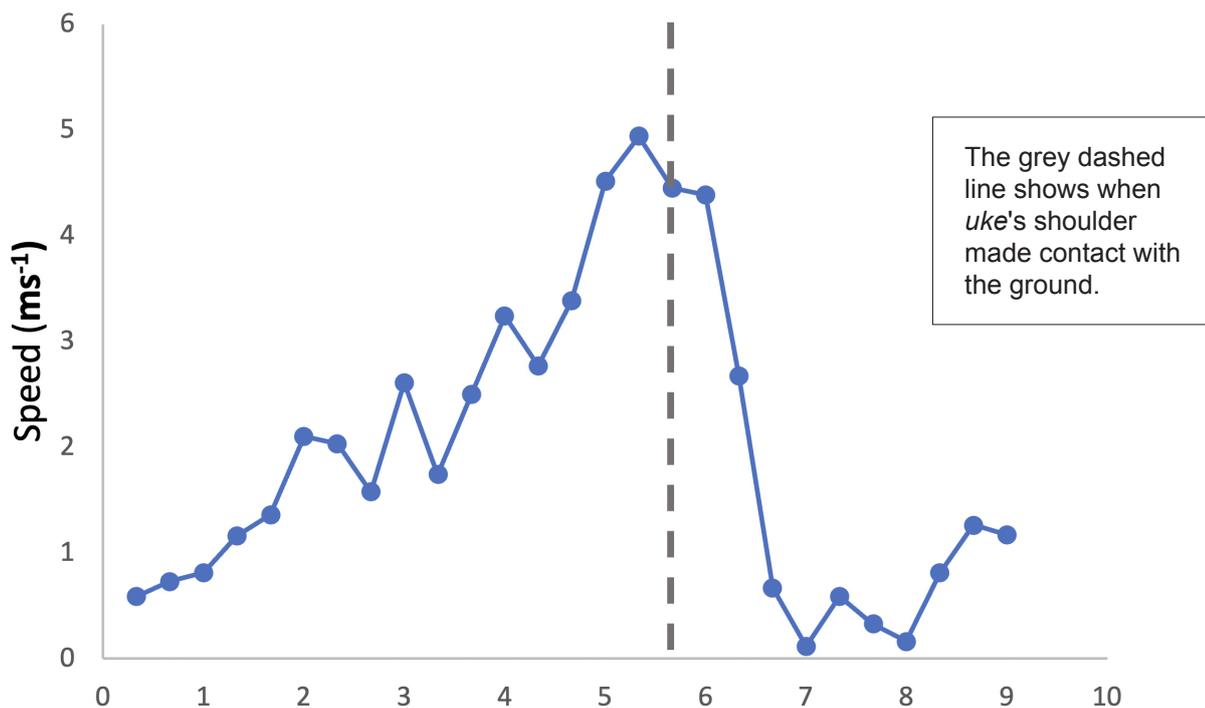


Figure 3b. Kinematics of ISN throw shown as a graph of speed vs time

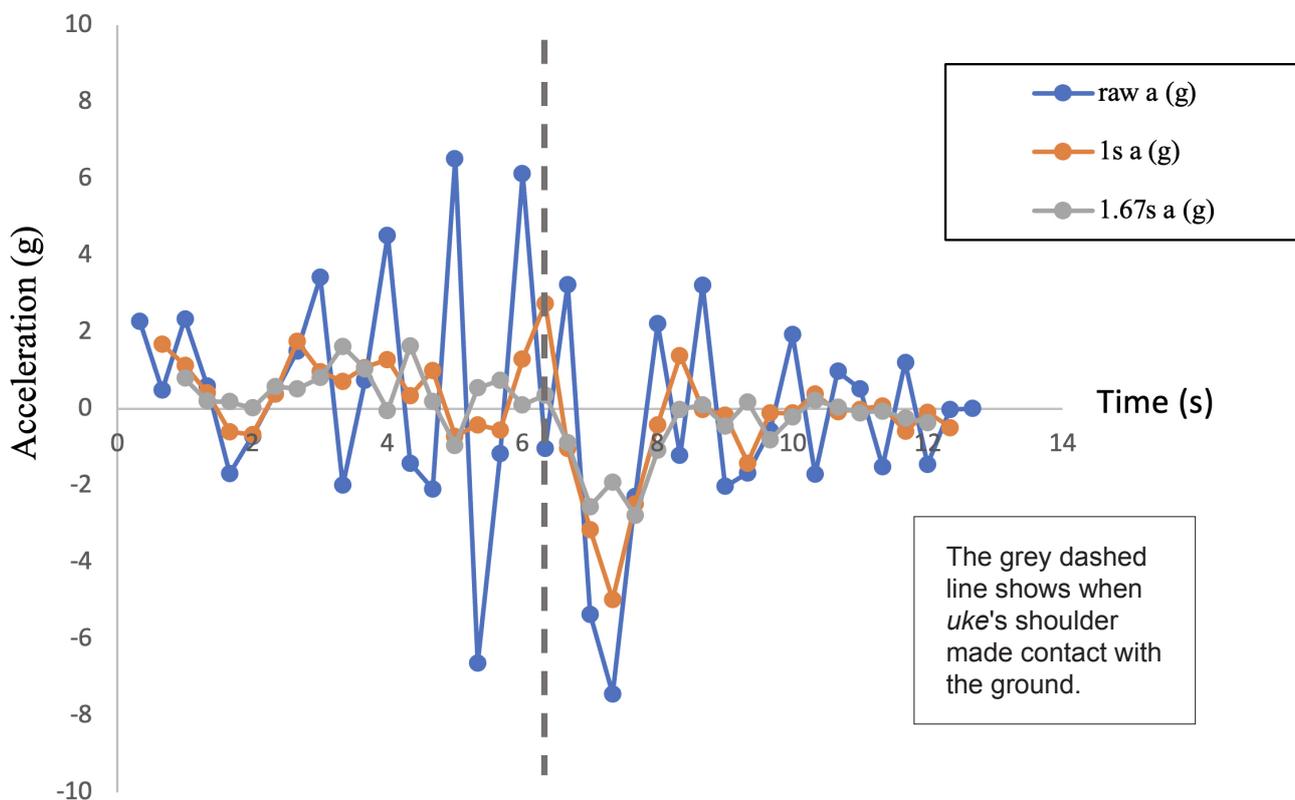


Figure 3c. Kinematics of UM throw shown as a graph of acceleration vs. time

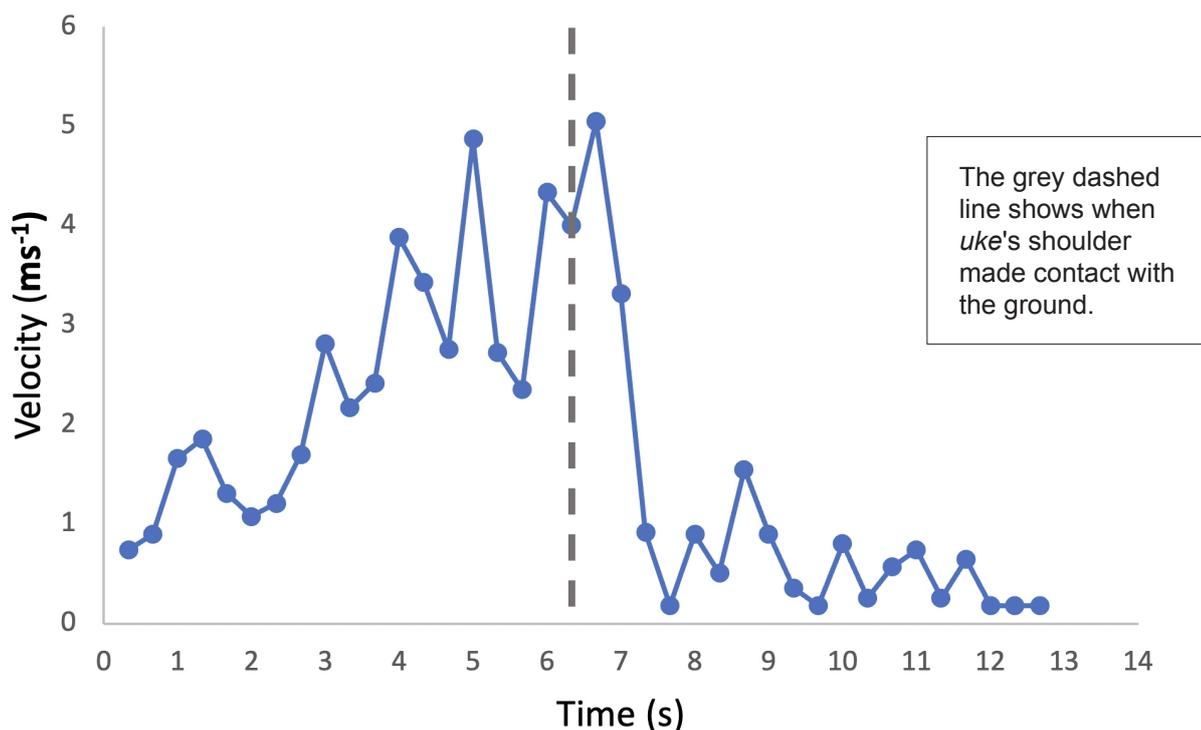


Figure 3d. Kinematics of UM throw shown as a graph of speed vs. time

## DISCUSSION

The three main variables measured in this study (peak positive acceleration, peak negative acceleration and peak speed) were each used to assess one possible mechanism of injury during a judo throw. Peak positive acceleration was used to estimate the G force that *uke's* shoulder experienced during the throwing phase, which can lead to unnatural stretching of the shoulder. Peak negative acceleration was used to give an indication of the maximum force experienced by *uke's* shoulder upon impact with the floor because  $F=ma$  (Force = Mass x Acceleration). Finally, peak speed was used to give an indication of the overall force experienced by *uke's* shoulder across the whole impact (or landing) phase. This is because speed is directly proportional to momentum, when mass is unchanged and change in momentum equals the impulse experienced by the shoulder. Impulse equals the area under the curve of a force vs time graph, so an indication of the overall force experienced by *uke's* shoulder is provided by the magnitude of the impulse (Hsieh & Newell, 2016; Hashimoto, Ishii, Okada, & Itoh, 2015).

The research hypothesis of this study was that one of these three main variables would be higher in ISN than UM throws, in order to explain the increased injury incidence from ISN throws found by Barsottini et al. (2006). The main finding of this study is that the peak speed was shown to be significantly higher in ISN than UM throws, with a p value of 0.021 being calculated from the paired t-test. This suggests that the overall force experienced by

*uke's* shoulder may be the main cause of injury incidence from judo throws. In contrast to this, there was no evidence to show that peak negative acceleration was different between ISN and UM throws and little evidence to show that peak positive acceleration was higher in UM than ISN throws, with only the 0.167s smoothed results being statistically significant.

Another key finding was that the values for peak negative acceleration were considerably higher than peak positive acceleration values for both throws at all levels of smoothing. This indicates that the forces experienced by *uke's* shoulder during the throwing phase are considerably smaller than the forces during the impact phase. Therefore, injuries are much less likely to occur during the throwing phase. This supports the evidence that the most commonly reported injuries in judo competitions are due to high-speed impact with the mat when falling (Voinea, 2015; Elliott, 1972). Therefore, the fact that UM throws showed a higher peak positive acceleration than ISN throws is unlikely to be linked to injury incidence.

The results for peak positive acceleration were also shown to have poor to moderate reliability by the ICC, so these results are not considered as relevant as the peak speed results which had good to excellent reliability. This good to excellent reliability provides further support for the fact that peak speed results showed there was a statistically significant difference between the biomechanics of the ISN and UM throws.

## Future Research

The poor reliability in calculating peak acceleration values in judo throws suggests that further research investigating this may need to use a different methodology, such as using force plates or accelerometers (O'Sullivan et al., 2009; Detanico, Arins, Pupo, & Santos, 2012). However, this equipment is far more expensive and such studies may be more difficult to perform because judoka may be required to visit a laboratory to use this equipment. The use of force plates to investigate judo throws could also provide more accurate force vs time graphs, allowing for increased validity in calculating results of peak force and impulse to support the findings of this study.

In the history of judo as a sport, there have been various throws and techniques that have been deemed too dangerous for competition due to the high risk of permanent injury, including *ashi-garami* and *kawazu-gake* (Kodokan Judo Institute, 2019). These are two throws among those known as *kinshi-waza*, which are forbidden techniques in Kodokan judo competitions, due to being too dangerous (Kodokan Judo Institute, 2019). Specifically, the *ashi-garami* and *kawazu-gake* are thought to be extremely dangerous to the knee. However, there may be some throws in judo that are still legal and have been overlooked despite the high risk of shoulder injuries. As shown by the research performed by Barsottini et al. (2006), shoulder injuries are extremely common in judo competitions and therefore, efforts to reduce shoulder injury should be made. Further research should be performed to investigate whether there are any throws allowed in judo competitions that may cause high risk of injury, especially throws that are rarely used and therefore not commonly noticed to cause injury. However, it must be said that it is also not practical to ban core judo techniques such as ISN and UM, because this will remove aspects of judo that make it a unique sport.

It is also important to consider the fact that the force of the throw is not the only mechanism affecting the risk of shoulder injury. The angle of impact between *uke's* shoulder and the mat, the way *tori* finishes the throw and the use of *ukemi* are further factors that affect injury risk and therefore further research should be conducted around these factors. The high shoulder injury incidence shown in the research performed by Barsottini et al. (2006) also raises the question of whether judo mats are thick enough in competitions. Further research should use force plates to investigate the magnitude of the forces and impulses in different judo throws that commonly result in shoulder injury. Force plates should also be used to investigate how different thicknesses of judo mat are able to dissipate the forces when *uke* lands on their shoulder, in order to show how much difference various thicknesses of mats would make in dissipating impact forces and whether thicker mats would provide a considerable increase in safety in judo competitions.

## Limitations

A possible limitation of this study was the difficulty in locating the acromioclavicular joint accurately during video analysis. Placing a sticker on the judoka to mark the acromioclavicular joint was considered but was not performed. This was because the participants must all wear *judogi* (uniform), because *tori* must grab *uke's judogi* to perform the throw correctly. However, this *judogi* covers the acromioclavicular joint, so the sticker must be stuck onto the *judogi* itself. During the throw, the *judogi* is likely to move around, meaning that the sticker will not show the acromioclavicular joint correctly in the video. Therefore, tracking of the shoulder on Kinovea was judged by eye. This led to the potential for the joint not being tracked accurately and therefore, the calculated values of speed and acceleration being inaccurate. Although Kinovea is a validated tool, 2D video analysis of these judo throws may have limited accuracy when compared to 3D video analysis, due to the involvement of multiplanar movements. Therefore, the results of this study should also be validated using gold standard techniques, including 3D video analysis and the use of force plates in future research.

An iPhone 7 camera was used due to the lack of availability of a higher quality camera. The high-speed motion involved in judo throws and the use of a low-quality camera led to some portions of the videos being blurry and therefore difficult to analyse. This led to the shoulder being less precisely marked and tracked on Kinovea. The study could be improved by using a higher quality camera, able to record at a higher frame rate, since this would lead to less blurry footage. A higher frame rate would also allow for more data points per unit of time, so the raw values for speed and acceleration would be more precise and may require less smoothing (Balsalobre-Fernández et al., 2014).

## CONCLUSION

There was very little evidence to suggest that there is a difference in the positive and negative peak acceleration of UM and ISN throws. However, there is quite strong evidence to show that the peak speed is generally higher in ISN throws than UM throws, suggesting that the impulse may be the cause of the higher injury incidence from ISN throws observed in the study by Barsottini et al. (2006). More research is needed to show whether this increased impulse is indeed the cause of high injury rates, possibly through the use of force plates and whether the thickness of judo mats must be increased to prevent further injuries.

## Acknowledgements

I would like to thank my project supervisors, Dr Nikos Malliaropoulos and Dr Stuart Miller, for their guidance throughout this project. I would also like to thank the Budokwai Judo Club and all the participants of this study, for allowing me to perform this research and volunteering their time.

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### Article history

Received: 30 October 2019

Accepted: 23 June 2021



# Toward an Inclusive and Learning-Friendly Dojo

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**Abstract:** *This research note aims to provide insights into environmental design strategies, based on the field of environmental psychology, to support the design of a learning-friendly dojo. By directing attention to the physical training environment, it is expected that judo managers and instructors can develop environmental competence; the ability to use the physical environment in the most efficient way to obtain desired results. Firstly, this research note proposes the dojo as a learning environment and establishes connections between environmental psychology and the design of an inclusive and learning-friendly dojo. Then, this work focuses on the influence of sensory aspects of the dojo on student learning, demonstrating how sensory inputs from the dojo can favour or inhibit children's learning and development. Finally, this research note closes by listing interventions that judo managers and instructors can apply to optimise the function of the sensory processing system so that students more efficiently integrate the dojo sensory elements in order to organise their own behaviour for the benefit of carrying out the wide range of activities that constitute the judo classes. It is suggested that it is possible to make changes and treatments in the environment to favour equity and the performance of children's activities, optimising their success.*

**Key words:** *judo; environmental psychology; sensory integration; learning-friendly environment*

**J** This research note aims to provide insights into environmental design strategies, based on environmental psychology, to support the planning of a learning-friendly dojo. By directing attention to the physical training environment, it's expected that managers and judo instructors can develop what Steele (1980) called environmental competence: the ability to use the physical environment in the most efficient way to obtain desired results.

## The Dojo as an Inclusive and Learning-Friendly Environment

One of the judo instructor's goals is to be able to create an environment that favours student learning and development (All Japan Judo Federation, 2012, p. 14). To accomplish this goal, managers and judo instructors can take advantage of insights from environmental psychology, the branch of psychology that studies the influence of the environment on the experiences, behaviours and well-being of human beings (Steg et al., 2019). One of the main postulates of environmental psychology states that the environment is capable of constantly influencing the emotional state of individuals (Mostardeiro, 2019, p. 48). Along this line of thought, studies document the effects of the physical environment on children's learning, development and well-being (Lackney, 2004; Evans, 2021; 2006), while a growing body of scholars has been dedicated to designing child-friendly learning environments (Nagib & Williams, 2016; Khare & Mullick, 2009; Mostafa, 2008; Scott, 2009).

According to UNESCO (2015), in short, a "learning-friendly environment" is one in which both students and instructors learn using their full potential, within a safe and

welcoming context. In turn, the concept of "inclusive" means seeking all available means to teach all children, regardless of their circumstances. In this sense, it is possible to make changes and treatments in the environment to favour equity and the performance of children's activities, optimising their success (Cherry, 2012; Kirby et al., 2017; Nagib & Williams, 2016). Since the dojo is a learning environment, in which resources can be used to optimise the teaching and practice of judo, this research note proposes insights to develop environmental competence, taking into account, in a broad way, environmental psychology and more specifically, the concepts of "learning-friendly environments" and "inclusion" (UNESCO, 2015), the "Sequence of Engagement" (SE) (Winfrey & Perry, 2021) and the "Sensory Design Matrix" (SDM) (Mostafa, 2008).

## The Influence of Sensory Aspects of the Dojo on Children's Learning

According to Winfrey & Perry (2021), the brain can be organised into four interconnected areas: brainstem, diencephalon, limbic system and cortex, with information received continuously from within the body and the surrounding environment, that is processed sequentially, starting from the lower parts (brainstem and diencephalon) and then to the limbic system and finally to the cortex.

First there is the reception and processing of sensory inputs in the lower areas of the brain (Winfrey & Perry, 2021), influencing orientation in the environment (Gibson, 1986) and thus interfering with the development of motor skills, in the individual's ability to relate and in the individual's cognitive functions (Winfrey & Perry, 2021). Thus, learning depends on the individual's ability to process and



integrate sensory elements and use them to plan and organise behaviour (Bundy & Lane, 2020, p. 4).

However, an environment can be characterised by an abundance of sensory stimuli, the exposure of which can overload the individual's sensory processing system, contributing to the distorted, confusing, painful or uncomfortable experience of the environment, awakening a sense of insecurity (Porges, 2011) which results in adaptive behaviours that impair learning, such as flight, aggressiveness and the so-called autonomic storm (Caldwell & Horwood, 2008). In this sense, a lower ability to process and integrate sensory elements can result in difficulties in producing appropriate actions, which, in turn, can interfere with behaviour and learning (Bundy & Lane, 2020, p. 4).

The implication is that intervention with the sensory elements of the dojo is fundamental to brainstem regulation, which opens the door to conducting a wide range of activities that involve the function of the upper parts of the brain. In this way, according to SDM (Mostafa, 2008), managers and judo instructors can intentionally modify the sensory aspects of the environment through specific design interventions.

### Interventions Directed to the Sensory Processing System

This research note focuses on intervention with the sensory processing system as a fundamental condition for learning, by favouring the processing and integration of students' senses. The following interventions are a brief synthesis of the works of Horowitz & Röst (2007), Dunlap et al. (2008) and Caldwell & Horwood (2008).

The dojo can be designed to allow for modulation of lighting. In the case of artificial lighting, more diffuse and indirect light points and the use of dimmer switches can be considered. In the case of natural lighting, blinds can be used to soften the entrance of light. Then a spacious, minimalist environment with neutral colours minimises sensory overload.

The dojo's acoustics can be modulated to minimise background noise, echo and reverberation. In addition to defining the location of the dojo itself, the use of sound barriers, sound mufflers and the acoustic characteristics of the finishing and cladding materials can be considered.

The mat area can be located as far away from odours as possible (such as food and strong-smelling hygiene products). The instructor can instruct students to always be clean to inhibit sweat odours and to use hygiene items with the mildest scent possible.

The instructor can pay attention to the ventilation, heating and air conditioning of the environment to favour environmental comfort. Students with allergies can be hy-

persensitive and easily distracted and annoyed by stimuli such as dust. Thus, using washable and easy-to-maintain materials helps to avoid the accumulation of dirt. Then the dojo can favour predictability and accessibility, being organised in such a way as to enable inclusion, equity and also to make clear to all users the behavioural expectations in the environment, enabling the proper use of spaces and helping the users to be located and to behave with maximum autonomy.

Finally, students may be exposed to hazards on and off the mat that must be anticipated. One of the main aspects of safety is a layout that favours supervision and facilitates broad observation by the instructor.

In conclusion, this research note presents insights that can contribute to environmental competence: the most efficient use of the physical environment in order to optimise learning and development through judo.

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# The Origins and Development of Kanō Jigorō's *Jūdō* Philosophies

By Lance Gatling

**Abstract:** *Kanō Jigorō's widely known jūdō philosophy seiryoku zenyō jita kyōei is commonly interpreted as 'best use of energy / mutual benefit,' but there are no known detailed explanations in English or Japanese of the two terms' specific origins. This paper explains Kanō's classic and modern education, his role in producing Japan's first official ethics book, his dissatisfaction with using the traditional jū no ri 'principle of flexibility' to describe jūdō and the historical origins and his development of the terms.*

*Research was performed with primary and secondary Japanese and English sources, primarily Kanō essays, Ministry of Education records and heretofore unknown Imperial Household archives. Chinese texts consulted led to the author's first known English translation of 'The Upper Strategy of The Three Strategies of Huang Shigong' (Pinyin: Huáng Shígōng Sānlüè), one of China's ancient 'Seven Military Classics' and finding the likely Confucian origin of the term dō of jūdō; Japanese sources indicated jū was first adopted by jūjutsu schools during Japan's Tokugawa era (1603-1867).*

*The research cited supports the conclusion that Kanō's jūdō philosophy elements were derived from 19th century English Utilitarianism and the follow-on philosophy of energism.*

**Keywords:** *Kano Jigoro; seiryoku zenyo jita kyoei; judo; ju no ri; utilitarianism; Confucianism; Daoism*

**M**artial arts have long sought to establish legitimacy or enhance their status through attendant philosophies, which can be motivators for recruiting and incentives for expanded studies and scholarship.

A number of schools have distinct, clear connections to an integral, established philosophy, such as China's *Shaolin Kungfu* and Japan's *Shorinji Kempō*, both developed by and closely related to legitimate *Ch'an* (Japanese: *Zen*) Buddhist sects. (Green and Svinth, 2010). Others seek to establish a heritage of philosophy through claims to vague snippets of Buddhist or Shinto texts somehow related to the school or one of its leaders. Finally, some are simply contrived, such as the claimed *Zen* philosophical roots of *kyūdō* Japanese archery (Herrigel: 1948), later debunked as baseless. Despite its highly dubious claims, Herrigel's popular *Zen* in the *Art of Archery* has had a tremendous impact, as many archery practitioners cite interest in spiritual development, *Zen* and motivation by Herrigel's book as decisive factors in their choice of martial art (Yamada, 2001), demonstrating the persuasive influence of such aspirations to a higher calling.

So, how about *jūdō*? Even though Kanō Jigorō (1860-1938), the founder of *jūdō*, propounded a very specific philosophy, today it is not well understood. This is not from a lack of material, as Kanō explicated it in detail over many years, through essays, interviews and speeches but today questions remain regarding exactly what Kanō meant by *seiryoku zenyō jita kyōei*, its final, shortest form.



Authors' affiliation: *The Kanō Chronicles*

In an attempt to fill this vacuum and reintroduce an understandable ethics and morality to postwar sport judo, the French Judo Federation created its own 'judo moral code' and recently the International Judo Federation adopted an English version of it. (Brousse, 2021) These invented traditions were apparent attempts to reintroduce a *jūdō* philosophy as the original seemed lost after World War II.

Post-World War II the priority for Japan's *jūdō* leadership was to have it accepted again into the completely revamped Japanese education system, which would not only help to provide employment for the thousands of *jūdō sensei* unemployed as a result of the occupation's *budō* ban but would also reestablish *jūdō* in Japanese culture, but post-war that meant a new focus on equality and democratisation, not traditional *jūdō* philosophy. Post-war Kodokan publications left out the detailed explanations and examples of *jūdō* philosophy in action, that Kanō had repeated time and again. Also, post-war, many Japanese people did not want their children to be lectured to about ethics and philosophy by *būdō* martial arts instructors, all too often men who had been enthusiastic supporters of the wartime militarist regime (Gatling, 2021). After some years the explanations of *jūdō* philosophy were increasingly brief and cryptic, primarily repeating the final form without explanation, as the apparently few people who actually understood its details and background faded away:

*Seiryoku zenyō / jita kyōei*: most efficient use of energy / mutual benefit.

But what do these two terms really mean?

More importantly, could understanding their detailed origins and meaning enhance the status of *jūdō* or provide a better understanding of Kanō's *jūdō* itself?

Finally, could a correctly explained *jūdō* philosophy be attractive to potential new students as a recruiting and retention asset and be more interesting to *jūdō* scholars?

These questions and more perhaps make understanding *jūdō* philosophy more important today than ever.

## Kanō's *Jūdō* Philosophy

In 1915, in the new *Jūdō* magazine, Kanō *shihan* (master) wrote that "*Jūdō is the way to the most effective use of body and spirit*" in a series of articles entitled 'Outline of Kodokan *Jūdō*.'

From 1920, when he retired from a career of nearly 40 years as one of Japan's premier educators, in hundreds of speeches and writings, including numerous calligraphies, Kanō referred to the two phrases of *jūdō* philosophy in several different forms. Their final, shortest form, well known to *jūdōka* worldwide today, reads:

精力善用・自他共栄

精力善用 自他共栄

Various Westerners have given different translations, but the last known translation given by Kanō himself while giving a lecture in English in the United States is:

Maximum efficiency and mutual welfare and benefit (Kanō, 1932)

Kanō himself wrote cryptically and briefly that he did not in fact create those specific concepts but rather that they were the brainchild of other Japanese people; however, he also never seemed to specify their sources and apparently no prior research has identified their specific Western or Eastern sources. For over 20 years the author collected and researched original pre-World War II Japanese, ancient Chinese sources, heretofore unknown Meiji era Imperial records as well as contemporary commentaries in Japanese and English to develop possible answers.

*Seiryoku* is the term for energy, force or power, while *zenyō* is taken simply to mean best or utmost use. The term *jita kyōei* 'Mutual welfare and benefit' is apparently original to Kanō. Today, taken together, it is usually thought to mean that if you use your energy efficiently, both you and your *jūdō* opponent will best benefit, presumably through learning the best *jūdō*, getting the best physical workout, etc. So far, so good but this understanding does not serve to illustrate what Kanō meant when he so often said that *seiryoku zenyō / jita kyōei* also applied to life outside the *dōjō* (martial arts place of practice), on the interpersonal basis and even at the level of societies and nations.

To understand the background, it is necessary to go back even earlier, first to the ancient fundamental principles underlying *jūjutsu* as well as Kanō's education and professional life.

## *Jū no Ri*: the Principle of *Jū* (Suppleness / Flexibility / Gentleness) 柔の理

The group of martial arts known today as *jūjutsu*, literally 'gentle technique,' was developed in Japan as early as the 16th century but the earliest remaining schools, developed before the Tokugawa era (1603 to 1867), including Takeuchi *Ryū* (school) and Araki *Ryū* did not use the term *jū* at all, but used a number of other terms: *kogusoku* (light armor), *kumiuchi* (grappling), *taijutsu* (body technique), etc. Only during the Tokugawa era did schools such as the Sekiguchi *Ryū* begin to use the term *jūjutsu*, thought to be at least in some part due to the increased influence of neo-Confucian thought (Sakuraba, 1935), which became the approved, orthodox philosophy of the Tokugawa *bakufu* military government.

Orthodox neo-Confucianism in Japan included a sign



ficant appreciation of Daoist elements, which was also known and studied separately in Japan and was included in the Chinese classics Kanō studied from his youth. Sometimes called the ‘Watercourse Way,’ Daoism emphasises yielding before strength and not fighting directly against strength (Makeham, 2010). *Jū* is the character for gentleness / suppleness / softness; it is read *jū* in compound words or *yawara* as a single-character word. In 1888, in the earliest description of *jūdō* in English, Kanō described *jūjutsu* as the art of winning by yielding, by being pliant when attacked with strength and direct power. (Lindsay and Kanō, 1888) Over time he called his art *jūdō*, the way of yielding or pliancy, with “the meaning of the way being the concept of life itself,” (Kanō, 1932), disclosing his intent to make his new style *jūjutsu* a purposeful teaching vehicle for life skills.

*Jū no ri*, the principle of flexibility, is Kanō’s formulation of a Daoist concept, stressing pliancy and flexibility. The *dō* of *jūdō*, the way or path, is not Daoist (even though *dao* is Chinese for way). Instead, it is clear that the *dō* of Kanō’s *jūdō* is more consistent with the Confucian concept of *dō*, the way as a path to an ethical, political and civilised order. (Rainey, 2010) Kanō’s way is prescriptive of how individuals attain self-perfection through cultivation of the discipline, knowledge, morality and physical ability to engage the world as better people. The Daoist way is sometimes called the ‘watercourse way’ because under its teachings, enlightened humans seek to understand and to conform to the way of nature, not to struggle against it; in Kanō’s way, humans seek self-cultivation to better the world, as noted in his description of the ultimate goal of *jūdō*:

“*Jiko o kansei shi (perfect one’s self), yo o hoeki suru (to benefit the world)*”

(Kanō Sensei Denki Hensan Kai, 1964).

One could argue that other elements used to describe *jūdō* are also consistent with other Daoist concepts: use of intuition, winning by yielding before power and the importance of calmness and patience. Some *jūdōka* and observers, notably Katsu Kaishū (1823-1899) in the famous poem he wrote to memorialise Kanō’s performance of *Koshiki-no-kata*, go beyond, to cite the mysterious and abstruse 妙 *myō* (Chinese: *miao*) aspects of superb *jūdō* techniques (Sanada, 2018). Kanō does not appear to refer to such esoteric concepts but rather restricts himself to more concrete, scientific explanations. In Kanō’s *jūdō* there were no secrets, no esoteric teachings for select adherents. He tried to make the techniques to master *jūdō* and its philosophies explicit, even to the point of significant repetition (Gatling, 2021).

The semi-legendary origin of the term *jū*, describing the *jūjutsu* and *jūdō* philosophy of flexibility and pliancy against hardness and strength, is found in an ancient Chinese military text, *the Three Strategies of Huang Shigong*, 黄石公三略 (Chinese: *Huáng Shígōng Sānlüè*), one of China’s Seven Military Classics. It is thought to date from around 200 BCE to 0 CE and consists of three

parts: the Upper, Middle and Lower Strategies. The Upper Strategy, considered the most important, was claimed in the text as not original to Huang but to actually be a recitation of an even more ancient Chinese text, the apocryphal Military Prophecies. It provides strategies of how to deal with people successfully, rulers to subordinates, commanders to soldiers and its concepts draw on a combination of ancient Daoist, Confucian and Legalist ideas.



A 17th century Japanese copy of *The Three Strategies of Huáng Shígōng* 黄石公三略

The first portion of the Upper Strategy translated into English reads:

軍讖曰 柔能制剛 弱能制強  
The Military Prophecies cites: Flexibility controls hardness, weakness controls strength.

柔者德也 剛者賊也  
弱者人之所助 強者怨之所攻  
The flexible have virtues, the unyielding have faults. The weak attract assistance, the strong attract opposition.

柔有所設 剛有所施 弱有所用 強有所加  
At times be flexible, at times apply hardness, at times use weakness, at times add strength.

兼此四者 而制其宜  
One using all four will then prevail. (Huang, 1604. English translation ©2020 Lance Gatling)

### *Jūdō*’s Earliest Definition

Kanō’s earliest known extended writing on *jūdō*, an 1888 lecture in English explaining *jūdō* to the almost entirely western audience of a meeting of the Asiatic Society of Japan, explained *jūjutsu* as “the art of gaining victory by yielding or pliancy” (Lindsay and Kano, 1888), using the classic Daoist explanation of the use of *jū* by the individual *jūjutsuka* practitioner from *The Three Strategies*. The lecture listed the principles of *jūjutsu* as:

1. Not to resist an opponent, but to gain victory by pliancy.
2. Not to aim at frequent victory.
3. Not to be led into scolding (bickering) by keeping the mind (empty) composed and calm.



4. Not to be disturbed by things.
  5. Not to be agitated under any emergency but to be tranquil.
- For all these, rules for respiration are considered important, (Lindsay and Kano, 1888).

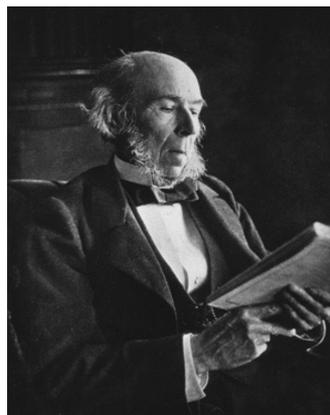
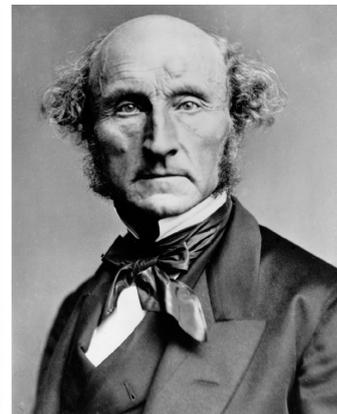
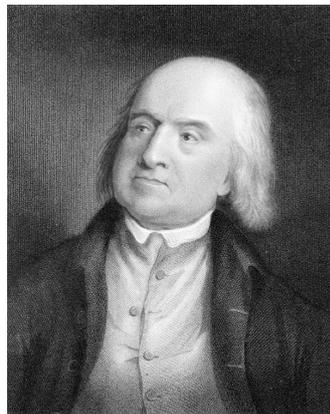
Their lecture described *jūdō* as an eclectic school of *jūjutsu*, developed into a “system of athletics and mental and moral training” which investigates “the laws by which one may gain by yielding, practice is made subservient to the theory, although when studied as a system of athletics, practice plays a more important part” (Lindsay and Kano, 1888). This provided a glimpse of the early duality of the Kodokan: students interested in learning signed the oath of the Kodokan and studied the theory and laws “by which one may gain by yielding,” namely *jū no ri*, presumably through *kata* and experimentation, while others, not sworn in as Kodokan members, focused on practical, physical practice and studied *jūdō* as a *bugei taisō* martial technique gymnastics, (Motohashi, 2019).

During their lecture, neither Kanō nor Lindsay specified which moral training was used and made no claims on higher philosophy. Tantalisingly, they state that another paper would be submitted to explain the mental and moral aspects of *jūdō*. Although such a paper was submitted by Kanō about 30 years later, the Society did not publish it. The author located a copy of the paper and will explain in another manuscript, (Gatling, 2021).

## Kanō’s Education Spanned 2500 Years of Chinese and Western Philosophy

To better understand Kanō’s mindset and the origin of his *jūdō* philosophy, it is useful to review his education and his approach to philosophy and ethics.

Kanō began studying the Chinese classic Confucian philosophical and military strategy texts at age seven and continued his interest in Confucian studies throughout his life. After studying English in Tokyo private schools and the government’s official English school, during which time he continued his Confucian studies in Chinese at the forerunner of today’s Nishōgakusha University, Kanō entered Tokyo University, studying political economy. Graduating with its second class in 1881, he then entered a one-year graduate programme in philosophy, finishing in 1882. For four of those five years Kanō studied in small classes with *oyatoi* “honourable hired specialist” American Ernest Fenollosa (1853-1908), who arrived in Japan in 1878. Fenollosa taught philosophy and political economy from popular English language western philosophy texts of the day, drawing heavily on the works of English Utilitarian philosophers John Stuart Mill, Jeremy Bentham and Herbert Spencer (1820-1903).



**Top (L-R): English Utilitarians Jeremy Bentham and John Stuart Mill - Bottom (L-R): Herbert Spencer, and American Ernest Fenollosa (Wiki), Tokyo University oyatoi and Kanō mentor**

Spencer was so popular in Japan that the 1870s to 1880s were described as a ‘Spencer Boom’ as his ideas informed a range of discussions among the elite planning and creating the new Japan. (Godart, 2016). In fact, one of the first publications of the new Tokyo University in 1877 was an English reprint of Spencer’s influential ‘Philosophy of Style: An Essay’ (Spencer, 1877). Kanō and his classmates studied Spencer’s original works in English but almost all were eventually translated into Japanese.

Minds across the world in those years struggled to incorporate new scientific knowledge into philosophy. In particular the First Law of Thermodynamics, also known as the Law of Conservation of Energy, which states that energy cannot be created or destroyed in an isolated system, created a surge of efforts to accommodate it both in science and philosophy.

Although largely overlooked today, Spencer introduced his notions regarding energy in ‘First Principles of a New System of Philosophy.’ Spencer sought to unify science, religion, and philosophy in one ‘Synthetic Philosophy.’ Its first principle was ‘Persistence of Force;’ as Spencer was unsatisfied with the term ‘conservation of energy’



and so he adopted his own version of that term (Spencer, 1857). With this new, comprehensive philosophy, Spencer sought to build on the works of Newton, Kant and Laplace and “combining this with the doctrine of the Persistence of Force, was led to discover the law of the entire cosmical process from star to soul” (Macpherson, 1901, p.58), as one admirer assessed his universal, monistic philosophy.

Spencer saw the balance between *egotism* and *altruism*, the inherent tensions between individual self-interest, egoism, versus consideration of group interests, altruism, as the fundamental driving mechanism not only of individuals but of all societies and even international relationships, a concept Kanō helped make a key concept in Japan’s first official ethics textbook.

Spencer’s other contributions included developing the concept of Social Darwinism; indeed, he coined the phrase ‘survival of the fittest,’ which is often mistakenly thought to be from Darwin himself. Spencer applied the notion to societies and nations, in which strong societies progress by taking advantage of weaker ones. This concept was so widely discussed in Japan that it later became a common reference for western critics of the expansionist, colonising Imperial Japan, who accused it of using Social Darwinism to justify its military adventures against weaker neighbours (Godart, 2016).

## Kanō and Japan’s First Ethics Manual: The *Rinrishi* 倫理書 (1888)

After the 1858 Meiji Restoration, official Japan abandoned the ancient neo-Confucian ethics that guided the Tokugawa regime for almost 300 years. While the early Meiji Japan education system used western texts for science, medical and engineering references, ethics simply were not addressed. The new education system was focused on the rapid integration of the knowledge, technology and culture of advanced western countries, so education stressed individual effort and objective knowledge (Saito, 2004). Which ethics and moral instruction to teach or even whether to teach them at all was left up to individual schools’ discretion. The lack of a standard created problems when students from various backgrounds came together in higher education situations, bringing ethical and moral notions ranging from traditional Confucianism to the latest western thought to none whatsoever.

Japan’s first Minister of Education, Mori Arinori was a Satsuma samurai who spent much of his life overseas in the US and England, first as a student and then as a diplomat. In the US he researched constantly, including studying and discussing the works of Spencer. When he moved to London he sought out and became personally acquainted with Spencer himself. The two men discussed a range of issues from ethics to Japan’s draft constitution and Spencer continued corresponding with Japanese people linked to the government for years thereafter.

In his earlier role as the Education Magistrate after the Restoration, Mori had countered attempts to insert traditional Confucian measures into Japan’s ethics education system. He also pursued education reforms that forced austerity measures on schools, students into dormitories and from 1886, dictated military style physical education and discipline in the normal school (i.e., teacher’s education) system, largely in accordance with Spencer’s ‘Education: Intellectual, Moral and Physical’ (Spencer, 1861). The Spencerian concept that complete education must encompass those three aspects became so entrenched in Japanese education that the term coined to describe it, *san iku shugi*, the three educations-ism, survives in Japan even today.

Kanō adopted these three aspects as standard elements for his philosophy of education, as did Japan’s Ministry of Education. Even into the 21st century, one hundred and sixty years later, Japan’s Ministry of Education, Science and Technology (MEXT) cites the importance of a balance between what it terms the Cognitive, Affective and Psychomotor Domains, using modern terms while including the characters 知徳体 *chi, toku, tai*: knowledge, virtue, body, as adopted in the 19th century as reference (Japan Ministry of Education, Science and Technology, 2020).

Shortly before Mori was named Minister of Education in Japan’s first cabinet, a Ministry top bureaucrat ordered the adoption of a Confucian-based ethics training programme but Mori immediately cancelled the programme (Abe, 1969) as he was firmly against incorporating any religious or traditional philosophies, including Confucianism, into Japan’s new ethical system. To address the void, to assemble modern Japan’s first official ethics textbook, he established a compilation and editorial committee consisting of:

- Nishimura Shigeki: former Samurai, educator, staunch Imperialist
- Nose Sakae: academic, Ministry of Education assistant to Mori Arinori
- Walter Denning: former English missionary, English teacher, scholar
- Suga Ryōhō: Buddhist priest cum academic, studied education in Europe
- Kanō Jigorō: then vice principal and lecturer at the Imperial Household Agency’s Gakushūin Peers’ School, seconded to the Ministry of Education for the project (Lin, 2012)

At the time Kanō was a member of the *Tetsugakkai* Philosophic Academy, Japan’s first philosophy organisation. In early 1887, around the time of his *jūjutsu / jūdō* lecture to the Asiatic Society of Japan, the Academy’s magazine published a long, detailed, two-part essay by Kanō, entitled ‘Discussing Utilitarianism,’ in which he compared and contrasted Utilitarian philosophers Gregory Bentham and John Stuart Mill and introduced Spencer’s contributions to the field (Kanō, 1887), perhaps the first comprehensive presentation on Utilitarianism in Japanese and 26 year old Kanō’s first known published writing.



(L-R) Minister of Education Mori Arinori, Kanō Jigorō, c1888, year of *Rinrishi* publication (Wiki)

Nose Sakae was the Ministry's bureaucrat inside the committee. He was essentially Mori's assistant and right-hand man and years later Kanō credited him for the committee's success. Mori's original notion was to produce a detailed, 500-page guide for teachers on how to implement ethics training, but the text, finally published in October 1888, titled *Rinrishi: Chūgakkō Shihan Gakkō Kyōka Yō Sho* (Ethics Text: A Textbook for the Use of Middle and Normal Schools), was a mere 86 pages long. By design it adhered strictly to Spencer's Principles of Ethics, which had been translated into Japanese in 1883; it even contained a section labelled 'Standards of Conduct,' with a subsection entitled 自他並立 *Jita heiritsu* (self and others standing side by side), a novel Japanese term coined for the *Rinrishi*, but subtitled in English 'The Cooperation of Self and Others,' taken from Spencer's exact language in his 'Principles of Ethics' and incorporating Spencer's notion of compromising egoism against altruism to mutual benefit (Lin and Lu, 2020).



Japan's first ethics manual: *Rinrishi* 倫理書 1888

Years later, Denning described the *Rinrishi* in detail in a speech to an assembly of the Asiatic Society of Japan:

*"This work declares the ultimate end of man to be conformity to reason and perfection and the standard of conduct to be followed in endeavouring to attain to this end is said to be the co-ordination of the ego and the alter. Readers of Mr. Spencer's Data of Ethics will remember how clearly, he shows that pure egoism and pure altruism are alike illegitimate; that the maxim 'Live for Self' and the maxim 'Live for Others' are both wrong; that a compromise is the only practicable course. Viscount Mori was an intimate friend and a great admirer of Herbert Spencer, and I have the best authority for stating that the Standard of Ethics adopted by the late Minister of Education as intended to be in entire accordance with Spencerian philosophic principles. Consequently, I am not inclined to attach too much importance to the Chinese term jita-heiritsu. Spencer distinctly says that while egoism and altruism are to a large extent interdependent there are times when they are in direct opposition to each other, when one or the other has to be exclusively followed..."* (Denning, 1913).

Denning then outlined the key nature of Spencer's 'Cooperation of Self and Others' that the *Rinrishi* adopted as *Jita heiritsu*, literally, I and others standing abreast, but Denning disregarded what he calls 'the Chinese term' (i.e., *jita heiritsu*, the novel Japanese term using Chinese characters) in favour of the original English. He cited its centrality in Spencer's philosophy and demonstrated that the members of the *Rinrishi* committee fully understood and discussed it in detail. Spencer believed that the co-existence or co-equality of egoism and altruism were critical to the advancement of humankind. According to Spencer, this balance of interests was the process through which cultures and nations progress, working together, in balance to varying degrees, or in extreme cases in complete opposition.

Denning goes further, translating a portion of the *Rinrishi*:

*"It is in the relation of the ego to the non-ego that has brought the ethical world into existence and in proportion to the degree of nicety with which this relationship is adjusted do nations make moral progress."* (Denning, 1913)

Then he continued in his own words:

*"It will be seen, then, that the standard determined on is practically Utilitarian in character. The highest interests of mankind constitute the Ultimate End and this end is to be reached by the maintenance of the mutual relationship of the individual and society on lines that yield the largest amount of attainable happiness to each. This is the essence of Utilitarianism and this was the main principle of Japan's Ministry of Education official ethics in Mori's time and for some years subsequent to his assassination (February 11, 1889)",* (Denning, 1913).



## Kanō's Philosophy of Spencer's 'Cooperation of Self and Others:' *Jita Kyōei* 自他共栄

When the Kodokan's official Kanō biography, *Kanō Jigorō*, was compiled in the early 1960s, Dr. Morohashi Tetsuji (1883-1982) was one of the editors. Morohashi graduated from Kanō's Tokyo Higher Normal School in 1908 and then Kanō funded his nearly two-year-long research trip to China, 1917-1919, that started Morohashi's long career as a Sinologist. For years he contributed essays on the appreciation of classic Chinese poetry to *Jūdō* magazine and the men remained close for nearly 40 years.

As a trusted associate of Kanō *shihan*, Dr. Morohashi was entrusted with broad access to Kanō's private papers. In fact, he was one of few scholars in Kodokan circles who had the education and experience to explain the development, intricacies and significance of Kanō's philosophy in any language; by the 1960s, the classically educated, nearly 80-year old Morohashi was likely the sole member of the editorial group that could fully understand Kanō's near hundred year old essays, the earliest written in Sino-Japanese, a thousand-year-old writing style long abandoned and his references to 2500-year-old Chinese philosophy and texts. The biography, in a portion almost certainly influenced by Morohashi, simply noted that *Jita kyōei* was Kanō's version of *Jita heiritsu* without referring to the term's origin or citing Kanō's role in the *Rinri-sho* ethics textbook compilation committee (Kanō Sensei Denki Hensan Kai, 1964).

Spencer's 'Cooperation of Self and Others' that the *Rinri-sho* adopted as *Jita heiritsu* is clearly the source of Kanō's *Jita kyōei*, 'Mutual benefit.' While he credited the words to another unspecified Japanese writer, its origin was Spencer's writing. The Japanese intermediary who coined the term *jita heiritsu* was likely either Mori or his associate Sakae, who wrote much of the content of the *Rinri-sho*. Kanō adopted it as a universal moral standard, a monism that can be applied to all human affairs, from a solitary man to society to nations and international affairs. This was not at all incidental to *jūdō*; while the practice was abandoned after his death and the occupation of Japan after World War II, early observers noted that up to half of *jūdō* instruction was lectures by Kanō on ethics, morality and health.

Kanō wrote a number of times about 共栄 *kyōei*, mutual prosperity, noting that he got many questions about the term 栄 *sakaeru*, 'to prosper' and that most people didn't understand the word. Some people only had a superficial understanding of it, thinking only of physical pleasures or material plenty, not the deeper meaning of prosperity. Finally, he wrote that, to him, prosperity meant satisfying a rational need, not more (Kanō, 1933). This is a departure from classic Utilitarianism, which places no such restraint on pleasures or materialism and can be accused of leading to hedonism.

## Kanō's Energism Philosophy: Seiryoku Zenyō 精力善用

After retiring in January 1920, Kanō toured Europe and the United States for eight months. Returning to Tokyo, he announced two decisions:

- Japan needed to ensure its people were of the best possible quality to deal with numerous stronger foreign countries, even though he termed them 'splendid,' noting that they now were competing with nations worldwide.
- With Japan limited in resources such as iron ore and farmland, its human capital must improve to benefit society at large.

Kanō summed up the problems. "*Along with our country having scarce resources as sources of wealth, the day will come when the people are unprepared*" (Kanō Sensei Denki Hensan Kai, 1964, p.494). So, he became even more determined to use *jūdō* instruction to teach the proper way of life, to prepare the people by teaching the most efficient use of mind and body.

Spencer had also noted that energy is critical to any development, that intellect without the energy to pursue a conclusion is pointless, that energy drives the development of individuals and societies and that proper physical education is necessary to cultivate individual energy. Kanō adopted these ideas, stressing the need for physical education to cultivate the physical and mental strength to be productive humans.

*Jūdō* techniques are, optimally, based on flexibility and movement to avoid force against force confrontations when possible, so Kanō would also have had great interest in Spencer's discussions of the role of energy or force, a seemingly Daoist concept with a semi-scientific approach, describing what today would be called force vectors:

"Where repulsive forces alone are concerned, or rather are alone appreciable, movement takes place along their resultant, which is usually known as the line of least resistance. And where both attractive and repulsive forces are concerned, or are appreciable, movement takes place along the resultant of all the tractions and resistances" (Spencer, 1857, p.270).

Perhaps the greatest proponent of the philosophy of energism was the German Nobel Prize-winning physical chemist Wilhelm Ostwald (1853-1932), who became embroiled in the monumental controversies regarding the existence or non-existence of the atom. Ostwald supported the primacy of the theory of energy over the theory of the atom, *energism* versus *atomism*, and eventually became the former's foremost proponent. Ostwald was known worldwide for his pioneering work in physical chemistry, for which he won the Nobel Prize in 1909. He was also well known among the first Japanese chemists; many of Japan's earliest chemists studied in Germany, a number under Ostwald himself. His theories were famous worldwide and his works translated into Japanese.

Ostwald introduced his Energism (German: Energetik) energy theory in 1887 at the University of Leipzig and spoke about it throughout Germany and Europe. Indeed, it is quite possible that Kanō first heard of energism during his first visit to Europe (1889-1891), of which he spent many of the early days in Germany, then travelled throughout Europe, surveying European education systems as a functionary of the Imperial Household Agency, reporting back to the Emperor Meiji himself upon his return. (Imperial Household Agency, 1891)

Kanō's earliest known formal address to include *seiryoku* energy was an 1892 lecture he gave while the principal of the Fifth High School in Kumamoto. In it, he introduced the notion of a broad universal energy and then dwelt at length on the necessity to cultivate energy through bodily strength and mental fortitude, required to be efficient and effective, giving numerous examples and discussing the roles of exercise, rest and nutrition and individual will. (Kanō, 1892)

Nearly three decades after after the 1867 Meiji Restoration, the abolition of the *han* fiefdoms and the subsequent collapse of traditional *bujutsu* martial arts, supported almost entirely by the *daimyo* feudal lords, during the first Sino-Japanese War (1894-1895). Kanō and other martial arts teachers were flooded with applicants eager to practise *jūdō* and *gekiken* Japanese fencing, as lurid newspapers around the country stoked war fever and touted the virtues of native martial arts as manly, warlike and patriotic. The monthly magazine *Kokushi* ('Patriot' or 'Nationalist' - October 1898 to December 1903), published by Kanō's *Zōshikai* Gentleman-making Association and edited by Kanō himself was a reaction to the greatly increased interest in *budō* and Kanō's interest in using *jūdō* to teach greater patriotic, nationalist, ethical and moral lessons. (Gatling, 2021)

In 1899, Kanō's subordinate, Tokyo Higher Normal School chemistry professor and *kyūdōka* archer Sakurai Toranosuke wrote in *Kokushi* of the "way of the use of energy" as a bridge between the practical world of physics and human society. As a chemist, he was certainly aware of Ostwald's energism theory and in fact indirectly referred to it in his explanation of research into energy and energie, the respective English and German terms. Like Kanō in his Kumamoto speech seven years before, Sakurai divided energy into two classes: the natural energy of the universe and personal human energy, the motive power of mind and body. He cited the benefits of increased understanding and use of energy on society but noted that it made society much more complicated. He also cited the importance of cultivating and conserving energy and not wasting it, standard fare in energism.

Sakurai noted that the most influential, important knowledge regarding universal energy (including the identification and utilisation of numerous newly created hydrocarbon fuels) advanced through application of the personal energy of researchers, citing developments in chemistry, his personal speciality. He concluded by noting that while both *jūdō* and *gekiken* sword training play critical roles in cultivating strong physiques, the strict practice of the 'way of the use of energy' also included multiple other life lessons in *Kokushi* which, if mastered in full, could propel its students to become some of the

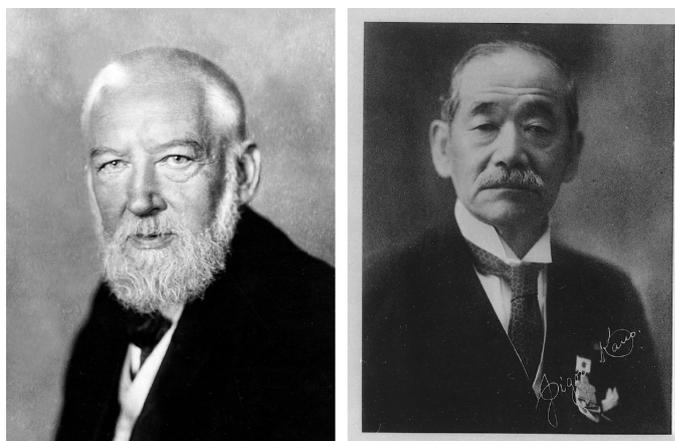
wealthiest and most powerful people in Japan, men who would be glad to be known as patriots of value to the nation (Sakurai, 1899). In this we see Kanō's desire to make *jūdō* philosophy important for the world at large, pertinent to everyone, not just *jūdōka*.

Over its short life, *Kokushi* magazine published many articles on scientific advances, including physics and chemistry. In Japan the connections between physics and philosophy were so close that the very term *rigaku*, first used in Japan to mean philosophy, then came to mean the physical or natural sciences, then physics ([www.tan-gorin.com](http://www.tan-gorin.com), *rigaku*).

*Kokushi* only ran until 1903. The next magazine Kanō edited was *Jūdō*, first published in 1915. During the gap Kanō provided numerous articles to other magazines but mostly on student, teacher and physical education rather than philosophy. Accordingly, the progress of his thoughts on philosophy are not revealed for years, except in one unique book: Kanō's *Seinen Shūyō Kun*. One of modern Japan's first children's ethics books, written from Kanō's influential position as the principal of Tokyo's Higher Normal School, essentially Japan's teacher training university, this 'Youth Training Teachings' included a chapter entitled *seiryoku no saizen riyō*, the *best use of energy*. In it, Kanō expounded at length on the best, correct use of energy and changed the term from Sakurai's general study of *seiryoku no riyō 'the use of energy'* to a universal imperative: *seiryoku no zenyō riyō*, the best cultivation and use of energy (Kanō, 1910).

During the interim between those Kanō-edited magazines, atomism progressed beyond theory into tested, accepted science while Ostwald expanded his concept of energism to become a unitary, scientific monism focussed more on the metaphysical than the physical realm. Eventually Ostwald developed the key principle of energism, the universal 'energetic imperative,' which he summarised as:

*"Do not waste energy, but convert it into a more useful form"* (Holt, 1970, p.389.).



(L-R) Wilhelm Ostwald 1909, Kanō Jigorō c.1930  
(photos: Wiki Commons)

Over time energism assumed a twofold definition:

- Firstly, as the doctrine that certain phenomena (including mental states) are explicable in terms of energy and
- Secondly, as an ethical theory regarding self-realisation.

The latter is the notion that the supreme good consists in the efficient exercise of normal human faculties rather than the hedonistic pursuit of happiness or pleasure (Energism. 2021. In *Merriam-Webster.com*). In energism, neither happiness nor pleasure, but rather self-realisation is the objective of ethical action, which also matches Kanō's teachings. The emphasis of energism on personal perfection and its benefit to the world is borne out in Kanō's description of the ultimate two-fold objective of *jūdō shugyō*, the sincere, disciplined practice of *jūdō*: *jiko o kansei shi* (perfect oneself) *yo o hoeki suru* (to benefit the world) (Kanō Sensei Denki Hensan Kai, 1964).

German idealist monistic philosopher Friedrich Paulsen summarized energism:

*"It is a fact that man's actions are determined by motives which exist in the form of purposes, i.e., as ideas of a good to be attained by action. Thus the question arises: What is the final aim or the highest good for the sake of which everything else is desired?"*

*Hedonism answers: Pleasure; it is for this that everything else is desired.*

*This view is opposed by another theory, which does not seek the highest good in subjective feelings, but in an objective content of life or, since life is activity, in a specific mode of life.*

*Permit me to call this view energism."* (Paulsen, 1895, p.421).

While known among German-reading Japanese chemists such as Sakurai, Ostwald and energism were introduced to the Japanese general public by muckracking tabloid newspaper editor-cum-philosopher Kuroiwa Ruikō (1862-1920). In 1904 he wrote an essay entitled 'I Believe in Energism' for *Gunjikai* (Military Affairs World) magazine, in which he translates Ostwald's energism (エネルギーズム *enerugizumu* in Japanese) as *seiryoku shugi* (literally, energy-ism) and notes its importance to Japan (Kuroiwa, 1904). Later various other Japanese thinkers also wrote of *seiryoku*, including notable friends of Kanō, colleagues and fellow enthusiasts of traditional and western philosophy: educator Dr. Katō Hiroyuki, philosopher Sugiura Jūgō, educator Dr. Inoue Enryō and the chair of the Japan Chemistry Society, Dr. Ikeda Kikunae, who personally studied under Ostwald for a year and a half. These and other papers and articles were created in an energism interest mini-boom in Japan that quickly faded away, other than Kanō's ongoing efforts, as he experimented with and refined various versions of the sayings of his Utilitarian- and energism-based *jūdō* philosophy.

## What is Jūdō?

In one of the earliest known descriptions of *jūdō*, around 1887 Kanō wrote an outline in a private notebook for a speech and a letter to the President of the Navy School describing *jūdō* in purely physical terms, without reference to any philosophies (Motohashi, 2019), but from the early days of the Kodokan, Kanō and his staff researched *jū no ri*, the principle of flexibility which produced the Japanese saying *jū yoku sei gō*, the pliant controls the rigid. He collected *densho* transmission scrolls of secret knowledge from many schools and interviewed *jūjutsu* masters to research the history, philosophy and applications of *jū no ri* (Sakuraba, 1935).

In January 1915, Kanō announced the establishment of the *Jūdōkai* Judo Association, which he chaired and launched the monthly *Jūdō* magazine, which he edited. In the very first sentence in the foreword of the first edition, Kanō cites the importance of the many imported western systems and cultural features that made great contributions to make Japan strong and prosperous. Later he noted that Japan should be careful to maintain and develop its native culture, to maintain its unique identity and to contribute to global civilisation (Kanō, 1915a). Kanō's acknowledgement of the utility of western culture and systems technology but cautioning against the erosion of Japanese culture is consistent with the Meiji era Japanese concept of *wakon yōsai* Japanese sensibilities with western technology, the term for importing western material-physical technology while maintaining a unique Japanese culture and spirit. (Morishima, 1982).

In its second edition, Kanō answered the question, what is *jūdō*?

*"Jūdō is the way to the most effective use of the energy of mind and body. Through training in attack and defence, the discipline of jūdō forges and cultivates the mind, body and spirit to master the essence of this way. Because of this, one can perfect oneself and benefit the world, the ultimate objective of the discipline of jūdō."* (Kanō, 1915b)

## Jūdō Philosophy Complete: *Seiryoku Zenyō Jita Kyōei* 精力善用自他共栄

Kanō wrote that he became unsatisfied with using *jū no ri* as the ultimate principle of *jūdō* when he considered examples such as fighting against an opponent armed with a sword or when seized from behind. In these cases and others, the defences or escapes required actions not in accordance with 柔 *jū*, flexibility or pliancy, but other movements, even strong force against an opponent, or blows to *kyūsho* vital points to injure or kill. Finally, he wrote he came upon the concept that *jūdō* was "the way of something like the technique of the most efficient use of the mind and body,"

心身最有効使用術とか道, *shinshin saiyūkō shiyō jutsu toka michi*, (Kanō, 1926a), the saying he used in one form or another from as early as 1910.

After over a decade of near silence on the issue, Kanō's emphasis on *seiryoku* / energism was made explicit in the *Kodokan Bunkakai* Culture Association, which he founded in 1922 and chaired until his death, a platform he used to proselytise *jūdō* philosophy throughout the Empire and the world. Immediately after establishing the *Bunkakai*, Kanō travelled throughout the Empire, Korea, Taiwan and major Japanese settlements in China, for weeks, lecturing and recruiting members.

#### *Kodokan Bunkakai Sōsetsu no Shushi*

The Main Points of Establishing the Kodokan Culture Association

Objective: to inspire cultural character ....

*Seiryoku Saizen Katsuyō* (Utmost, best utilisation of energy) is the main point of personal perfection

1. Personal perfection is fulfilled by assisting others' perfection
2. Personal perfection is the foundation of mankind (Kano, 1922).

Over time, Kanō cited various versions of his energism philosophy but moving towards a sort of shorthand final form. First he reduced the four-character term 心身の力 *Shinshin no chikara*, 'energy of mind and body' to two characters 精力 *seiryoku*: energy, vigor, vitality. He shortened the five-character term 最有効使用 *saiyūkō shiyō* 'most effective use' into four, 最善活用, *saizen katsuyō*: best use.' In the Kodokan he wrote the combined terms 精力最善活用, *seiryoku saizen katsuyō*, which became known as 'the best use of energy' (Kanō, 1926a). Of course, 善 *zen* should not be simply translated as the 'best' or 'good,' while that suffices for a simplified English translation, more correctly the Japanese character actually means good, goodness, right, righteous, virtue and virtuous (Zen, 1962). If Kanō intended to impart more of a traditional Chinese sensibility, as he often did, that would add the definitions of charity and kindness (Zen, n.d.).

In the essay *Shūyō to Jigyō*, Cultivation and Business, in which Kanō ventures into explaining *jūdō* philosophies to the Japanese business world, he noted that different people have different goals for cultivation, naturally. Energy from different speciality fields, best cultivated 善養 *zenyō*, must be carefully used in the interest of the ultimate success of any endeavor. Finally, he notes that because of this, both cultivation 修養 *shūyō* and use 利用 *riyō* together are in fact the best use 善用 *zenyō* of energy (Kanō, 1926b).

In a 1924 essay Kanō wrote that the six-character phrase 精力最善活用 *seiryoku saizen katsuyō* has the identical meaning of the four-character 精力善用 *seiryoku zenyō* (Kanō, 1924). This final, shortest form made it a *yojijukugo*, one of thousands of four-character Japanese lexeme idiomatic phrases and a nice parallel with the four-character term *jita kyōei*, itself a *yojijukugo*, as was its precursor term *jita heiritsu* (Gatling, 2021).

Sakkō published a number of essays on fractious international relations and global labour and socialist movements, which were becoming more problematic in Japan. In 1925, Kanō wrote a remarkable essay in Sakkō magazine, 'Why it is Necessary to Emphasise *Seiryoku Saizen Katsuyō* Jita Kyōei.' In it he notes that the teachings of various new philosophies had multiplied to the point that students and even teachers were confused by the conflicts between them. If they considered one, they neglected the others, while some created problematic thought. His answer was to offer *jūdō* philosophy as the solution to be used over and above the multiple philosophies current in the world. Kanō's solution to the proliferation of philosophies and the troublesome 'thought problems' of increasing numbers of leftists was to propose the universal philosophies of *jūdō* - *seiryoku zenyō jita kyōei* - as overarching monisms that could guide human activity from individual interactions to exercise to education to business to international affairs was (Kanō, 1925b).

In a 1925 speech, Kanō noted that the *Kodokan Bunkakai* had established branches all over Japan, from Sakhalin in the far north, south to Taiwan and west to Korea and Manchuria for the purpose of spreading *jūdō* philosophy throughout the world. In the speech he claimed that *jita kyōei* 'mutual benefit' underlies all human society and recommends *seiryoku zenyō shugi* 'the principle of best use of energy,' (Kanō, 1925a) i.e., energism, for all human interactions. Kanō later stressed the reason to call the most effective the best is because the objective of human behaviour must be to do good in the most effective way. To achieve this end, he said, mankind should make the best use of its energies (Kano, 1926a), another prescription consistent with energism.

In 1929, in answer to a series of questions, Kanō noted that the true objective of the Kodokan Culture Association was "as one with Utilitarianism" (Kano, 1929a), another reference to that western philosophy. The Utilitarianism of Betham and Mill that Kanō studied and wrote about held that an action (or type of action) is correct and good if it tends to promote happiness or pleasure and wrong and evil if it tends to produce unhappiness or pain (Duignan and West, 2021).

So, *seiryoku zenyō / jita kyōei* is the final, shortest form of Kanō's energism philosophy. Today it is usually translated into English more or less as written: best use of energy / mutual benefit. However, the development above shows this is a crude approximation at best. Over time, Kanō developed the terms as contractions for 'best / virtuous / righteous cultivation and use of the energy of mind and body, balanced in pursuit of the best / virtuous / righteous results in accomplishing the objective' and 'balancing egoism and altruism for mutual benefit.'

In response to questions asking which principle was primary and which subordinate, Kanō wrote a long essay describing their complex interplay. Society requires cooperation to maintain harmony, but when one acts to help others in accord with *jita kyōei*, their personal actions should be in



accordance with *seiryoku zenyō*. *Jita kyōei* helps social harmony but does not hold personal fulfillment in regard and personal fulfillment does not hold social harmony in regard. Kanō's solution was to offer *seiryoku zenyō jita kyōei* as the way to navigate such conflicting situations, as both must be satisfied (Kanō, 1929b). Interestingly, in doing so Kanō balances the greatest good for the group against personal fulfillment through self-perfection. This seems to be a solution in accordance with Confucianism, as that philosophy focuses on the proper role of mankind's participation in society and the necessity for the individual to support society's interests over their own. However, personal perfection, emphasised in the Culture Association's charter and consistent with energism, is also prominent in ancient Confucian teachings. This and other fortuitous similarities with eastern thought perhaps helped disguise the western origins of *jūdō* philosophies for generations of scholars. In fairness, Kanō himself presented neither western energism nor eastern Confucian or Daoist principles as the foundation of his own philosophies; he simply recited them without historic reference.

(To be explicit, the author is in no way criticising Kanō for adopting western philosophies. Kanō himself called *jūdō* eclectic and perhaps the most eclectic aspect of it is his incorporation of eastern and western philosophical elements, spanning 2500 years, to create a martial art cum sport cum lifestyle that has attracted tens of millions across the entire planet and myriad cultures for over 120 years. This is a remarkable feat).

An earlier observer proposed two options for the development of *jūdō* philosophies: that Kanō proposed them as universal principles only after developing them for his *jūdō*, or he adopted them from the beginning with the ultimate intent to make them universal principles (Cadot, 2006). The discussion herein supports a third option: Kanō adopted two existing universal principles, energism and mutual cooperation, used them for *jūdō* under names he devised and then proselytised them as *monisms*, universal principles through his publications and broad public persona as an educator, founder of Japan's amateur athletics, House of Peers member and International Olympic member (Gatling, 2021).

Late in life, Kanō claimed that *jūdō* philosophy is so enlightening that faithful, regular practice of its precepts in the *dōjō* and throughout life outside the *dōjō* would lead to the same level of enlightenment as practising *zazen* seated Zen meditation for years (Maruyama, 1939). In a combination worthy of the most philosophical martial arts, such as *Shaolin kungfu*, unspoken were the additional benefits of physical conditioning and the ability to attack and defend, the latter Kanō's constant theme as the fundamental technical learning of *jūdō*.

From the mid-1920s Kanō's presentations of *jūdō* philosophies remained consistent, repeating these themes time and again. One example is a speech he gave at the University of Southern California in Los Angeles, on the occasion of 11th Olympic Games in 1932, which, seen today through

the lens of energism, rings as a clear, detailed appeal to that Utilitarian philosophy and Kanō's proselytising it as a monistic, universal philosophy.

## The Contribution of Judo to Education by Jigoro Kano

*"The object of this lecture is to explain to you in a general way what Jūdō is. In our feudal times, there were many military exercises such as fencing, archery, the use of spears, etc. Among them there was one called jujutsu which was a composite exercise, consisting principally of the ways of fighting without weapons; using, however, occasionally daggers, swords and other weapons.*

*The kinds of attack were chiefly throwing, hitting, choking, holding the opponent down and bending or twisting the opponent's arms or legs in such a way as to cause pain or fracture. The use of swords and daggers was also taught. We had also multitudinous ways of defending ourselves against such attacks. Such exercise, in its primitive form, existed even in our mythological age but systematic instruction, as an art, dates only from about three hundred fifty years ago.*

*In my younger days I studied this art with three eminent masters of the time. The great benefit I derived from the study of it led me to make up my mind to go on with the subject more seriously and in 1882 I started a school of my own and called it Kodokan. Kodokan literally means a school for studying the way, the meaning of the way being the concept of life itself. I named the subject I teach judo instead of jujutsu. In the first place I will explain to you the meaning of these words. ju means gentle or to give way, jutsu, an art or practice, and do, way or principle, so that jujutsu means an art or practice of gentleness or of giving way in order to ultimately gain the victory; while jūdō means the way or principle of the same.*

.....

*I will finish my talk about the intellectual phase of jūdō by referring shortly to the rational means of increasing knowledge and intellectual power. If we closely observe society, we notice everywhere the way in which we foolishly expend our energy in the acquisition of knowledge. All our surroundings are always giving us opportunities? Are we always making the best choice of books, magazines and newspapers we read? Do we not often find out that the energy which might have been spent for acquiring useful knowledge is often used for amassing knowledge which is prejudicial not only to self but also to society?*

.....

*If I now state in a concise form what I have said, it might be summed up as follows:*



*Jūdō is a study and training in mind and body as well as in the regulation of one's life and affairs. From the thorough study of the different methods of attack and defence I became convinced that they all depend on the application of one all-pervading principle, namely: 'whatever be the object, it can best be attained by the highest or maximum efficient use of mind and body for that purpose.' Just as this principle applied to the methods of attack and defence constitutes jiu-jitsu, so does this same principle, applied to physical, mental and moral culture, as well as to ways of living and carrying on of business, constitute the study of and the training in, those things.*

*Once the real importance of this principle is understood, it may be applied to all phases of life and activity and enable one to lead the highest and the most rational life. The real understanding of this principle need not necessarily be arrived at through the training in the methods of attack and defence, but as I came to conceive of this idea through training in these methods, I made such training in contest and the training for the development of the body the regular means of arriving at the principle.*

*This principle of maximum efficiency, when applied to the keying up or perfecting of social life, just as when applied to the coordination of mind and body, in the science of attack and defence, demands, first of all, order and harmony among its members and this can only be attained through mutual aid and concessions, leading to mutual welfare and benefit.*

*The final aim of judo, therefore, is to inculcate in the mind of man, a spirit of respect for the principle of maximum efficiency and of mutual welfare and benefit, leading him so to practise them that man individually and collectively can attain to the highest state and at the same time develop the body and learn the art of attack and defence."*

(Kano, 1932) .....

In January 1938, before departing on his final voyage around the world, Kanō made a dire warning: with the expanding conflict in China and isolation from the world, Japan had entered the most dangerous period of its entire 2600-year history. His solution for saving Japan from this deadly situation, which he distributed in a small private pamphlet to his circle of friends and key potential supporters; - Depend even more on *seiryoku zenyō jita kyōei!* (Nagata, 2018).

Kanō Jigorō died on 4th May 1938 in his cabin on a luxury passenger ship during his return trip just days out of Yokohama. He apparently never acknowledged the western sources of his *jūdō* philosophies.

## Conclusion

The earliest *jūdō* philosophies were not specified in the 1880s. Kanō was clearly cognisant of Utilitarian philosophy, writing on it at length in 1887. Kanō was satisfied with *jū no ri*, the principle of flexibility, as the fundamental prin-

ciple of *jūdō* and began to develop a new *jūdō* philosophy based on energism and Spencer's 'Cooperation of Self and Others.' The precise date of this development is not known.

Kanō's earliest known mention of *seiryoku* was in a speech in 1892, after Ostwald's energism was known in Japan and Kanō's first trip to Europe, where it was widely discussed. Discussions of *seiryoku zenyō* seems more numerous than *jita kyōei*.

The development of *jūdō*'s energism and mutual cooperation philosophies are evident in Kanō-edited 1920's magazines, along with other Kanō essays and speeches. Over time he developed its final short form: *seiryoku zenyō jita kyōei*.

*Jūdō* is supported by legitimate, detailed philosophies developed by Kanō *shihan*.

**Author's notes:** Hopefully this research, while contributing to *jūdō* history, shines a new light on *jūdō* philosophies and will trigger discussion of how they could broaden the appeal of today's sport judo. This paper is adapted from a longer, unpublished manuscript, The Kanō Chronicles®: The Untold History of Japan.

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#### Article history

Received: 13 October 2021

Accepted: 25 November 2021

# The Influence of Judo Kata Exercise on Adolescents

By Slaviša Bradić, Mike Callan & Florin Daniel Lascau

**Abstract:** *Psychological problems that occur in adolescents relate in part to concentration, which in turn can negatively affect education and development (Tkalec, 2012). In Croatia, various methods are used within teaching to help solve such conditions (Vulić-Prtorić & Lončarević, 2016). Physical activity that promotes increased activation of concentration can certainly contribute to the development of mental characteristics (Smojver-Ažić et al., 2016). The structure of judo kata includes precisely defined techniques that are performed in order to demonstrate basic principles and techniques (Kotani, 1970).*

*This research aims to unlock an understanding of the reasons adolescents take part in kata training and competition. Adolescent competitors in the Croatian Judo Federation National Kata Competition were interviewed. The interviews were analysed thematically.*

*Just performing the forms in kata requires a great deal of concentration because the progress of training in judo kata is based on building perfection from big to small details. The development of perfection in judo kata practice is closely correlated with the ability to concentrate. At the time when competition in judo kata for younger age categories started, kata officially became part of the judo curriculum. By analysing the mental impact on adolescents, we can detect elements that kata develops which could help solve some problems or help develop mental characteristics at this age*

**Keywords:** *Randori no Kata; adolescents; judo development; attention deficit disorder*

Judo: Jigoro Kano created judo from different styles of *jujutsu*, with the aim of developing physical, mental, intellectual and moral potentials (Callan, 2018a; Kawamura & Daigo, 2000). The original purpose of the old *jūjutsu* schools was to fight the enemy with the goal of destruction. Kano attained a high level of mastery by training at various *jūjutsu* schools, for which he also received the *Menkyo Kaiden* certificate, a traditional honour bestowed by the master of a school to a pupil who was considered to have obtained a complete knowledge of the style (Bennett, 2009; Watson, 2000).

A number of schools have distinct, clear connections to an integral, established philosophy, such as China's *Shaolin Kungfu* and Japan's *Shorinji Kempō*, both developed by and closely related to legitimate *Ch'an* (Japanese: *Zen*) Buddhist sects. (Green and Svinth, 2010). Others seek to establish a heritage of philosophy through claims to vague snippets of Buddhist or Shinto texts somehow related to the school or one of its leaders. Finally, some are simply contrived, such as the claimed *Zen* philosophical roots of *kyūdō* Japanese archery (Herrigel: 1948), later debunked as baseless. Despite its highly dubious claims, Herrigel's popular *Zen* in the *Art of Archery* has had a tremendous impact, as many archery practitioners cite interest in spiritual development, *Zen* and motivation by Herrigel's book as decisive factors in their choice of martial art (Yamada, 2001), demonstrating the persuasive influence of such aspirations to a higher calling.

Jigoro Kano went on to establish the Kodokan, a place to study the way of judo (Brousse & Matsumoto, 2005; Hoare, 2009), where Jigoro Kano's Kodokan Judo practice methods were *randori* (free practice), *kata* (formal practice), *kogi* (lectures) and *mondo* (dialogue) (Kano, 2005). Through studying a number of the martial arts systems that existed at the time and practising techniques from different schools (Callan, 2018b), Kano realised that in the exercise itself, there was a particular influence on the development of one's ethical and moral values (Kanō & Lindsay, 1887).

After some years of development, the ultimate goal of practising judo was defined in two principles as the maximum development of one's physical and intellectual potential and their immediate benefit to society through mutual prosperity (150th-Anniversary-Committee, 2020). The positive impact of judo on human development is evident across different ages and genders (Amoedo & Juste, 2016; Borisenko et al., 2015; Pelin et al., 2015; Witkowski et al., 2014). As a popular sport, judo today has many participants in younger age categories. In the Croatian Judo Federation, the largest number of registered members are the early adolescents (10 - 13 years old) and middle adolescents (14 - 17 years old) (Hrvatski-judo-savez, 2021). Competition in judo *kata* for adolescents is in the developmental stage. In the Croatian Judo Federation, *kata* competitions have been held since 2011 and since 2016 younger age categories have also been included (Hrvatski-judo-savez, 2021).

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The aforementioned youth population practises judo as a sport, with competitive content that includes going through various training, methodological and psychological processes intended for judo development. In parallel to sport and judo training, adolescents also go through biological, emotional, and cognitive development. Adolescents who train several times a week or daily certainly experience the impact of training and judo activities on their overall development (Bratić, 2016; Itamar et al., 2013; Jankowicz-Szymanska et al., 2015)

## Kata

The sport element of judo is primarily focused on competition and as such is the most popular element. Other aspects of judo, including judo *kata*, are expanding access to judo for different age groups who are not competitively orientated. Children who engage in organised sports activities are generally less prone to deviant behaviours and have fewer problems in monitoring classes and teaching materials (Mitić et al., 2011; Torbarina, 2011). In some countries, judo *kata* is also practised with younger age categories as part of training, such as parts of judo *kata* that are in belt exams or feature as competition *kata*.

*Kata* is defined as 'form,' formal exercises, practised as patterns. These formal movement patterns contain idealised movements that model specific combat principles (Kawamura & Daigo, 2000). *Kata* in judo is a way of practising in order to achieve a better understanding of *randori* and is best compared with the relationship between grammar (*kata*) and learning to write (*randori*) (Kano, 2005). The popularity of *randori* as an exercise mode means that the fundamental grammar that underpins it (*kata*) can be at risk of being neglected, an exercise mode that is beneficial to progress regardless of personal preference. The goal of personal development must be a priority when considering the various ways of exercising for judo (Kano, 2005).

*Nage no Kata* and *Katame no Kata* together are known as *Randori no Kata* because these two *kata* contain and teach the techniques and principles used when practising both *randori* and *shiai* (Kotani et al., 1968; Otaki & Draeger, 1983a, 1983b). When teaching, different methodical forms of *kata* can be presented in an interesting way to younger judoka, for training and learning basic techniques and principles and ultimately *kata* competitions can be participated in. Learning and practising *kata* can be achieved at several different levels, involving technical, combat and mental components (Bradić & Callan, 2018).

## Concentration Problems in Adolescents

This paper considers psychological impacts, on adolescents, of training in *kata* and therefore a brief introduction to concentration problems in adolescents is outlined. The general behaviour of children in adolescence is marked by specific behaviours that manifest themselves in physical, psychological, emotional and other changes (Vulić-Prtorić & Lončarević, 2016). Sometimes these changes lead

to behavioural problems which can be divided into those categorised as externalised and internalised issues. Externalised behavioural problems relate to insufficiently controlled and other-directed behaviours. Internalised problems are often passive problems and relate to behaviours that are overly controlled and self-directed (Bouillet & Uzelac, 2007; Patel, 2010)

Externalised behaviours include problems with concentration, self-control, avoidance of cooperation, as well as antisocial or aggressive behaviours. Internalised disorders related to depression, withdrawal, anxiety, inferiority, shyness, hypersensitivity and feelings of somatic difficulties (Bornstein & Davis, 2010; Stauffer, 2010).

In relation to behaviour and influences on behaviour in adolescents, Vulić-Prtorić & Lončarević (2016) found that characteristics which often manifest are Attention Deficit Disorder (ADD), increased activity (hyperactivity) and impulsiveness. Bayrakdaroğlu and Tekin (2020) explain that Attention Deficit Disorder is a condition which affects the ability to control behaviour and attention. Children with Attention Deficit Disorder have a negative self-perception, higher likelihood of lack of attention, more frequent and intense hyperactivity, violence and impulsivity, difficulties in peer (social) relationships and weak motor skills.

Studies have shown that children who are diagnosed with ADD may not pay attention to details, may make frequent mistakes due to insufficient depth of understanding of tasks and do not follow instructions or listen to their teachers adequately. Boys may exhibit overt aggression and disruptive behaviour disorders and a higher incidence of disciplinary and behavioural problems in school (Lage et al., 2021). Relevant variables associated with the early onset of the condition include low socioeconomic status.

Other behaviours include being easily distracted by external stimuli, hyperactivity, frequent urges to get up and move or move limbs, impatience in listening and responding and disturbing others through speech or behaviour (Garcia et al., 2020).

## Focus of the Study

The focus of the study was to understand the mental effects of practising *kata* among an adolescent population.

## Research Design

The subjects participated in the 2016 National Judo Championships, held in Rijeka. They were drawn from the middle adolescent age group (14-17 years old) of the Croatian Judo Federation. There were 10 participants (5 male and 5 female). All subjects competed in the *Nage no Kata* event. During the competition the participants were interviewed by television media, Rijeka Sport Association - TV, about their reasons for training and performing in the *kata* competition. The interviews are available online at: <https://youtu.be/EYcIXm86HmU>

Participants in kata competitions can be divided broadly into the following three categories according to their interests: competitors participating in both *shiai* and kata, competitors participating only in kata and competitors preparing for their black belt examination. The author analysed the interview responses thematically, to better understand the perspectives of the adolescents, regarding practising and competing in kata.

## Discussion

The analysis of the interviews provided insight into the thinking and awareness of adolescents who practise and compete in judo kata. Three main themes emerged.

The most common comments identified kata as good preparation for them to increase their technical level (64%), which correlates with their abilities, considering that all the respondents also compete in *shiai* competitions. The importance of competition and results was mentioned by a smaller number of respondents (25%) and the third emergent theme was that respondents believe that judo kata is important for mental development (11%) (Figure 1). The reflections also show how the adolescents' judo goals and their understanding differ from those of their coaches.

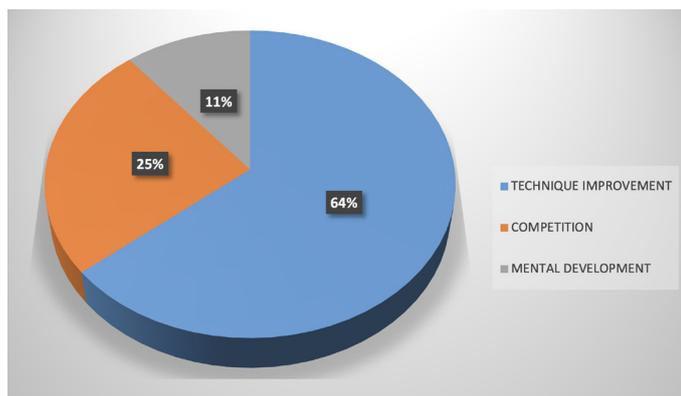


Figure 1. An overview of the factors that kata competitors (medal winners) note as important

## Value of *Randori no Kata* – Technical Aspects

The original name for *Randori no Kata* refers to *Nage no Kata* and *Katame no Kata* because of the applicability of techniques and principles from kata to *randori* training and *shiai* competition (Kodokan, 2014; Leggett, 1964; Leggett, 1963; Otaki & Draeger, 1983a). This is supported by the comments from the respondents who mentioned the value of kata training to their *randori* and *shiai*;

“Kata helps me as a fighter because it helps me understand techniques deeper and better.”

and “Kata really helps me to understand techniques better.”

With the launch of judo kata competitions, another dimension of the application of kata in judo was obtained through the popularisation and recognisability of the competition kata. Following the introduction of competition kata, the lowering of minimum age limits, to include younger categories began (Bradic et al., 2017). Initially within Croatia children's competitions covered three groups of *Nage no Kata* and one group of *Katame no Kata* (Bradić & Callan, 2016) (Figure 2, Figure 3). The respondents acknowledged,

“*Katame no Kata* helps me with my co-ordination and is improving my technique.”

The technical aspects found in *Nage no Kata* include the following 10 elements:

1. Bow – *tachi-rei / za-rei*
2. The way the judogi is held – *kumi-kata*
3. Movement technique – *tsugi-ashi, ayumi-ashi*
4. Distance - *mai*
5. Stances – *shizen-hontai, jigo-tai* (a traditional defensive stance without holding a judogi)
6. Throwing techniques – *te-waza, koshi-waza, ashi-waza, ma-sutemi-waza, yoko-sutemi-waza*
7. Throwing stages – *kuzushi, tsukuri, kake*
8. Impact techniques (*atemi-waza*) – *naname-uchi*
9. Vital point (*kyu-sho*) – *tendo*
10. Falling techniques (*ukemi-waza*) – *yoko-ukemi, mae-mawari-ukemi*



Figure 2. Competition *Nage no Kata*, three *tachi-waza* groups

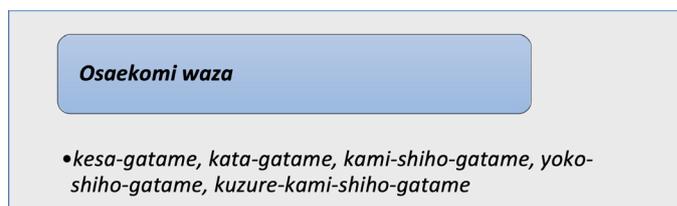


Figure 3. Competitions *Katame no Kata*, one group

## Value of *Randori no Kata* Mental Aspects

When the technical elements within kata are practised as a physical activity this is also a mental exercise. The very performance of a certain defined form naturally requires the activation of various mechanisms whose action is maximally focused on the best possible performance of the form. The mental component is crucial because in order for the form, as defined by the rules, to be derived, mental activity is maximally activated and associated with the physical action (Bradić et al., 2018).

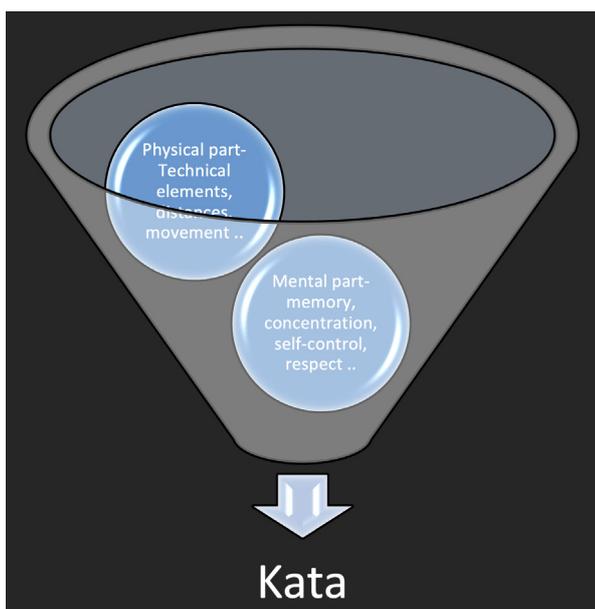
The respondents mentioned how kata helped their mental development,

*“Kata helps me in my everyday concentration, study, learning and that sort of thing”*

and

*“We love judo and kata because they help us in real life; we learn how to concentrate and how to be cool in situations.”*

As a mental activity, kata activates and develops memory, concentration, self-control and respect (Callan, 2018a; Campos et al., 2001; Pelin et al., 2015). In order for kata to be performed with all the given elements within the learned order, it is naturally necessary to have maximum concentration and focus on the performance. Assistance in the form of guidance, advice and correction by the coach decreases in proportion to an increase in the level of mastery of the technique (Warner & Kanamaru, 2018). Thus, inevitably, concentration and focus on an accurate performance increase when the performance takes place completely independently.



**Figure 4.** An illustration of the combination of key performance elements for a high level of mastery in kata

## Influence on Memory Development

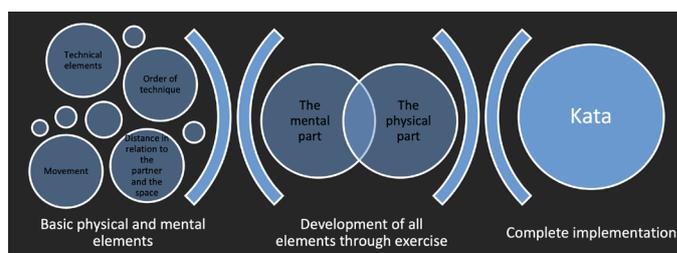
Kata is composed of a series of given technical elements that are performed according to established principles and order. The performance lasts 7-10 minutes and is performed with a partner, without verbal communication. This has a significant impact on the development of memory, especially due to the pronounced default to synchronised physical activity. The techniques themselves are defined with several individual elements, each of which has additional elements. Thus, performance develops from simple and basic elements to upgrades with smaller specific elements.

Many of the respondents saw parallels between this memorising of information in the dojo and their educational life (Figure 5),

*“Kata helps me in school and in life also”*

and

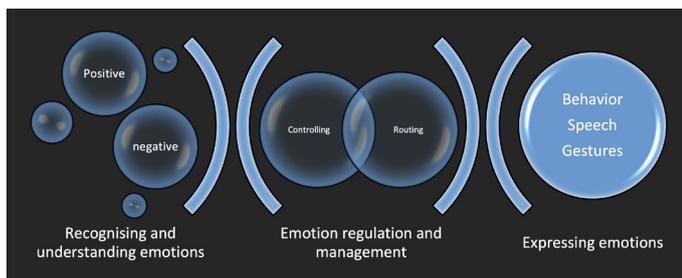
*“Kata really helps me in school.”*



**Figure 5.** A model of the physical and mental development of memory in the practice of kata

## Influence on the Development of Self-control

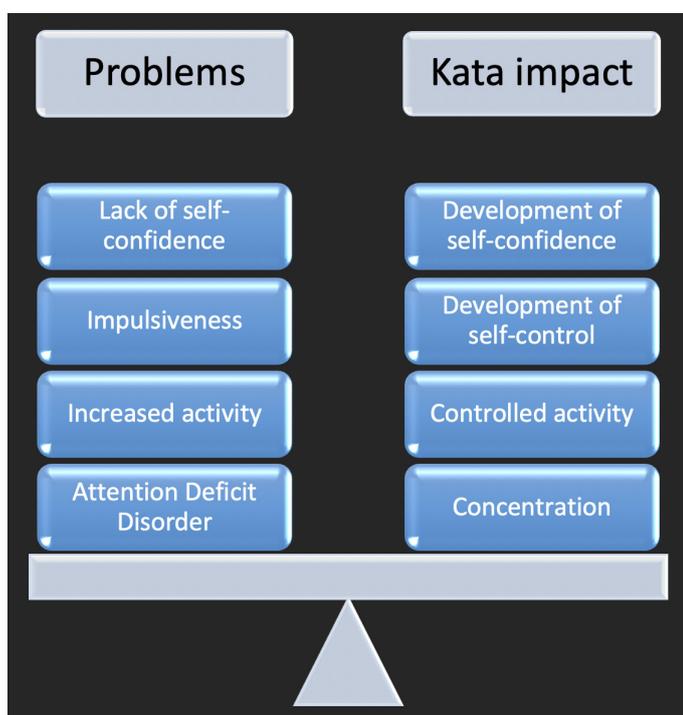
Performing the given elements from the level of learning requires a great commitment to the level of mastery of the kata. The learning stage is directly correlated with the largest number of errors that require corrections by the coach. The increased state of various information that needs to be shaped into a given form requires an element of self-control (Bradić et al., 2018; Lage et al., 2021). Self-control is defined in performing kata through different emotional states that have different external and internal initiators during exercise. Matsumoto and colleagues (2009) explored differing expressions of emotion in judo (Matsumoto et al., 2009; Willingham & Matsumoto, 2007). Practising kata as a form is impossible without a high level of self-control because it is a factor that from a mental point of view keeps the performance of the form correct regardless of various influences (Matsumoto & Konno, 2005).



**Figure 6. An overview of the process of the action of emotions on their visible manifestation**

## Influence on the Development of Respect

In judo, kata is performed in pairs through the roles of *tori* and *uke*. The performance of kata is defined in the exact order of *tori* and *uke*, which means that their roles and relationship are of equal value, for the successful performance of kata. Regardless of the roles in kata, they are both aware of the importance of the partner, their level of knowledge and desired synchronisation. Synchronisation, as a key element of development, is a factor that significantly develops respect for the partner (Kozdraš, 2019). Maximum practice achieves mutual adaptation in the mental and physical elements of kata.



**Figure 7. The relationship between the problems and the impact of kata exercise in adolescents**

By comparing the problems and impact of judo kata practice in adolescents, we can conclude that the practice of kata has a positive impact. Positive influence can be directed through specific methodological ways towards specific and targeted emphasis on a particular factor, whether it is self-control, behaviour, concentration or other elements (Munjas Samarin & Takšić, 2009).

This research, with its results, can be a platform for further research in the field of kata practice in judo for all age groups. It is certain that the contribution of judo practice, through the prism of kata, can contribute to the community positively. The synergy of the development of kata practice also contributes to the development of judo culture, the preservation of tradition and the understanding of the educational element of kata within the judo community.

The results of this analysis can be a guide for a methodological approach to working with adolescents in kata training, creating training opportunities that will be interesting and motivating (Brdic, 2018).

## Conclusion

An analysis of the characteristics of kata activity in adolescents and the correlation with behavioural problems, concentration, attention and similar conditions, suggests a possible positive impact. In addition to the existing pedagogical work through specialised institutions for education, judo definitely has a positive effect on the behaviour and upbringing of adolescents (Takšić et al., 2015).

Judo kata brings a specific way of training and performing, defined by clear rules that use different methodological and mental ways of exercising (Fukuda, 1973). Comparing basic issues from the segment of behaviour, concentration and attention in adolescents with the positive effects of practising judo kata (*Randori no kata*), we can find links to positive influences.

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#### Article history

Received: 14 August 2021

Accepted: 06 December 2021

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The Arts and Sciences of Judo (ASJ) is an international and interdisciplinary academic journal published by International Judo Federation (IJF) and IJF Academy which welcomes articles on various aspects of judo and all its values. ASJ will publish conceptual or primary research papers, that are not published elsewhere, papers that are relevant for the development of judo and offer new insights on certain aspects of judo. All submissions should describe and explain research methodology and also put emphasis on practical implications of the research. Therefore, the ASJ can fulfil all its goals: to become a forum for the disseminating of important judo research results and to bridge the gap between academic research and the needs of practical work in judo.

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